Preliminary Study of Radioactive Limonite in Colorado, Utah, and Wyoming

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GEOLOGICAL SURVEY BULLETIN 1046-N

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By T. G. LOVERING *and* E. P. BERONI

CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

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PRELIMINARY STUDY OF RADIOACTIVE LIMONITE IN COLORADO, UTAH, AND WYOMING

By T. G. Lovering and E. P. Beroni

ABSTRACT

Nine radioactive-limonite localities of different types were sampled during the spring and fall of 1953 in an effort to establish criteria for differentiating limonite outcrops associated with uranium or thorium deposits from limonite outcrops not associated with such deposits. The samples were analyzed for uranium and thorium by standard chemical methods, for equivalent uranium by the radiometric method, and for a number of common metals by semiquantitative geochemical methods. Correlation coefficients were then calculated for each of the metals with respect to equivalent uranium, and to uranium, where present, for all the samples from each locality. The correlation coefficients may indicate a significant association between uranium or thorium and certain other metals. Occurrences of specific metals that are interpreted as significant vary considerably for different uranium localities but are more consistent for the thorium localities.

Samples taken from radioactive outcrops in the vicinity of uranium or thorium deposits can be quickly analyzed by geochemical methods for various elements. Correlation coefficients can then be determined for the various elements with respect to uranium or thorium; if any significant correlations are obtained, the elements showing such correlation may be used as indicators of uranium or thorium elsewhere in the area. Soil samples of covered areas in the vicinity of the radioactive outcrop may then be analyzed for the indicator elements and any resulting anomalies used as a guide for prospecting where the depth of overburden is too great to allow the use of radiation-detecting instruments. Changes in color of limonite stains on the outcrop may also be a useful guide to ore in some areas.

Correlation coefficients of the associated indicator elements, used in conjunction with petrographic evidence, may be useful, too, in interpreting the origin and paragenesis of radioactive deposits.

INTRODUCTION

The radioactive-limonite localities discussed in this report were examined in order to determine whether field criteria could be found that would differentiate between indigenous radioactive limonite and transported radioactive limonite. Nine localities with differing geologic environments and types of radioactive material were selected. At each locality samples were taken of both the radioactive and nonradioactive material; wherever possible, a continuous channel sample,

consisting of individual samples representing 1-foot segments, was taken across the radioactive-limonite zone and into the nonradioactive material on both sides. Changes in color and texture were noted. The samples were analyzed for equivalent uranium and for uranium and other metals for which geochemical field tests are available. The purpose of the analyses was to determine whether any of these metals show significant correlations, or dispersion halos, with respect to uranium or thorium in the outcrop.

Semiquantitative spectrographic analyses for about 60 elements were obtained on the samples from some of the localities. The sensitivity of both spectrographic and geochemical analysis varies greatly from one element to another. The spectrograph will reveal the presence of as little as 0.00005 percent silver in a sample but cannot detect mercury in concentrations less than 0.1 percent. The concentrations of the elements are reported in semiquantitative spectrographic analyses in powers of 10 with (+) plus or (−) minus appended, when applicable, to indicate whether the concentration is near the top or bottom of the range, thus: $0.X^{+}$=0.5–1.0 percent, 0.X=0.2–0.5 percent, $0.X^{-}$=0.1–0.2 percent; comparisons of this type of semiquantitative results with those obtained by quantitative methods, either chemical or spectrographic, show that the assigned group includes the quantitative value about 60 percent of the time. The geochemical analyses are reported in parts per million rather than in percent, and are accurate approximately to the first significant figure.

Most of the field examinations were made by the authors during the latter part of October 1953. The Lucky Break iron mine was visited by T. G. Lovering and W. R. Griffitts in June 1953, and the mines in the Golden Gate Canyon area were visited and sampled by E. P. Beroni early in November 1953. The localities discussed in this report are shown on the index map (fig. 34).

Correlation coefficients have been calculated for each group of samples in an attempt to express mathematically the relative degree of association between the radioactive elements and some of the other metals in the sample. The authors feel that where high correlations were obtained the possibility of a significant association warrants further investigation, even though the small number of samples obtained from the various localities does not constitute a valid approximation to a representative statistical sample.

The correlation coefficients were determined by a modification of the method used by Miesch and Shoemaker (1953, written communication). In calculating the correlation coefficients, all assays were first expressed in parts per million in order to make relative concentrations of the various elements more readily apparent. The logarithms of the assays were then tabulated and average values for the

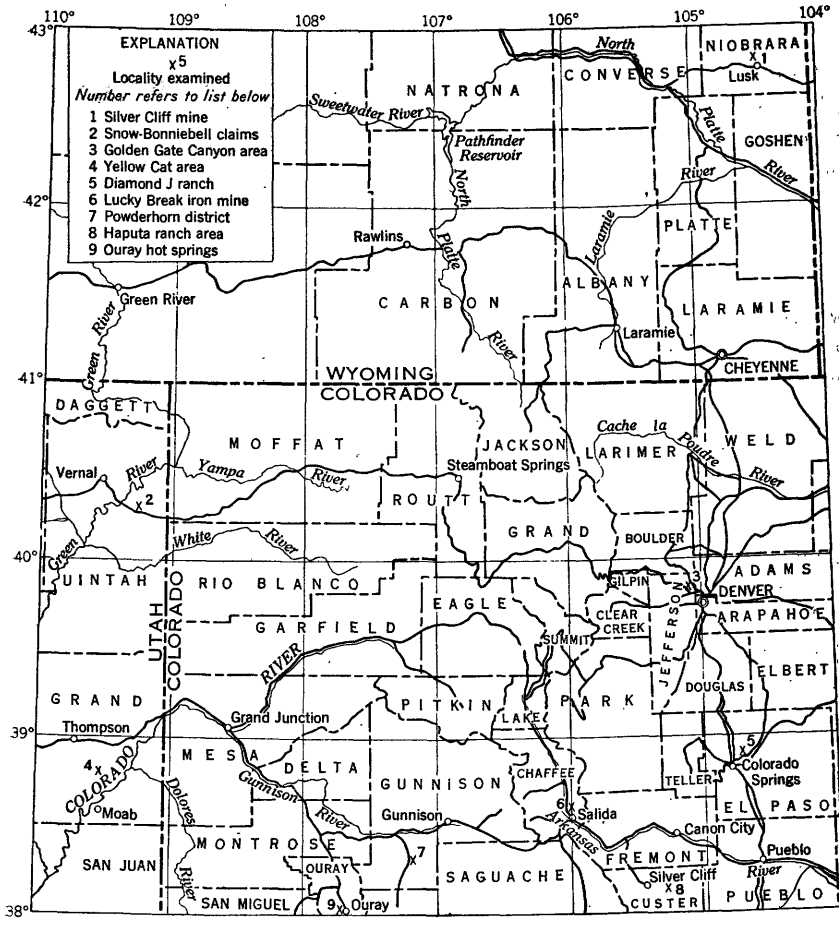

FIGURE 34.—Index map showing localities examined for radioactive limonite.

log concentrations of each element were determined. The use of logarithms was considered preferable to the use of straight assay data because of the extreme range in concentrations represented by the assays. (The logarithmic transformation greatly decreases the effect of a few extremely high values, thus making correlations more nearly representative of the whole group of assays involved.) Next, for each element, the deviation from the average was determined for each log assay; these deviations were then squared and the sum of the squares was found so that the standard deviation could be calculated according to the formula:

$$\bar{\sigma}=\sqrt{\frac{\Sigma D^2}{n-1}}$$

where $\bar{\sigma}$=standard deviation, D=deviation from the mean log assay, n=number of assays.

The individual log assays for equivalent uranium and for uranium, where present, were next multiplied by the corresponding log assays of each of the other elements in turn, and the mean value of the products determined thus:

$$M=\frac{\Sigma ab}{n}$$

where M=mean product, Σ=summation, a=uranium log-assay value, b=log-assay value of some other element, n=number of assays. The correlation coefficients were then calculated according to the formula

$$\bar{r}_{ab}=\frac{\frac{\Sigma ab}{n}-\left(\Sigma\frac{a}{n}\cdot\Sigma\frac{b}{n}\right)}{\bar{\sigma}a\cdot b\bar{\sigma}}$$

where $\bar{r}$=correlation coefficient, a=log assay eU or U, b=log assay of one of the other elements, $\bar{\sigma}a$=standard deviation for U, $\bar{\sigma}b$=standard deviation for the other element. A perfect positive correlation is $+1$, a perfect inverse relationship is indicated by a correlation of -1, and a completely random distribution of two elements with respect to each other is represented by a correlation of 0. For normally distributed populations, the threshold of significance of a correlation coefficient is inversely proportional to the number of samples analyzed. Most of the individual sample groups collected for this study contained no more than 5–15 samples, so only those correlation coefficients exceeding ± 0.4 were considered significant (Dixon and Massey, 1951, p. 164).

