UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Thorium deposits in the Wet Mountains area, Fremont and Custer Counties, Colorado

By

T. J. Armbrustmacher

Open-File report 76-284

1976

Contents

Illustrations

Thorium deposits in the Wet Mountains area, Fremont and Custer Counties, Colorado[1]

By T. J. Armbrustmacher

Introduction and geologic setting

Thorium deposits have been known to exist in the Wet Mountains area since at least the early 1950's. This talk summarizes some of the earlier work on the deposits, especially by the Geological Survey, and outlines some of the preliminary results of the current studies being conducted there.

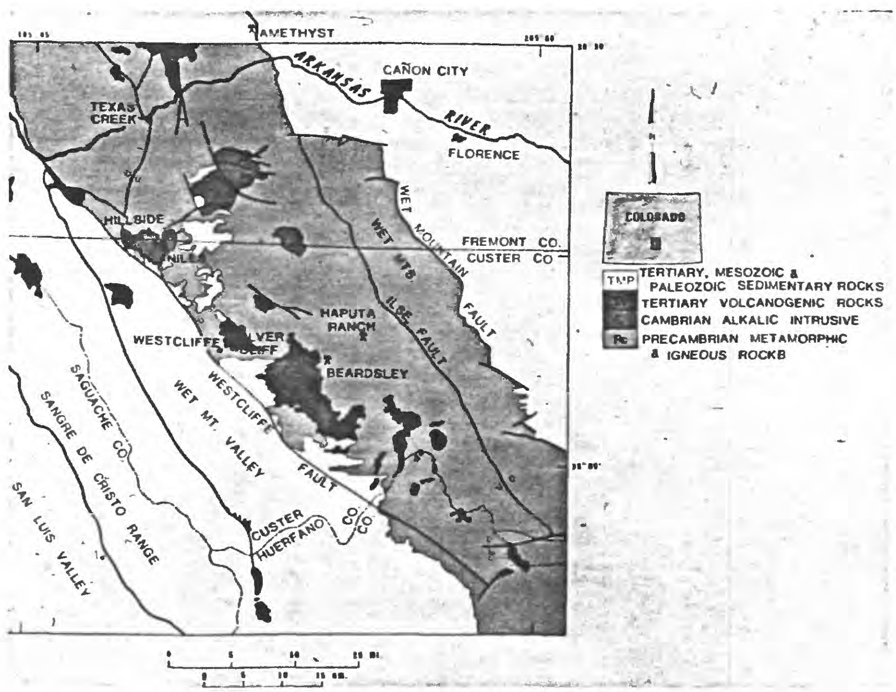
The area of interest (fig. 1) is located in the vicinity of the Wet Mountains of south-central Colorado in southern Fremont and Custer Counties. The thorium deposits occur in an area bounded more or less by the Arkansas River on the north, the Custer-Huerfano County line on the south, the Ilse fault on the east, and the Westcliffe Fault on the west. The small communities of Westcliffe and Silver Cliff are located just west of the center of figure 1.

Thorium deposits in the Wet Mountains area occur as dikes and veins in Precambrian metasedimentary rocks and intrusive granitic rocks. The metasedimentary rocks consist of layered gneisses, chiefly granitic gneiss, migmatite, hornblende, and biotite gneiss, and other lithologic variants assigned a Precambrian X age by Taylor and others (1975a, b). The intrusive granitic rocks of the area are correlative with Boulder Creek Granodiorite (Precambrian X) and Silver Plume Quartz Monzonite (Precambrian Y) (Taylor and others, 1975a; Taylor, 1974). Small bodies of gabbro and ultramafic rock within the metasedimentary rocks are also considered Precambrian by Brock and Singewald (1968).

---

[1]Abstract for this paper was previously released in Open-File report 75-595 "Abstracts of the 1975 Uranium and Thorium Research and Resources Conference." This report is based on talk given at the U.S. Geological Survey Uranium and Thorium Research and Resource Conference held December 8-10, 1975 at Golden, Colorado.

