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GEOLOGICAL SURVEY CIRCULAR 290

THORIUM INVESTIGATIONS 1950–52, WET MOUNTAINS, COLORADO

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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By R. A. Christman, A. M. Heyman, L. F. Dellwig, and G. B. Gott

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Washington, D. C., 1953

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By R. A. Christman, A. M. Heyman, L. F. Dellwig, and G. B. Gott

ABSTRACT

The Wet Mountains thorium district was examined in 1950 by the U. S. Geological Survey during reconnaissance investigations for uranium made on the behalf of the Atomic Energy Commission. The size of this new district is not known, but the deposits found before 1953 are in an area 20 miles long and about 10 miles wide, the southwest boundary of which extends north-northwestward from Querida and Rosita, Custer County, into Fremont County, Colo. Most of the deposits, however, are in the southeastern half of this area.

The thorium minerals occur in northwest-trending shear zones that contain barite-sulfide veins and cut a pre-Cambrian complex of amphibolite, biotite-granite gneiss, metagabbro, migmatite, microcline granites, pegmatite and white granite, and syenite(?). Pre-mineralization basic dikes are found along the shear zones.

Thorite has been tentatively identified as the principal radioactive mineral. It commonly is associated with barite, quartz, galena, fluorite, limonite, pyrite, and rare-earth oxides. Some of the shear zones perhaps can be traced for more than a mile, but the largest known thorium-bearing ore body is 300 feet long, 26 feet wide, and 400 feet deep. Channel samples from the veins contain as much as 4.5 percent equivalent ThO_2. The uranium content is generally about 0.002 percent.

Eleven diamond-drill holes, totaling 3,291.2 feet have explored five shear zones on the Haputa ranch. Three ore bodies of possible economic interest are indicated in two interconnecting shear zones. No other deposits of thorium in the Wet Mountains have been explored or even sampled enough to permit an estimate of the grade and tonnage of reserves.

INTRODUCTION

Thorium-bearing shear zones were discovered in 1950 at Haputa ranch, 5 miles northeast of Rosita, on the west side of the Wet Mountains in Custer County, Colo. (figs. 1 and 2), but the size of this new metallogenic province of thorium is incompletely known. Most of the known radioactive localities are in an area about 12 miles long and 6 miles wide that extends from Haputa ranch north-northwestward into Fremont County ("project area" of fig. 1). However, a few scattered localities are further to the northwest (fig. 2). The entire known thorium-bearing area is about 20 miles long and 10 miles wide. To the east is the highest part of the Wet Mountains; to the west is the Wet Mountain Valley, which borders the Sangre de Cristo Mountains.

Before discovery of thorium in the Wet Mountains, the only extensive geologic investigation within the region was a study of the Rosita-Querida-Silver Cliff-Westcliffe mining district by Emmons and Cross (1896). This district comprises an area of predominantly Tertiary volcanic rocks and contains silver, lead, gold, zinc, and copper in veins and associated breccias. No abnormally radioactive rocks have been found in it to date (1952). The thorium deposits are farther east, in shear zones that cut unmapped pre-Cambrian igneous and metamorphic rocks. Within the shear zones are minor deposits of silver, lead, and barite that may or may not be radioactive as well as thorium deposits devoid of silver, lead, and barite. The largest of the lead deposits is the cerussite mine at Ilse (fig. 2).

In July 1950, Gott and Dellwig detected the radioactive shear zones by means of a car-mounted Geiger counter while enroute to investigate a slightly radioactive granite sample submitted to the Geological Survey by Lawrence Knobbe from George Haputa's ranch. Soon thereafter thorite was identified as the radioactive substance. During August 1950 Dellwig, assisted by C. G. Bowles, made an outcrop map of the Haputa ranch property and during the summer of 1951 Dellwig and Heyman mapped the Tuttle, Greenwood and Haputa extension properties (Dellwig, 1951). In 1950-51, Gott, Dellwig, and Heyman examined other prospects in the Wet Mountains area. By radiometric reconnaissance, they traced several of the larger shear zones. As a result of preliminary studies it was decided to diamond drill the best known deposits at the Haputa ranch to determine their characteristics at depth. Between November 1951 and April 1952 the U. S. Bureau of Mines, under contract to the Atomic Energy Commission, cored 11 diamond-drill holes at Haputa ranch. Kenneth Bell and assistants of the Geological Survey obtained gamma-ray logs of the drill holes. Heyman and Christman were responsible for the geologic studies, but over-all supervision of the drilling was the responsibility of C. C. Towle, Jr., of the Division of Raw Materials, Atomic Energy Commission. Dellwig and Gott spotted the first seven drill holes and Heyman was the geologist in the field. Christman assumed responsibility for the project at the end of February 1952 and with Heyman supervised the later phases of the drilling program, revised Dellwig's map in accordance with the new data obtained

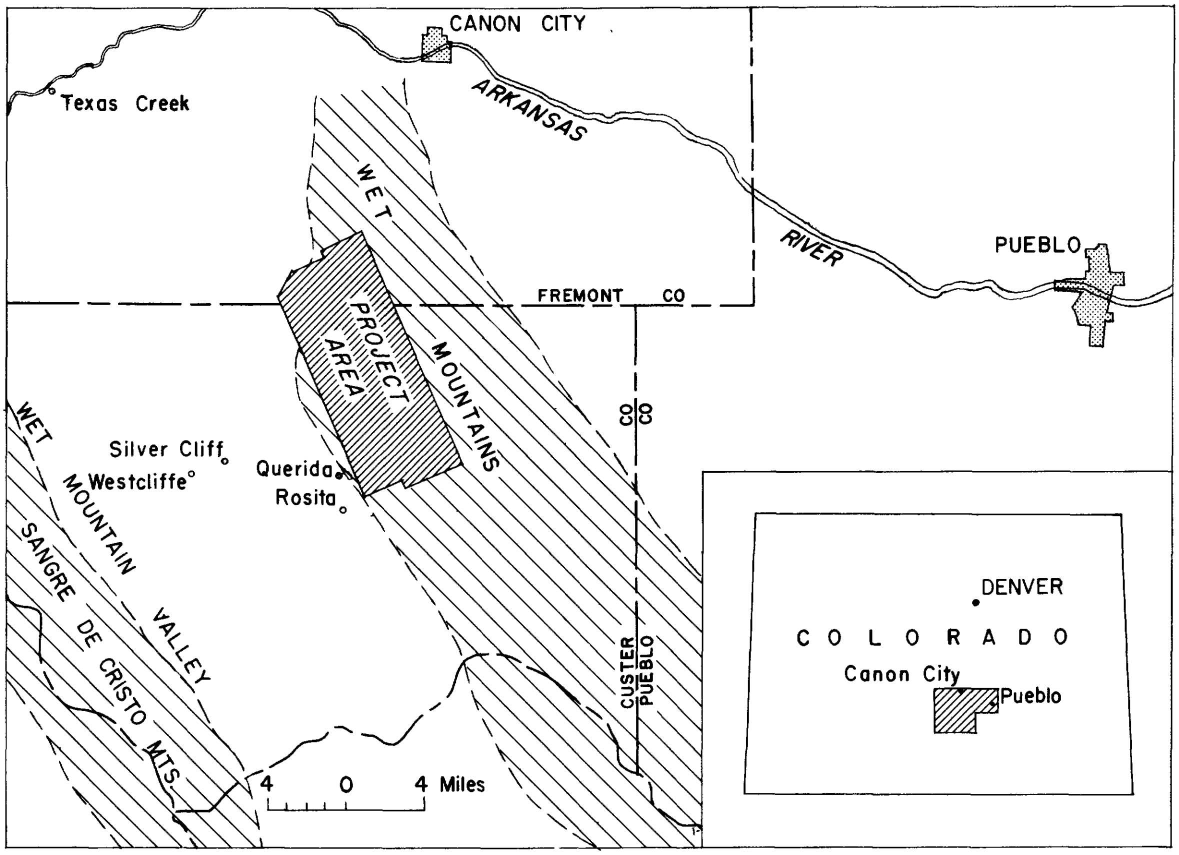

Figure 1.—Index map of Wet Mountains area, Colorado.

during drilling, and prepared this report, which summarizes all information gathered in the area before August 1952.

As a second phase of thorium investigations in the Wet Mountains, systematic geologic mapping at a scale of 1:6,000 on a topographic base of 60 square miles was started by the U. S. Geological Survey in July 1952 (fig. 2). This study, under the direction of Q. D. Singewald, is part of a larger regional program. This report should be considered preliminary as many of the ideas here presented are subject to change as more information is obtained.

All work by the Geological Survey in the Wet Mountains area has been done on behalf of the Division of Raw Materials, Atomic Energy Commission. Special acknowledgment should be made to the personnel of the Trace Elements Section, Denver Laboratory, who made all the analyses. The writers also are indebted to Willis Tuttle, M. Greenwood, L. Knobbe, Ernest Sparling, and particularly G. Haputa, for their cooperation and aid in locating many of the radioactive deposits.

ROCK UNITS

The pre-Cambrian metamorphic and igneous rocks in the Wet Mountains area are composed principally of an older series of schists and gneisses and a younger microcline granite that commonly occurs interlayered with the older rocks. In the southern half of the area, a coarse-grained hornblende-rich rock called a metagabbro, older than the microcline granite and younger than the gneisses and schists, is an important rock unit. All these rocks are cut by pegmatite and basic and acidic dikes.

Mapping units that may be distinguished locally within limited tracts were established at the Haputa, Greenwood, and Tuttle properties. Mapping units applicable to the area as a whole were not established because time was not available for regional stratigraphic studies. Although this report is a compilation of work done by several men at different times, some similarity existed between the map units designated for the various deposits. In redrafting the earlier maps slight changes were made in terminology so that the rock units on all the maps now are as nearly alike as possible. These units, however, are subject to change as mapping proceeds.

The rocks in the Haputa ranch area are best known as a result of data from the drilling and the detailed geologic mapping. The pre-Cambrian rocks are divided into the following units, listed in order of decreasing age: (1) amphibolite, (2) biotite granite gneiss, (3) metagabbro, (4) migmatite, (5) three varieties of microcline granite, (6) pegmatite and white granite, and (7) syenite(?). The only rocks believed to be Tertiary in age are veins and basic dikes. These units are described in detail below and, along with

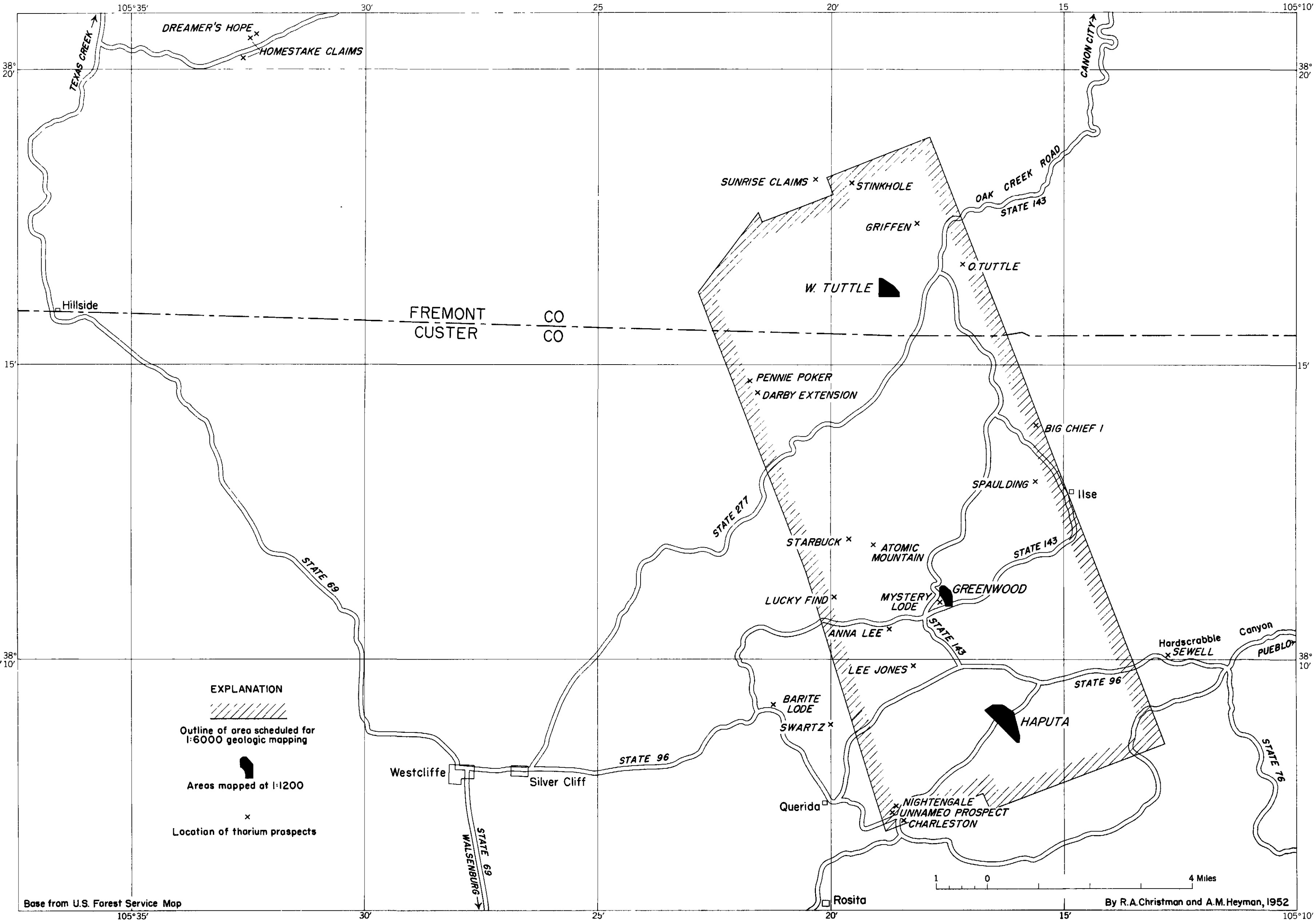

Figure 2.—Map of known thorium areas and prospects, Custer and Fremont Counties, Colo.

differences that are noted for the Greenwood and Tuttle properties, serve as the general description of the rocks in the area.

Amphibolite

The amphibolite is probably the oldest rock in the Haputa ranch area. It has a uniform, fine-grained texture and is composed of hornblende, plagioclase, and a small amount of biotite. Thin sections of some varieties reveal small amounts of quartz. The foliation is generally good; lineation is obscure. Because the rock weathers easily and the exposures are poor, a much larger amount of amphibolite was found in the drill core and trenches than in surface outcrops. Probably 30 percent of the covered areas mapped as "biotite granite gneiss and amphibolite" at Haputa ranch may be underlain by amphibolite. If the exposures were better, it is likely that several varieties of amphibolite and hornblende schist could be distinguished on the basis of the quartz and biotite content and the degree of schistosity.

Most of the amphibolite is found within the biotite granite gneiss as pods, stringers or wisp-like masses, generally alined with the foliation of the granite gneiss. In places it is folded and contorted. In a few places, the rock is in short dike-like masses that are at angles of less than 10° to the foliation of the granite gneiss. Dellwig believes these dikelike masses, mapped as amphibolite, are a hornblende-andesine gneiss of slightly younger age.

At Haputa extension and the Tuttle property the gneiss mapped as amphibolite contains in addition to plagioclase and hornblende small amounts of visible quartz. At the Tuttle property garnet and a variety of the amphibolite that contains garnet was mapped as a separate unit. It is dark gray to brown, fine grained, and contains biotite, quartz, and brown to dark-red garnet as minor constituents; some of the biotite has been derived from the hornblende. At the Greenwood property, no quartz was found in the amphibolite; locally a small amount of garnet was found.

Biotite granite gneiss

The biotite granite gneiss in the Haputa ranch area is a pink to gray, medium-grained, well-foliated rock. It is composed mainly of pink and white feldspar (about 60 percent), quartz (30 percent), and mafics (10 percent). The mafic minerals—mostly biotite and hornblende—in a few places comprise as much as 70 percent of the rock. They are responsible for the well-developed foliation; in a few places the gneiss has a steep or vertical lineation.

The biotite granite gneiss is poorly exposed and weathers to a brownish rock in which the foliation is strongly emphasized. On plate 1 the location of outcrops is shown by the position of the foliation symbols; many of the covered areas were assumed to be granite gneiss.

Where the biotite granite gneiss has been altered by lit-par-lit injection or migmatitic introduction of younger granitic material, it forms a resistant outcrop, and in places the biotite granite gneiss grades along strike into a ridge-forming migmatite. Rock with less than 20 percent added material was mapped as biotite granite gneiss; rock with more than 20 percent was mapped as migmatite in the Haputa ranch area.

A similar biotite granite gneiss was mapped at the Haputa extension and the Greenwood properties; it is absent at the Tuttle property. At the Greenwood property the unit was extended to include a hornblende granite that was too poorly exposed to be mapped separately.

The origin of the granite gneiss is unknown; it may be a true igneous rock or, more likely, it is granitized or migmatized sedimentary rock.

Metagabbro

In the Haputa ranch area, metagabbro is the second most abundant rock type; it underlies most of the southern part of the area. General reconnaissance indicates, however, that it is not as abundant elsewhere in the Wet Mountains area. The most common variety is a medium-grained, dark-green to black rock containing 60 to 50 percent mafic minerals and 40 to 50 percent plagioclase (labradorite). The mafic minerals are hornblende and minor amounts of green pyroxene and biotite. Where fine grained, the rock is difficult to distinguish from amphibolite, especially if the pyroxene is not visible. Locally, another common variety resembles a hornblendite or peridotite; this rock consists entirely of medium- to coarse-grained hornblende with negligible plagioclase. The core from the diamond-drill holes Ha-1 and Ha-2 showed that the peridotite-like rock is gradational to the normal type of metagabbro and is probably a facies of it. A third variety is a striped rock in which the plagioclase is most abundant in layers 1/16 to 1/8 inch thick that separate hornblende-rich layers. In addition to variations between these types, changes in grain size and degree of foliation give the rock a variety of appearances.

In places the metagabbro has well-developed lineation, foliation, or both; in others it is almost granitoid. It is difficult to determine its structure in the field, however, because the rock weathers to rounded masses which are seldom in place and the outcrops are too small and scattered to decipher the many variations in the foliation and lineations. The foliation in a metagabbro mass north of the county road that crosses the Haputa ranch is well developed and parallels the regional trend. In several places the gabbro contact parallels the foliation of the older biotite granite gneiss (or migmatite), but in other places the contact is at right angles to the foliation suggesting that the gabbro is probably intrusive. The fact that the metagabbro may be granitoid in areas of well-foliated rocks suggests that it might be, in part, contemporaneous with the metamorphism.

Reconnaissance in other areas has indicated that additional work is necessary to determine the variations and origin of this unit. Rocks that are megascopically similar apparently are igneous intrusions in one place and metasedimentary(?) gneisses in other places.

Metagabbro occurs at the Haputa extension; it is scarce at the Greenwood property and is absent at the Tuttle property.

Migmatite

The biotite granite gneiss in many places has been intruded lit-par-lit by microcline granite to form migmatite or injection gneiss. The introduced granitic material ranges from intrafoliational films to sills several feet wide; most commonly it is found as seams or small augen-like masses along the foliation planes. The migmatite is generally more resistant than the surrounding biotite granite gneiss and forms ridges parallel to the trend of the foliation.

The migmatite, as mapped (pl. 1), is a unit gradational between biotite granite gneiss and microcline granite. It contains 20 to 80 percent microcline granite. Migmatites commonly surround the masses of microcline granite and in some places appear to be localized near the shear zones.

On the Haputa extension and Tuttle property maps similar appearing rocks, which previously were mapped as "injection gneiss," are included in a unit of "undifferentiated granitic rocks." In these areas granitic gneiss and microcline granite occur as layered sequences or as intimate mixtures. At the Greenwood property only a few outcrops of migmatite were found.

Microcline granite

Several varieties of microcline granite are found throughout the area as stringers along the foliation planes of the gneisses and as sills, dikes, and as small pods or masses. The granite is characterized by a large percentage of microcline feldspar and a pink color. In the Haputa ranch area, three varieties of microcline granite are closely related in age. They easily can be distinguished in most places in the field.

An alaskitic variety is the most common and is most readily recognized. It is characterized by a high quartz content and by a paucity of mafic minerals; a small amount of biotite is locally present. The rock is commonly fine grained to "sugary" in texture and may be quite friable when weathered; in some places local streaks of coarser material give the rock a slight foliation. The alaskitic granite caused most of the migmatitization of biotite granite gneiss in the Haputa ranch area. It occurs as sills, where thicker layers have been injected along the foliation planes, and as small masses. Occasionally it occurs as pods or crosscutting dikes.

A coarse-grained facies of the alaskitic granite is locally common as small masses in the vicinity of drill holes Ha-3 and Ha-7. This rock is medium to coarse grained with conspicuous large grains of quartz, although the total quartz content is probably less than in the sugary textured facies. The mafic content is relatively high (about 10 percent) and consists of hornblende and biotite; in some places the rock is weakly foliated. Within a few feet along the strike, the coarse-grained facies was observed to grade into the sugary facies.

The second variety of microcline granite is characterized by a higher percent of biotite, moderate to low quartz, and a lower microcline content than the other microcline granites. It is generally distinguished by its gray color. This facies occurs mostly as sills or layers along the foliation north of the Haputa ranch area where it is the dominant type of microcline granite. This variety (pl. 1) is probably gradational with the other two types of microcline granite.