Only those elements were correlated that showed a significant variation in concentration from one sample to the next in each group. No elements were correlated whose concentration fell below the threshold of analytical sensitivity in more than 25 percent of the samples within a given group. If the concentration of an element fell below the threshold of sensitivity in only a few samples within a group, the concentration of that element was arbitrarily assigned to the middle of the next lower order of magnitude. For example, the arsenic concentration of 2 samples from the Little Johnny mine area was reported as <10 ppm (parts per million); these samples were assigned a value of 5 ppm. If a few analyses were reported as <1 ppm, the same procedure was followed, but all assays were multiplied by 10 to avoid the use of negative logarithms.

The writers wish to express their appreciation to the analysts of the U. S. Geological Survey who furnished the analytical data on

which this report is based. H. E. Crowe and J. H. McCarthy made the geochemical determinations, and S. P. Furman and R. F. Dufour made the uranium, equivalent uranium, and thorium analyses. Thanks are also due to many members of U. S. Geological Survey field parties for valuable aid in finding outcrops for study and for assistance in understanding their geologic setting. The cooperation of the various owners in allowing access to their properties is much appreciated. The work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

LOCALITIES

YELLOW CAT AREA, GRAND COUNTY, UTAH

The Yellow Cat area, Thompson district, is principally within T. 22 S., Rs. 22 and 23 E., in east-central Grand County, Utah. The rocks exposed are the Summerville and Morrison formations of Jurassic age and consist of alternating conglomerates, sandstones, and mudstones of continental origin. More than a hundred thousand tons of uranium and vanadium ore has been produced from the area; nearly all of it came from sandstone beds in the Salt Wash member of the Morrison formation which overlies the Summerville formation with slight disconformity and is overlain conformably by the Brushy Basin member of the Morrison formation; the Brushy Basin member consists predominantly of red mudstones. All the rocks in the area dip gently to the north. A few gentle folds are present locally, but there is little evidence of faulting.

The uranium-vanadium deposits of the Yellow Cat area have been examined and described by many geologists during the past fifty years. The most recent, and probably the most comprehensive, published report on the area was written by Stokes (1952).

SAMPLES AND ANALYSES

Thirteen samples were collected from the Yellow Cat area. All the samples were analyzed by geochemical-prospecting methods for a number of common elements, and a separate split of each sample was analyzed fluorometrically for uranium and radiometrically for equivalent uranium. [These analyses are shown in table 5, p. 372.]

The variation of equivalent uranium and uranium and various other metals in a 7-foot vertical channel sample, taken on the Cactus Rat claim, is shown in figure 35. In order to avoid confusion, data are graphed only for those metals that appeared to show significant changes in concentration and for which assays were available on all samples.

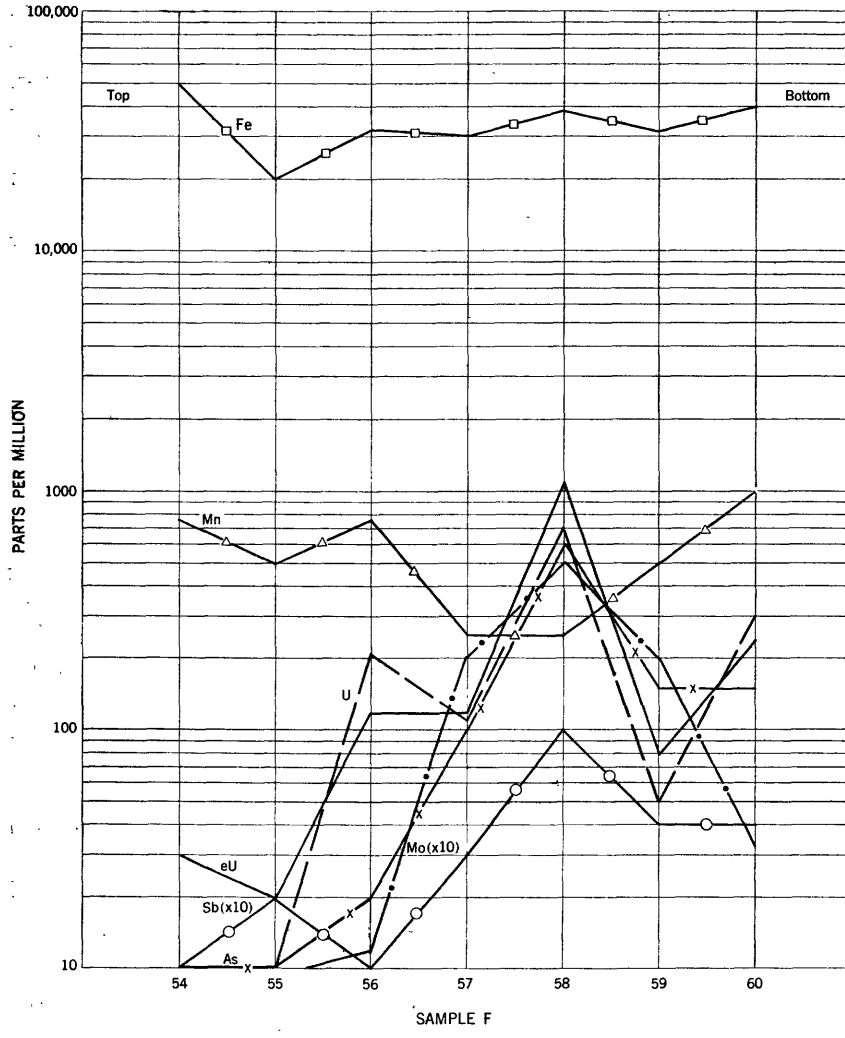

FIGURE 35.—Graph showing variations in equivalent uranium and uranium and other metals in the 7-foot vertical channel sample from the Cactus Rat claim, Grand County, Utah.

Correlation coefficients for eight metals with respect to both uranium and equivalent uranium are shown in the table below.

Correlation coefficients, Yellow Cat area

[13 samples]

	eU	*U*		*eU*	*U*
Mo	[1]+0.38	+0.29	Cu	−0.07	−0.06
As	[2]+.70	[2]+.65	V	[2]+.58	[2]+.70
Sb	[2]+.55	[1]+.46	Mn	[1]−.47	[1]−.45
Zn	+.09	+.17	Fe	−.01	−.08

[1] Possibly significant. [2] Probably significant.

CONCLUSIONS

Information derived from samples taken in the Yellow Cat area suggests that geochemical prospecting for elements associated with uranium may be a useful tool in exploration, but there is no visible characteristic of the limonite that is diagnostic of proximity to uranium deposits.

A comparison of thin and polished sections of sample F57 with those of sample F58 does not reveal any significant difference in the nature of the iron oxides that can be correlated with the difference in the uranium content. Red hematite breccia in a veinlet cutting goethite-impregnated sandstone (sample F61) is unexpected because of the proximity of this ferric oxide to carbonaceous material that might have been expected to reduce the iron to the ferrous state. The work of Tunnell and Posnjak (1931) has shown that under atmospheric conditions in the Fe_2O_3–H_2O–SO_3 system, goethite is stable below 130°C and hematite above that temperature. The presence of gypsum indicates that the sulfate ion was probably available. The late hematite thus suggests that moderately hot solutions may have come in along small fractures at some time after the lithification of the sandstone and the development of early goethite.

The variation in metal content of the channel sample shown in figure 35 suggests leaching of iron from a zone about 2 feet below the surface and reconcentration of this iron in the surface layer. Iron content appears to be completely unrelated to uranium content, manganese shows an inverse relationship with uranium, but arsenic, antimony, and molybdenum correlate positively with uranium.

A study of the correlation coefficients shown in table on p. 344 also brings out the random distribution of uranium with respect to iron, its negative correlation with manganese, and its good positive correlation with arsenic and antimony. In addition, the table illustrates that vanadium gives a good correlation with uranium, but that for the total 13 samples, molybdenum does not correlate as well with uranium as it appeared to in the 7 samples that constitute the channel sample (table 5, p. 372). Zinc and copper, like iron, appear to have a more or less random distribution with respect to uranium.

If more detailed sampling in this area should confirm the relationship between uranium and arsenic, antimony, and vanadium suggested by this preliminary work, geochemical prospecting for these indicator elements might be of value in the search for additional uranium deposits in the Yellow Cat area, where depth of overburden precludes the use of Geiger counter or scintillation counter.

The close association of antimony and arsenic, as well as vanadium, with the uranium indicates that these two minor elements may also be present in small amounts in carnotite, which is the major ore

mineral of the district. It also suggests the possibility that they were present in the primary mineral from which the carnotite was derived.

SNOW-BONNIEBELL CLAIMS, UINTAH COUNTY, UTAH

The Snow-Bonniebell claim group is in secs. 17, 18, and 24, T. 6 S., R. 24 E., in the eastern part of Uintah County, Utah. The claims are at an altitude of about 5,500 feet on the crest and the south slope of a hogback ridge of sandstone of the Mesaverde formation of Cretaceous age. This sandstone ridge is on the southern flank of the large Split Mountain anticline; the ridge rises about 200 feet above a nearly level plain cut on the underlying Mancos shale to the north.