Figure 1.--Location and geologic map of the Wet Mountains area.



The Precambrian terrane is intruded by a differentiated sequence of alkalic rocks which forms three complex stocks, the McClure Mountain Complex to the north, the Gem Park Complex to the southwest, and the Democrat Creek Complex to the southeast (fig. 1). Also included in the alkalic sequence is a wide variety of younger, genetically related dikes and veins--many thorium bearing--which cut the Precambrian rocks and also the alkalic stocks. According to Richard F. Marvin (unpublished data, 1975), the alkalic rocks of the Wet Mountains were emplaced during Middle Cambrian to Early Ordovician time. The alkalic intrusions have been studied by Parker and Sharp (1970), Shawe and Parker (1967), and Parker and Hildebrand (1963).

Country rocks adjacent to the alkalic intrusions and associated dikes and veins are characteristically fenitized. Granitic host rocks tend to be pink to reddish pink in color due to the formation of hematitic alkali feldspar. Alkali pyroxenes and amphiboles also form at the expense of preexisting mafic minerals. Fenitization of mafic or ultramafic host rocks may result in the formation of vermiculite, sometimes in economic concentrations.

Tertiary volcanic rocks (fig. 1) post-date the thorium mineralization.

Thorium deposits

Anomalous concentrations of thorium occur in several general types of deposits including carbonatites, so called "red rock" syenite dikes, quartz-barite veins, and shear zones. The various types may overlap and gradations between types have been observed. The thorium deposits are typically 1-2 m thick, although a few are as thick as 15 m. They are remarkably continuous along strike especially south and southeast of the alkalic intrusions. Strikes of the deposits in the area south of the Fremont-Custer County line generally trend northwest-southeast so that the angle between the strike of the deposit, and the strike of the host rock foliation approaches 90°. Much of the mineralized material, including fenite, emits a strong fetid odor immediately after it is broken. This characteristic odor is attributed to hydrocarbon-fluorine gas of probable magmatic origin by Heinrich and Anderson (1965).

During this discussion of thorium deposits we will illustrate examples keyed to localities shown on figure 1: the Niles mine carbonatite located within the Gem Park Complex, vein deposits at the Beardsley mine, a syenite dike about 0.5 km northeast of the Beardsley mine, and shear zones at the Haputa Ranch.

Carbonatites

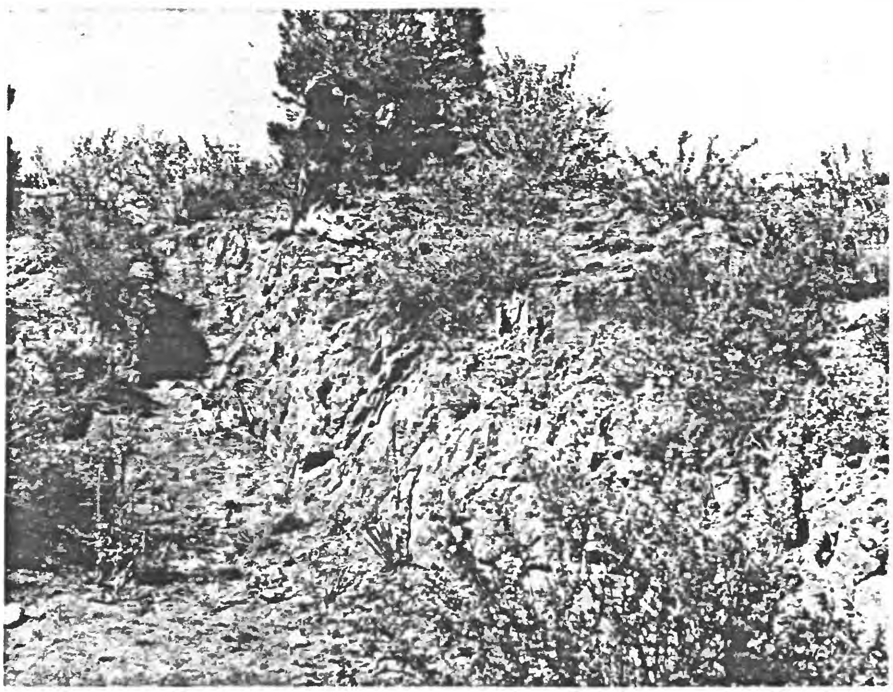
Carbonatites tend to be localized in and around the alkalic complexes, especially the Gem Park Complex, but are found as far as 20 km away. A few carbonatite dikes are found within the McClure Mountain Complex, and they appear to be absent in the Democrat Creek pluton. Although carbonatite occurs mainly in dikes, several small plugs have also been observed.