The third variety of microcline granite is characterized by its massive or dense appearance, red feldspar, and low quartz content; most of the rock appears to be composed of red feldspar and variable proportions of hornblende. It is medium to fine grained but does not have clearly defined mineral grains. The rock commonly is highly fractured; the fracture surfaces are smooth and stained with limonite. It occurs principally as small dikes that cut the amphibolite, biotite granite, gneiss, and metagabbro. It appears to cut the alaskitic granite in one locality.

The high potash content of the microcline granites is reflected in the radiometric logs of the drill holes. The radioactivity of many of these bodies is about twice background (fig. 9).

Microcline granite was mapped in all the areas studied.

Pegmatite and white granite

Small pods and dikes of pegmatite and white granite occur throughout the Haputa ranch area. The pegmatite is composed of various proportions of white quartz and pink microcline containing some mica or hornblende. These minerals may be as much as 4 inches in diameter; some quartz and feldspar is in graphic intergrowth. Other minerals generally are absent but one 6-inch pegmatite in drill hole Ha-1 contained several blades of an unidentified, light-brown, radioactive mineral. In places, the pegmatite has been irregularly emplaced along shear zones or faults.

A white granite is associated with the pegmatite, but is too uncommon or too limited in size to be mapped as a separate unit. It is a coarse-grained granite composed entirely of white feldspar and quartz. Pod-like masses in the Haputa ranch area are found most frequently along the contacts of metagabbro, or within it. Small pegmatitic stringers of white granite are numerous in the drill core of metagabbro and migmatite.

Syenite(?)

A dike similar in appearance to ones designated by Emmons and Cross (1896) as syenite in the area to the west was mapped along the northeastern margin of the Haputa ranch area. The rock is fine grained; in some specimens the individual grains cannot be easily detected megascopically. It is a smoothly fractured, homogeneous, dull reddish-brown rock that is resistant to weathering and forms conspicuous float. In some places, the rock has the strong fetid odor characteristic of the mineralized rock in the district and in a few places the dike is slightly radioactive. At the Haputa ranch area the dike cuts all rock units with which it is in contact. If, as seems probable, it is continuous beneath the valley alluvium between the two outcropping areas, the dike has a length of more than 2,000 feet; it is 5 feet wide where it was cut by drill hole Ha-9.

This rock forms aplitic-textured dikes in all the areas studied to date.

Basic dike rock

Basic dikes occur along most of the major radioactive shear zones or faults in the Wet Mountains thorium district. These dikes are reported to be similar to the lamprophyres in the Spanish Peaks region 50 miles to the south. Two types of basic dikes were identified in the Haputa ranch area; an older type that appears to be displaced along the shear zone no. 1 (fig. 6) and a younger type that parallels the shear zone and shows no evidence of offset.

The only known basic dike of the older type is a fine-grained to medium fine-grained, dark-green rock composed chiefly of small hornblende crystals and abundant pyrite in a fine-grained groundmass. It has an aphanitic border that contains white and pink calcite amygdules.

The younger dike rocks are aphanitic to fine grained and blue-gray, green-gray, or dark-gray. Phenocrysts are seldom seen megascopically although in the thin section the rock contains many feldspar laths. The rock is commonly amygdaloidal; the amygdules are calcite, and rarely, purple or white fluorite. The rock is hard and dense and forms a competent wall rock where unweathered.

The relationship of the younger dikes to the thorium veins apparently are purely structural. The dikes are only slightly radioactive, except where they are cut by small veinlets of radioactive minerals. The dikes are commonly highly altered; in most places they are essentially limonite. In some places they occupy one side of the shear zone and the veins occupy the other side, in other places they form the wall rock of the veins. There may be as much as 20 feet of sheared rock between the radioactive vein and the dike.

The dikes in the Wet Mountains area are tentatively considered to be Tertiary.

Other units

Units of a "highly altered and leached hornblende-plagioclase rock" and "diorite" were mapped at the Greenwood property (pl. 4). These have no apparent equivalents in the Haputa ranch or Tuttle property areas. The diorite is limited to two outcrops in a 50- by 150-foot area in the southern part of the map area and is a gray granitoid rock composed largely of plagioclase and subordinate amounts of hornblende. The highly altered and leached hornblende-plagioclase rock unit includes several varieties of sericitized, epidotized, chloritized, and partly silicified rocks that are limited to a small area in the southern part of the map.

At the Tuttle property a small amount of quartzite was mapped in the southeastern part of the area. The rock is gray hard thinly laminated and occurs as a 70-foot lens in the granitic-layered sequence.

STRUCTURE

The metamorphic and the igneous rocks of the Wet Mountains have a regional trend of N. 45°—75° E.; the average is N. 60° E. The foliation dips 45° NW to vertical; the average is about 80° NW. Local variations resulting from drag folds or faults are uncommon. The area at first appears to be monoclinally folded, but incomplete evidence from areal mapping done in 1952 suggests that it may be isoclinally folded on a large scale. Lineation is rare. Many of the faults and shear zones trend about N. 50° W. and transect the pre-Cambrian rocks (pls. 1, 3, 4, and 5). The shear zones are nearly vertical and range from less than 1 foot to 26 feet in thickness. The age of the shearing is not known; in places the localization of microcline granite along the shear zone suggests that the shear is pre-microcline granite in age but elsewhere microcline granite and some of the barite in Tertiary(?) veins has been brecciated to indicate recent movements. The largest displacement noted is about 400 feet along a shear zone in the northern part of the area.

THORIUM DEPOSITS

Although many prospect pits and surface exposures, made while prospecting for base and precious metals, are available for study, the presence of thorium has only recently been discovered. None of the deposits has been sufficiently explored underground to outline the shape of the thorium-bearing ore bodies. Drill holes at the Haputa ranch showed that ore bodies are not coextensive with shear zones and that some ore bodies extend to depths of more than 400 feet, whereas others are less deep.

The thorite and rare-earth minerals occur as fracture fillings, as coatings on fractures, and as replacement bodies in sheared rock. There is a close association of sulfides, fluorite, and barite, suggesting that the deposits formed at low temperatures. The deposits are tentatively designated as Tertiary in age because they are younger than the basic dike rocks which are believed to be Tertiary.

Distribution

The known thorium deposits of the Wet Mountains are scattered irregularly, as shown by figure 2, over an area about 10 miles wide that extends about 20 miles from northeast of Rosita to about 6 miles southeast of the village of Texas Creek. In late 1952, more than 32 separate, abnormally radioactive zones had been found. The precise boundaries of the thorium-bearing province remain to be delineated. The deposits are in shear zones within any one of which the ore shoots have irregular distribution, as is illustrated by the isorad map of ore bodies in the Haputa ranch area (pl. 2). The localization of thorium deposits in the shear zones shows no apparent relation to the type of country rock, to the intersection of structures, or to changes in strike and dip of the shear zones.

The radioactive shear zones may extend for considerable distances; shear zone no. 1 on the Haputa ranch property has been traced for a distance of more than 5,000 feet. Moreover, the Anna Lee property, 10,000 feet northwest of the Haputa ranch, is along the general line of projection of the Haputa shear zone.

Mineralogy

The most abundant minerals associated with the thorium are rare-earth minerals, quartz, barite, limonite, and hematite. The less common vein minerals include purple fluorite and smaller amounts of yellow and white fluorite, siderite, galena, chalcopyrite, bornite, and pyrite. Silver and gold are reported to have been found in small quantities. The quartz is commonly massive and white but also occurs as large crystals in vugs. Most of the crystals are smoky and display well-developed interior zoning. The barite ranges in color and form from white crystalline cleavage masses to red cryptocrystalline granular masses. The cleavage angle is between 80° and 85° rather than the normal 90°; if it were not for the high specific gravity, the mineral could be mistaken easily for calcite.

In areas of strong radioactivity, small veinlets and blebs of the thorium-bearing mineral, tentatively identified as thorite, can usually be found. The mineral is dark red-brown, has a greasy luster, a hardness greater than 5 and a tendency to break with a splintery, conchoidal fracture. The thorite in quartz commonly is surrounded by a series of radiating fractures.

The thorium-bearing minerals are rarely recognizable except by the use of a Geiger counter, and the rare earths have only been identified by laboratory work. They normally occur with abundant hematite and limonite or alone in red-stained rocks. Because much of the radioactive material is fine grained and is masked by the iron oxides, it is not known whether this material represents disseminated thorite, hydrated and altered thorite, or thorium molecules in the lattice of, or absorbed by, other minerals.

The identification of thorium-bearing material as a variety of thorite by X-ray pattern was made at the laboratories of the Geological Survey in Washington. Spectrographic analyses of two specimens (table 1) show that the mineral contains a large number of minor constituents. The material contains more iron and less uranium than normal thorite and may be the variety known as ferrothorite. In other districts a similar appearing thorium mineral is reported to be hydrated thorite.

Rare-earth oxides are associated with the thorium in the veins, but the exact form and amount are not known. The content of rare-earth oxides has been determined by subtracting the percent of ThO_2 from the combined percentage of rare-earth and thorium oxides; thus, the rare-earth determination is dependent upon the accuracy of the ThO_2 analyses.

Most of the mineralized material in the shear zones has a strong fetid odor; it is especially strong in some of the reddish-stained granitic rocks. The odor can be detected only for a few seconds after the rock has been broken. The odor was thought to be caused by selenium compounds but a chemical analysis of the rock showed only traces of selenium. The volatile compounds however may have escaped during the grinding of the sample. It also has been suggested that the odor may be due to arsenic or phosphorous compounds. Regardless of its origin, the odor is characteristic of the Wet Mountains thorium area and is useful in tracing the shear zones where other evidence of mineralization is lacking.

A megascopic study by Dellwig of the paragenesis of the minerals in the Haputa ranch area indicates that siderite was deposited first and was followed by fluorite, quartz, and the copper sulfides. The galena and barite are considered to be only slightly younger. The final stage in the sequence is the deposition of the thorium and rare-earth minerals. In places the thorite appears contemporaneous with the barite, but elsewhere it cements brecciated barite.

Size and grade

The sizes of ore bodies within the radioactive shear zones depend in part upon the arbitrary cutoff grade used in determining their limits. A grade of about 0.3 percent equivalent ThO_2 was used in this study in delimiting ore shoots. On this basis the longest known ore body is the Anna Lee lode (fig. 3). It extends along the shear zone continuously for 400 feet and discontinuously for a total of almost 1,000 feet. Where observed, the ore is as much as 1.3 feet thick and consists of 2 inches of high-grade thorite in lower grade thorium-bearing rock (table 10). No information is available as to the vertical extension of this deposit. The larger of two ore bodies in shear zone no. 1 in the Haputa ranch area is roughly 200 to 300 feet long and 6 feet wide at the surface; it extends at least 400 feet in depth; a thickness of about 26 feet of radioactive material was cut in drill hole Ha-3 (fig. 6). The other ore body in shear zone no. 1 is 160 feet long and 2 to 7 feet wide on the surface. It extends more than 140 feet in depth where a drill-hole cut about 10 feet of vein material (fig. 7). These, however, are the exceptional, high-grade ore bodies.

In this report the assay results are given as equivalent ThO_2 ($eThO_2$) which is calculated by subtracting the chemical uranium from the equivalent uranium and multiplying the difference by the conversion factor of 5.6. This factor, which varies with radiometric equipment, is the one determined by the Trace Elements Section Denver Laboratory on thorium standards from the National Bureau of Standards. Most of the samples have been counted against the thorium standard (table 2) and the results are in agreement with the calculated value. In 14 samples ThO_2 was determined by a radiochemical method whereby the thorium is separated chemically and analyzed radiometrically (table 2). The agreement of the values obtained by these methods shows that the difference between the equivalent uranium and chemical uranium is due entirely to thorium since no excess radium or daughter disintegration products with natural radioactivity could be detected by radiochemical methods.

The chemical determination of thorium is difficult when large amounts of barium are present, as is the case of the samples from the Wet Mountains. In most samples the chemical ThO_2 substantially agrees with the equivalent ThO_2 within the limits of laboratory error (table 2). Where the values were not in agreement, radiochemical methods failed to show the presence of other radioactive materials. At present there is no reliable, rapid chemical method for ThO_2 below 0.1 percent (personal communication with L. F. Rader, Jr.). For this reason, many of the samples were not submitted for chemical analyses. The equivalent ThO_2 values, therefore, are used in this report to maintain uniformity of data.

A few semiquantitative spectrographic analyses were made; the results are shown in tables 1, 5, and 10.

The equivalent ThO_2 values obtained from the gamma-ray logs of the drill holes (table 6) are higher than those obtained in the core samples (table 5). The difference probably is due to the loss of pulverized radioactive materials with the sludge. In places the evidence in the core samples shows that thorium-bearing material is missing from the fractures; one side of a fracture may be radioactive while the other side is washed clean. The conversion factor of 2.5 for directly converting equivalent uranium to equivalent thorium without subtracting chemical uranium from equivalent uranium is the best estimate that can be made at this time. The factor has not been established by laboratory work and is subject to later revision.

The highest values obtained from channel samples were 4.02 percent equivalent ThO_2 for a length of 1.3 feet at the Anna Lee lode (RA-76, table 10) and 4.47 percent equivalent ThO_2 for 3.7 feet at Haputa ranch (RA-95, table 3). The grade varies not only along the strike and down the dip but across the width of the shear zone with the highest grades occurring as thin veins or groups of veins. The average grade of the higher grade deposits is probably less than 0.5 percent ThO_2, 0.002 percent uranium, and 0.3 percent rare-earths oxides. One grab sample from the Homestake claims (LD-8a, table 10) contained as much as 6.51 percent rare-earths oxides, and a sample from the Griffen property (LD-31, table 10) contained 0.058 percent uranium.

SUGGESTIONS FOR PROSPECTING

Although an assured evaluation of thorium potentialities in the Wet Mountains cannot be made in advance of detailed study now in progress, the preliminary results suggest that the area is favorable for prospecting. The most readily found radioactive localities are along shear zones on which many prospect pits were dug at some previous date in search for silver, gold, lead, or barite. In the absence of prospect pits, the zones can also be found by the presence of (1) radioactivity, (2) siderite, quartz, and/or barite, (3) basic rocks, commonly completely altered to limonite, (4) a fetid odor of the altered rocks, (5) a characteristic red stain of the sheared rocks, or (6) green or blue amphibole(?) minerals coating the fractures of the country rock.

In some zones, the most abundant radioactive material is in areas that contain barite and/or smoky quartz; in others it is in areas containing only thorite minerals (as veinlets) and intensely red stained country rocks. No mineralized or altered rock from this region can be rejected by visual inspection as not containing thorium. All such rocks should be tested with radiation-detection instruments such as the Geiger or gamma-scintillation counter. The gamma-scintillation counter is more sensitive to slight changes in radioactivity and is very useful for making quick evaluations of an area. It is especially useful in areas of light cover where the soil may still contain the thorium minerals.

Table 1.—Spectrographic analyses of thorite

Looked for but not fonnd: Na, Ag, As, Au, B, Bi, In, Ir, Hf, Hg, La, Li, Nb, Os, Pd, Pt, Re, Rh, Ru, Sb, Sm, Ta, Tl, Te, U, W, and Zn.
Not looked for: K, Ce, Nd.

	Si	Al	Fe	Ti	Mn	P	Ca	Mg	Ba	Be	Co	Cr	Cu
RA-86[1]	X	0.X	XX	0.0X	0.0X	X	0.X	0.0X	0.X	0.00X	0.0X	0.0X	0.00X
RA-87[2]	X	.X	XX	.X	.00X	.X	.X	.0X	.0X	.00X	.00X	.0X	.00X

	Ga	Ge	Mo	Ni	Pb	Sc	Sn	Sr	Th	V	Y	Zr
RA-86[1]	---	0.00X	0.0X	0.0X	0.0X	0.0X	0.00X	0.0X	XX	0.0X	0.X	0.0X
RA-87[2]	0.000X	.00X	.0X	.00X	.0X	.0X	.00X	.0X	XX	.0X	.X	.0X

[1] From Anna Lee lode.
[2] From Haputa ranch; shaft above drill holes Ha-3 and Ha-7.

Table 2.—Comparison of thorium values obtained by calculation and by radiometric, radiochemical, and chemical methods

Sample no.	Equivalent ThO_2 (percent)			ThO_2 (percent)
	Calculated[1]	Radiometric[2]	Radiochemical[3]	Chemical
LD-38	1.11	1.17	1.12	---
LD-50	.77	.78	.80	---
LD-51	.52	.47	.44	---
AH- 9	.43	.40	.53	---
AH-15	.48	.49	.53	---
AH-22	.52	.52	.47	---
AH-25	.84	.85	.76	---
AH-26	.62	.58	.56	---
AH-27	.56	.57	.58	---
AH-28	.29	.30	.31	---
AH-51	.54	.54	.53	---
AH-49	.72	.67	.69	---
AH-16	.18	.15	.16	---
GG-42	1.22	.96	---	1.08
GG-47	3.34	3.6	---	3.19
GG-54	.15	.12	---	.10
GG-59	6.93	6.8	---	6.29
GG-65	.13	.10	---	.07
GG-69	.06	.06	---	.04
GG-72	.10	.08	---	.08
GG-79	.38	.38	---	.31
GG-82	.13	.13	---	.13
LD-8a	.35	.33	---	.30
LD-10a	.10	.09	---	.10
LD-12a	.13	.12	---	.14
LD-13a	.08	.08	---	.09
LD-52	.60	.59	---	.57
LD-54	2.00	1.9	---	1.91
AH- 5	.11	.11	---	.10
AH- 5a	.29	.27	---	.26
AH-19	1.56	1.5	---	1.43
RA-23	2.12	2.2	---	1.98
RA-26	1.00	1.0	---	.84
RA-28	1.67	1.7	---	1.59
AH-40	.24	.25	---	.21
AH-42	.23	.21	---	.15
AH-45	.24	.25	---	.25
AH-50	.20	.26	---	.28
AH-53	1.60	1.7	---	1.78
RA-51	6.70	5.7	---	6.51
RA-52	2.21	2.1	---	1.71
RA-76	4.02	3.7	---	3.81
RA-93	2.57	2.5	---	2.77
RA-94	.72	.68	---	.64
RA-95	4.49	4.5	---	4.96
RA-96	.61	---	---	.55
RA-97	1.11	---	---	1.18
KR- 2	1.43	1.4	---	1.28
KR- 3	6.68	6.8	---	6.96
KR- 4	.77	.77	---	.55
KR- 5	.55	.54	---	.40
KR- 8	1.00	1.1	---	.81
KR- 9	.95	.95	---	.82

[1]Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor 5.6.

[2]Samples compared radiometrically against National Bureau of Standards thorium standards without correction for the small amounts of uranium in the unknown.

[3]Involves chemical separation and radiometric determination by a method of J. N. Rosholt, Jr. ("A quantitative radiochemical method for the determination of the major sources of natural radioactivity in ore and minerals", TEIR in preparation.)

DESCRIPTION OF PROSPECTS

Haputa ranch area

The first radioactive minerals discovered in the Wet Mountains were found on the Haputa ranch, 11 miles east of Westcliffe (fig. 2) in SE$\frac{1}{4}$ sec. 12, T. 22 S., R. 71 W. Many of the contacts on the map (pl. 1) are approximate or inferred because of the complex geology and the poor exposures. The outlines of the outcrops are not shown.

Rock units

The rock units mapped at Haputa ranch are: (1) amphibolite, (2) biotite granite gneiss, (3) metagabbro, (4) migmatite, (5) three varieties of microcline granite, (6) pegmatite and white granite, (7) syenite(?), and (8) basic rock. These units have been described in the section on general rock descriptions and will not be treated further. However, a few words more about the older hornblende-rich dike are in order. This dike, discovered in drill holes Ha-3 and Ha-7, weathers so easily that a careful search revealed no float from it, though later bulldozing exposed it for a width of 22 feet. More dikes of this type, therefore, may be concealed beneath the soil. The dike strikes about N. 70° W. and dips 77° NE and probably occupies a subsidiary fault of small displacement. Although the dip changes at depth, its position in the drill holes suggests that it has been displaced (fig. 6) 50 feet along the main shear zone, either by orogenic movement or by dilatation by later dikes and veins along this zone. No radioactivity is associated with the dike, but it is altered, and the dike rock along the contacts has a fetid odor.

Structure

The prevailing foliation in the biotite granite gneiss and in the migmatite strikes about N. 60° E. and dips about 80° NW (pl. 1). Changes of strike in the granitic rocks, other than those associated with the metagabbro, are never abrupt or large; they probably represent local warping. Some minor folding or contortions occur in the small amphibolite within biotite granite gneiss. Locally near the contacts with the metagabbro the strike of the biotite granite gneiss or migmatite may parallel the contact and deviate as much as 90° from the prevailing trend. Lineation was observed only in a few locations; no interpretations were possible.

The dominant structural features of the Haputa ranch area (pl. 1) are five mineralized shear zones. Evidence concerning the size and shape of these structural breaks is limited to exposures in prospect pits and data from drill holes. The shear zones have a general trend of N. 50° W. and a vertical or nearly vertical dip. In many places their trend is reflected in the strike of joints. In the vicinity of hole Ha-6, two en echelon shears are connected diagonally by a tension fault,1 foot wide (pl. 2). All the large continuous shears contain basic dikes whereas the smaller ones, such as this tension fault, do not contain dikes; both may be mineralized. The longest shear zone, no. 1, at drill hole Ha-3, has a maximum width of 26 feet, is 13 feet wide at hole Ha-8, 12 feet wide at hole Ha-6, and 8 feet wide at hole Ha-2. In a few places, as south of drill hole Ha-3, the break is narrow and is more correctly called a fault.