Small areas of anomalous radioactivity occur at intervals along a high-angle normal fault which cuts the sandstone near the ridge crest. The fault trends nearly parallel to the sandstone outcrop and dips steeply southward. Spotty radioactive anamolies are also present as much as several hundred yards south of the fault.

The Snow-Bonniebell group of claims was examined and sampled in 1950 by E. P. Beroni and F. A. McKeown (1952, p. 14–20).

SAMPLES AND ANALYSES

Eleven samples were collected from the Snow-Bonniebell claim group (table 6, p. 373). Three of these constitute a channel sample across a limonite seam on the east wall of an opencut on the Bonniebell No. 3 claim about a quarter of a mile south of the ridge crest. Six other samples were taken in consecutive 1-foot segments across a radioactive fault zone approximately half a mile east-northeast of the opencut. In addition, 2 grab samples of radioactive limonitic material were collected, 1 from the vicinity of the cut and 1 from the fault zone.

All 11 samples contained less than 300 ppm of vanadium and less than 10 ppm of cobalt and nickel. The concentrations of other elements in these samples are shown in table 6.

The graphs in figure 36 indicate the variations in concentrations of selected elements in the six samples collected across the fault zone. The correlation coefficients for uranium and equivalent uranium with respect to these elements are shown in table below.

Correlation coeffients, Snow-Bonniebell claims

[11 samples]

	eU	*U*		*eU*	*U*
Zn	+0.04	[1]−0.40	Fe	[1]+0.38	[1]+0.39
Mo	−.07	−.08	As	+.12	−.13
Mn	[2]+.61	[2]+.65			

[1] Possibly significant. [2] Probably significant.

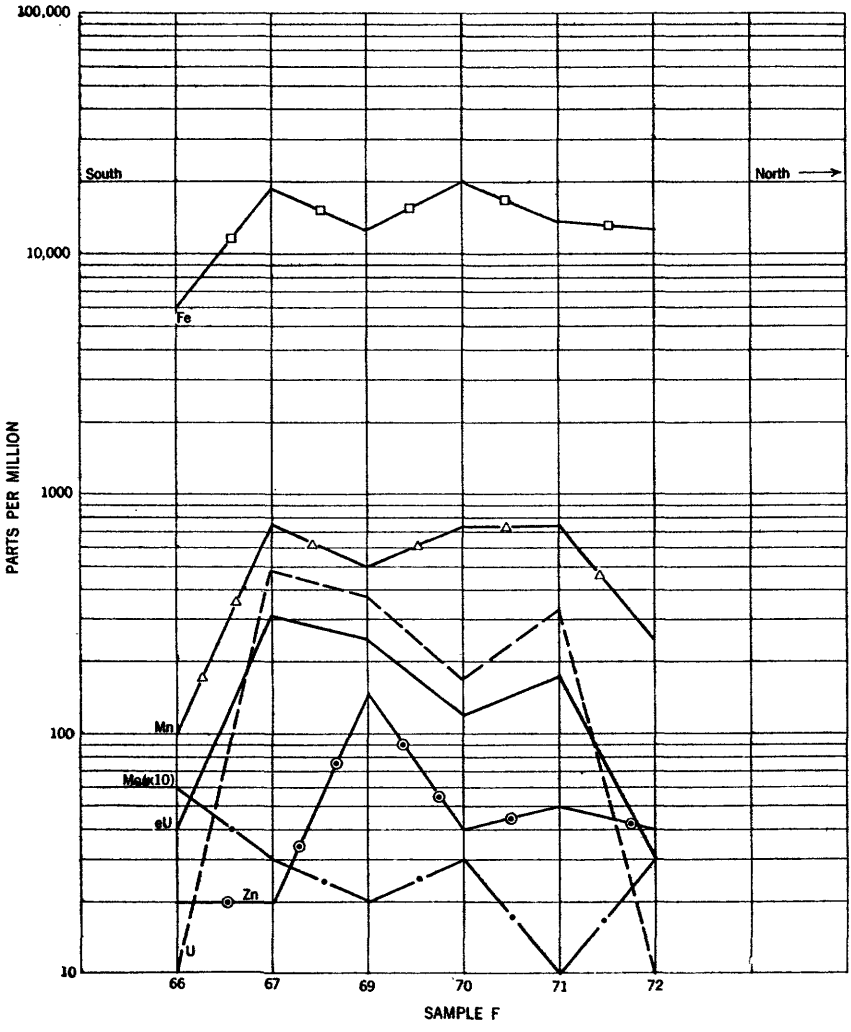

FIGURE 36.—Graph showing variations in equivalent uranium and in uranium and other metals in samples from fault zone, Snow-Bonniebell claims.

CONCLUSIONS

Compared to the wall-rock samples (F63–F64) on either side, sample F65 from the iron-stained clay seam on the wall of the opencut contains high concentrations of zinc, copper, arsenic, molybdenum, and uranium. Yet none of these elements shows significant correlations with uranium in the samples taken across the fault zone, half a mile away (table, p 346). Manganese, on the other hand, which shows no increase in concentration in the limonitic clay seam relative to the wall-rock samples in the opencut, is the only element of the group that correlates well with uranium in the fault zone. This may

indicate that the elements concentrated in the clay seam were deposited with the clay, but that the uranium and manganese along the fault were deposited by ground water circulating along this permeable zone. It is, of course, also possible that the number of samples collected was too small to be representative and that the apparent correlations are merely coincidental.

In any event, the available data do not appear to indicate the presence of any large concentrations of uranium minerals in this area.

SILVER CLIFF MINE, NIOBRARA COUNTY, WYO.

The Silver Cliff mine is in sec. 7, T. 32 N., R. 63 W., half a mile west of Lusk, Niobrara County, Wyo. The mine is at an altitude of about 5,200 feet and is near the crest of a prominent hill which is capped by dense brown quartzite of Cambrian age. The quartzite lies unconformably on a Precambrian metamorphic complex which consists of schist, gneiss, and quartzite and is intruded by pegmatite dikes. A high-angle northward-trending reverse fault that dips about 60° E. is exposed near the summit of the hill where Precambrian rocks in the hanging wall have been moved into contact with the quartzite of Cambrian age of the footwall.

The Silver Cliff mine was first opened in 1880; in addition to uranium, gold, silver, and copper have been produced there. The ore deposits are localized along the reverse fault and in fractured quartzite of Cambrian age in the footwall. The uranium deposits have been described by Lind and Davis (1919) and more recently by Wilmarth and Johnson (1954).

SAMPLES AND ANALYSES

Five samples were collected from 1 locality about 50 feet southwest of the entrance to the opencut leading to pit 1 (fig. 37 and table 7, p. 374). The table below gives the correlation coefficients for equivalent uranium with elements that were present in determinable amounts in at least four of the samples.

Correlation coefficients, Silver Cliff mine

[5 samples]

	eU		*eU*
Zn	[1]+0.72	Mo	[2]+0.60
Cu	[1]+.73	V	+.53
Co	+.40	Mn	[2]+.63
As	[2]+.65	Fe	+.02

[1] Possibly significant.
[2] Probably significant.