Figure 2 shows a more or less typical carbonatite dike cropping out at the Niles mine. This dike is about 4 m thick, strikes N. 65°W., and is vertical. It can be traced laterally for only a few 10's of metres. The shallow workings along the contacts with alkalic gabbro of the Gem Park Complex contain abundant coarse-grained vermiculite, a product of fenitization.

In outcrop the weathered surfaces of carbonatites, in general, are typically dark chocolate brown to reddish brown in color. Fresh surfaces are typically dark olive brown, red brown, and occasionally lighter shades of gray and blue gray. Variations in thickness along strike can occur rapidly and the dikes seem to pinch and swell.

Detailed mineralogical studies of carbonatites reveal the presence of a rather large variety of minerals. The most abundant minerals include calcite, dolomite, and magnesite in various proportions. Quartz, alkali feldspar, aegirine, crocidolite, siderite, rhodochrosite, goethite, magnetite, and hematite, may be abundant. Accessory minerals include phlogopite, chlorite, rutile, epidote, fluorapatite, spinel, pyrite, bastnaesite, synchisite, monazite, xenotime, and pyrochlore. All identifications have been verified by X-ray diffraction techniques.

Figure 2.--Carbonatite dike cropping out at the Niles mine.



Additional minerals have been identified in Gem Park carbonatites by Parker and Sharp (1970) and in several other unusual carbonatites in the area by Heinrich and his various coworkers.

Figure 3 is a photomicrograph of the carbonatite at the Niles mine. The high relief, highly birefringent grain aggregates right and left of center are bastnaesite, the rare earth fluocarbonate. The most abundant, light-colored material X-rays as both calcite and dolomite and the carbonate is somewhat iron-oxide stained. The opaque grain near the top is probably titaniferous magnetite, and at the right hand margin, partly at extinction, is a low birefringent grain of barite. There are no obvious silicate minerals in this specimen.

The specimen shown in figure 4 was collected from a carbonatite referred to by Dahlem (1965) as the Cabin Group. It is located about 6.5 km west of the McClure Mountain Complex. Of particular interest are the quartz grains containing abundant radiating and randomly oriented rod- and blade-shaped crystals of fluorapatite. The quartz seems to post-date the iron-oxide-stained carbonate which occupies much of the right hand side of the slide. Barite and probably specular hematite are also present. Heavy mineral separates of this specimen also contain synchisite, the calcium-cerium fluocarbonate.

Figure 5 is a photomicrograph of a carbonatite from a small prospect pit about 12 km south-southeast of the Democrat Creek Complex just south of Brush Hollow Creek. The very highly birefringent, euhedral grains are xenotime, the yttrium phosphate. Barite, ferric-oxide-rich carbonate, and minor alkali feldspar are also present.

Trace element analyses of 30 carbonatite samples show considerable variation in element abundances. As might be expected there are fairly strong concentrations of rare earth metals, niobium, and thorium. Total rare earth to thorium ratios are generally greater than one and can be as high as 25. Thorium averages about 220 ppm but ranges from 9 to 916 ppm. Uranium averages about 20 ppm.