The apparent displacement along shear zone no. 1 is small. About midway between the sites of holes Ha-8 and Ha-11, two pegmatite bands and a migmatite band, that have slightly divergent strikes, are displaced about 20 feet along the fault, the northeast side having moved southeast. The "older" basic dike near drill hole Ha-3 was intersected in the drill holes on either side of the shear zone no. 1. A maximum vertical displacement of about 50 feet is shown for this dike (fig. 6). Elsewhere, the displacement along the faults is not evident, or is very small.

The structure, which includes shear zones nos. 1 and 2, can be traced for a considerable distance; it is known to extend at least 7,000 feet and probably extends more than 17,000 feet. The displacement is apparently small.

Exploration

Surface exploration.—In addition to sampling and studying the surface exposures and many small prospect pits, a survey was made of the surface radioactivity with a gamma-scintillation detector. The area was thoroughly traversed and all areas having radioactivity of more than 200 cpm (counts per minute) over a background of about 100 cpm are recorded in plate 2. Isorads are drawn for radioactivities of 200, 300, 400, and 500 cpm.

The isorad map was made by irregularly traversing the radioactive areas and locating points of 200, 300, 400, and 500 cpm by pinning pieces of colored crepe paper to the ground. After a few points were located the shape of the isorad lines could be seen on the ground and additional readings could be made at critical points. The data were plotted on the plane table map.

The isorad lines give a valuable picture of the distribution and concentration of the radioactivity; however, no quantitative correlation can be safely made between the isorad lines and the size of the deposit because of the masking effect of cover and the anomalous effect of float and ore material on prospect dumps. Obviously, a reading of 500 cpm in a prospect pit where ore is exposed represents less radioactive material than the same reading in a covered area. The ore body at Ha-8 was discovered through 8 inches of soil cover, showing that radioactivity can be detected in areas of light soil cover. On the other hand, areas of heavy alluvium cover, as northwest of Ha-8, may contain concealed deposits that cannot be detected. The movement of radioactive float down a gently gullied slope is shown by the irregularly shaped contour for the 200 cpm isorad at Ha-8 (pl. 2).

The analyses of the samples collected from the surface exposures and the prospect pits are given in table 3.

Diamond-drilling exploration.—Eleven diamond-drill holes totaling 3,291.2 feet explored the thorium-bearing veins on Haputa ranch. Five holes (Ha-3, -6, -7, -8, -10, and -11) explore shear zone no. 1 for a strike length of 1,440 feet; three (Ha-1, -2, and -6) explore shear zone no. 2 for a length of 600 feet; two (Ha-4, and -5) explore shear zones nos. 3 and 4 for a length of 245 feet; and one hole (Ha-9) explores shear

Table 3.—Analyses of samples from prospect pits and surface exposures at Haputa ranch

Sample No. [1]	Type [2]	Length (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [3] (percent)	Total rare-earth oxides and ThO_2 (percent)	Chemical ThO_2 (percent)	Rare-earths oxides [4] (percent)
Locality from the vicinity of drill holes Ha-3 and Ha-7								
GG-57----	A	1.6	0.026	0.001	0.14	0.32	---	0.18
GG-58----	A	4.0	.011	.001	.06	.31	---	.25
GG-59----	A	0.5	1.24	.002	6.93	6.84	6.29	.55
Locality from the vicinity of drill hole Ha-8								
GG-74----	B	2.0	0.027	0.001	0.15	0.16	---	0.01
GG-73----	B	10.0	.015	.001	.08	.31	---	.23
RA-93----	A	5.0	.46	.001	2.57	3.30	2.77	.53
RA-94----	A	5.0	.13	.001	.72	.79	.64	.15
RA-95----	A	3.7	.81	.009	4.49	5.76	4.96	.80
GG-72----	B	10.0	.019	.001	.10	.15	.08	.07
Locality from the vicinity of drill holes Ha-10, Ha-11, and Ha-6								
GG-70----	B	25.0	0.016	0.001	0.08	0.21	---	0.13
RA-97----	A	2.0	.20	.002	1.11	2.71	1.18	1.53
RA-96----	A	2.0	.11	.001	.61	.95	.55	.40
GG-42----	A	1.9	.22	.002	1.22	1.11	1.08	.03
GG-43----	A	5.0	.07	.001	.39	.19	---	---
GG-47----	A	2.0	.60	.002	3.34	3.19	3.19	---
GG-69----	B	5.0	.012	.001	.06	.27	.04	.23
GG-68----	B	12.0	.012	.001	.06	.23	---	.17
Locality from the vicinity of drill holes Ha-2 and Ha-1								
GG-75----	B	2.0	0.038	0.001	0.21	0.17	---	---
GG-48----	A	1.8	.007	.001	.03	.20	---	.17
GG-71----	B	3.0	.009	.001	.04	.18	---	.14
GG-76----	B	2.0	2.94	.004	16.44	14.82	---	---
Locality from the vicinity of drill hole Ha-4								
GG-55----	B	1.0	0.068	0.001	0.38	0.33	---	---
GG-56----	B	.5	.014	.001	.07	.39	---	0.32
GG-60----	A	.5	.012	.001	.06	.87	---	.81
Locality from the vicinity of drill hole Ha-5								
GG-52----	A	1.8	0.007	0.001	0.03	0.51	---	0.48
GG-53----	A	2.25	.01	.001	.05	.44	---	.39
GG-54----	A	.05	.027	.001	.15	.20	0.10	.10
GG-65----	A	1.0	.025	.001	.13	.39	.07	.32
GG-66----	A	1.3	.007	.001	.03	.40	---	.37
Locality from the vicinity of drill hole Ha-9								
LD-16----	A	4.0	0.008	0.001	0.04	---	---	---
LD-18[5]---	C	---	.020	.001	.11	---	---	---
LD-20[6]---	C	---	.016	.001	.08	---	---	---
LD-17[7]---	C	---	.007	.002	.03	---	---	---
LD-19----	A	8.0	.005	.001	.02	---	---	---

[1]Samples listed from north to south along individual shear zones, beginning with shear no. 1. See plate 2 for approximate locations.
[2]A, channel sample; B, chip channel sample, and C, grab sample.
[3]Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor of 5.6.
[4]Obtained by subtracting the chemical percent ThO_2 from the chemical percent of total rare-earth oxides plus ThO_2. Where a chemical ThO_2 value is not available, the equivalent ThO_2 is used.
[5]From 7- by 2-foot zone.
[6]From 2- by 3-foot zone.
[7]From dump.

zone no. 5. The position of the drill holes is shown in plates 1 and 2. A summary of the data regarding the drill holes is given in table 4 and the analyses of the samples from the drill core are given in table 5.

After the completion of the drilling, the drill holes were logged for radioactivity. These logs are shown diagrammatically in figures 6-15 by representing the radioactivity of the counts per minute on a logarithmic scale to condense the length of the higher peaks. The radioactivity recorded on the logs can be correlated easily with the geology logged from the core of the drill holes.

A quantitative interpretation of the radioactivity expressed in the higher peaks in these gamma-ray logs is given in table 6. Because previous interpretations had been limited to uraniferous studies, the results were given as U_3O_8 and these have been converted to equivalent ThO_2 by a series of calculations. The higher values of the gamma-ray logging compared to those of the core samples is believed to be due to loss of radioactive material from the core into the sludge.

Thorium deposits

All the shear zones at Haputa ranch are very weakly radioactive; however, only about 15 percent of their length is sufficiently radioactive to measure twice background on a gamma-scintillation detector. The size and shape of the anomalies is shown by the isorads on plate 2. The remaining 85 percent of the shear zones is either too deeply covered, or the radioactivity is too weak to show isorads of this type. The individual deposits or ore shoots at Haputa ranch are described in detail in the drill logs computed at the end of this report (p. 30).

Haputa extension

As shown by plate 3, the geology in the area designated as Haputa extension is similar to that in the Haputa ranch area to the southeast. No new rock units are present, although the abundance of each rock type is different. The major shear zones can be correlated across the alluvium valley between the two areas. Thorium minerals are less abundant in the shear zones exposed on the Haputa extension.

Geology and thorium deposits

The gneissic microcline granites at Haputa extension were not separated into the three varieties as in the Haputa ranch area. In the Haputa extension the microcline granite characterized by biotite and a moderate to low quartz and microcline content appears to be the most abundant. It makes up many of the sills and dikes, including one sill that is at least 1,200 feet long.

Shear zone no. 1 was traced 1,500 feet southeast from the shaft in the northwest part of the area and was postulated to continue another 1,000 feet across the alluvium-filled valley to connect with the shear zone cut by drill holes Ha-3 and Ha-7. In the northwest, it is moderately radioactive for a distance of about 350 feet; the vein in the shear zone is 2 to 4 feet thick and consistently gives Geiger-Mueller counter readings of about 0.5 mr/hr.[1] (background about 0.03 mr/hr; geometry 2π). It is possible that other parts of the shear are radioactive but have not been detected because of the poor exposures. The samples collected from this shear zone contain from a trace to 0.88 percent equivalent ThO_2 (table 7), less than 0.005 percent uranium, and as much as 0.15 percent rare-earth oxides. Appreciable amounts of quartz, barite, and galena occur with the radioactive material; galena is reported to have been mined from the shaft. A basic dike containing fluorite-filled vesicles similar to the dike occurring above drill holes Ha-3 and Ha-7 was found in the shear zone where exposed in the shaft.

The eastern of the two shear zones designated as no. 7 contains a biotite-bearing basic dike and a 2- to 3-foot zone of mineralized granite and gneiss containing quartz and barite. In a pit at the northern end of the shear zone the vein and dike are highly sheared; the dike is altered in part to a silver-blue, fibrous amphibole. The channel sample across the shear (LD-13) contained 0.03 percent equivalent ThO_2. The western shear is marked by reddish-stained granite,

Table 4.—Summary of diamond-drill hole data, Haputa ranch

Hole no.	Location (shear zone)	Length (feet)	Direction	Inclination	Depth of first core[1] (feet)	Core recovery (percent)
Ha-1	2(?)	327.0	S. 6° W.	-45°	35.0	99.3
Ha-2	2	275.0	N. 77° E.	-45°	91.0	99.3
Ha-3	1	283.0	N. 44° E.	-45°	23.3	97.5
Ha-4	3 and 4	294.3	N. 55° E.	-45°	31.0	99.2
Ha-5	3 and 4	213.5	N. 55° E.	-45°	45.0	99.4
Ha-6	1 and 2(?)	437.5	N. 41° E.	-45°	10.0	99.5
Ha-7	1	486.1	S. 44° W.	-45°	47.0	99.1
Ha-8	1	200.2	N. 44° E.	-60°	4.4	99.9
Ha-9	5	215.8	N. 54° E.	-45°	29.0	99.6
Ha-10	1	248.7	N. 61° W.	-45°	65.0	100.0
Ha-11	1	210.1	N. 4° W.	-45°	42.0	96.1
Total		3,291.2				

[1] Reported by U. S. Bureau of Mines. Some core fragments recovered above these depths.

[1] Milliroentgens per hour.

Table 5.—Analyses of diamond-drill cores, samples from the holes at Haputa ranch, Custer County, Colo.

Field no.	Drill hole	Depth (feet)	Length of sample (feet)	Corrected sample length [1] (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [2] (percent)	Chemical ThO_2 [2] (percent)	Radiochemical ThO_2 [3] (percent)	Spectrographic analyses: Th	Ba	Sr	Pb	La	Ce	Nd	Y
AH-69	Ha-2	169.5-171.1	1.6	1.1	0.001	0.001	0.00	---	---								
AH- 5	Ha-2	171.1-176.9	5.8	4.1	.021	.002	.11	0.10	---								
AH- 5a	Ha-2	175.9-176.9	1.0	.7	.052	.001	.29	.26	---								
AH- 6	Ha-2	188.0-188.3	.3	.2	.007	.001	.03	---	---								
AH- 7	Ha-2	230.6-231.4 and 231.8-232.0	1.4	1.0	.005	.001	.02	---	---								
AH-55	Ha-3	229.9-233.0	3.1	2.2	.007	.001	.03	---	---								
AH- 8	Ha-3	233.0-236.4	3.4	2.4	.010	.001	.05	---	---								
AH- 9	Ha-3	236.4-238.4	2.0	1.4	.078	.001	.43	---	0.53	0.X	0.X	0.0X	0.00X	0.00X	0.00	0.00	0.00X
AH-10	Ha-3	238.4-239.4	1.0	.7	.004	.001	.02	---	---								
AH-11	Ha-3	239.4-240.5	1.1	.8	.016	.001	.08	---	---	.0X	.X	.0X	.00X	.00X	.00	.00	.00X
AH-12	Ha-3	240.5-241.6	1.1	.8	.008	.000	.04	---	---								
AH-13	Ha-3	241.6-242.0 and 242.8-245.2	2.8	2.0	.005	.000	.03	---	---	.00	.X	.0X	.000X	.000	.00	.00	.00X
AH-14	Ha-3	242.0-242.8	.8	.6	.008	.000	.05	---	---								
AH-15	Ha-3	245.2-247.0	1.8	1.3	.086	.001	.48	---	.53	.X	.X	.0X	.00X	.000	.00	.00	.0X
AH-16	Ha-3	247.0-248.9	1.9	1.3	.033	.000	.18	---	.16								
AH-17	Ha-3	248.9-249.3	.4	.3	.028	.000	.16	---	---	.0X	.X	.0X	.00X	.000	.00	.00	.0X
AH-18	Ha-3	249.3-251.0	1.7	1.2	.008	.001	.04	---	---								
AH-19	Ha-3	251.0-251.5	.5	.4	.28	.001	1.56	1.43	---	X	.X	.X	.0X	.0X	.0X	.00	.X
AH-20	Ha-3	251.5-253.1	1.6	1.1	.026	.001	.14	---	---								
AH-21	Ha-3	253.1-255.6	2.5	1.8	.008	.001	.04	---	---	.00	.X	.0X	.000X	.000	.00	.00	.000X
AH-22	Ha-3	255.6-256.3	.7	.5	.092	.000	.52	---	.47								
AH-23	Ha-3	256.3-257.5	1.2	.8	.018	.000	.10	---	---	.0X	.X	.0X	.00X	.000	.00	.00	.00X
AH-24	Ha-3	257.5-259.0 and 259.3-259.9	2.1	1.5	.005	.000	.03	---	---								
AH-25	Ha-3	259.0-259.3	.3	.2	.15	.000	.84	---	.76	.X	.X	.0X	.00X	.00X	.00	.00	.0X
AH-26	Ha-3	259.9-262.0	2.1	1.5	.11	.000	.62	---	.56								
AH-27	Ha-3	262.0-264.0	2.0	1.4	.10	.000	.56	---	.58	.X	.X	.0X	.00X	.00X	.00	.00	.0X
AH-28	Ha-3	264.0-265.8	1.8	1.3	.052	.000	.29	---	.31								
AH-29	Ha-3	265.8-270.0	4.2	3,0	.063	.001	.35	---	.29	.X	.0X	.0X	.00X	.000	.00	.00	.X
AH-30	Ha-3	270.0-270.5	.5	.4	.006	.000	.03	---	---								
AH-56	Ha-3	270.5-273.4	2.9	2.1	.005	.001	.02	---	---								
AH-31	Ha-4	165.6-167.2	1.6	1.1	.004	.000	.02	---	---								
AH-32	Ha-4	167.2-168.9	1.7	1.2	.004	.000	.02	---	---								
AH-33	Ha-4	170.1-170.5	.4	.3	.003	.000	.02	---	---								
AH-34	Ha-4	249.0-249.9	.9	.6	.003	.000	.02	---	---								
AH-35	Ha-4	253.1-253.5	.4	.3	.005	.000	.03	---	---								
AH-36	Ha-5	147.4-148.2	.8	.6	.006	.001	.03	---	---								
AH-37	Ha-5	189.9-190.4	.5	.4	.009	.000	.05	---	---								
AH-38	Ha-5	191.6-191.9	.3	.2	.004	.000	.02	---	---								
AH-39	Ha-5	192.8-193.4	.6	.4	.012	.001	.06	---	---	.0X	.X	.X	.00X	.00X	.00	.00	.0X
AH-44	Ha-6	122.0-122.6 and 123.6-124.5	1.5	1.1	.009	.001	.04	---	---								
AH-45	Ha-6	122.6-123.6	1.0	.7	.044	.001	.24	.25	---								

See footnotes at end of table.

Table 5.—Analyses of diamond-drill cores, samples from the holes at Haputa ranch, Custer County, Colo.—Continued

Field no.	Drill hole	Depth (feet)	Length of sample (feet)	Corrected sample length [1] (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [2] (percent)	Chemical ThO_2 [2] (percent)	Radiochemical ThO_2 [3] (percent)	Spectrographic analyses							
										Th	Ba	Sr	Pb	La	Ce	Nd	Y
AH-66	Ha-6	124.5-132.2	7.7	5.4	0.002	0.001	0.01	---	---								
AH-67	Ha-6	132.2-134.5	2.3	1.6	.008	.001	.04	---	---								
AH-46	Ha-6	190.6-192.1	1.5	1.1	.010	.001	.05	---	---								
AH-47	Ha-6	339.6-340.5	.9	.6	.043	.001	.24	---	---								
AH-48	Ha-6	340.5-341.6	1.1	.8	.013	.001	.07	---	---								
AH-57	Ha-7	490.9-495.3	4.4[4]	3.1	.002	.001	.01	---	---								
AH-40	Ha-7	495.3-497.5	2.2	1.6	.044	.001	.24	0.21	---	0.X	0.0X	0.0X	0.000X	0.000	0.00	0.00	0.00X
AH-41	Ha-7	497.5-498.2	.7	.5	.006	.001	.03	---	---	.00	.0X	.0X	.000X	.000	.00	.00	.000X
AH-59	Ha-7	498.2-500.8	2.6	1.8	.007	.001	.03	---	---								
AH-42	Ha-7	500.8-502.4	1.6	1.1	.042	.001	.23	.15	---	.X	.0X	.0X	.000X	.000	.00	.00	.00X
AH-58	Ha-7	502.4-505.7	3.3	2.3	.009	.001	.04	---	---								
AH-43	Ha-7	505.7-506.7	1.0	.7	.009	.001	.04	---	---	.00	.X	.0X	.00X	.000	.00	.00	.000X
AH-60	Ha-7	506.7-511.8	5.1[4]	3.6	.012	.001	.06	---	---								
AH-61	Ha-8	132.6-139.2	6.6	4.0	.006	.001	.03	---	---								
AH-49	Ha-8	139.2-140.4	1.2	.7	.13	.002	.72	---	.70	.X	.X	.0X	.0X	.00X	.00	.00	.0X
AH-62	Ha-8	140.4-140.7	.3	.2	.003	.001	.01	---	---								
AH-50	Ha-8	140.7-141.8	1.1	.7	.036	.001	.20	.28	---	.X	.X	.0X	.00X	.00X	.00	.00	.0X
AH-63	Ha-8	141.8-143.7	1.9	1.1	.005	.001	.02	---	---								
AH-51	Ha-8	143.7-147.3	3.6	2.2	.097	.001	.54	---	.53	.X	.X	.0X	.0X	.000	.00	.00	.X
AH-52	Ha-8	147.3-149.7	2.4	1.4	.040	.001	.22	---	---	.X	.X	.0X	.000X	.000	.00	.00	.0X
AH-53	Ha-8	149.7-150.4	.7	.4	.29	.005	1.60	1.78	---	X	.X	.0X	.00X	.00X	.0X	.00	.X
AH-54	Ha-8	150.4-151.8	1.4	.8	.032	.001	.17	---	---	.0X	.0X	.0X	.0X	.000	.00	.00	.0X
AH-64	Ha-8	151.8-157.3	6.5	3.9	.005	.001	.02	---	---								
AH-65	Ha-8	157.3-170.6	13.3	8.0	.003	.001	.01	---	---								
AH-68	Ha-10	220.8-221.7	.9	.6	.10	.002	.55	---	---								

[1] As the holes were drilled at angles of 45° or 60°, the sample lengths have been corrected to give the true width across the vein.

[2] Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor of 5.6.

[3] A method of analysis in which the radioactive material is separated chemically and determined radiometrically.

[4] Sampled interval in which more than 20 percent of the core was missing.