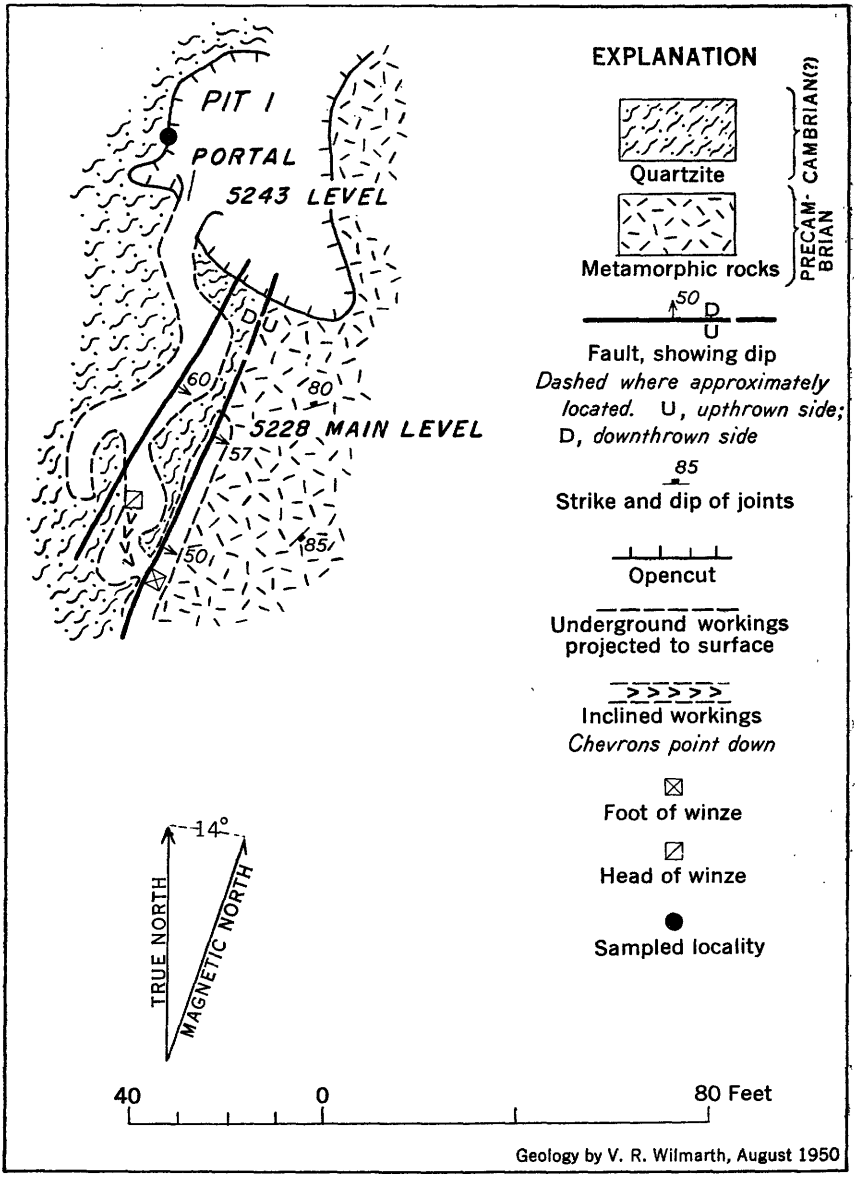

FIGURE 37.—Map of part of the Silver Cliff mine showing sampled locality.

CONCLUSIONS

The relatively high correlations between equivalent uranium and all the other elements tested, with the exception of iron, suggest that these elements were introduced along the same open fractures in the relatively dense impermeable quartzite and were then deposited

in films or coatings on the fractures. The brown quartzite contains some indigenous iron oxide, as shown by rounded grains of hematite in a thin section of sample F75; the barren red quartzite represented by sample F77 contains several times as much iron, in the form of primary red hematite, as any of the other four samples. This indigenous iron oxide could easily account for the lack of correlation between uranium and iron. Sample F77 also contains an unusually large amount of nickel (30 ppm) and of copper (150 ppm). Two grab samples of the red quartzite, collected from separate localities a thousand feet or more away from the mine workings, also contained about 30 ppm of nickel and about 120 ppm of copper. These abnormal concentrations suggest that a certain amount of copper and nickel, as well as iron, was originally present in the sediments from which the quartzite bed was derived. The close association between equivalent uranium and zinc, copper, arsenic, molybdenum, and manganese in samples from this deposit suggests that some or all of these five elements might be useful as uranium indicators for prospecting in this area.

GOLDEN GATE CANYON AREA, JEFFERSON COUNTY, COLO.

The Golden Gate Canyon area is in T. 35 S., R. 70 W., Jefferson County, Colo. Most of the uranium prospects are near the bottom of the canyon at an altitude of 6,500 to 7,000 feet.

Rocks exposed in the area consist of a thick series of steeply dipping schists and gneisses of the Precambrian Idaho Springs formation. These rocks have a regional trend of about N. 80° E.; they have been cut by numerous faults and breccia "reefs" which strike northwestward and dip steeply.

Pitchblende and base-metal sulfides appear to have been localized by the intersection of northwestward-trending faults or fractures with certain favorable stratigraphic zones in the Idaho Springs formation. The uranium deposits of the Golden Gate Canyon area have been studied and described by Adams, Gude, and Beroni (1953). Two of these deposits, at the Union Pacific prospect and at a road cut near the portal of the Buckman adit, were sampled for this study.

SAMPLES AND ANALYSES

Ten samples were collected from the two localities examined (table 8, p.375); four of these constitute a discontinuous channel sample across the radioactive zone in a road cut near the portal of the Buckman adit; the other six constitute a channel sample across the uranium-bearing vein and breccia zone exposed near the collar of the shaft on the Union Pacific property.

All samples were analyzed for equivalent uranium, uranium, copper, lead, zinc, arsenic, antimony, and molybdenum. Correlation coefficients were determined for both uranium and equivalent uranium with respect to the other six elements (table below).

Semiquantitative spectrographic analyses were made of the 10 samples in order to determine whether any elements, in addition to the 6 tested geochemically, showed significant occurrence in relation to uranium (table 9, p. 376).

Correlation coefficients, Golden Gate Canyon area

[10 samples]

	eU	*U*		*eU*	*U*
Cu	−0.24	+0.11	As	+0.13	+0.02
Pb	−.36	+.15	Sb	+.17	+.06
Zn	+.11	+.02	Mo	[1]+.45	+.34

[1] Possibly significant.

CONCLUSIONS

The correlation coefficients calculated for all 10 samples appear to indicate a very poor correlation between uranium and the other metals, with the possible exception of molybdenum. However, when the assay values for the various metals are plotted separately against those of uranium and equivalent uranium for the two channel samples (figs. 38 and 39), it is apparent that this is not true. In the samples both from the Buckman adit and the Union Pacific prospect, the content of copper, lead, arsenic, and antimony, as well as molybdenum, tend to vary directly with uranium content. The poor correlation coefficients may be explained by the fact that the uranium content was high relative to the other metals at the Buckman adit, but, at the Union Pacific prospect the reverse was true. When the samples from the two localities were pooled for statistical study, the highest uranium assays did not correspond to the highest assays for the other metals; consequently, the correlation coefficients for the pooled sample were much lower than they would have been for either deposit had the samples not been combined. This indicates a pitfall to be avoided in the application of correlation coefficients to assay data. If too many samples from different localities are combined in an effort to obtain a significantly large number of analyses for statistical treatment, the resulting correlation coefficients may obscure rather than emphasize the relationships sought.

A study of the semiquantitative spectrographic analyses (table 9, p. 376) suggests that silver, bismuth, yttrium, and ytterbium may also be closely associated with uranium in these deposits.

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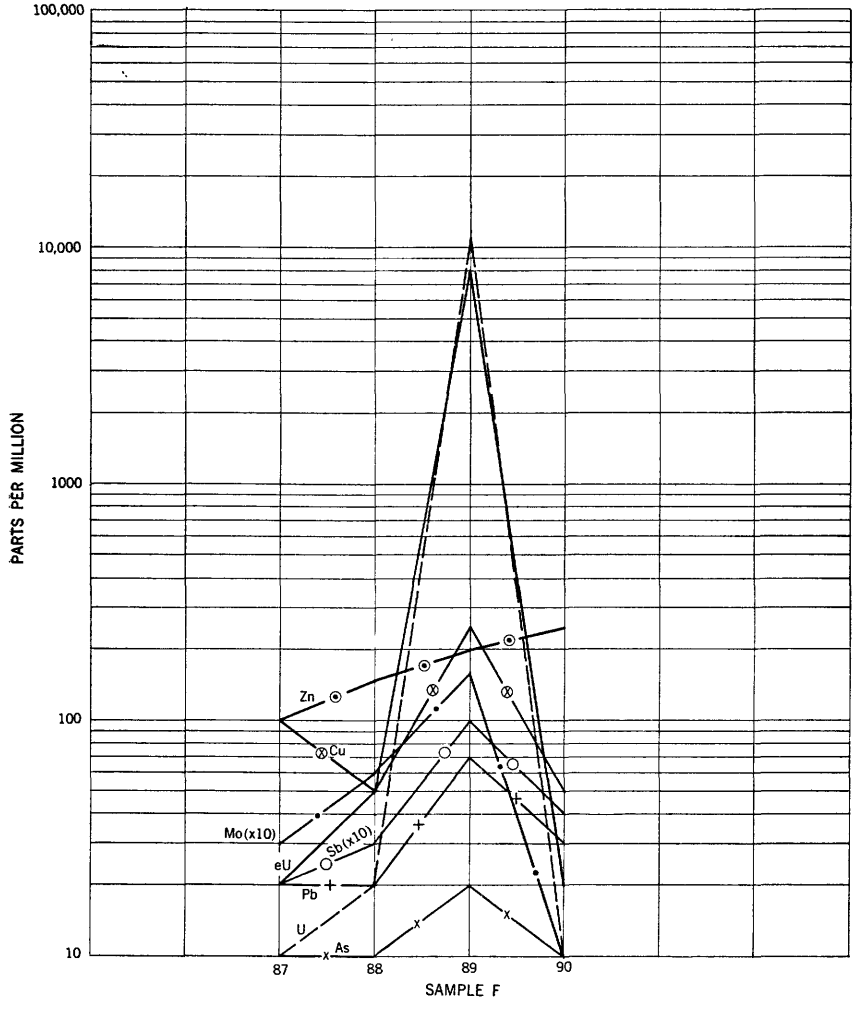


FIGURE 38.—Graph showing variations in equivalent uranium and in uranium and other metals, Buckman adit, Golden Gate Canyon.