Figure 3.--Photomicrograph of carbonatite from same locality as figure 2. Bar equals 1 mm. Crossed nicols. (B) bastnaesite, (C-D) calcite and dolomite, (m) magnetite, (Ba) barite.

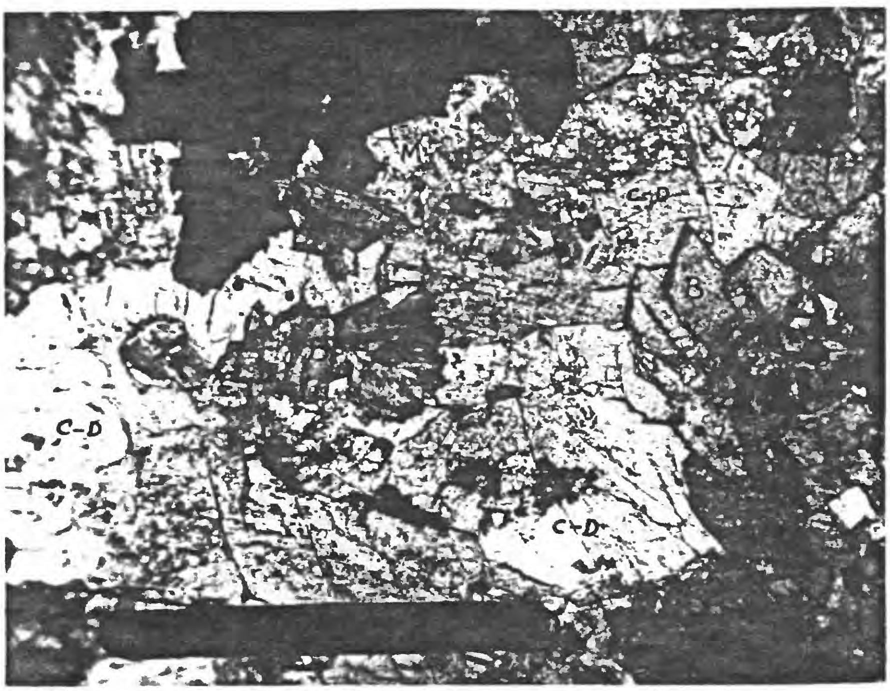


Figure 4.--Photomicrograph of carbonatite from the Cabin Group. Bar equals 1 mm. Crossed nicols. (Q) quartz, (F) fluorapatite, (H) hematite, (Ba) barite, (c) carbonate.