Table 6.—Equivalent U_3O_8 and equivalent ThO_2 as determined from the gamma-ray logs of the drill holes, Haputa ranch

Drill hole		Radioactivity	
No.	Footage (feet)	Gamma-ray activity expressed as equivalent U_3O_8 (percent)	Calculated equivalent ThO_2 [1] (percent)
Ha-1	68.8- 69.5	0.008	0.02
	156.1-156.9	.014	.03
	156.9-157.5	.006	.02
Ha-2	102.9-106.9	.004	.01
	169.5-170.4	.015	.04
	170.4-171.3	.106	.26
	171.3-172.2	.028	.07
	172.2-173.2	.019	.05
	173.2-174.5	.030	.07
	174.5-175.4	.260	.63
	175.4-176.8	.035	.08
	186.5-187.5	.011	.03
	230.4-231.3	.014	.03
Ha-3	204.5-205.0	.016	.04
	210.9-212.9	.004	.01
	215.5-216.4	.016	.04
	219.1-219.9	.011	.03
	229.9-231.8	.004	.01
	231.8-233.8	.024	.06
	233.8-235.3	.021	.05
	235.3-236.4	.050	.12
	236.4-237.4	.425	1.03
	237.4-238.6	.224	.54
	238.6-241.1	.016	.04
	241.1-242.4	.040	.10
	242.4-243.5	.012	.03
	243.5-245.2	.022	.05
	245.2-247.0	.310	.75
	247.0-248.2	.250	.60
	248.2-249.0	.230	.56
	249.0-250.9	.056	.14
	250.9-251.7	.680	1.65
	251.7-252.2	.600	1.45
	252.2-253.2	.460	1.11
	253.2-255.3	.016	.04
	255.3-256.1	.890	2.15
	256.1-257.1	.130	.32
	257.1-259.6	.010	.02
	259.6-261.6	.240	.58
	261.6-263.0	.290	.70
	263.0-264.1	.400	.97
	264.1-265.3	.470	1.14
	265.3-266.6	.500	1.21
	266.6-269.2	.380	.92
	269.2-271.4	.010	.02
	271.4-272.4	---	---
	272.4-273.4	.006	.02
	276.7-277.3	.012	.03
Ha-4	236.3-239.2	.002	.01
	239.2-242.1	.003	.01
	248.4-250.6	.003	.01

Table 6.—Equivalent U_3O_8 and equivalent ThO_2 as determined from the gamma-ray logs of the drill holes, Haputa ranch—Continued

Drill hole		Radioactivity	
No.	Footage (feet)	Gamma-ray activity expressed as equivalent U_3O_8 (percent)	Calculated equivalent ThO_2 [1] (percent)
Ha-5	147.0-148.0	0.020	0.05
	189.3-190.2	.021	.05
	190.2-191.1	.015	.04
	191.1-191.9	.006	.02
	191.9-192.7	.040	.10
Ha-6	121.8-122.5	.065	.16
	122.5-123.3	.170	.41
	123.3-124.1	.350	.85
	124.1-125.5	.011	.03
	125.5-126.2	.004	.01
	126.2-127.2	.008	.02
	132.2-133.1	.495	1.20
	133.1-134.3	.006	.02
	148.2-149.0	.036	.09
	183.6-185.3	.015	.04
	190.6-191.8	.024	.06
	191.8-192.7	.007	.02
	255.8-256.9	.003	.01
	325.0-326.0	.003	.01
	340.1-341.2	.170	.41
	341.2-342.5	.013	.03
	359.3-360.0	.005	.01
	418.8-433.5	.003	.01
Ha-7	372.4-373.0	.012	.03
	391.5-392.6	.011	.03
	392.6-393.9	.004	.01
	468.9-470.2	.005	.01
	490.9-491.7	.260	.63
	491.7-494.0	.013	.03
	494.0-496.5	.035	.08
	496.5-499.2	.012	.03
	499.2-500.1	.220	.53
	500.1-501.6	.016	.04
	501.6-502.0	.005	.01
	502.0-505.6	.017	.04
	505.6-506.3	.110	.27
	506.3-506.7	.030	.07
	506.7-508.8	.060	.14
	508.8-510.3	.014	.03
	510.3-511.8	.009	.02
	511.8-514.5	.005	.01
	514.5-515.4	.011	.03
	515.4-516.5	---	---
	516.5-518.6	.004	.01
	518.6-520.2	.011	.03
Ha-8	114.8-116.0	.029	.07
	132.6-133.5	.040	.10
	134.8-137.4	.006	.02
	137.4-138.4	.027	.06
	138.4-139.0	.007	.02
	139.0-140.3	.120	.29
	140.3-142.0	.190	.46
	142.0-143.0	.019	.05
	143.0-144.3	.085	.21
	144.3-145.8	.330	.80
	145.8-147.0	.210	.51

Table 6.—Equivalent U_3O_8 and equivalent ThO_2 as determined from the gamma-ray logs of the drill holes, Haputa ranch—Continued

Drill hole		Radioactivity	
No.	Footage (feet)	Gamma-ray activity expressed as equivalent U_3O_8 (percent)	Calculated equivalent ThO_2 [1] (percent)
Ha- 8-------------------------	147.0-148.5	0.110	0.27
	148.5-149.6	1.100	2.66
	149.6-150.5	2.300	5.57
	150.5-152.2	.092	.22
	152.2-155.4	.009	.02
	155.4-156.4	.007	.02
	156.4-157.3	.026	.06
	157.3-158.9	.006	.02
	158.9-160.2	.004	.01
	165.6-168.0	.004	.01
	169.2-170.6	.005	.01
Ha- 9-------------------------	33.7- 34.7	.004	.01
	42.4- 43.1	.009	.02
	95.0- 96.1	.003	.01
	96.1- 97.5	.004	.01
	97.5-100.5	.008	.02
	100.5-102.4	.012	.03
	102.4-103.5	.003	.01
Ha-10-------------------------	134.0-134.9	.022	.05
	196.6-199.4	.003	.01
	199.4-201.2	.006	.02
	201.2-203.0	.013	.03
	203.0-203.7	.007	.02
	219.3-220.2	.430	1.04
Ha-11-------------------------	0.0- 0.9	.009	.02
	56.1- 70.0	.003	.01
	72.7- 75.6	.003	.01
	75.6- 76.5	.009	.02
	79.8- 82.3	.004	.01
	130.0-130.8	.006	.02
	173.2-175.3	.006	.02

by limonite, and by minor amounts of quartz, barite, and siderite. The shear is weakly radioactive. Radioactivity can be traced less than 25 feet from the two pits on the shear zone. The sample from the southern pit contained a trace of equivalent ThO_2; its rare-earth oxide content a trace of equivalent ThO_2; its rare-earth oxide content of 4.29 percent (LD-2) is noteworthy.

A sample (LD-14) taken at shear zone no. 8 to determine the value of maximum radioactivity contained 0.13 percent equivalent ThO_2. Radioactivity can be traced for about 50 feet, but it is weak except for about 15 feet along the shear zone. Black quartz crystals coat the granite wall rock in the single outcrop of the vein.

Shear zones nos. 5 and 6 are weakly radioactive at the exposures in prospect pits and show no measurable radioactivity in covered areas between pits. Both zones contain quartz-barite-siderite-limonite veins, 3 to 9 feet wide in shear zone no. 5, and less than 2 feet wide in shear zone no. 6, and are associated with silicified basic dikes. The average thorium content of both veins is low, but sample (GG-80) shows 0.35 percent rare-earth oxides in shear zone no. 5. Gold ore valued at $22 to $29 per ton was reported to have been mined from this pit.

The short adit on the north-central part of the map exposes a 2-foot fractured and silicified basic dike that has been mineralized and partly recemented by quartz, barite, and weakly radioactive hematite. A grab sample (LD-1) of selected fragments of a 2-inch quartz-hematite veinlet contained only 0.02 percent ThO_2 but contained as much as 2.01 percent rare-earth oxides.

Greenwood property

The Greenwood property, 3 miles north of the Haputa ranch, includes three mining claims registered in the Custer County courthouse: (1) the Blue Bird claim, located by J. Susman and W. L. Susman; (2) the Cora B claim, owned by Henry G. Prior and others; and (3) the Pine Tree claim located by William Klein and Fred Jones.

Table 7.—Analyses of surface samples, Haputa extension, Custer County, Colo.

Sample No.	Type [1]	Length (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [2] (percent)	Total rare-earth oxides and ThO_2 (percent)	Chemical ThO_2 (percent)	Rare-earth oxides [3] (percent)
LD 1	C	---	0.007	0.004	0.02	2.03	---	2.01
LD 2	A	1.0	.008	.001	.04	4.33	---	4.29
LD 3	A	8.0	.012	.001	.06	---	---	---
LD 5	C	---	.006	.001	.03	---	---	---
LD 6	A	.9	.16	.002	.88	---	---	---
LD 7	A	1.0	.021	.004	.10	---	---	---
LD 8	C	---	.027	.001	.15	---	---	---
LD 9	A	18.0	.008	.001	.04	---	---	---
LD 10	A	2.0	.013	.001	.07	---	---	---
LD 11	A	3.5	.006	.001	.03	---	---	---
LD 12	C	---	.010	.001	.05	---	---	---
LD 13	A	5.0	.006	.001	.03	---	---	---
LD 14	A	---	.025	.001	.13	---	---	---
LD 15	A	6.0	.011	.001	.06	---	---	---
GG 79	C	---	.069	.001	.38	---	0.31	---
GG 80	A	---	.012	.001	.06	.41	---	.35
GG 82	C	---	.024	.001	.13	.28	.13	.15

[1] A, channel sample; B, chip sample; C, grab sample.
[2] Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor of 5.6.
[3] Obtained by subtracting the chemical percent ThO_2 from the chemical percent of total rare-earth oxides and ThO_2. Where a chemical ThO_2 value is not available, the equivalent ThO_2 is used.

The thorium deposits on this property were mapped in August 1951 by Dellwig and Heyman at a scale of 1:1,200 (pl. 4). Because of soil cover and limited time available only an outcrop map was prepared. The Pine Tree claim is reported to have yielded 400 pounds of hand-sorted thorite.

Geology

The dominant rocks on the Greenwood property are probably biotite granite gneiss and hornblende granite. Weathering has obscured their relationships, but they are considered to be about the same age and both contain inclusions of amphibolite. These rocks have been intruded by diorite and gabbro, which later were metamorphosed. In the vicinity of the Pine Tree shaft, a light-green aphanitic rock, a fine-grained hornblende-plagioclase rock, and a cream-colored plagioclase rock, all of them altered and leached, have been lumped together and designated as "highly altered and leached hornblende-plagioclase rock". All the older rocks have been cut by many sills and dikes of aplite, pegmatite, and gneissic microcline granite, that form injection gneiss in places. Basic dikes occur in the Pine Tree shear zone; the northeastern of two Bluebird shear zones; and in one of the three exposures of the Cora B shear zone. These dikes are premineralization in age.

The foliation has a prevailing trend averaging N. 60° E. and dips steeply northwest. It is about parallel to most of the dikes and sills of granitic rocks.

The Cora B shear zones trend about N. 60° W. and dip 75° to 85° NE. The Bluebird and Pine Tree shear zones are roughly parallel to the Cora B shear zones in strike, but dip steeply southwest. On the Cora B claim, three independent shear zones or segments of mineralized fractures have been mapped. These are probably all part of the same structure, but they cannot be readily connected in the field.

Two faults of small displacement have been mapped.

Thorium deposits

On the Pine Tree claim, five shafts and two prospect pits have been dug along 600 feet of the exposed barite-bearing vein, which averages 4 feet in width. This vein contained small amounts of high-grade thorite, but none is now exposed at the surface and the workings at the bottom of the 60-foot shaft are inaccessible. The material on the dumps shows that thorite occurs with barite, both with the white cleavage masses and the red granular varieties, and with small quantities of quartz and galena. Blebs of pure thorite, as much as 2 inches in diameter, are found in the barite. The dump now contains very little ore-grade material because the ore was carefully hand-picked and the dump subsequently "picked over" for ore specimens.

Radioactivity could not be traced beyond the limits of the mapped vein. The thorite-rich part of the vein probably is about 300 feet long, as the vein, where exposed in pits outside this 300-foot length, is only weakly radioactive. Grab samples from dumps of the Pine Tree workings contained from a trace to 0.32 percent equivalent ThO_2 (samples LD-57, 58, 59, and 60, table 8). The highest uranium content for these samples was 0.002 percent.

Table 8.—Analyses of surface samples, Greenwood property, Custer County, Colo.

Sample No.	Type [1]	Length (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [2] (percent)
LD 56	C	---	0.007	0.001	0.03
LD 57	C	---	.008	.002	.03
LD 58	C	---	.025	.001	.13
LD 59	C	---	.058	.001	.32
LD 60	C	---	.033	.002	.17
LD 61	C	---	.010	.001	.05
LD 63	A	1.0	.026	.001	.14
LD 64	C	---	.024	.001	.13

[1]C, grab sample; A, channel sample.
[2]Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor, 5.6.

The Cora B claim includes two shafts and four prospect pits along a shear zone that trends N. 65°W. The vein, associated with a brown silicified dike, is 2 to 4 feet thick and can be traced intermittently for more than 550 feet. It is comprised principally of vuggy, white, "bull" quartz and smoky quartz crystals, many of which are coated with red hematite. No thorite was observed; the strongest radioactivity is associated with the hematite suggesting the presence of disseminated thorium. The radioactivity of the rock averaged about 0.2 mr/hr (background about 0.03 mr/hr; geometry 2-2.5π on a Geiger-Mueller counter). The readings were consistent over most of the length of the vein; samples contained a trace to 0.14 percent equivalent ThO_2 (samples LD-63 and 64). The fetid odor common to other radioactive deposits in the region is present in unusually strong concentrations in the quartz.

Along the projected strike of the shear zone at the Cora B claim, an isolated outcrop of the shear occurs 1,000 feet southeast of the Cora B shaft. The vein at the shaft is 2 feet wide and is composed of barite, quartz, and a small amount of siderite; terminated quartz crystals are found in the barite. The fetid odor is strong in the granite. One sample (LD-61) contained only a trace of ThO_2.

The shear zones on the Bluebird claim contain barite-limonite veins; the northeastern zone contains a sheared, silicified basic dike rock. They can be traced only about 150 feet. The only sample taken at the claim contains a trace of equivalent ThO_2; the uranium content was 0.001 percent (sample LD-56).

Tuttle ranch area

Thorium deposits were detected on the Tuttle ranch in 1950 by Gott and Dellwig (pl. 5). These deposits are 9 miles north-northwest of the Haputa ranch (fig. 2) and are owned by W. Tuttle.

Geology

The pre-Cambrian rocks in the Tuttle ranch area form a series of interlayered gneiss, migmatite, and granite cut by shear zones that trend northwest. The geology is similar to that of the Greenwood property except that the Tuttle area is less complex and does not contains diorite, metagabbro, or biotite granite gneiss.

Two varieties of amphibolite composed chiefly of hornblende and plagioclase, but distinguished by the presence of garnet in one, crop out in sufficient quantity to be mapped as individual units. Both varieties occur as small lenses interbedded with large masses of migmatite and gneissic microcline granite. In places granitic material has been added to the garnet amphibolites to form a series of garnet-bearing rocks that grade from garnetiferous amphibolite to microcline granite. The amphibolite, however, also occurs as large masses or lenses in the southern and eastern parts of the area. It commonly is jointed and epidotized, and the large bodies are slightly magnetic. The southernmost mass of gneiss is exposed in an area of 550 by 200 feet and is roughly concordant with the granitic gneisses; the smaller eastern body appears to be discordant. The single 70-foot quartzite lens is concordant with the foliation, and probably represents a silica-rich metasediment of the gneiss series.

The most abundant rock types in the Tuttle ranch area are the undifferentiated granitic rocks. These form a continuous series that range from granite gneiss to almost pure microcline granite, migmatite being the most common rock type. A gneissic microcline granite, similar to that which occurs as sills, is responsible for the migmatization, and was mapped as discordant granite dikes.

Basic dike rocks are found in and out of the shear zones. The float of one resistant dike facilitates the tracing of the long shear zone on the eastern edge of the map through covered areas. No evidence of mineralization or subsequent shearing was observed in the two dikes in the northwestern and southwestern parts of the area, although they are emplaced, in part, in joints or fractures that have the same northwesterly trend as the shear zones.

Foliation is singularly uniform, striking N. 45° E., the dip ranges from 55° NW in the southeastern part of the area to vertical in the northwestern part. Two prominent northwestward-trending faults displace the layered sequence. The amount of displacement along the easternmost fault is not known; but along the westernmost one, the probable horizontal displacement is less than 15 feet.

Thorium deposits

Seven mineralized shear zones were mapped in the Tuttle ranch area; shear zone no. 5 is the most radioactive and can be traced, although discontinuously, for 2,700 feet. The vein averages about 1 foot in width, but in the southeastern prospect pits it is 4 feet wide. The radioactivity is spotty and weak over the entire length except for the southeasternmost 100 feet where the strongest radioactivity is found. At the northwest end of this 100-foot zone, mineralization occurs where the shear cuts across a syenite dike. The dike is sheared, stained red, has a strong fetid odor when broken, and is moderately radioactive. At the southeast end, the mineralization occurs in sheared granite and migmatite. The thorium is disseminated in a 4-foot zone bordered by a light-green clay and, also, concentrated in a central 4-inch zone of red earthy material; thorite was not megascopically visible. Three samples (LD-52, LD-53, and LD-54, table 9) contained from a trace to 2.0 percent equivalent ThO_2 and as much as 1.91 percent rare-earth oxides. Other samples along the shear zone contained a trace of equivalent ThO_2 (LD-39, LD-40, LD-41, LD-42, and LD-49).

Shear zone no. 1 is less than 500 feet long and 1 foot wide. The vein, exposed in several prospect pits, two trenches, and one shaft, is composed of pink barite, quartz, siderite, and a trace of a radioactive thorium mineral that is not megascopically visible.

Shear zone no. 2 is about 30 feet long and 2.5 feet wide. Shear zone no. 3 is about 260 feet long and ranges from several inches to 2 feet in width. The vein consists of quartz, barite, and many dark-red veinlets, less than 1/8 inch wide, of radioactive hematitic material. The barite occurs as red, massive, granular material and as younger white cleavage masses. Shear zone no. 4 is about 50 feet long and 6 inches wide. These zones are only weakly radioactive; the samples (LD-43, LD-44, LD-45, LD-46, LD-47) contained from a trace to 0.08 percent equivalent ThO_2.

Shear zone no. 6 is about 200 feet long and 2 feet wide; it is found in a brecciated granite. The sample (LD-65) from this zone contained 0.35 percent equivalent ThO_2. Shear zone no. 7 contains malachite and some copper sulfides in a quartz-barite vein cutting the amphibolite minerals; no radioactivity was found.

Other minerals have a sporadic distribution in the area and along the shear zones. Quartz, either the vuggy or milky variety, and barite are the most common minerals. Much of the material in the shear zones has the fetid odor, characteristic of the district. Large, zoned quartz crystals coated with hematite are found at the northwestern part of shear zone no. 5.

Other thorium deposits

Anna Lee lode

Anna Lee lode is 3-1/2 miles north-northeast of Querida and 3/4 mile west of State Route 143 (fig. 2) and is claimed by Lee Jones and L. Knobbe. The

Table 9.—Analyses of surface samples, Tuttle ranch, Fremont County, Colo.

Sample			Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [2] (percent)	Chemical ThO_2 (percent)
No.	Type [1]	Length (feet)				
LD 39	A	1.0	0.004	0.001	0.02	---
LD 40	A	1.5	.000	.001	---	---
LD 41	C	---	.003	.000	.02	---
LD 42	C	---	.003	.001	.01	---
LD 43	C	---	.009	.001	.04	---
LD 44	A	3.5	.015	.000	.08	---
LD 44A	C	---	.007	.003	.02	---
LD 45	A	0.9	.016	.001	.08	---
LD 46	A	2.5	.008	.000	.04	---
LD 47	C	---	.014	.001	.07	---
LD 48	C	---	.008	.001	.04	---
LD 49	A	1.0	.008	.001	.04	---
LD 50	A	5.0	.14	.002	.77	---
LD 51	C	---	.094	.001	.52	---
LD 52	A	4.0	.11	.002	.60	0.57
LD 53	A	4.0	.007	.001	.03	---
LD 54	A	.4	.36	.002	2.00	1.91
LD 65	C	---	.063	.001	.35	---

[1]C, grab sample; A, channel sample.
[2]Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor of 5.6.

property was examined early in 1952. Several small pits and trenches were examined and an isorad map (fig. 3) was made.

The thorium-bearing shear zones trend N. 60° W. through an area of granite that is locally stained red. The total length of the shear has not been determined, but the discontinuously mineralized part, as indicated by the isorads of figure 3, is about 1,000 feet long. The shear may continue to the northwest; heavy alluvium prevented further radiometric study of the vein in that direction. Narrow syenite dikes, sheared and heavily iron stained, are exposed in the workings and probably trend parallel to the shear zone. The shear zone is entirely covered by a thin soil mantle except where exposed in the prospect pits.

The highest radioactivity found with a Geiger-Mueller counter was 13-20 mr/hr (background about 0.03 mr/hr; geometry 2 to 3π) in vein material 2 to 10 inches wide; the average radioactivity of the shear zone was about 0.5 mr/hr. The thorium-bearing material occurs in the more strongly iron stained and sheared rocks within the shear zone. The

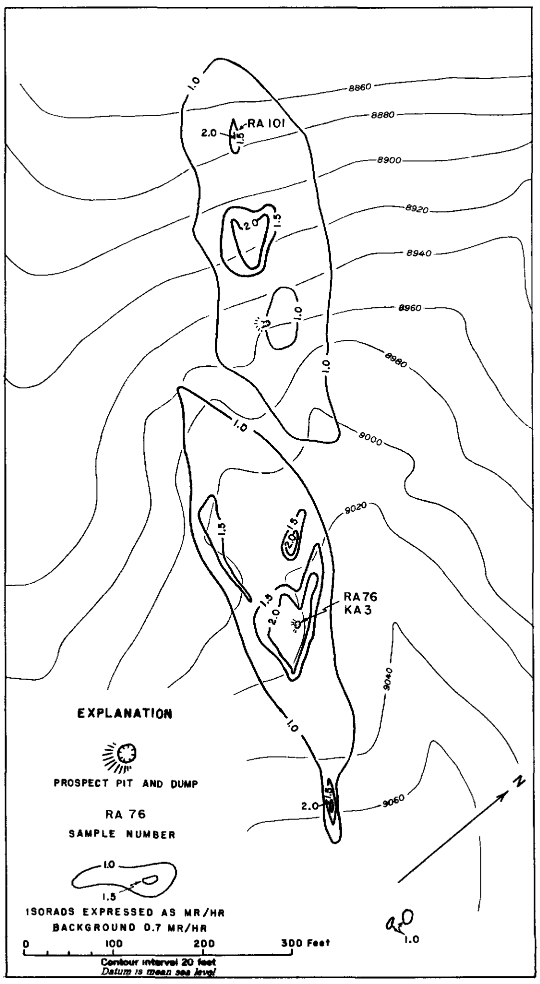

Figure 3.—Isorad map of Anna Lee lode, Custer County, Colo.

vein where best exposed in the easternmost pit (fig. 3) strikes N. 47° W., dips 85°NE, and is about 10 inches wide. It consists of a sheared fine-grained red rock, probably altered syenite, that contains 1- to 2-inch dark-red stringers of thorite. The distribution of the "ore shoots" along the radioactive shear zone probably is shown by the irregular distribution of the isorads (fig. 3).