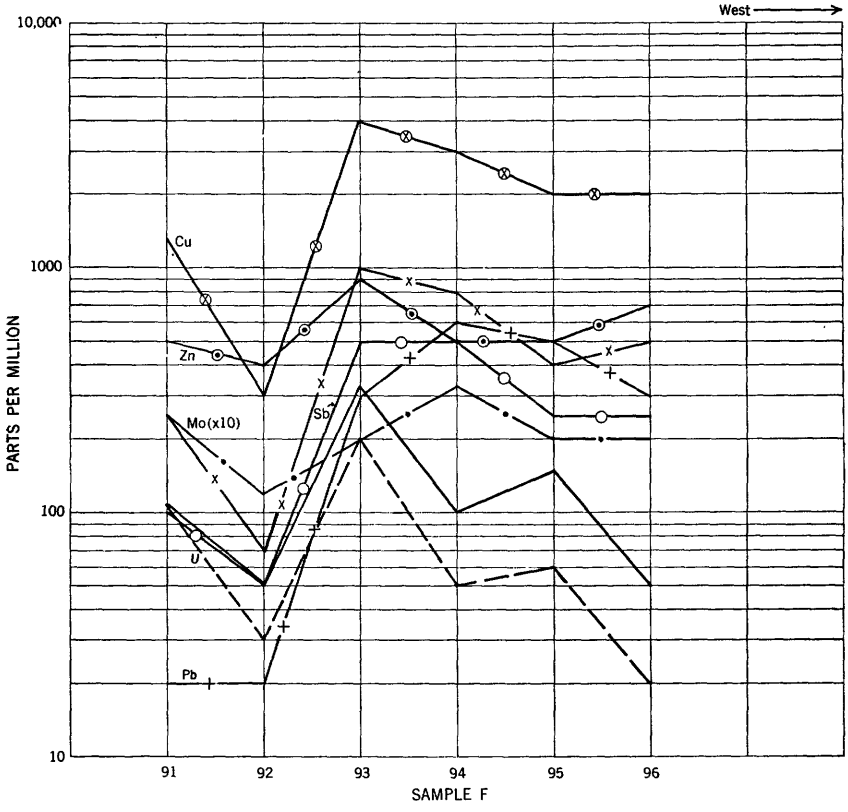


FIGURE 39.—Graph showing variations in equivalent uranium and in uranium and other metals, Union Pacific property, Golden Gate Canyon.

DIAMOND J RANCH, EL PASO COUNTY, COLO.

The Diamond J ranch is about 10 miles north-northeast of Colorado Springs in T. 12 S., R. 66 W. The deposit, on the north face of a low hill, at an altitude of about 6,500 feet, was discovered in 1951 by H. E. Burgess. It is in the nearly flat-lying Dawson arkose of Late Cretaceous and Paleocene age and consists of an irregular body of coarse sandstone and arkosic conglomerate heavily impregnated with iron and manganese oxide. It is very irregular in form with small local "rolls", has a northwesterly trend, and appears to be nearly 150 feet long with a maximum width of about 25 feet and a maximum exposed thickness of about 10 feet (fig. 40). L. R. Page and G. B. Gott made a reconnaissance examination and sketch map of this deposit in 1952 (written communication).

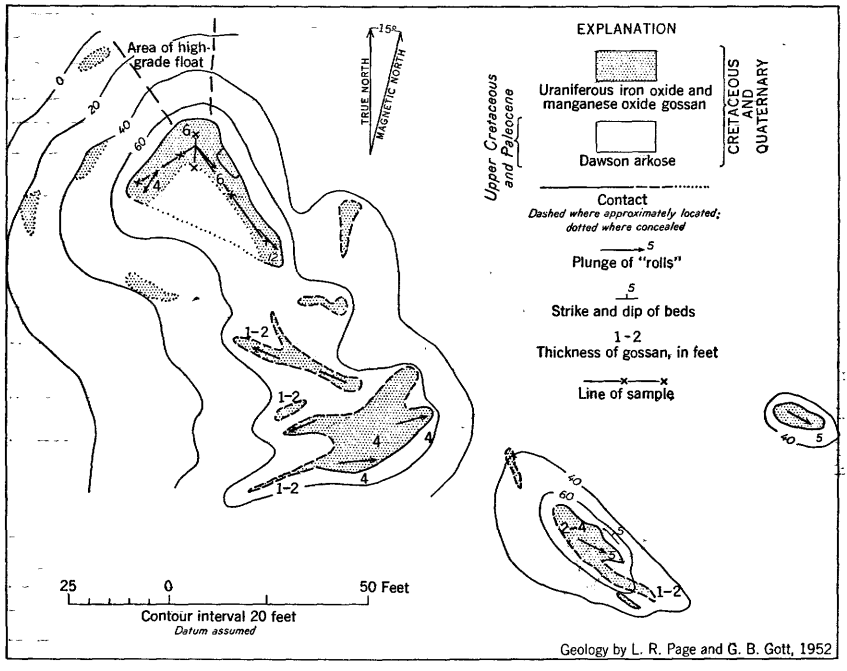


FIGURE 40.—Sketch map of radioactive-limonite zone on Diamond J ranch, showing sampled localities.

SAMPLES AND ANALYSES

Thirteen samples were collected from the deposit. Localities sampled are shown on figure 40. All samples were analyzed for equivalent uranium, uranium, zinc, lead, copper, nickel, cobalt, antimony, arsenic, molybdenum, manganese, and iron (table 10, p. 377).

The variation in concentration of equivalent uranium, uranium, zinc, copper, arsenic, molybdenum, manganese, and iron for both the vertical and horizontal samples is shown in figure 41.

Correlation coefficients which were calculated for copper, zinc, arsenic, molybdenum, manganese, and iron with respect to both equivalent uranium and uranium in all 13 samples, are given below.

Correlation coefficients, Diamond J ranch

[13 samples]

	eU	*U*		*eU*	*U*
Cu	[1]—0.66	—0.27	Mo	—0.12	[1]—0.55
Zn	+.13	—.30	Mn	[2]—.39	—.31
As	—.16	—.15	Fe	—.09	—.34

[1] Probably significant.
[2] Possibly significant.

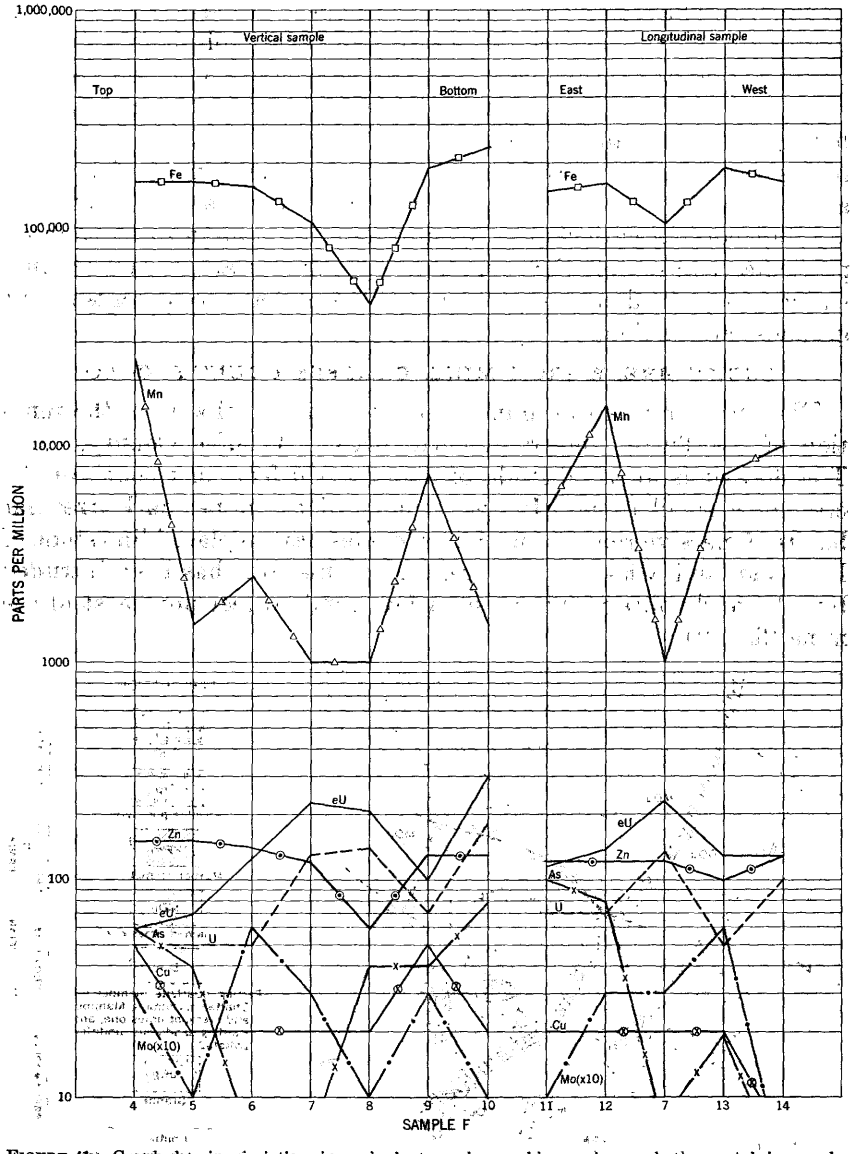


FIGURE 41.—Graph showing variations in equivalent uranium and in uranium and other metals in samples taken longitudinally and vertically across radioactive zone, Diamond J ranch.