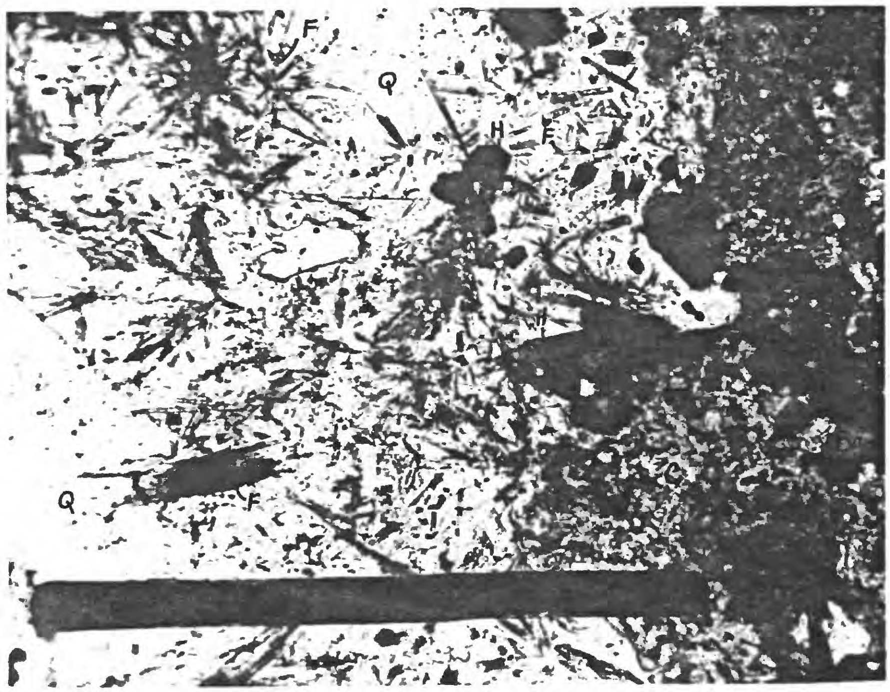
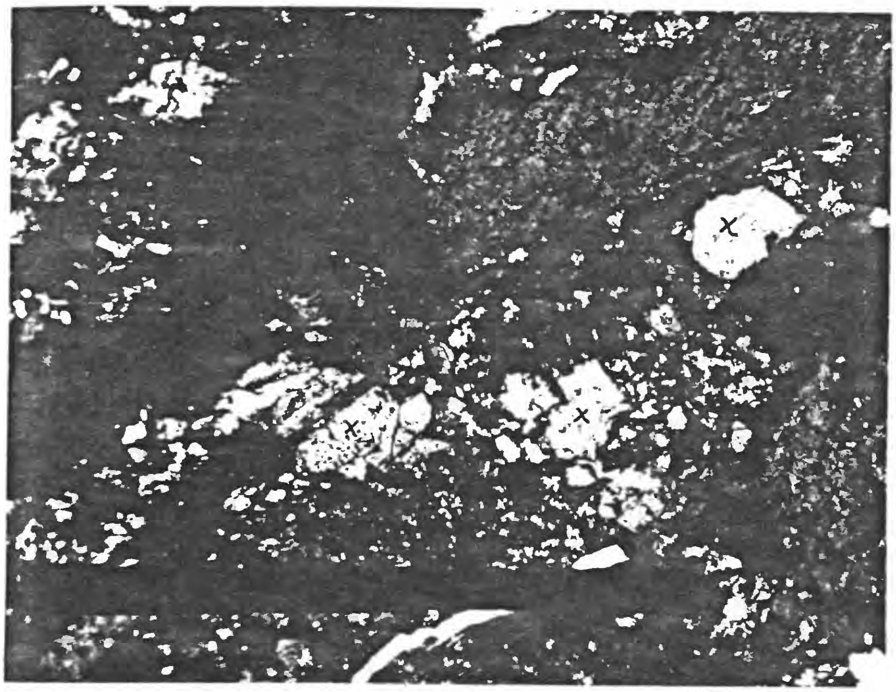


Figure 5.--Photomicrograph of carbonatite from Brush Hollow Creek area. Bar equals 1 mm. Crossed nicols. (X) xenotime.



"Red rock" Syenite Dikes

Figure 6 illustrates a prospect pit in a so called "red rock" syenite dike 1.5 km northeast of the Beardsley claim. This syenite dike is about 2 m thick at ground level and wedges out downward into a shear zone.

These bright pink to red dikes tend to be somewhat more persistent along strike than carbonatites but, like carbonatites, are also somewhat more abundant in the general vicinity of the alkalic intrusions. Many of the syenite dikes are not anomalously radioactive, suggesting that the episode of thorium mineralization post-dates the emplacement of the syenite.

The most abundant mineral in the red rock syenites (fig. 7) is alkali feldspar variably clouded by ferric oxide. Additional minerals occurring in variable but usually trace amounts include iron oxides, thorite, barite, rutile, xenotime, bastnaesite, and brockite. The coarse-grained, microcline-rich syenite is often partially replaced by finer grained material containing ferric-oxide-rich feldspars. A few vugs filled with chalcedonic quartz and lined with botryoidal ferric oxide may be developed during replacement.

Trace element analyses show that syenites generally contain smaller average amounts of cerium group rare earth metals than the carbonatites, but larger average amounts of yttrium group rare earths and thorium.