A medium-grained basic dike, very highly altered to a soft, crumbly, light-gray material, is adjacent to the radioactive shear in one of the shallow prospect trenches. Specular hematite occurs at one place in the shear zone as narrow stringers and lenses as much as 1/4 inch wide.

The locations of collected samples are shown on figure 3 and the results of the assays are in table 10. Two channel samples (RA-76-RA-101) ranged from 4.02 to 1.20 percent ThO_2 and one selected sample (KR-3) contained 6.68 percent equivalent ThO_2 and 1.53 percent rare-earth oxides.

Atomic Mountain claim

The Atomic Mountain claim is 5 miles north of Querida (fig. 2) and is owned by E. Sparling and L. Knobbe. A vertical vein, exposed in two adits, one shaft, and many prospect pits, was traced for 1,200 feet along a shear zone that trends N. 50° W. The country rock consisting of interlayered granite and injection gneiss strikes N. 40° E., and dips 80° NW. The vein ranges from a few inches to 2 feet in width and consists of quartz, barite, limonite, and siderite. The vein and a basic dike, now completely altered to a brown silicified rock which may be slightly radioactive, were emplaced in a shear zone as much as 6 feet wide.

The radioactivity is low to moderate; a maximum reading of 1.5 mr/hr (background about 0.03 mr/hr, geometry 2π) was obtained with a Geiger-Mueller counter. The analyses of two samples (RA-23 and KR-9, table 10) believed to represent material from the bottom of the shaft, represents the highest grade ore found on the dump; they contained 2.12 and 0.95 percent equivalent ThO_2.

Barite lode

The Barite lode, belonging to Pete Cowan and George Schweigert, is about 6 miles east of Westcliffe along State Route 96 and consists of a caved shaft, about 11 prospect pits, and two bulldozed trenches about 2,000 feet long. The vein can be traced an additional 1,000 feet northwestward beyond the limits of the claim. The area was visited by Dellwig in 1951 and revisited by Heyman in 1952.

The deposits are along several northwest-trending mineralized zones in an area of microcline granite and quartz-hornblende and granite gneisses. A highly silicified brown dike rock occurs in some of the shear zones. Four shear zones apparently have en echelon arrangement; the strike ranges from N. 67° W. to N. 45° W. and the dip ranges from 70° NW to vertical. The vein material has a maximum observed width of 6 feet, but generally is much narrower. It is composed of limonite, white and massive red barite, white and smoky quartz, red massive and specular hematite, thorite(?), and a minor amount of

Table 10.—Analyses of surface samples from other prospects

Locality	Sample no.[1]	Type of sample[2]	Length of sample (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [3] (percent)	Total rare-earth oxides and ThO_2 (percent)	Chemical ThO_2 (percent)	Rare-earth oxides [4] (percent)	Spectrographic analyses									
										Th	La	Ce	Nd	Sm	Pr	Y	Gd	Dy	Yb
Anna Lee lode.	RA 76	A	1.3	0.72	0.003	4.02	4.13	3.81	0.32	X	0.0X	0.X	0.X	---	---	0.X	---	---	---
Do------	RA 101	A	.9	.22	.005	1.20	1.12	1.09	.03	.X	.X	.X	.X	0.0X	0.00X	.X	0.0X	0.0X	0.0X
Do------	KR 3	C	---	1.2	.007	6.68	8.49	6.96	1.53										
Atomic Mountain claim.	RA 23	C	---	.38	.001	2.12	---	1.98	---										
Do------	KR 9	C	---	.17	.001	.95	.82	.82	.00										
Barite lode.	52H2	A	1.5	.015	.002	.07	---	---	---										
Do------	52H3	B	---	.11	.001	.61	---	---	---										
Do------	LD 55	A	4.0	.042	.001	.23	---	---	---										
Big Chief I claim.	LD 23	A	1.2	.009	.002	.04	---	---	---										
Darby extension property.	LD 22	C	---	.022	.001	.12	---	---	---										
Dreamer's Hope claim.	LD 12A	B	---	.025	.001	.13	.60	.14	.46										
Griffen property.	LD 29	C	---	.013	.001	.07	---	---	---										
Do------	LD 30	A	2.2	.005	.001	.02	---	---	---										
Do------	LD 31	C	---	.089	.058	.17	---	---	---										
Homestake claims.	LD 7a	B	---	.011	.001	.06	.63	---	.57										
Do------	LD 8a	C	---	.063	.001	.35	6.81	.30	6.51										
Do------	LD 9a	B	---	.019	.001	.10	.82	---	.72										
Do------	LD 10a	C	---	.018	.001	.10	.27	.10	.17										
Do------	LD 11a	C	---	.024	.003	.12	4.52	---	4.40										
Do------	LD 13a	B	---	.016	.001	.08	.26	.09	.17										
Do------	RA 102	A	6.6	.007	.001	.03	.07	.04	.03	.0X	.0X	.0X	.0X	.00	.00	.0X	.00X	.00X	.000X
Lee Jones property.	LD 32	C	---	.022	.001	.12	---	---	---										

Lucky Find claim.	LD 26	A	20.0	.006	.001	.03	---	---	---										
Do------	LD 27	A	7.0	.004	.001	.02	---	---	---										
Do------	LD 28	A	3.0	.013	.001	.07	---	---	---										
Do------	KR 4	C	---	.14	.002	.77	.73	.55	.18										
Mystery lode.	LD 24	C	---	.006	.001	.03	---	---	---										
Do------	LD 25	C	---	.097	.001	.54	---	---	---										
Do------	KR 5	C	---	.10	.001	.55	.63	.40	.23										
Nightengale claim.	KR 2	C	---	.26	.004	1.43	1.85	1.28	.57										
Do------	LD 33	A	5.0	.049	.001	.27	---	---	---										
O.Tuttle property.	LD 37	C	---	.003	.000	.02	---	---	---										
Do------	LD 38	C	---	.20	.002	1.11	---	---	---										
Pennie Poker claim.	LD 21	C	---	.064	.001	.35	---	---	---										
Sewell ranch property.	RA 71	A	4.0	.013	.001	.07	---	---	---	0.0X	0.0X	0.X	0.0X	---	---	0.0X	---	---	---
Do------	RA 72	A	3.8	.022	.001	.12	---	---	---	.0X	.0X	.X	.0X	---	---	.0X	---	---	---
Do------	RA 73	A	4.6	.018	.001	.10	---	---	---	.0X	.0X	.X	.0X	---	---	.0X	---	---	---
Do------	RA 74	A	3.5	.012	.001	.06	---	---	---	.0X	.0X	.0X	.0X	---	---	.0X	---	---	---
Do------	RA 75	A	3.5	.042	.001	.23	---	---	---	.X	.X	.X	.X	---	---	.0X	---	---	---
Do------	RA 96A	A	.5	.010	.001	.05	---	---	---										
Do------	RA 97A	A	6.0	.007	.001	.03	---	---	---										
Do------	RA 98	A	1.0	.059	.001	.32	---	---	---										
Do------	RA 99	A	0.9	.11	.002	.60	---	---	---										
Do------	RA 100	A	1.0	.014	.001	.07	---	---	---										
Spaulding property.	LD 36	C	---	.008	.002	.03	---	---	---										
Starbuck claim.	RA 25	A	3.0	.021	.001	.11	---	---	---										
Do------	RA 26	A	1.0	.18	.002	1.00	---	.84	---										
Do------	RA 27	A	.5	.060	.001	.33	---	---	---										
Do------	RA 28	C	---	.30	.001	1.67	---	1.59	---										
Do------	KR 8	C	---	.18	.001	1.00	.93	.81	.12										
Stinkhole claim.	AH 2	C	---	.30	.001	1.67	---	---	---										
Do------	AH 3	A	2.0	.028	.001	.15	---	---	---										
Sunrise claims.	AH 4	C	---	.24	.027	1.19	---	---	---										

See footnotes at end of table.

Table 10.—Analyses of surface samples from other prospects—Continued

Locality	Sample no.[1]	Type of sample[2]	Length of sample (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Equivalent ThO_2 [3] (percent)	Total rare-earth oxides and ThO_2 (percent)	Chemical ThO_2 (percent)	Rare-earth oxides[4] (percent)	Spectrographic analyses									
										Th	La	Ce	Nd	Sm	Pr	Y	Gd	Dy	Yb
Swartz property	RA 51	C	---	1.2	0.005	6.70	---	6.51	---	X	0.X	0.X	---	---	---	0.X	---	---	---
Do------	RA 52	C	---	.40	.005	2.21	---	1.71	---	.X	.0X	.0X	---	---	---	.0X	---	---	---
Unnamed prospect	LD 34	C	---	.14	.002	.77	---	---	---										
Do------	LD 35	C	---	.080	.002	.44	---	---	---										

[1]Samples KR-2, -9 were collected by Truman Kuhn, U. S. Geological Survey (Defense Minerals Exploration Administration Docket 2537).

[2]A, channel sample; B, chip sample; C, grab sample, usually of selected vein material.

[3]Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the difference by the conversion factor of 5.6.

[4]Obtained by subtracting the chemical ThO_2 from the chemical percent of total rare-earth oxides and ThO_2. Where a chemical ThO_2 value is not available, the equivalent ThO_2 is used.

galena. The thorium occurs with, and is masked by hematite.

The two channel samples from the discovery shaft contained 0.07 and 0.23 percent equivalent ThO_2 (samples 524-2 and LD-55); one sample (52H-3) from a hematite-thorium pocket on the east wall of the shaft contained 0.61 percent equivalent ThO_2 (table 10). These samples contained only 0.001 to 0.002 percent U_3O_8.

Big Chief I claim

The Big Chief I claim, east of State Route 143 about 1.5 miles north of Ilse, is owned by A. P. Jensen. Originally staked as the "Star mine," the property was mined for barite. There are many workings throughout the length of the vein.

The wall rock is injection gneiss which strikes N. 70° E. and dips 85° NW. The steeply dipping vein is exposed for 400 feet along a N. 10° W. trend. It pinches and swells from 2-1/2 inches to 4-1/2 feet.

Barite, quartz, and iron carbonate are abundant; galena and chalcopyrite are present in small amounts. The radioactivity, although low, is fairly constant along the vein. The maximum Geiger-counter reading was 0.15 mr/hr (background 0.05 mr/hr; geometry 2 to 2.5π) with much material giving readings of 0.10 mr/hr. A 15-inch channel sample (LD-23, table 10) gave a trace of equivalent ThO_2 .

Charleston property

Four prospect pits are in moderately radioactive rock 1-1/2 miles east-southeast of Querida on the Charleston ranch. These pits are along a N. 20° W., vertical shear zone. The shear zone is 5 to 10 feet wide, 300 feet long, and contains a dark-red to brown nondescript silicified rock that probably represents a completely altered basic dike. The maximum radioactivity recorded was 4.0 mr/hr (background about 0.03 mr/hr; geometry 2 to 2.5 π). Much of the vein material gave readings of more than 1.0 mr/hr.

Darby extension property

C. L. Briggs holds patented rights to the Darby extension property on the A. Griffen ranch 8 miles north of Querida (fig. 2). Dellwig visited the property during the summer of 1951. The workings consist of two shafts, having estimated depths of 100 feet and 25 feet, and several prospect cuts and adits.

The mineral deposit is in a 100-foot wide, northwest-trending fault zone that has a lateral extent of more than 9,000 feet. The vein minerals are quartz, calcite, barite, iron carbonate, pyrite, chalcopyrite, galena, and fine-grained, dense, red and earthy-brown limonitic rock; both types of limonitic rock are radioactive. The country rock is hornblende gneiss and granite.

A grab sample (LD-22) from the dump of the larger shaft contained 0.12 percent equivalent ThO_2 (table 10). A later examination of the shear zone revealed more strongly radioactive rock a short distance to the east; the maximum Geiger-Mueller counter reading recorded was 3.5 mr/hr (background about 0.04 mr/hr; geometry 2 to 2.5 π). The counter reading for most of the shear zone was 1.0 to 2.0 mr/hr.

Dreamer's Hope claim

The Dreamer's Hope claim is in the vicinity of the Homestake claims, 3.9 miles east of State Route 69, about 6 miles northeast of Hillside, Fremont County (fig. 2). Weak radioactivity is found along a shear zone trending N. 55° E. in microcline granite. The maximum radioactivity reading was 0.5 mr/hr (background about 0.03 mr/hr; geometry 2.5 π). Dellwig and Gott collected one sample from the Dreamer's Hope in 1950. It contained 0.46 percent rare-earth oxides and 0.13 percent equivalent ThO_2 (sample LD-12A, table 10). The prospect had been worked for lead.

Griffen property

Albert Griffen's property, 1.1 miles north of the junction of State Routes 143 and 277, was visited by Dellwig in July 1951. A northern vein having an attitude of N. 80° W., 75° SW was traced for only 50 feet; another vein 70 feet to the south having an attitude of N. 80° W., 75° SW, contained radioactive material for a distance of 270 feet. The southern vein was traced about 2,000 feet farther southeast, but only slight radioactivity was found. Both veins cut pre-Cambrian fine-grained microcline granite gneiss. The northern vein, exposed in three closely spaced prospect pits, is about 3 feet wide and consists principally of pink barite having small amounts of siderite and quartz. The vein material was fractured then recemented with a red material that is slightly radioactive. The southern vein apparently follows a shear zone, 2 to 3 feet wide, that has a silicified basic dike adjacent to the northern edge of the vein. Red massive hematite and some specularite, barite, and chalcopyrite are found in the pit where the highest radioactivity was found.

The maximum radioactivity reading was 2.0 mr/hr (background about 0.04 mr/hr; geometry 2.5 to 3 π). Three samples contained from a trace to 0.17 percent equivalent ThO_2 (samples LD-29, -30, and -31, table 10). Sample LD-31 contained 0.058 percent uranium which is the largest amount, associated with the thorium, that has been found in this region.

Homestake claims

The Homestake claims are 3.9 miles from State Route 69 about 6 miles northeast of Hillside, Fremont County (fig. 2). The claims are located along shear zones(?) trending N. 55° E. in an area of microcline granite. The granite has a foliation that strikes N. 55° W. to N. 70° W. and dips 60° NE to vertical. Weakly radioactive material is found at three prospect pits and in one shaft on the Dreamer's Hope and Homestake no. 1 structure for a distance of about 2,000 feet; the maximum radioactivity was 0.5 mr/hr (background about 0.03 mr/hr; geometry 2.5 to 3 π).

Dellwig and Gott visited the area in 1950 and collected six samples that contained as much as 6.51 percent rare-earth oxides and 0.35 percent equivalent ThO_2 (table 10).

Lee Jones property

The thorium property on Lee Jones ranch, 5 miles northeast of Querida (fig. 2) was examined by Dellwig in July 1951. The country rock consists of fine-grained and dark coarse-grained varieties of microcline granite. Moderate radioactivity was associated with limonitic stained rock from a small caved prospect pit in an area largely covered by alluvium. No other evidence of mineralization was observed. The maximum radioactivity was 0. 55 mr/hr (background 0. 04 mr/hr; geometry 2. 5 π) for two hand specimens from the north dump that were chosen as a sample to represent maximum radioactivity. Although this sample analysed 0. 12 percent equivalent ThO_2 (sample LD-39, table 10), radioactivity in most of the surrounding area is only slightly above background.

Lucky Find claim

The Lucky Find claim, owned by E. Sparling and L. Knobbe, is 4 miles north of Querida (fig. 2). In July 1951, Dellwig examined the property. The workings consist of one prospect shaft, 15 feet deep, and several smaller pits.

The Lucky Find is in a moderately radioactive vertical shear zone, 2 to 7 feet wide that is about 1, 500 feet. Its average trend is N. 70° W. The country rock is injection gneiss that strikes N. 70° E. and dips vertical. The vein, in the shear zone, pinches and swells from 1 to 3 feet in thickness. The principal vein mineral is barite which along with minor quartz has been broken, sheared, and recemented. Slickensides are common in the shear zone and are coated with thorite. A basic dike of pre-mineral age parallels the south side of the vein, and contains some chalcopyrite.

Three channel samples, two from the shaft and one from a prospect pit 530 feet east of the shaft, contained from a trace to 0. 07 percent equivalent ThO_2 . One grab sample containing 0. 77 percent equivalent ThO_2 (samples LD-26, 27, 28, and KR-4, table 10), was taken from a shallow prospect pit 260 feet east of the shaft. The strongly radioactive material is restricted to a pod-shaped area about 2 by 4 feet; its vertical dimension is unknown.

Mystery lode

The Mystery lode is near the Greenwood property, about 3 miles southwest of Ilse. The owners of the claim are E. Sparling and L. Knobbe. The workings consist of a 20-foot shaft. The property was examined by Dellwig in 1951.

The Mystery lode is on a 2-foot quartz vein of unknown length, that cuts injection gneiss. The strike of the vein is N. 15° W., and the dip is 60° SW, the foliation of the injection gneiss is N. 60° E. and nearly vertical.

Barite, sphalerite, galena, and chalcopyrite are present in small quantities as stringers and isolated blebs in a gangue of vuggy quartz. Both milky and smoky quartz are zoned crystals in the vugs.

Three samples from the dump were selected to determine maximum radioactivity. These contained from a trace to 0. 55 percent equivalent ThO_2 (samples LD-24, 25, KR-5, table 10).

Nightengale claim

The Nightengale claim, owned by L. Knobbe and J. Tomsick, is 1. 4 miles east of Querida (fig. 2). It was visited by Dellwig in July 1951.

The claim consists of 3 prospect pits along a 6-foot vertical shear zone that trends N. 45°W. in hornblende and granite gneisses. Because exposures are scarce the shear zone was traced for only 100 feet; both ends are exposed by prospect pits. The large pit on the northwest end has exposed an aplite dike that has been sheared and somewhat mineralized with quartz veinlets, galena, chalcopyrite, pyrite, and abundant black coatings of manganese(?) on the granitic and aplitic rocks; no barite is present. A maximum reading of 1. 3 mr/hr (background about 0. 04 mr/hr; geometry 2 to 2. 5 π) was found as a surface coating associated with the black coatings.

One channel sample across the vein contained 0. 27 percent equivalent ThO_2 (sample LD-33, table 10). A selected sample contained 1. 43 percent equivalent ThO_2 and 0. 57 percent rare-earth oxides (sample KR-2).

O. Tuttle property

A radioactive vein located 2, 500 feet N. 80° W. of the intersection of State Routes 143 and 277 (fig. 2) was examined by Dellwig in 1951. O. Tuttle owns the mineral rights and Charles Paine has the surface rights on the property. A 40-foot shaft and two large prospect pits have been dug along 150 feet of the vein; mineralized material occurs along the same structure to the southeast.

The vein and a basic dike were emplaced in a shear zone about 5 feet wide, where observed. The zone strikes N. 22° W. and dips 70° SW; the granite gneiss country rock has a foliation of N. 80° E. The vein consists of white cleavage masses of barite, granular barite, quartz, siderite, small quantities of copper sulfides and carbonates, a small amount of galena, and radioactive material. The sulfides occur in the barite; the most abundant sulfide is chalcopyrite. Radioactivity apparently is due chiefly to the dark-red to black hematitic-like material that is disseminated through the barite. Some of the quartz is also slightly radioactive.

Moderate radioactivity occurs along the vein; the highest reading was found on the dump of the 40-foot shaft. Here, a maximum reading of about 1. 0 mr/hr (background about 0. 03 mr/hr (geometry 2 π) was recorded on a single barite specimen and readings of 0. 18 mr/hr were common in barite and quartz. Two selected samples (LD-37 and LD-38, table 10) showed an equivalent ThO_2 content of 1. 11 percent in the barite and 0. 02 percent in the quartz.

Pennie Poker claim

The Pennie Poker patented(?) claim is on the same mineralized fault as the Darby extension and joins that claim on the north. The property was leased by E. Sparling in 1951. It was examined by Dellwig in 1951. Mine workings include a 25-foot shaft, a caved adit having a reported length of 180 feet, two prospect cuts, and a prospect shaft. The radioactive zone is similar in composition, but much narrower, than the Darby extension vein. The average width of the shear zone is about 15 feet; the average width of the vein is 3 feet.

A grab sample collected from the shaft dump contained 0. 35 equivalent ThO_2 (sample LD-21, table 10). Geiger-Mueller counter readings as much as 4. 0 mr/hr (background about 0. 04 mr/hr; geometry 2 π), were recorded.

Sewell ranch property

Sewell ranch is in Hardscrabble Canyon (fig. 2). The radioactive vein is on a ranch owned by George F. and Claude A. Sewell. The workings consist of two

40-foot adits, a 40-foot shaft, and several prospect pits. This deposit was mapped in the summer of 1952; an isorad map is shown in figure 4.