CONCLUSIONS

The negative or nearly random correlation of uranium and equivalent uranium with the other elements in this suite of samples is quite unusual. Field observations and petrographic studies indicate that iron and manganese oxides containing small amounts of copper, zinc, arsenic, and molybdenum were probably introduced early. The solu-

tions from which they were deposited appear to have attacked the quartz but not the feldspar, suggesting that these solutions may have been alkaline rather than acid. At a later time uranium and possibly silica were introduced along small fractures; the negative correlations between uranium and the other elements suggest that the other elements were locally leached out at the same time uranium was deposited, although there is no petrographic evidence of such leaching. The low uranium content with respect to equivalent uranium in these samples, particularly in sample F16, suggests leaching of uranium and residual enrichment in its daughter products. This probably represents recent ground-water action.

LUCKY BREAK IRON MINE, CHAFFEE COUNTY, COLO.

The Lucky Break iron mine is about a mile northwest of the junction of the Turret and Whitehorn roads in Chaffee County, Colo. The deposit is at an altitude of about 9,000 feet, just south of the crest of a small ridge. In the vicinity of the mine, dark irregular bands of massive red and black iron oxides have replaced limestone of Devonian and Mississippian age. This limestone has been intruded by a large rhyolite prophyry sill a few hundred feet northeast of the mine (fig. 42).

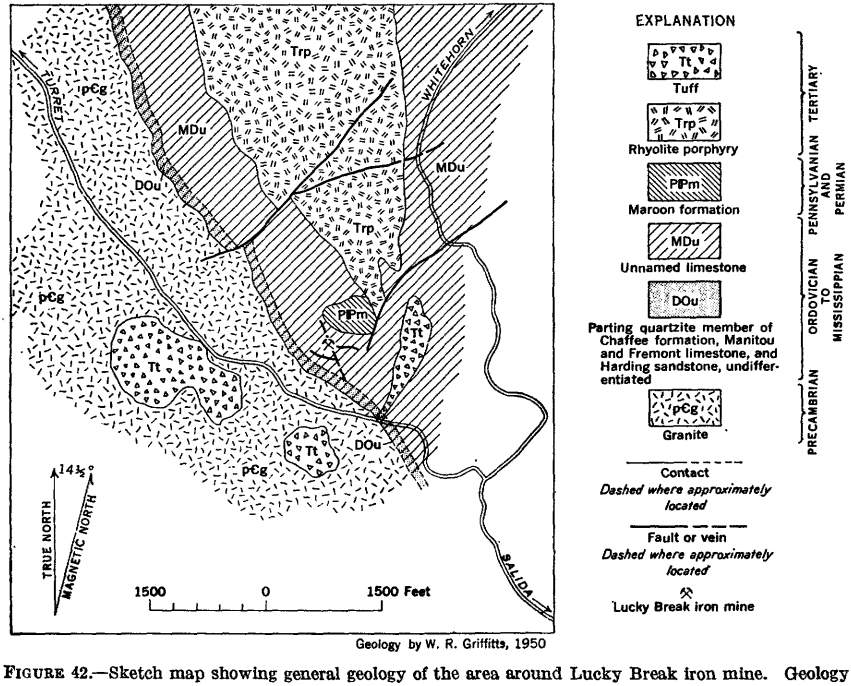


FIGURE 42.—Sketch map showing general geology of the area around Lucky Break iron mine. Geology generalized from an aerial photograph. (Since this report was prepared, the unit shown above as unnamed limestone has been classified as the Leadville limestone and Dyer dolomite member of the Chaffee formation, undifferentiated.)

According to K. G. Brill (1948, written communication) the deposit is cut and offset by a north-northwestward-trending normal fault which dips steeply to the east. Intense alteration in the vicinity of the mine appears to have obscured this fault.

Development on the property in June 1953 consisted of a large glory hole roughly 150 feet in diameter and 100 feet deep with a short adit which provided access from a haulage road to the bottom of the pit on the south side.

The surrounding area has been studied by W. R. Griffitts, who accompanied the senior author to this locality in June 1953.

SAMPLES AND ANALYSES

Four samples were collected from the south wall of the pit a few feet west of the adit (table 1). All four were analyzed radiometrically for equivalent uranium and spectographically for 36 elements; X-ray (powder diffraction) studies were also made on all four samples in order to verify the major mineral constituents (table 11, p. 378).

TABLE 1.—*Description and radioactivity and X-ray analyses of samples from the Lucky Break iron mine*

[Analysts: E. J. Fennelly and W. F. Outerbridge]

Sample	Locality	Type	Description	Analyses	
				eU (percent)	Mineral constituents
F1-TL-53	10 ft west of adit, on south wall of pit.	Grab	Moderate reddish-brown to dusky-red fine-grained hematitic iron ore.	0.002	Hematite.
F1A-TL-53 [1]	do	do	Blackish-red ore with moderate reddish-orange and dark yellowish-orange bands.	.002	Hematite, goethite.
F2-TL-53 [1]	Fracture zone, 5 ft west of adit, on south wall of pit.	do	Dusky-red fine-grained hematitic iron ore.	.018	Hematite, goethite, quartz.
F3-TL-53 [1]	do	do	do	.069	Hematite, quartz.

[1] For petrographic description see table 3.

CONCLUSIONS

Megascopically, there is little to distinguish the radioactive from the nonradioactive material in this deposit. Examination of the mine walls with a Geiger counter suggests that the most highly radioactive material is localized along late fractures. Examination of a section cut from the most radioactive specimen shows that small fractures filled with late quartz are more common in it than in the sections cut from nonradioactive material. A study of the spectrographic data indicates a tendency toward enrichment in copper, zinc, cobalt, beryllium, and yttrium and depletion in aluminum, titanium,

calcium, magnesium, sodium, potassium, barium, strontium, gallium, and zirconium, in the more radioactive material.

It thus seems probable that uranium was introduced after the original replacement of limestone by iron oxide. The data suggest that the uranium was probably introduced along small fractures in the previously formed iron oxide body by solutions containing large amounts of silica and minor amounts of copper, zinc, and cobalt. If this hypothesis is correct, it could indicate the proximity of a uraniferous base-metal sulfide body from which these solutions were derived.

OURAY HOT SPRINGS, OURAY COUNTY, COLO.

The Ouray hot springs deposits are near the bottom of a steep-walled canyon near the southwest edge of Ouray, Colo., just east of the Uncompahgre River, at an altitute of 7,700 feet.

The tufa deposits from the springs are interbedded with Quaternary stream gravel and overlie Ouray limestone of Devonian age on the northwest side of the northeastward-trending Ouray fault. This fault brings the Ouray limestone down against Precambrian slates and phyllites on the southwest.

The Ouray hot springs are in the area described in Burbank's report (Burbank, 1940), and their location is shown on his map. These deposits are briefly described in a later report by Burbank and Pierson (1953).

SAMPLES AND ANALYSES

Five samples of tufa were collected from 2 localities 100 yards apart. Three samples of tufa were collected near the fault which is about 250 feet southeast of the Canyon Creek road bridge over the Uncompahgre River; the other 2 were from the east bank of the river about 50 feet north of this bridge. All five samples were analyzed for equivalent uranium, uranium, zinc, lead, copper, nickel, cobalt, molybdenum, arsenic, antimony, vanadium, manganese and iron. The uranium content of all samples was <20 ppm and the copper and nickel content was <10 ppm. Results of the other analyses are shown in table 12, p. 379.

Correlation coefficients were determined for zinc, antimony, arsenic, molybdenum, manganese, and iron with respect to equivalent uranium in all five samples as shown below.

Correlation coefficients, Ouray hot springs

[5 samples]

	eU		eU
Zn	+0.69	Mo	+0.70
Sb	−.06	Mn	+.72
As	+.47	Fe	+.31

[1] Probably significant.
[2] Possibly significant.

One sample of radioactive tufa collected from this deposit by Burbank and Pierson was analyzed for uranium and equivalent uranium, and also was submitted to semiquantitative spectrographic analyses. This sample contained 0.11 percent eU and 0.001 percent U. Other elements detected were present in the following concentrations:

Element	*Percent*[1]
Mn	XX.
Ba, Ca, Fe, Si, Sr, W	X.
Al, As, Mg, Na	.X
Be, Cu, Mo, Sb, Ti, Tl, V, Zn	.0X
Co, Pb, Zr	.00X
Cr	.000X

[1] See Introduction, p. 340, for explanation of values.