Quartz-barite Veins

Quartz-barite veins are also quite persistent. Individual structures containing vein material have been traced along strike for up to 8 km. Veins rarely exceed 1 m in width but can partially occupy wider structures which may contain fenite, lamprophyre, red rock syenite, carbonatite, or shear zones.

Figure 8 shows the workings at the Beardsley deposit. The head frame sets over a shaft about 20 m deep. The backpack in the foreground sets in the middle of a strongly radioactive zone 15 m thick, delineated more or less by the area cleared of vegetation. This zone consists of very odoriferous fenite cut by a network of smoky and white quartz veins nearly 0.5 cm thick. Though fenite and red rock syenite are nearly

Figure 6.--Prospect pit in a red rock syenite dike located 1.5 km northeast of the Beardsley claim.

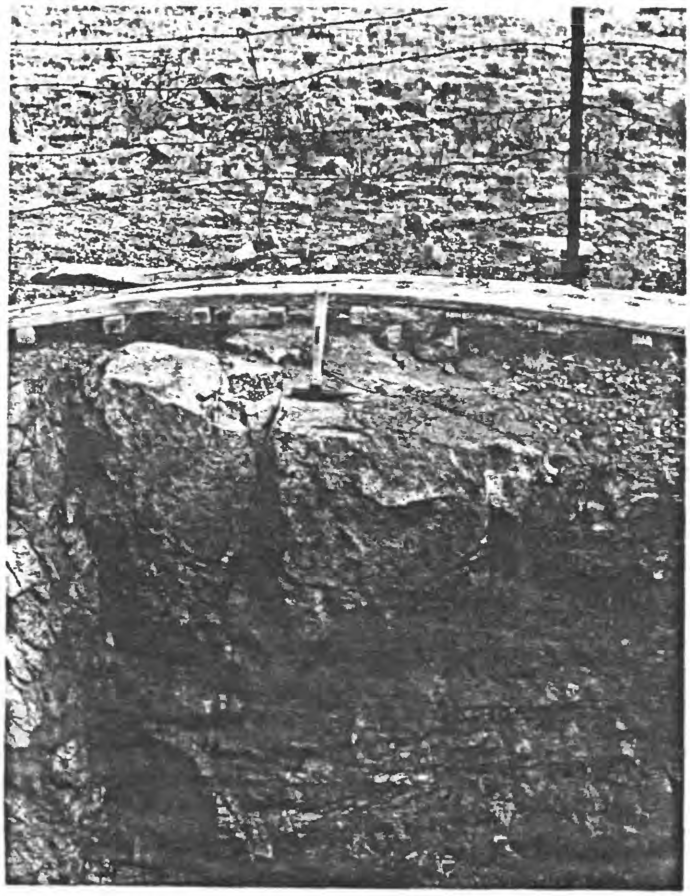


Figure 7.--Red rock syenite from the same locality as figure 6.