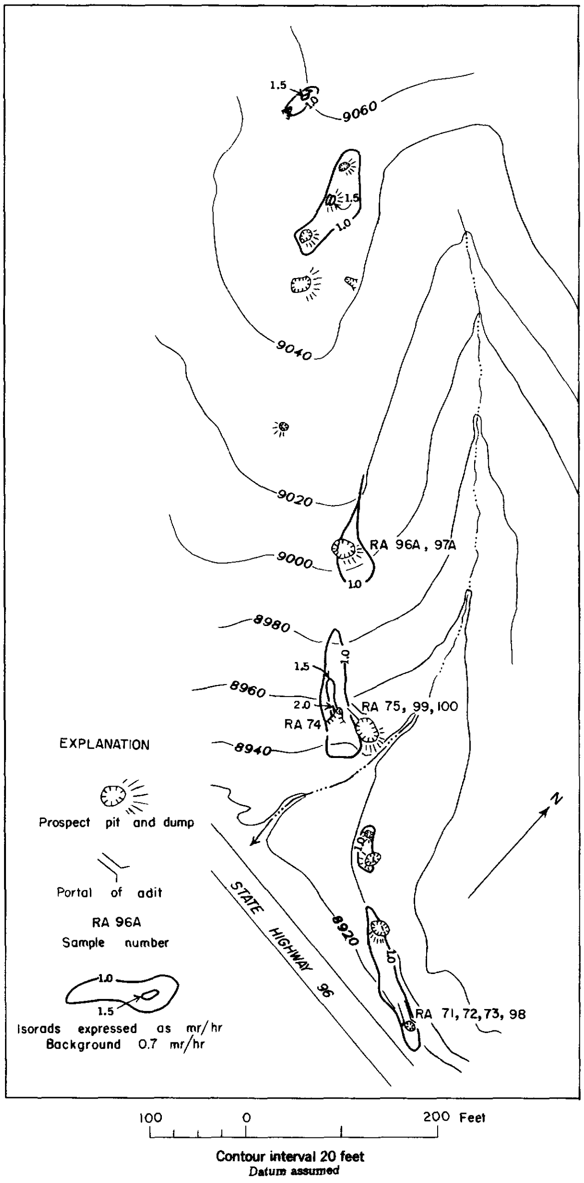

Figure 4.—Isorad map of part of Sewell ranch, Custer County, Colo.

The thorium is in a quartz-barite-limonite vein 6 to 10 feet wide and at least 1,000 feet long. It has an average strike N. 45° W. and dips 80° NE. The country rock is granite and hornblende gneiss. Moderate to weak radioactivity was found throughout the exposed length of the vein; the strongest radioactivity was associated with barite. The vein is strongly sheared and contains abundant earthy red iron oxides along the shears. The vein also contains traces of calcite and galena.

About 100 feet west of the vein a syenite dike 3 feet wide has about the same trend as the vein. A strongly altered basic dike, 10 feet wide, is exposed in the road cut 300 feet west of the vein. The basic dike cannot be traced in either direction, but its trend apparently is about the same as that of the syenite dike and the vein. The thorium-bearing vein and the syenite dike have been offset by a series of eastward- and northeastward-trending faults.

Ten channel samples were collected from locations shown on figure 4. They contain from a trace to 0.60 percent equivalent ThO_2 and the spectrographic analyses showed traces of rare-earth oxides (samples RA-71-75, and RA-96-100, table 10).

Spalding property

The Spalding prospect is about 0.4 mile, S. 50 W. from the owner's home on State Route 143, northwest of Ilse (fig. 2). Dellwig examined the claim in July 1951. The workings consist of one 40-foot shaft and five prospect pits. The country rock is microcline granite and injection gneiss, whose foliation strikes N. 45° E. and dips 75° NW.

A quartz-barite vein in a shear zone strikes N. 25° W. and dips 85° SW. It was traced for 150 feet along the strike but is reported to extend for half a mile. The width ranges from 18 to 24 inches. The radioactivity is low; it is highest where shattered barite has been cemented by hematite(?) and an unknown black mineral. The maximum reading was 0.14 mr/hr (background 0.04 mr/hr; geometry 2 to 2.5 π) of a Geiger-Mueller counter. Quartz and barite are the dominant vein minerals, but locally a fibrous blue amphibole is abundant. Presumably the latter causes some of the quartz and barite to be pale blue. Galena is a minor vein mineral.

Sample LD-36 (table 10) contains a trace of equivalent ThO_2 and represents the highest radioactive material on a dump 150 feet southeast of the shaft.

Starbuck claim

The Starbuck claim is 6 miles north of Querida (fig. 2) on the north side of a ridge which is the site of the "Atomic Mountain" claims. The claim was staked by E. Sparling and L. Knobbe and has been prospected by eight pits and a partly caved adit (fig. 5). It was examined briefly by Christman and Heyman in 1952.

The prospect pits occur along a vertical shear zone, 1,000 feet long, that trends N. 35° W. The shear zone cuts granite gneiss, biotite schist, and amphibolite. The vein has a maximum observed width of 3 feet and is composed of quartz, barite, and large amounts of limonite and hematite.

Although the entire shear is weakly radioactive, the concentrations of thorium-minerals are near the adit and the southeastern prospect pit. A 3-foot channel sample (RA-25) from this prospect contained 0.11 percent equivalent ThO_2; more selective samples (RA-26 and KR-8, table 10) from the same pit contained 1.00 percent equivalent ThO_2. A selected sample (RA-28) from the dump at the caved adit contained 1.67 percent equivalent ThO_2 and a 0.5-foot channel sample from a prospect pit northwest of the adit contained 0.33 percent equivalent ThO_2.

Stinkhole claim

The Stinkhole claim, owned by George Stultz, is about 1.8 miles north of the Tuttle ranch (fig. 2). The locality was visited by Heyman in September 1951. The workings consist of one shaft, an adjacent prospect pit, and a second prospect pit about 100 feet to the southeast.

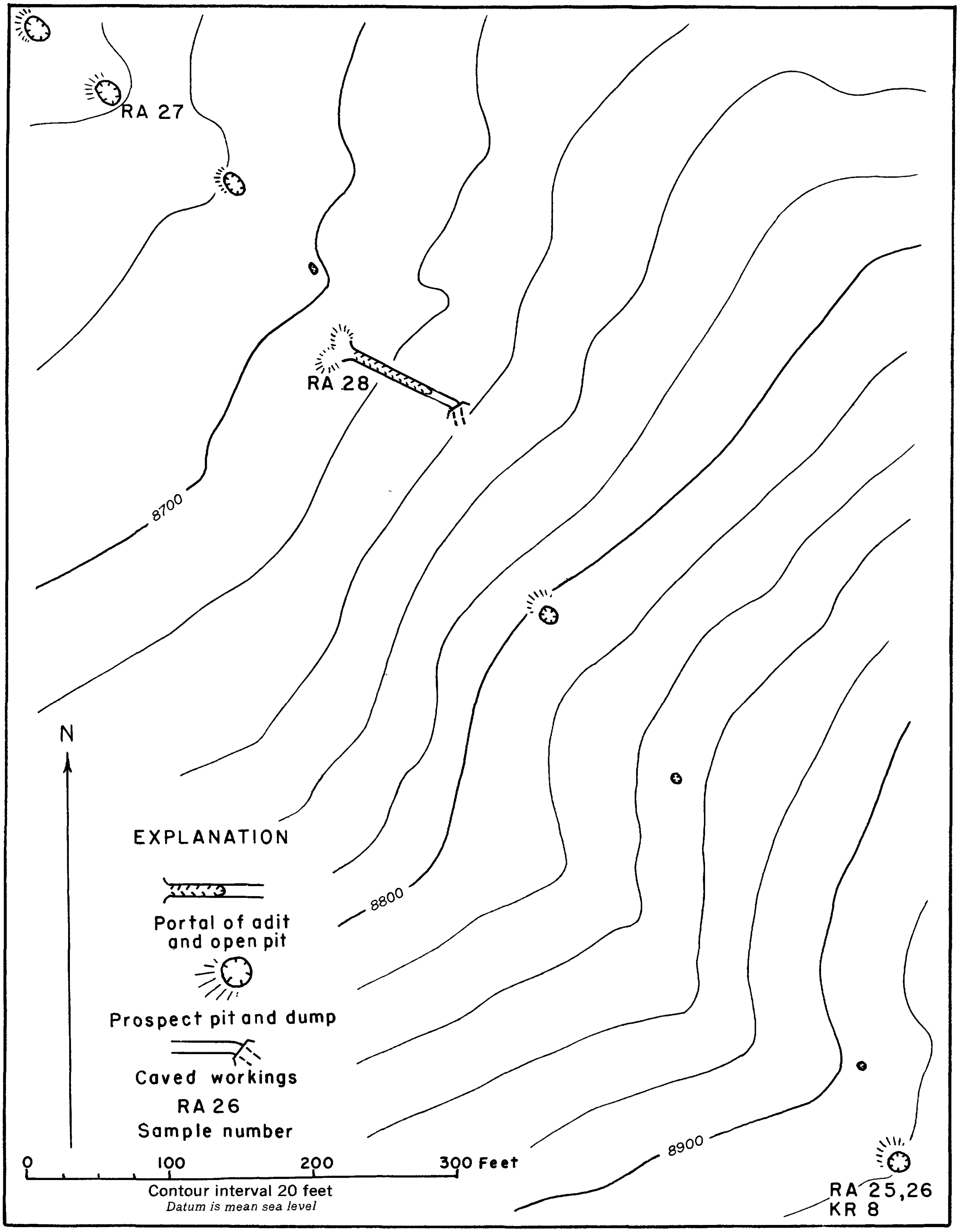

Figure 5.—Prospects on Starbuck claim, Custer County, Colo.

The country rock is dominantly granite and contains a minor amount of hornblende-plagioclase gneiss. A vein 2 feet thick transects the foliation of the country rock at a high angle and occurs in a shear zone that strikes N. 40° W. and dips 55° SW. A basic dike characterized by alined feldspar phenocrysts, trends N. 65° W. through the south pit. Radioactivity is moderately high; much of the vein material on the dumps gave readings 1.8 mr/hr (background about 0.03 mr/hr; geometry 2 to 2.5 π). The dominant vein minerals are white and red fractured barite cemented by red radioactive material and zoned, smoky quartz. Milky quartz is also common, and some occurs in masses having radiating fractures. Specular hematite and limonite mixed with thorite(?) are disseminated through the vein and as coatings on barite and quartz. Siderite is found in small amounts, but its former abundance is recognized by rhombohedral cavities in the quartz associated with abundant limonite. Lead has been reported. The fetid odor of the vein material is very strong, especially in the smoky quartz.

Two samples were taken, one was to indicate maximum radioactivity and the other a 2-foot channel sample across the vein. They contained 1.67 percent and 0.15 percent equivalent ThO_2 (samples AH-2, -3, table 10).

Sunrise claims

The Sunrise claims I, II, and III are in a rather inaccessible area, 2 miles northeast of the Tuttle ranch (fig. 2). Although the owner, George Stultz, primarily worked the Sunrise I claim for barite, some lead was produced. Heyman examined the properties in September 1951. The Sunrise I and II claims are on a northwesterly-trending vein to the southwest of a parallel vein on which Sunrise III is located. Both veins occur in shear zones that cut pre-Cambrian granites and gneisses. There are two prospect pits on the Sunrise III claim. On the Sunrise I and II claims a vertical vein of barite, 3 feet wide, has been mined to a depth of 25 feet for 30 feet along the strike. Southeast of this cut there are many prospect pits and adits along the vein. Where mined, the vein was pure white barite and contained only minor impurities of quartz, carbonate, and galena. Several hundred feet to the southeast and about 100 feet lower in elevation, the vein branches into five veinlets each a few inches wide. A basic dike is present wherever the vein is exposed. It is sheared in many outcrops and locally is silicified or partly altered to green clay. In the main cut, however, the dike is comparatively unaltered in the middle of white barite.

Although both veins may be traced for more than half a mile, the radioactivity is low and very localized. At one point on Sunrise III, radioactive material giving 0.5 mr/hr (background 0.03 mr/hr; geometry 2 to 2.5 π) is present. Radioactivity at Sunrise I and II is negligible.

The only sample analyzed (AH-4, table 10) was taken from the most radioactive part of Sunrise III and, therefore, indicates maximum radioactivity. The chemical uranium content is 0.027 percent which is one of the highest recorded in the thorium deposits; the equivalent ThO_2 content was 1.19 percent.

Swartz property

Two prospect pits on a patented(?) claim owned by D. P. van Nouhuys in the northern part of the Swartz ranch were briefly examined by Heyman and Christman. The Swartz ranch is on State Route 96, 2 miles north of Querida. The pits are on either side of Tyndall Gulch about 1,000 feet apart and are probably along a shear zone which trends N. 28° W.

The country rock at the southeast pit is metagabbro(?) and at the northwest pit is hornblende-plagioclase gneiss. The mineralized material is associated with sheared wall rock and a silicified dike rock. The only vein minerals recognized were limonite and hematite that mask the thorite.

One sample of the most highly radioactive material was taken from each pit. The sample (RA-52, table 10) from the northwest pit contained 2.21 percent equivalent ThO_2. The sample (RA-51) from the southeast pit contained 6.70 percent equivalent ThO_2, and subsequent studies have shown that this sample (RA-51) contains as much as 40 percent bertrandite ($H_2Be_4Si_2O_9$). The pits are so badly slumped that the amount of the vein material is unknown; it is probably small because the known radioactive material is restricted to a few specimens on dumps.

Unnamed prospect

During the 1951 field season, Dellwig examined a strongly radioactive prospect consisting of a single pit located about 1,000 feet south-southwest of the main pit on the Nightengale property and 1,200 feet northwest of the Charleston property (fig. 2). The Tertiary volcanic area around Querida mapped by Emmons and Cross (1896) lies about half a mile west. The ownership of the property is not known.

The prospect pit is in an open field, largely covered by alluvium. Several other mineralized zones, showing greater resistance to weathering than the country rock, crop out as ridges of reddened granite and are exposed in many shallow prospect pits. The country rocks are hornblende and granite gneisses whose average foliation strikes N. 60° W. At least one rhyolite dike crops out near the prospect and cuts across the mineralized zone 175 feet north of the pits. The vein can be traced about 400 feet and is irregularly radioactive. The only indications of mineralization are the high radioactivity and the red staining of the granitic rock. The staining both permeates the rock and occurs as thin surface coatings. Because no visible thorite could be found, the thorium probably is disseminated in the red material responsible for the staining.

The radioactivity recorded on a gamma-scintillation detector along 10 to 15 feet of the mineralized zone compares favorably with the values obtained at some of the most radioactive deposits known in the Wet Mountains area. The maximum Geiger-Mueller counter reading of 5.0 mr/hr (background about 0.03 mr/hr; geometry 2 π) was recorded at the pit, and the dump averaged about 1.5 mr/hr. Two samples (LD-34 and LD-35, table 10) contained 0.77 and 0.44 percent equivalent ThO_2.

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LOGS OF DRILL HOLES

Area of drill holes Ha-3 and Ha-7

Economically, this area is the most important at Haputa ranch because drill hole Ha-3 showed an ore zone about 26 feet thick at a depth of 200 feet and Ha-7 showed that this same zone continues to a depth of 400 feet where it is more weakly radioactive. The ore body at the surface, on the basis of the distribution of radioactivity, is 200 to 300 feet long and is 6 feet wide where exposed in the 20-foot shaft (pl. 2).

The rocks exposed on the surface are principally migmatite and microcline granite. The coarse-grained facies of the alaskitic granite is found in the migmatite and in separate masses. Most of the rock cut in the drill holes is migmatite; the rock in the upper part of the holes more closely resembles microcline granite and in the lower part resembles biotite granite gneiss. Hole Ha-7 also cuts considerable amounts of fine-grained amphibolite. In both drill holes basic dike rock was adjacent to the radioactive zone.

Ha-3

0.0- 54.2 Migmatite; largely microcline granite.
54.2- 55.0 Amphibolite.
55.0- 63.1 Migmatite; highly fractured and limonite-stained in lower part.
63.1-104.6 Basic dike rock; lamprophyric rock containing hornblende phenocrysts with a chill facies and amygdaloidal zones at the contacts; last 8 feet mostly altered to gray-green clay minerals.
104.6-199.0 Migmatite; small percentage of microcline granite; first 10 feet adjacent to the dike slightly mineralized; fetid odor, but no radioactivity.
199.0-221.0 Migmatite slightly fractured and mineralized; thick hematite and limonite coatings on fractures; weakly radioactive by radiometric logging.
221.0-233.0 Migmatite.
233.0-270.5 Vein zone; mineralized granite and minor amounts of mineralized pegmatite, fractured and iron-stained throughout:
- 233.0-236.4 Weakly radioactive; abundant hematite, minor thorite.
- 236.4-239.8 Strongly radioactive; thorite blebs in two veins, 3/8 and 1/2 inch thick, as fracture fillings, quartz veinlets and much hematite and limonite.
- 239.8-245.0 Weakly radioactive; zones as much as a foot wide of strongly fractured material, gouge and iron oxides.
- 245.0-254.0 Strongly radioactive; thorite occurring as fracture coatings, filling small blebs, and disseminated in the iron oxides; four thorite veinlets less than 3/8 inch wide; strongly fractured zones are the most radioactive.
- 254.0-259.0 Moderately radioactive; thorite as fracture coatings and disseminated throughout, associated with iron oxides.
- 259.0-270.5 Strongly radioactive; thorite in highly fractured and hematite-stained, mineralized granite in first 6 feet; last 5.5 feet of crumbly red, earthy clay-like materials and altered granite with disseminated thorite.

270.5-277.0 Basic dike rock; aphanitic.
277.0-283.0 Migmatite, pegmatite, and amphibolite.

Ha-7

0.0-373.0 Migmatite with much amphibolite, minor pegmatite, and microcline granite.
373.0-377.0 Fine-grained dark-red microcline granite.
377.0-394.5 Migmatite.
394.5-396.0 Dark-red microcline granite.
396.0-446.5 Migmatite.
446.5-448.8 Slightly mineralized zone, reddened granite.
448.8-470.0 Basic dike rock; lamprophyric rock containing small hornblende phenocrysts; contact with granite about 20° measured from the axis of the drill core.
470.0-479.0 Basic dike rock and granite, slightly altered.
479.0-492.2 Migmatite and amphibolite.
492.2-518.4 Vein zone:
- 492.2-495.3 Migmatite and amphibolite slightly hydrothermally altered; moderately radioactive according to the radiometric log of the drill hole.
- 495.3-497.5 Moderately radioactive; altered and fractured microcline granite, chlorite along fractures; veins of dark-red iron oxides(?), no visible thorite.
- 497.5-500.8 Weakly radioactive; fractured microcline granite with mottled red-brown alteration in last foot.
- 500.8-502.4 Moderately radioactive; mineralized granite.
- 502.4-512.5 Weakly radioactive; mineralized and fractured microcline granite, large amount of core not recovered.
- 512.5-518.4 Weakly radioactive; locally fractured and mineralized microcline granite with strongest radioactivity associated with the fractures, veinlets of red-brown iron oxides, no visible thorite.
- 518.4-527.0 Basic dike rock, aphanitic.
- 527.0-586.1 Migmatite, amphibolite, and biotite granite gneiss.

The shear zone has a nearly vertical dip (fig. 6). At the surface it is about 10 feet wide, including the

Between the 200- and 400-foot levels the aphanitic basic dike in shear zone no. 1 shifts sides; at 200 feet

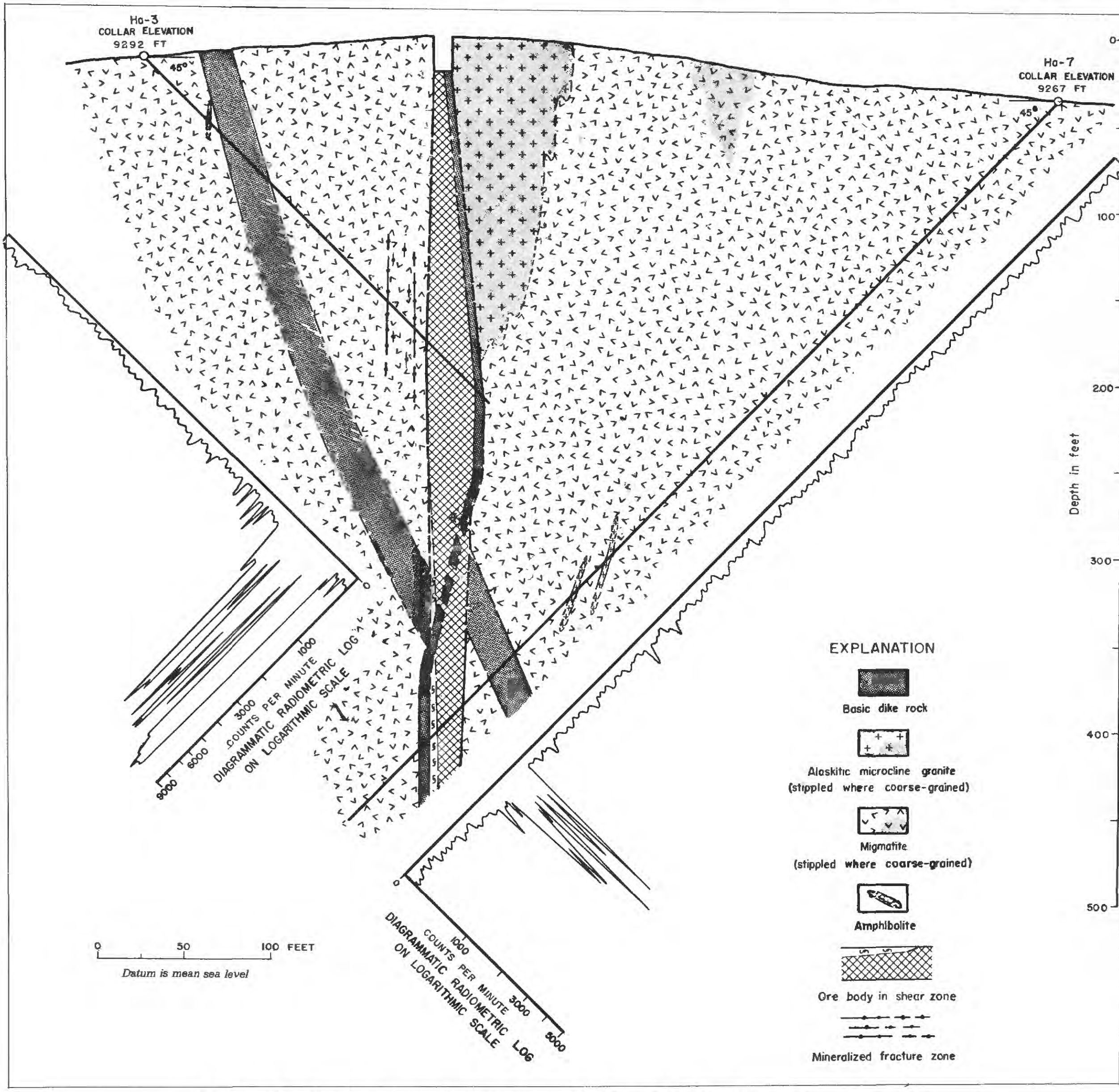

Figure 6.—Section through drill holes Ha-3 and Ha-7, Custer County, Colo.

basic dike; at a depth of 200 feet it is 30 feet wide; and at a depth of 400 feet it is 25 feet wide.