CONCLUSIONS

The colloidal texture of manganese oxide, evident in polished sections, and the high positive correlation between equivalent uranium and manganese suggest that the radioactive element was adsorbed by colloidal manganese oxide hydrate and precipitated with it. The high ratio of equivalent uranium to uranium suggests that the radioactive element now present in these deposits is probably radium. The unusually large amounts of tungsten, molybdenum, arsenic, antimony, and zinc in these samples also suggest the possibility of a uraniferous base-metal sulfide ore body in the vicinity, from which radium has been leached by the hot spring waters. Several silver-lead-zinc deposits occur in the Paleozoic rocks near the Ouray fault, within a mile of the Ouray hot springs (Burbank, 1940).

HAPUTA RANCH AREA, CUSTER COUNTY, COLO.

The Haputa ranch area is in the western foothills of the Wet Mountains 4 miles east-northeast of Querida in Custer County, Colo. The deposit, which was examined and sampled in detail, is a small open cut at an altitude of about 9,250 feet. The deposit is in a northwestward-trending shear zone cutting Precambrian amphibolite which has been intruded by a biotite granite gneiss about 25 feet south of the shear zone. An andesite dike, striking parallel to the shear zone, cuts the amphibolite near its contact with the gneiss (fig. 43). Drill-hole data indicate that this dike crosses the shear zone at a depth of about 100 feet. This locality has previously been examined by Christman and others (1953, p. 10–12, 32) and it is described in their report as "drill hole Ha–8."

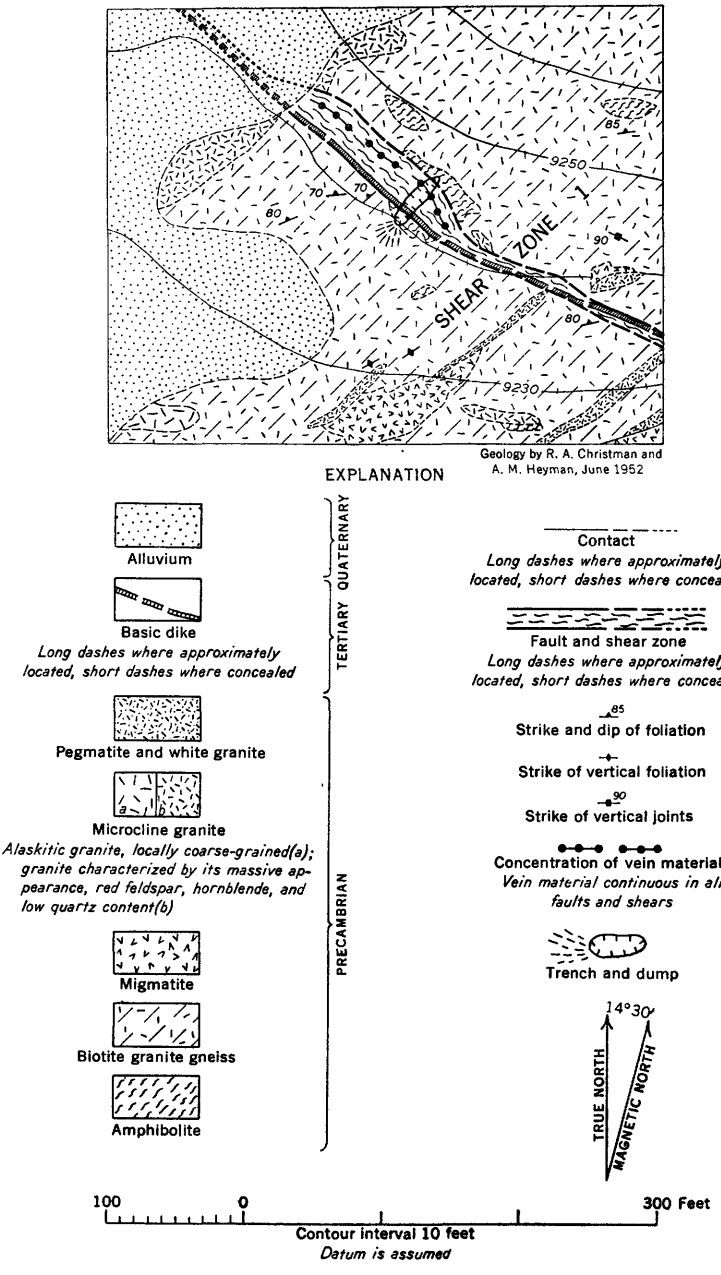


FIGURE 43.—Geologic map of part of the Haputa ranch.

SAMPLES AND ANALYSES

Eleven samples were collected from the Haputa ranch area. Nine of these are consecutive 1-foot channel samples across the radioactive zone shown in figure 43; the other two are selected grab samples. All 11 samples were analyzed radiometrically for equivalent uranium and geochemically for zinc, lead, copper, nickel, cobalt, arsenic, antimony, molybdenum, vanadium, manganese, and iron. In addition, three of the more radioactive samples were analyzed chemically for thorium. The results of these analyses are shown in table 13, p. 380.

A special sample of the thorium-bearing mineral was analyzed spectrographically by Katherine E. Valentine, and the results of this analysis were made available by R. A. Christman. The analysis shows the following components:

Element	*Percent* [1]
Si, Th	XX.
Fe	X.
Ba, Ca, Ce, Cu, La, Nd, Pb, Y	.X
Al, B, Co, Dy, Er, Eu, Gd, Lu, Ni, Pr Yb	.0X
Be, Mg, Mn, Mo, Sr, V, Zr	.00X
Ag, Cr, Ti	.000X

[1] See Introduction, p. 340, for explanation of values.

An exploratory diamond-drill hole cut the shear zone at a depth of 140–160 feet beneath the exposure from which samples F18–F26 were taken. The core from this hole was analyzed spectrographically by G. W. Boyes. Table 2 shows the concentrations of the same elements in the drill core for which geochemical assays were made on samples from the outcrop. The corrected sample lengths and equivalent-uranium concentration of drill-core samples were taken from Christman and others, 1953, p. 14, table 5.

The variations in concentration of equivalent uranium and selected elements in the 9-foot horizontal channel sample taken at the outcrop are shown in figure 44. Data are graphed only for those elements that showed significant changes in concentration.

Correlation coefficients were determined for zinc, lead, copper, nickel, arsenic, antimony, vanadium, and manganese with respect to equivalent uranium in all 11 samples for which geochemical assay data are available (table below).

Correlation coefficients, Haputa ranch area

[11 samples]

	eU		*eU*
Zn	+0.21	As	[1]+0.67
Pb	[1]+.76	Sb	[1]+.77
Cu	[1]+.53	V	[1]−.59
Ni	[2]−.48	Mn	−.11

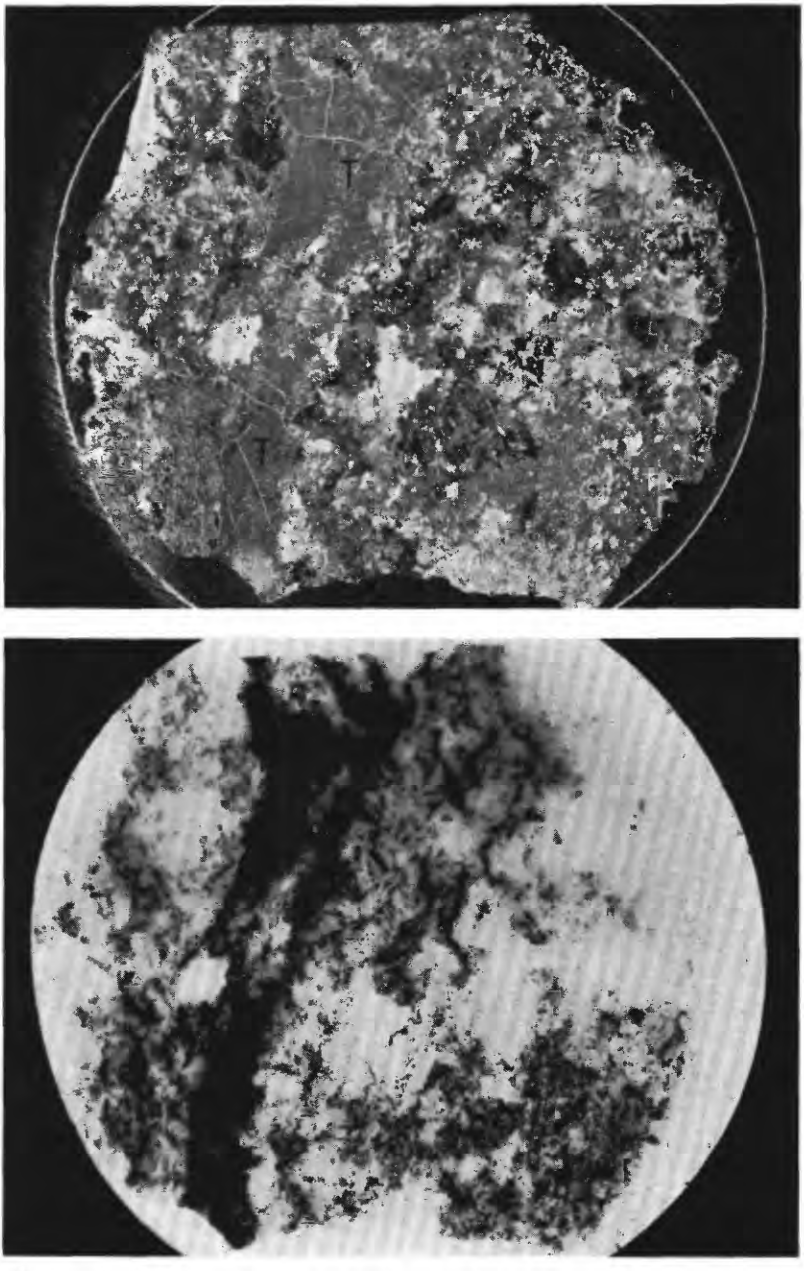
[1] Probably significant.
[2] Possibly significant.