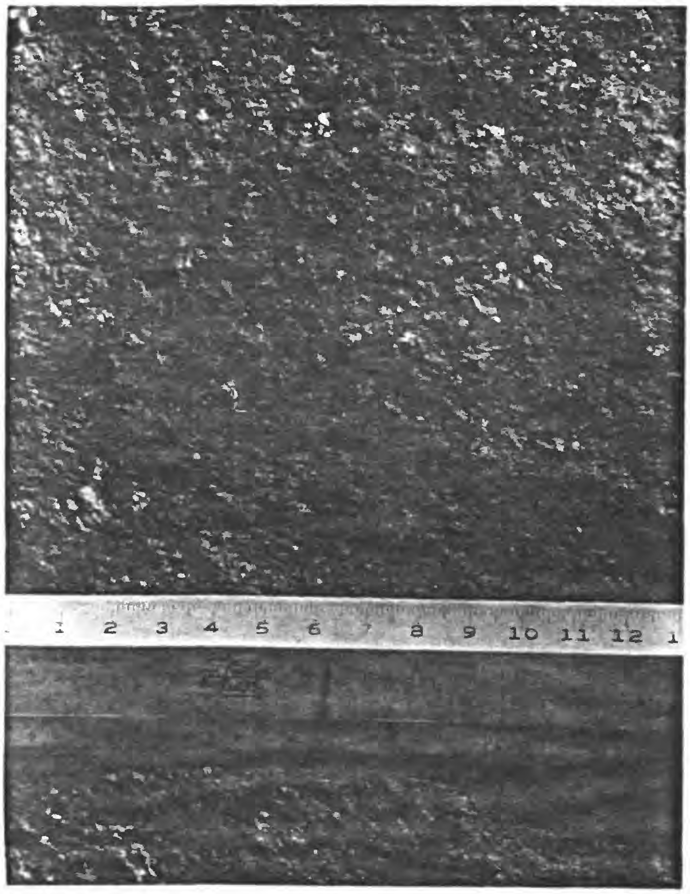


Figure 8.--Workings at the Beardsley claim.

identical in appearance, the fenite has gradational contacts with country rock and the syenite has sharp contacts. For veins in general, which can be considerably thicker and more distinct than the example cited, the proportions of major constituents may vary widely along strike. Portions of certain veins in the area were mined in earlier times for their barite content. Along strike, however, the solid barite may be progressively diluted by quartz or may disappear entirely so that the deposit becomes a shear zone.

Minerals which occur as major constituents in veins include smoky and clear quartz, microcline, barite, iron oxides, and carbonate minerals. Accessory minerals include many of those mentioned previously, especially rutile and various sulfides. Waxy, red thorite, commonly metamict, is the primary source of thorium.

Compared with carbonatites and syenites, the veins tend to contain larger average amounts of base metals and thorium, and average rare-earth contents intermediate between those of carbonatites and syenites.

Shear Zones

Although carbonatites, red rock syenites, and quartz-barite veins can undergo later shearing and fracturing, examples of shear zones which lack obvious megascopic vein minerals have been observed.

The shear zone in figure 9 was prospected on the Haputa Ranch, site of some of the earliest discovered thorium deposits. It is about 0.5 m thick and consists primarily of strongly brecciated, fenitized, odoriferous, radioactive host rock. This particular zone is also weathered so that the rock in and near the zone is quite punky. Further along strike to the southeast (fig. 10) the shear zone is not as intensely weathered. The highest radioactivity is detected along the edges of the shear zone, marked by the hammer on the left and the scintillator on the right. Shear zones, in general, may become veins or dikes along strike with addition of the appropriate material.

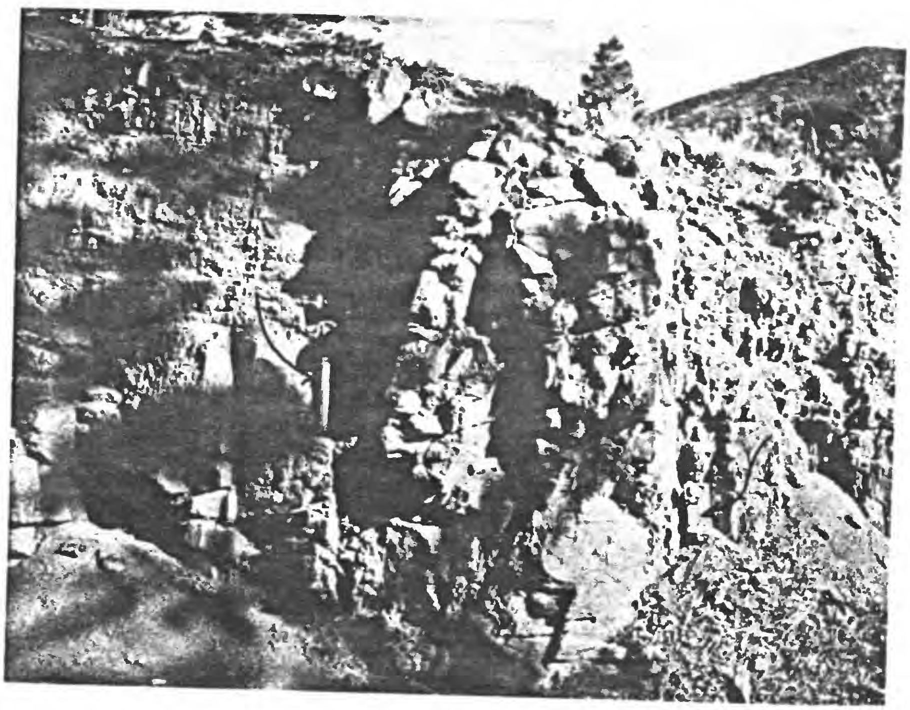
Mineral assemblages in the shear zones are not unique. Iron oxides are especially abundant along fracture surfaces and thorite is again the primary source of thorium.