The vein and the dike are exposed in the shaft and were cut by the drill holes. The vein consists principally of quartz, barite, and iron oxides (mostly limonite). The thorite occurs as blebs in the quartz and barite and is disseminated and/or masked by the iron oxides. Where the vein was cut by the drill holes only sparse thorite and quartz were found; most of the ore zone consisted of altered granite or earthy limonite or hematite that was radioactive. The basic dike is strongly altered to limonite. Some of the amygdules in the dike are filled with fluorite rather than calcite.

it is on the northeast side of the mineralization and at 400 feet it is on the southwest side. This dike is distinguished from the hornblende-rich dikes that appears to be displaced along shear zone no. 1.

The radioactive zone in the shaft contains 0.1 to 6.9 percent equivalent ThO_2, 0.001 to 0.002 percent uranium and as much as 0.55 percent rare-earth oxides (table 3). Core from drill hole Ha-3 contained as much as 1.56 percent equivalent ThO_2 and Ha-7 contained a maximum of 0.24 percent equivalent ThO_2 (tables 3 and 5). The gamma-ray logs showed as much as 2.15 percent equivalent ThO_2 in Ha-3 and 0.63 percent equivalent ThO_2 in Ha-7 (table 6). The logs show that the entire width of the shear zone, excluding the basic dike, is weakly to moderately radioactive in both drill holes. The comparative weakness of the radioactivity in Ha-7 does not preclude the possibility of high-grade ore extending to or below this level, as the ore has an irregular distribution within the shear zone. As the shear zone is strong at the 400-foot level, the possibility of the thorium deposit continuing to depth with additional high-grade ore is good.

Area of drill hole Ha-8

The ore at Ha-8, 800 feet southeast of drill holes Ha-3 and Ha-7 and 640 feet northwest of hole Ha-6 (pl. 2) along shear zone no. 1, probably is about 160 feet long as interpreted from the isorads and has a maximum width of 5 feet as shown in the bulldozed trench. The drill hole, which was located on the basis of a small but strong anomaly (pl. 2) located with the gamma-scintillation detector, proved that the ore body extends to a depth of at least 140 feet.

The surface outcrops around Ha-8 are biotite granite gneiss and a small amount of amphibolite and microcline granite. In the trench the vein is 5 feet wide and the basic dike lies 15 feet to the west giving the shear zone a width of as much as 25 feet. The vein consists of thorite and abundant limonite and hematite in fractured and reddened granite; quartz or barite are not present at the surface. The thorite is found in pockets and as veinlets occurring irregularly along the fractures.

The drill hole, likewise, was in biotite granite gneiss with less abundant microcline granite. The basic dike is on the east side of the vein giving it a dip of 86° NE and the vein dips 83° SW (fig. 7). Two hydrothermal veinlets cut the dike. Minor amounts of pyrite and fluorite occur in the main vein. The generalized log of the drill hole is given at the bottom of this page.

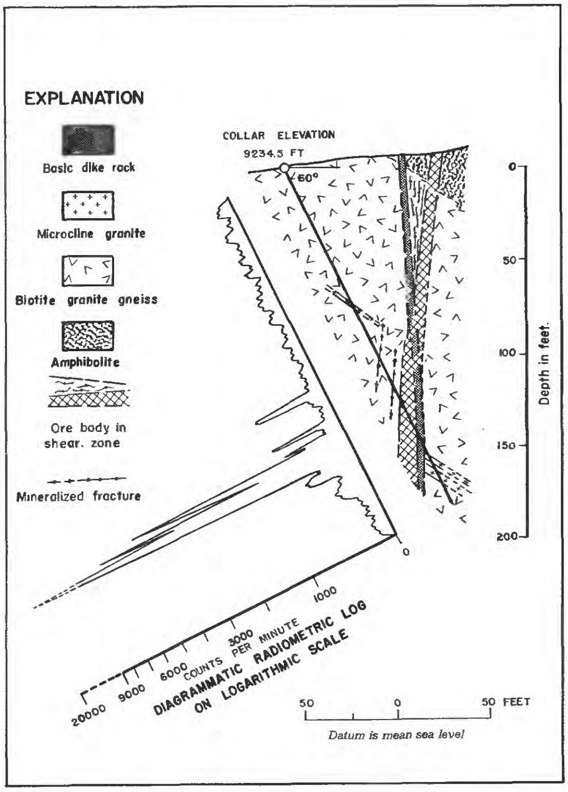

Figure 7.—Section through drill hole Ha-8, Custer County, Colo.

Ha-8

0.0- 81.0 Biotite granite gneiss cut by occasional small dikes and stringers of microcline granite and a few amphibolite stringers.
81.0- 82.5 Coarse-grained microcline granite.
82.5-114.0 Biotite granite gneiss.
114.0-115.2 Biotite granite gneiss; fractures coated with hematite, slightly radioactive.
115.2-131.4 Biotite granite gneiss.
131.4-139.2 Biotite granite gneiss, slightly reddened by hydrothermal mineralization.
  132.5 Fracture filled with 1/16 inch of thorite.
139.2-159.2 Vein zone:
  139.2-150.4 Strongly radioactive; hydrothermal vein material mostly in granite; strongest mineralization and radioactivity associated with fractures, some visible thorite.
  150.4-152.7 Weakly radioactive; hydrothermal vein material mostly in amphibolite with red feldspar, quartz, minor pyrite, and fluorite; amphibolite highly altered to chlorite and clay minerals.
  152.7-159.2 Weakly radioactive; hydrothermally altered mixture of fractured granite and amphibolite with minor fluorite and pyrite.
159.2-169.0 Basic dike rock, cut by two hydrothermal veins.
169.0-170.3 Mineralized and altered biotite granite gneiss.
170.3-200.2 Biotite granite gneiss cut by younger granite at 173 to 178.6 and 182.4 to 191.2.

The analyses of 5-foot channel samples RA-93 and RA-94 (table 3) taken 2 feet apart across the mineralized vein in the trench contained 2.57 and 0.72 percent equivalent ThO_2 and as much as 0.53 percent rare-earth oxides. Sample Ra-95 taken across the most radioactive part of the vein contained 4.49 percent equivalent ThO_2. Sample GG-72 from an outcrop along the shear zone 270 feet to the southeast assayed 0.10 percent equivalent ThO_2.

The main vein is 10 feet wide at a depth of 140 feet and parts of it are highly radioactive; the gamma-ray log of the drill hole shows the highest radiometric readings recorded in the Haputa ranch area, reaching 20,000 cpm in one thin zone. This represents 5.57 percent equivalent ThO_2 (table 6). The core samples contained a trace to 1.60 percent equivalent ThO_2 (table 5) and a spectrographic analyses showed that yttrium may be present in as much as 0.X percent and other rare earths present only as traces. Radioactivity was recorded in two zones of mineralized fractures on the west side of the main vein.

Area of drill hole Ha-10

In the vicinity of drill holes Ha-10, Ha-11, and Ha-6 a tension fault connects shear zone no. 1 with shear zone no. 2. The surface radioactivity in this area is the strongest found at Haputa ranch and covers the largest area (pl. 2). Unfortunately, the ore body does not continue at depth.

Exposures on the surface were very poor near drill hole Ha-10 at the time of drilling; later bulldozing showed that the area was composed of metagabbro with migmatite to the north and a small area of biotite granite gneiss and amphibolite to the south. The vein in the bulldozed trenches is only 2 feet wide but is strongly radioactive. The vein is similar to that near Ha-8, consisting of iron oxides and thorite without quartz or barite. All the granite in this area has a strong fetid odor and is reddened. The basic dike follows shear zone no. 1 but is not found in the tension fault.

The drill hole cut beneath the center of the area of high radioactivity but failed to locate ore or a strongly sheared zone. Except for the first 50 feet of migmatite, the hole passed through metagabbro and some amphibolite with minor radioactivity occurring on the west side of the basic dike, associated with a microcline granite, and in a narrow vein near the bottom of the hole which probably represents the western margin of the shear zone (fig. 8). The generalized log is given at the bottom of this page.

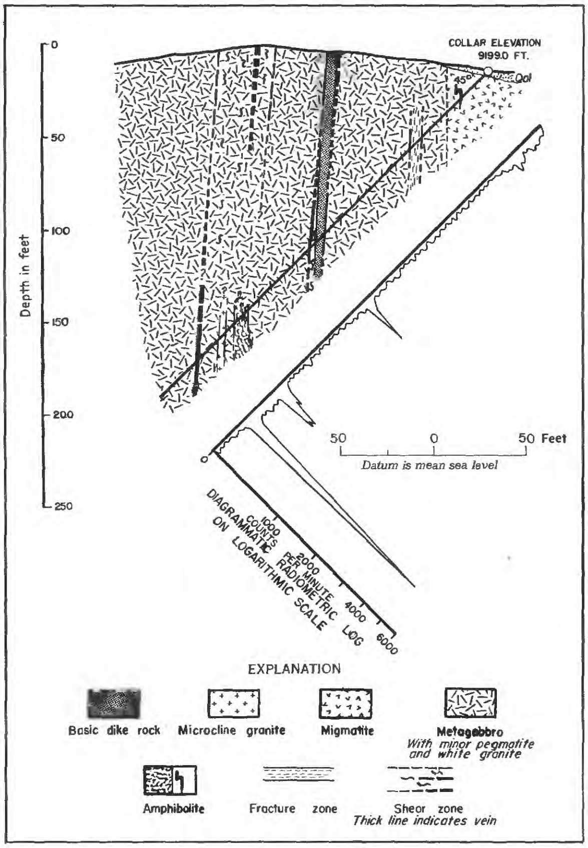

Figure 8.—Section through drill hole Ha-10, Custer County, Colo.

Ha-10

0.0- 31.1	Migmatite and a minor amount of amphibolite.
31.1- 50.6	Metagabbro, highly weathered in first 5 feet; fractured and weathered at 44.7 to 50.6.
50.6- 59.6	No core recovery, probably highly weathered and broken metagabbro.
59.6-123.7	Metagabbro, cut locally by pegmatite and white granite.
123.7-131.2	Basic dike rock, slightly mineralized.
131.2-136.4	Metagabbro.
136.4-137.7	Hydrothermal vein material, very weakly radioactive; vein material principally brick-red feldspar with minor barite and a few specks of galena; strong radioactivity on one fracture surface.
137.7-182.0	Metagabbro, cut locally by coarse- and fine-grained white and salmon-colored granite.
182.0-183.3	Amphibolite.
183.3-185.6	Metagabbro.
185.6-192.0	Amphibolite, poorly developed gneissic structure.
192.0-198.8	Metagabbro.
198.8-205.3	Microcline granite; slightly radioactive according to the radiometric log.
205.3-220.6	Metagabbro.
220.6-222.3	Hydrothermal vein material, mostly white to pale-green siliceous material: 221.0-221.5 Strongly radioactive zone of brick-red feldspar and microbreccia cemented by dense, fine-grained reddish-brown, radioactive material.
222.3-248.7	Metagabbro.

At the surface, the 2-foot channel samples of the vein in the bulldozed trenches contained 1.11 and 0.61 percent equivalent ThO_2 and as much as 1.53 percent rare-earth oxides (RA-97 and Ha-96, table 3). This vein is only weakly present at depth. The maximum radioactivity in the drill hole was observed in a narrow zone on the western margin of the shear of 1.04 percent ThO_2 by the radiometric log and of 0.55 percent equivalent ThO_2 in the core samples (tables 5 and 6).

Area of drill hole Ha-11

After drill hole Ha-10 failed to find as high-grade ore in depth as on the surface, drill hole Ha-11 was drilled in an attempt to cut a high-grade deposit a short distance to the north. The hole was planned to explore ground beneath one of the most radioactive surface areas, cutting the strike of the shear zone at an angle, to be in possible ore ground for a greater drilling length. The strongest radioactivity found in the hole was little more than twice background eliminating the possibility that the high-grade body might rake to the north.

The basic dike has an apparent dip of 74° to the south in the section of the drill hole (fig. 9) and has a true dip of about 78°; it probably forms the northeast side of shear zone no. 1 at the surface. In the drill hole, a 5-foot altered zone probably represents a fault contact (west side of shear zone connecting zones nos. 1 and 2) between the granite and the metagabbro. Between these limits the shear zone is not recognizable in the drill hole.

The gamma-ray log shows that the granitic wall rocks in this hole have radioactivity of about twice background and that the surface alluvium is also about three times background (fig. 9). The generalized log of the drill core is given at the bottom of this page.

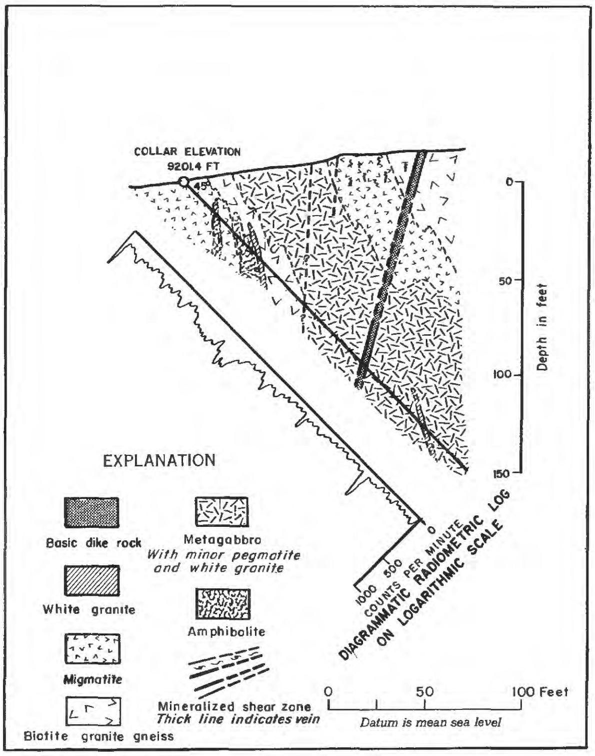

Figure 9.—Section through drill hole Ha-11, Custer County, Colo.

Ha-11

0.0- 20.7	Migmatite and minor amphibolite.
20.7- 24.0	Amphibolite.
24.0- 35.4	Migmatite and amphibolite, locally highly broken and limonite-stained with minor stringers of a basic dike at 29.5-31.5.
35.4- 56.0	Amphibolite, locally broken and limonite-stained.
56.0- 57.4	White granite stringers.
57.4- 87.5	Biotite granite gneiss; some migmatite and amphibolite, radioactivity slightly higher than background.
87.5- 92.4	Completely altered rock, clay(?).
92.4-128.4	Metagabbro cut locally by white granite; first 8 feet are altered.
128.4-129.3	Metagabbro cut by hydrothermal veins and veinlets of white siliceous bands with clear quartz centers and occasional specks of galena; not radioactive.
129.3-131.4	Basic dike rock and minor hydrothermal veinlets of quartz bounded by zones of reddish-brown silicified dike rock; not radioactive.
131.4-135.5	Basic dike rock.
135.5-174.6	Metagabbro.
174.6-176.8	White granite, coarse-grained, slightly radioactive.
176.8-210.1	Metagabbro.

Area of drill hole Ha-6.

About 95 percent of the surface outcrops and the rock cut by the drill hole are metagabbro; the remainder are granitic dikes and stringers, pegmatites,and the basic dike rock. On the surface just north of the projection of the drill hole (pl. 2) the vein divides; it is exposed in two prospect pits. The vein contains quartz, barite, and iron oxides in contrast to the vein 70 feet to the north that does not contain quartz or barite. The thorite occurs in blebs in the barite and quartz and is surrounded by radiating fractures.

Drill hole Ha-6 extends across shear zones nos. 1 and 2 as well as the connecting tension fault. The hole is on the south edge of the highly radioactive area outlined by the gamma-scintillation detector (pl. 2); its purpose was to determine if the ore body raked to the south and to obtain information on the structure in this area. The basic dike, and veins on the surface can be correlated with the dike and fractured zones, having less radioactivity, at depth. In these zones the metagabbro is cut by many small veins and veinlets of hydrothermal material characterized by a red color. They were probably formed by replacement along the fractures in the metagabbro and are composed of microcline, quartz and carbonate, and a minor amount of thorite. The dikes and the veins, or fracture zones, have a nearly vertical dip (fig. 10). A generalized log of this table is given below:

Ha-6

0.0- 18.3		Metagabbro cut by minor white granite dikes and stringers.
18.3- 19.3		Fractured zone in metagabbro, slight mineralization.
19.3-120.2		Metagabbro, in part the feldspar-low variety, cut by minor white granite stringers and pegmatite.
120.2-136.5		Metagabbro cut by hydrothermal veins and veinlets along fractures:
	120.2-120.7	Highly fractured with calcite coatings and much staining, minor thorite(?), weakly radioactive.
	120.7-122.0	Slightly altered metagabbro.
	122.0-124.2	Hydrothermal vein of quartz, brick-red feldspar, limonite, barite, minor fluorite, and radioactive material occurring as fracture coatings or disseminated in highly reddened zones; strongly radioactive.
	124.2-136.5	Metagabbro cut by 15 narrow hydrothermal veins, 13 of which are 1/4 to 3-1/2 inches thick with siliceous borders and quartz and/or calcite fillings and occasional blebs of fluorite.
	128.6	Strongly radioactive vein, 5/8 inch wide, with small masses of thorite.
	133.1-133.3	Strongly radioactive vein with thorite in blebs, quartz, pink feldspar, red barite, and minor fluorite; largest thorite mass 3/4 inch across longest dimension.
136.5-183.1		Metagabbro with granite dikes and stringers.
	148.5	Two 1/4-inch veins in fracture 1 inch apart with quartz, brick-red feldspar, and strongly radioactive fracture coatings.
183.1-194.4		Metagabbro cut by two 3-1/2 inch and many smaller hydrothermal veins and veinlets; weakly radioactive.
194.4-255.1		Metagabbro and minor white granite.
255.1-256.9		Microcline granite, slightly mineralized, fetid odor.
256.9-310 6		Metagabbro and minor white granite.
310.6-315.0		Basic dike rock.
315.0-345.0		Metagabbro cut by hydrothermal veins and veinlets along fractures.
	325.0	Vein, 5/8 inch thick, with specks of thorite and galena.
	339.6-341.6	Vein with thorite and minor fluorite in stringers, moderately radioactive.
	345.0-418.0	Metagabbro and minor white granite.
	418.0-432.2	Microcline granite, part having fetid odor; radioactivity twice background.
	432.2-437.5	Metagabbro and minor white granite.

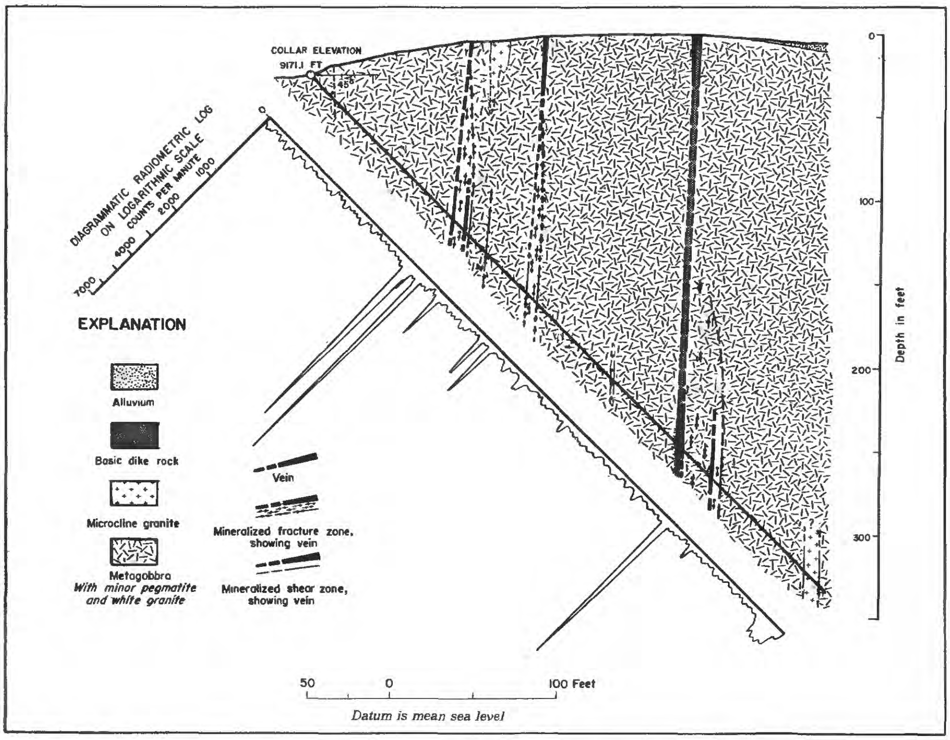

Figure 10.—Section through drill hole Ha-6, Custer County, Colo.