The highest average concentrations of yttrium and thorium are found in the shear zones. The average thorium content, which is about 0.3 percent, ranges between 0.004 and 2.6 percent, again emphasizing the wide variation in content.

In summary, preliminary studies suggest that the thorium deposits of the Wet Mountains area are genetically, spatially, and temporally related to the intrusion of the comagmatic alkalic complexes at McClure Mountain, Gem Park, and Democrat Creek, which are Cambrian in age. The deposits represent late-stage differentiates of a fractionated, low silica, high alkali magma. Cross-cutting relationships place the deposits in the genetic sequence "red rock" syenites, carbonatites, quartz-barite veins and shear zones.

Figure 9.--Shear zone on the Haputa Ranch. Dashed lines delineate radioactive zone.

Figure 10.--Shear zone on the Haputa Ranch. Arrows point to hammer and scintillator on contacts.



References cited

Brock, M. R., and Singewald, Q. D., 1968, Geologic map of the Mount Tyndall quadrangle, Custer County, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-596.

Dahlem, D. H., 1965, Geology of the Lookout Mountain area, Fremont County, Colorado: Ph.D. thesis, Univ. Michigan, 188 p.

Heinrich, E. W., and Anderson, R. J., 1965, Carbonatites and alkalic rocks of the Arkansas River area, Fremont County, Colorado. 2. Fetid gas from carbonatite and related rocks: American Mineral. v. 50, p. 1914-1920.

Parker, R. L., and Hildebrand, F. A., 1963, Preliminary report on alkalic intrusive rocks in the northern Wet Mountains, Colorado: U.S. Geol. Survey Prof. Paper 450-E, p. E8-E10.

Parker, R. L., and Sharp, W. N., 1970, Mafic-ultramafic igneous rocks and associated carbonatites of the Gem Park Complex, Custer and Fremont Counties, Colorado: U.S. Geol. Survey Prof. Paper 649, 24 p.

Shawe, D. R., and Parker, R. L., 1967, Mafic-ultramafic layered intrusion at Iron Mountain, Fremont County, Colorado: U.S. Geol. Survey Bull. 1251-A, 28 p.

Taylor, R. B., 1974, Reconnaissance geologic map of the Deer Peak quadrangle and southern part of the Hardscrabble Mountain quadrangle, Custer and Huerfano Counties, Colorado: U. S. Geol. Survey Map I-870.

Taylor, R. B., Scott, G. R., Wobus, R. A., and Epis, R. C., 1975a, Reconnaissance geologic map of the Cotopaxi 15-minute quadrangle, Fremont and Custer Counties, Colorado: U.S. Geol. Survey Map I-900.

_______1975b, Reconnaissance geologic map of the Royal Gorge quadrangle, Fremont and Custer Counties, Colorado: U.S. Geol. Survey, Map I-869.