A 2-foot channel sample from the prospect pit north of, and nearest to, the drill-hole site contained 3.34 percent equivalent ThO_2 and a 1.9-foot channel sample from the farther pit contained 1.22 percent equivalent ThO_2 (GG-47 and GG-42, table 3). In the drill hole below the first-named pit, the gamma-ray log indicated a maximum of 1.2 percent equivalent ThO_2 and the core samples contained 0.24 percent equivalent ThO_2 (tables 5 and 6). The fracture zone correlated with the vein in the second pit is only weakly radioactive. A small veinlet in a fracture zone east of the basic dike in the drill hole contained 0.41 percent equivalent ThO_2 by the gamma-ray log.

The rock between 418 and 432.2 feet in the drill hole is microcline granite that has a radioactivity of more than twice background. The granite is not fractured but a clearly detectable fetid odor suggests that it might be slightly mineralized.

Drill holes Ha-11 and Ha-6 show that the ore body does not rake to the north or south and drill hole Ha-10 shows that it does not extend vertically; therefore, it must be a shallow body that dies out with depth. The manner in which the veins become weaker at depth and apparently grade into fracture zones filled with hydrothermal veinlets suggests that the metagabbro is not a good host rock and contains ore only near its contact with granitic rocks.

Area of drill hole Ha-2.

The area around Ha-2 in the southeastern part of Haputa ranch is composed of metagabbro (pl. 1). The drill hole passes below a shaft on shear zone no. 2 and a shaft on a subsidiary fault, 35 feet to the east. The shafts in this area were sunk in search of gold, silver, and lead; a few pockets of galena were found in the eastern fault structure. The core from the drill hole is mostly metagabbro, as on the surface, but includes more microcline granite, pegmatite, and white granite than is exposed on the surface.

Ha-2

0.0- 29.0	Metagabbro.
29.0- 33.5	Microcline granite.
33.5- 93.1	Metagabbro, fractured, altered and limonite-stained, containing granite and pegmatite; sporadic recovery of core; granite at 42.9; pegmatite at 65.8 to 69.4 and 89.8 to 93.1.
93.1-102.2	Metagabbro.
102.2-107.3	Pegmatite.
107.3-170.4	Metagabbro, intruded locally by pegmatite.
170.4-171.5	Metagabbro, fractured and mineralized; minor hydrothermal vein material.
171.5-176.8	Hydrothermal vein material in silicified and altered gabbro and minor granite(?); small masses of white and red barite, veinlets of white barite, thorite with the barite at 171.7 and 175.6; purple fluorite disseminated in veinlets and as fracture coatings, many weakly radioactive veinlets of brick-red feldspar in the last foot.
176.8-180.4	Basic dike rock.
180.4-185.9	Metagabbro, plagioclase-low facies.
185.9-189.6	Pegmatite, in part sheared and mineralized.
189.6-200.6	Metagabbro, intruded locally by pegmatite.
200.6-217.0	Pegmatite; slightly sheared and mineralized containing a fetid gas 200.6 to 213.0; weakly radioactive 206.7 to 209.9.
217.0-227.3	Metagabbro, plagioclase-low facies.
227.3-252.8	Pegmatite; sheared and mineralized with red veinlets at 228.8-234.0; brick-red feldspar, minor barite, strong fetid odor when broken, and weakly radioactive; the fetid odor in intervals between 234.0 and 252.8.
252.8-275.0	Metagabbro, intruded locally by pegmatite.

The radioactivity of three samples (table 3) taken along shear zone no. 2 contained as much as 0.20 percent equivalent ThO_2. In the drill hole, the strongest radioactivity occurs in the shear zone on the west side of the basic dike that dips 82° W. The hydrothermal material consists of barite, fluorite, and thorite in a silicified zone. The highest equivalent ThO_2 values were 0.63 percent by gamma-ray logging and 0.29 percent in the core samples (tables 5 and 6). In the lower part of the hole, the pegmatites are fractured and mineralized (fig. 11).

Area of drill hole Ha-1

In the southern part of the area one of the most radioactive prospect pits on Haputa ranch is found south of drill hole Ha-2. It has no visible relation to shear zone no. 2, or to other shear or mineralized zones. The ore minerals are in a fractured zone at the contact between a pegmatite and metagabbro. The contact apparently trends N. 70° W., but a careful study with the gamma-scintillation detector failed to reveal any trend to the radioactivity. A sample from this prospect (GG-76) contained 16.44 percent equivalent ThO_2.

The prospect pit and the drill hole are in metagabbro and minor pegmatite dikes (pl. 1 and fig. 12). Two weak zones of radioactivity were found in the drill hole; one small radioactive vein and one pegmatite, containing a few crystals of a brown radioactive mineral, were cut. At about 200 feet vertically below the pit, a nonradioactive fracture zone was cut by the drill hole that might be correlated with the zone of strong radioactivity on the surface. A generalized log of the hole is given on the next page.

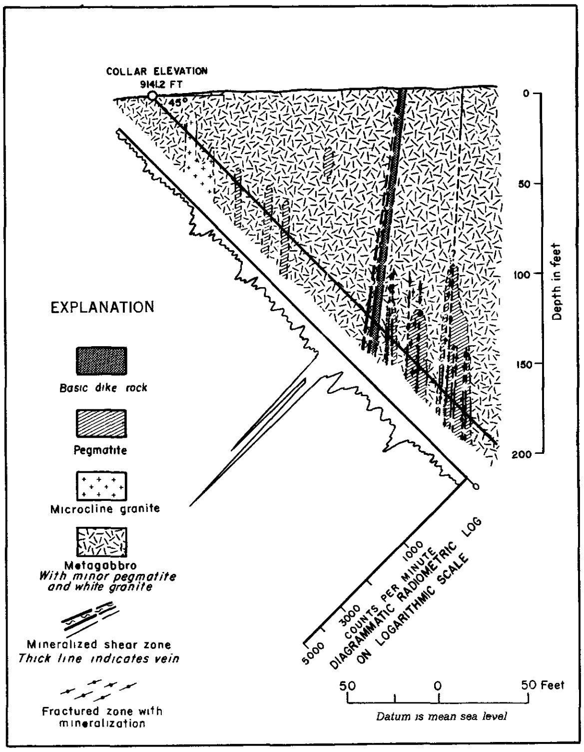

Figure 11. —Section through drill hole Ha-2, Custer County, Colo.

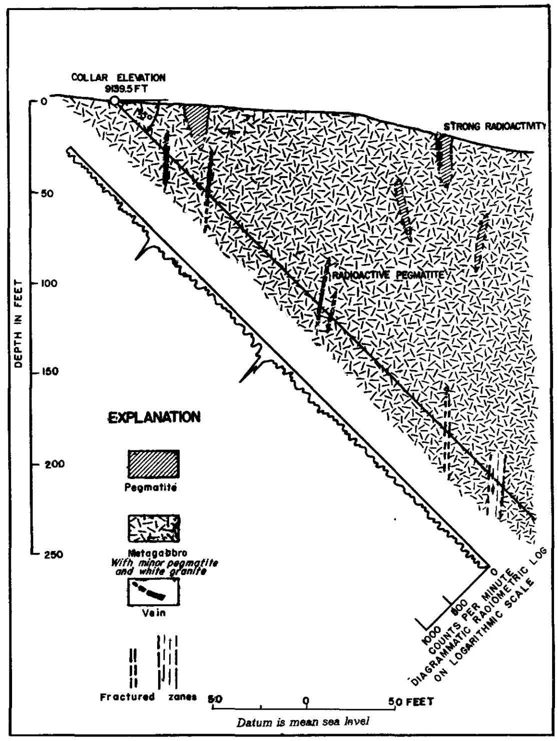

Figure 12. —Section through drill hole Ha-1, Custer County, Colo.

Ha-1

0.0- 41.9	Metagabbro.
41.9- 42.4	Pegmatite
42.4- 74.5	Metagabbro; minor pegmatite and white granite.
74.5- 75.3	Pink, salic hydrothermal vein material along fractures.
75.3-161.6	Metagabbro, in part the plagioclase-low facies, and minor pegmatite and white granite.
161.6-162.2	Pegmatite, slight radioactivity due to brown mineral.
162.2-167.1	Metagabbro.
167.1-169.2	Pegmatite.
169.2-258.2	Metagabbro, much is plagioclase-low facies, and minor pegmatite.
258.2-259.2	Fractured zone in metagabbro.
259.2-292.8	Metagabbro and minor pegmatite.
292.8-304.3	Fractured zone in metagabbro.
304.3-327.0	Metagabbro and minor pegmatite.

Area of drill hole Ha-4.

This area is composed of metagabbro, in part the hornblende-rich and plagioclase-low variety, and minor pegmatite that is cut by shear zones nos. 3 and 4 (pl. 1). The drill hole passed through the same rock types except that microcline granite, in part associated with fractured zones, was found in several places (fig. 13). Both the basic dikes with their associated minor mineralization were found in the drill hole to correlate with those of the surface. A summary of the log is given on the following page.

Ha-4

0.0- 25.9	Metagabbro with plagioclase-low facies; last 6 feet weathered and fractured.
25.9- 28.6	Microcline granite.
28.6- 54.6	Metagabbro, plagioclase-low facies, fractured and altered at 28.6 to 34.3 and 50.6 to 54.6.
54.6- 60.0	Microcline granite.
60.0- 92.3	Metagabbro intruded by a small quantity of pegmatite and white granite.
92.3- 93.1	Microcline granite and metagabbro.
93.1-161.6	Metagabbro cut by white granite stringers.
161.6-164.4	Metagabbro, pegmatite stringers and basic dike, last foot fractured and altered.
164.4-165.6	Basic dike.
165.6-170.1	Basic dike cut by hydrothermal vein material on hanging wall; fractured, limonite stained, and silicified along some fractures; one fluorite veinlet.
170.1-174.8	Metagabbro, plagioclase-low facies.
174.8-176.8	Pegmatite.
176.8-237.3	Metagabbro with plagioclase-low facies.
237.3-243.8	Microcline granite.
243.8-249.0	Metagabbro.
249.0-251.5	Basic dike with hydrothermal vein material on hanging wall.
251.5-274.0	Metagabbro with plagioclase-low facies.
274.0-277.7	Pegmatite.
277.7-294.3	Metagabbro, plagioclase-low facies.

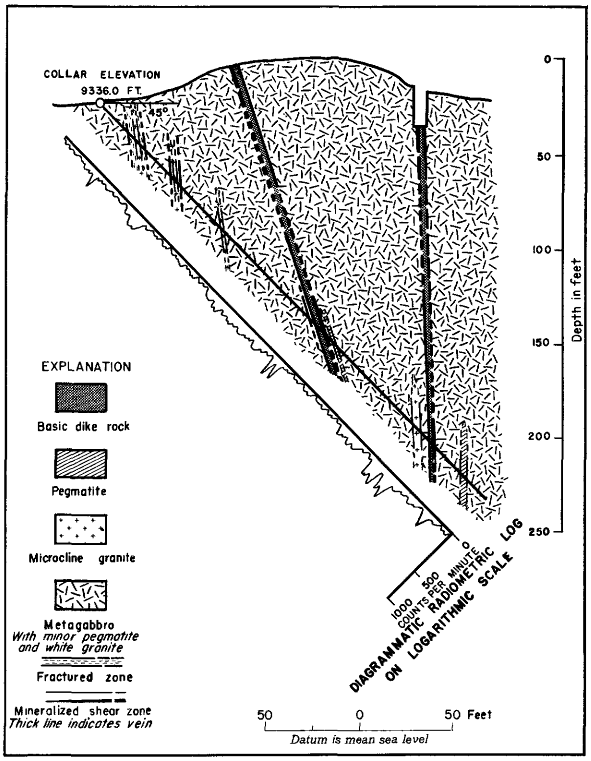

Figure 13. —Section through drill hole Ha-4, Custer County, Colo.

The maximum radioactivity at the surface along shear zone no. 3 was 0.38 percent equivalent ThO_2 near the shaft (table 3). The dump of the shaft was the only area along shear zones nos. 3 and 4 that was more than twice background on the gamma scintillation detector (pl. 2). Shear zone no. 4 contained only a trace of equivalent ThO_2 but as much as 0.81 percent rare earths.

The drill hole contained only a trace of equivalent ThO_2. The gamma-ray log shows that very minor radioactivity is associated with some of the microcline granite. Data from the hole shows that shear zone no. 4 dips 71° NE, and shear zone no. 3 dips 88° NE, suggesting that shear zones may join at depth.

Area of drill hole Ha-5

Drill hole Ha-5 which is about 240 feet southeast of Ha-4 also cuts shear zones nos. 3 and 4. The surface outcrops are biotite granite gneiss, migmatite, and microcline granite with minor amphibolite and metagabbro (pl. 1). The drill cuts granitic rocks in its upper parts but encountered considerable metagabbro in its lower parts (fig. 14).

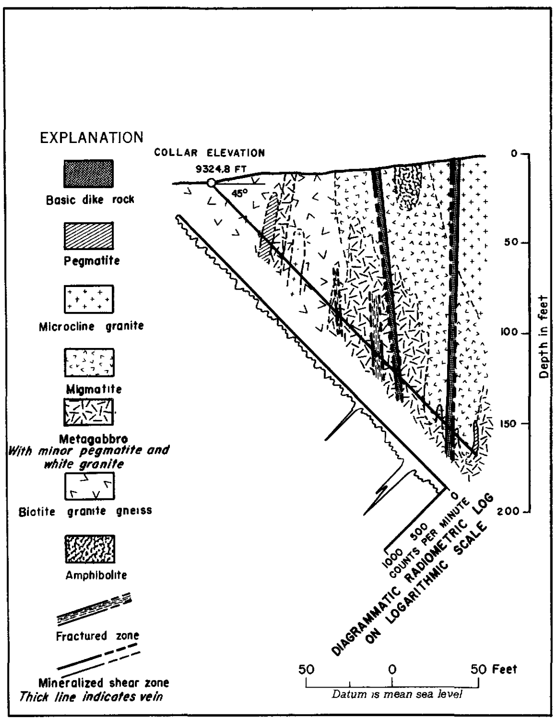

Figure 14. —Section through drill hole Ha-5, Custer County, Colo.

The basic dike and associated minor mineralization were found at depth. A summary of the log is given below:

Ha-5

0.0- 42.0	Probably largely biotite granite gneiss.
42.0- 49.3	Pegmatite.
49.3- 57.5	Metagabbro, fractured, altered and limonite stained.
57.5- 63.0	Biotite granite gneiss.
63.0- 71.8	Microcline granite.
71.8- 95.8	Biotite granite gneiss.
95.8- 98.5	Metagabbro, fine-grained chill facies at contact with gneiss.
98.5-147.4	Metagabbro, fractured and altered at 98.5 to 103.2 and at 127.8 to 137.7.
147.4-148.6	Hydrothermal vein material; abundant hematite, vein quartz, and silicified material in brecciated and altered pegmatite.
148.6-150.1	Basic dike.
150.1-170.9	Metagabbro cut locally by white granite.
170.9-182.2	Migmatite (biotite granite gneiss intruded by abundant stringers of microcline granite along foliation planes).
182.2-186.8	Metagabbro.
186.8-188.7	Migmatite.
188.7-192.8	Basic dike; cut by hydrothermal vein at 189.9-190.4; fluorite in blebs and veinlets, one 2-millimeter veinlet of galena, very weakly radioactive.
192.8-193.4	Hydrothermal vein material and altered basic dike rock; weakly radioactive, small amount of thorite and chalcopyrite(?).
193.4-210.6	Migmatite with small quantity of pegmatite and conformable metagabbro mass at 194.4 to 195.6.
210.6-211.6	Pegmatite.
211.6-213.5	Metagabbro.

Shear zone no. 4 is dipping 83° NE and shear zone no. 3 is almost vertical; they apparently intersect at depth. The trend of the shears suggest that they intersect on the surface about 160 feet to the southeast.

The surface prospect pits contained a trace to 0.15 percent equivalent ThO_2 and as much as 0.48 percent rare-earth oxides (table 3). In the drill hole only minor radioactivity is associated with the shear zones with the basic dikes serving as a wall. The highest equivalent ThO_2 of the core samples was 0.06 percent; the highest equivalent ThO_2 obtained by the gamma-ray logging was 0.10 percent for shear zone no. 3 (tables 5 and 6).

These results, as well as those obtained in hole Ha-4, seem to indicate that this part of the structure is not particularly favorable for high-grade thorium ore; however, because of the irregular distribution of ore along the shear zones, no structure can be completely disregarded on the basis of so few drill holes.

Area of drill hole Ha-9

The surface exposures in this area consist principally of biotite granite gneiss, migmatite, and amphibolite; a basic dike is exposed in one of the shafts and a syenite(?) dike is well exposed (pl. 1). The objective of drill hole Ha-9 was to test for radioactive deposits at depth in shear zone no. 5. The drill hole was planned to cut near the intersection of two faults where much shearing has taken place. The veins have been prospected by two shafts and several prospect pits; the veins contain abundant quartz, iron carbonate, minor amounts of sulfides, and weakly radioactive material.

Most of the core from the first 100 feet of the drill hole was highly broken and stained by limonite; locally it contains the fetid odor found in slightly radioactive zones in this area. The syenite(?) dike and younger granite are easily correlated with the surface; the rest of the rock is a complex mixture of granitic rocks and amphibolite (fig. 15). The lower part of the hole is much less altered and consists of biotite granite gneiss. A generalized log is given on the following page.

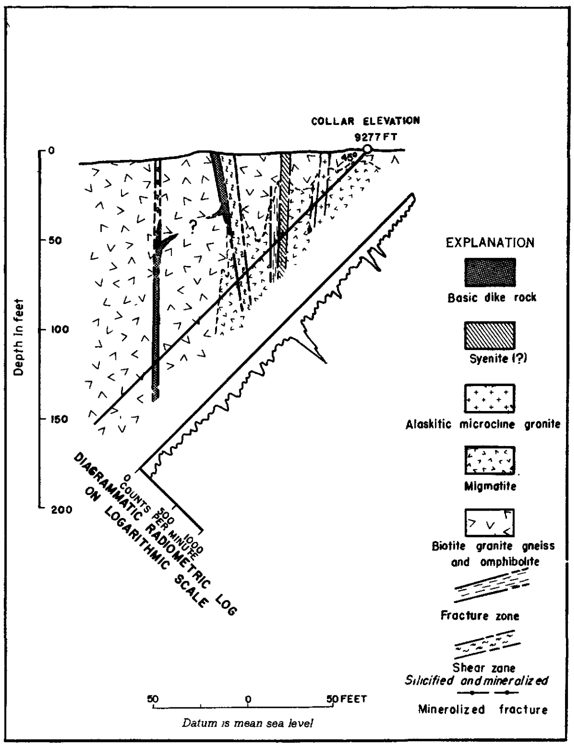

Figure 15.—Section through drill hole Ha-9, Custer County, Colo.

Ha-9

0.0- 34.0	Highly broken and limonite-stained biotite granite gneiss, migmatite, amphibolite, and small amount of granite.
34.0- 41.3	Alaskitic microcline granite, broken and limonite-stained, slightly mineralized having a fetid odor.
41.3- 64.0	Migmatite and amphibolite with minor amount of granite; pegmatite at 47.5 to 49.0 and 62.0 to 64.0.
64.0- 69.5	Syenite(?), slightly mineralized with fetid odor in last 2 feet.
69.5- 77.6	Highly broken and limonite stained, slightly mineralized granite, syenite(?), and amphibolite.
77.6- 95.8	Migmatite.
95.8-103.3	Silicified and hydrothermal vein material in granite, locally highly fractured; salmon and brick-red feldspar, quartz, calcite, reddish-brown iron carbonate, fine-grained epidote, and locally abundant iron oxides, particularly limonite; gamma-ray logging indicates some radioactivity between 97 and 105 feet.
103.3-166.6	Biotite granite gneiss, in part migmatite, with amphibolite and numerous small coarse-grained granite dikes.
166.6-169.8	Basic dike rock.
169.8-215.8	Biotite granite gneiss, partly migmatized, and amphibolite.

The mineralized faults exposed at the surface are both found in the drill hole; the principal difference is that the basic dike appears to have crossed over from one to the other between the surface and the 120-foot level (fig. 15). The structures are nearly vertical except that the stronger shear apparently dips slightly northeast. Only the easternmost fault is radioactive at depth.

The surface analyses (table 3) and the gamma-ray logs of the drill hole (table 6) indicate that this deposit probably does not contain ore of economic interest. One grab sample (LD-18) contained 0.11 percent equivalent ThO_2, but the drill hole contained a maximum of 0.03 percent equivalent ThO_2.

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