TABLE 2.—*Semiquantitative spectrographic analyses of selected elements in drill core from mineralized shear zone, Haputa ranch* [1]

[Analyst, G. W. Boyes]

Sample length (feet)	eU [2]	Zn	Pb	Cu	Ni	Co	As	Sb	Mo	V	Mn	Fe
4.0	60	<0.0X	Tr.	0.00X	0.00X−	0.000X+	<0.X−	<0.0X	Tr.	0.00X+	0.0X+	X
.7	1,300	<.0X	.0X−	.00X	.00X	.00X−	<.X−	<.0X	0	.00X+	.0X+	X
.2	30	<.0X	Tr.	.00X−	.00X	.000X+	<.X−	<.0X	.00X−	.00X+	.0X	X
.7	360	<-0X	.00X	.00X	.00X	.00X−	<.X−	<.0X	0	.00X+	.0X+	X
1.1	50	<.0X	Tr.	.00X	.00X	.00X−	<.X−	<.0X	.00X−	.00X+	.0X	X
2.2	970	<.0X	.00X+	.00X+	.00X+	.00X−	<.X−	<.0X	0	.00X+	.0X	X
1.4	400	<.0X	Tr.	.00X−	.00X	.000X+	<.X−	<.0X	0	.00X+	.0X−	X
.4	2,900	<.0X	.00X	.00X	.00X+	.000X+	<.X−	<.0X	0	.0X−	.0X−	X+
.8	320	<.0X	.00X+	.00X+	.00X	.00X−	<.X−	<.0X	0	.0X−	.0X+	X
3.9	50	<.0X	.00X	.00X	.00X	.00X−	<.X−	<.0X	Tr.	.0X−	.0X+	X
8.0	30	<.0X	Tr.	.00X+	.00X	.00X	<.X−	<.0X	.00X−	.0X−	.0X+	X+

[1] See Introduction, p. 340, for explanation of values.
[2] Data from Christman and others, 1953, p. 14, table 5.



Photograph (above) and autoradiograph of polished section of sample containing thorite (T), quartz with disseminated thorite, and limonite, from radioactive shear zone, Haputa ranch, Custer County, Colo.

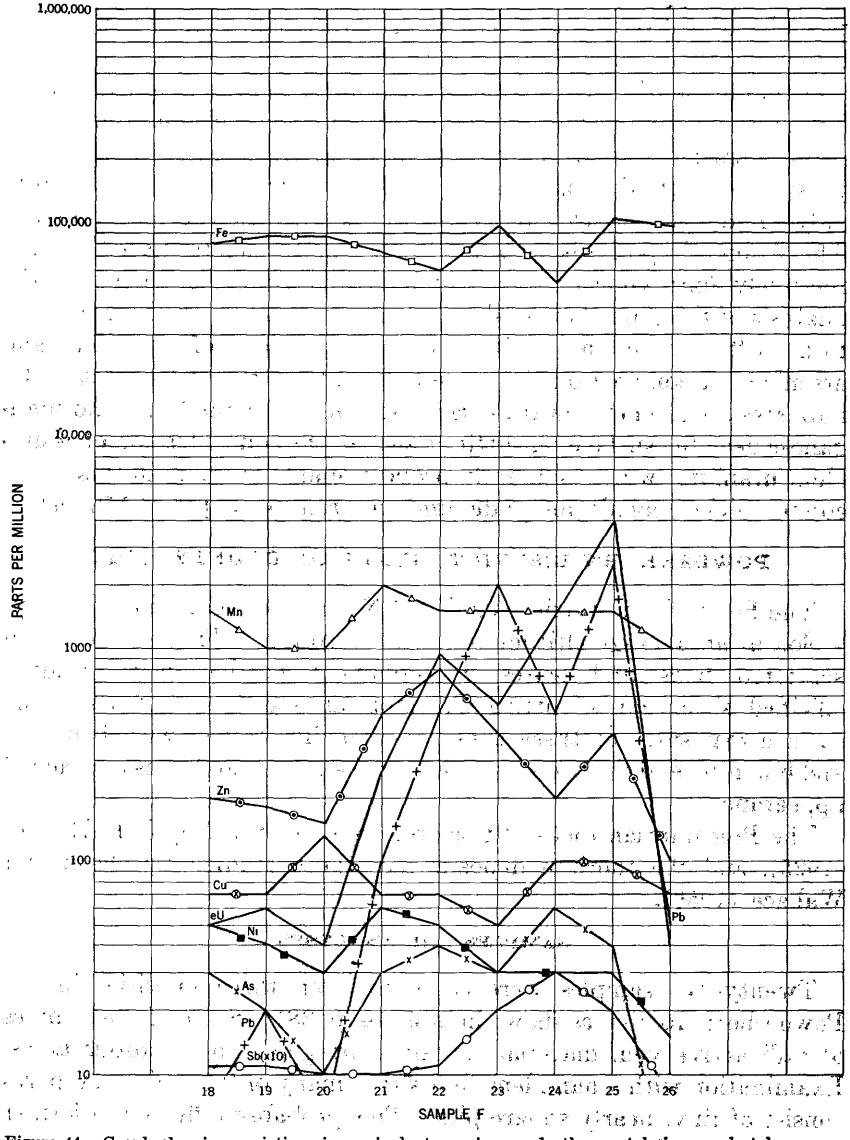


Figure 44.—Graph showing variations in equivalent uranium and other metals in sample taken across radioactive shear zone, Haputa ranch.

CONCLUSIONS

Much of the quartz has a rosy color caused apparently by submicroscopic particles of red hematite or thorite. Comparison of a polished section of sample F25, which is high in thorium, with its autoradiograph shows that these particles are radioactive (pl. 42).

In some of the samples, the apparent dispersion of submicroscopic

particles of a thorium mineral throughout quartz suggests that thorium may have been introduced in solution by hot silica-bearing waters and that some of it was precipitated simultaneously with the quartz. The high positive correlation between equivalent uranium and lead, copper, arsenic, and antimony suggests that either these elements are present in the thorium minerals or that they form other minerals, probably sulfides, which are closely associated with the thorium minerals. The former hypothesis appears to be partly substantiated by the relatively high concentrations of lead and copper reported in the analysis of the pure thorium-bearing mineral and by the high correlation coefficients coupled with low concentrations of antimony and arsenic.[1] A comparison of the assay data from the drill-core samples indicates a tendency toward enrichment in lead, vanadium, and manganese near the surface but little change in the concentration of equivalent uranium (which is directly proportional to thorium in this area), copper, nickel, cobalt, molybdenum, and iron to a depth of 150 feet.

POWDERHORN DISTRICT, GUNNISON COUNTY, COLO.

The Powderhorn district is in T. 47 N., R. 2 W., Gunnison County, Colo., at an average altitude of about 9,000 feet. Thorium occurs in scattered pods and lenses in prominent northeastward-trending silicified shear zones cutting Precambrian schist and gneiss. The surface exposures of these zones are heavily stained with hematite and limonite, and the country rock near them commonly has a bleached appearance.

The Precambrian rocks of this area were described by J. F. Hunter (1925), and the thorium deposits have been studied by Olson and Wallace (1956).

SAMPLES AND ANALYSES

Twenty-two samples were collected from three localities in the Powderhorn district, as shown in table 14, p. 381. Some of the samples of radioactive vein material contained irregular finely porous areas. Examination with a hand lens shows that many of the individual pores consist of tiny, nearly square pits. This probably reflects the former presence of pyrite.

All 22 samples were analyzed geochemically for zinc, lead, copper, nickel, cobalt, antimony, arsenic, molybdenum, vanadium, manganese,

[1] Antimony and arsenic cannot be detected by ordinary spectrographic methods in concentrations of less than 500–1,000 ppm, so it is not surprising that they were not reported in the spectrographic analyses.

and iron. They were also analyzed for equivalent uranium, and two of the most radioactive were analyzed chemically for thorium (table 14, p. 381).

The variation in equivalent uranium and some of the metals in samples taken across the Little Johnny vein and in the more widely spaced grab samples at the Jeanie No. 2 claim, is shown graphically in figures 45 and 46. Fig. 47 illustrates the location of samples from the Jeanie No. 2 claim relative to the vein.

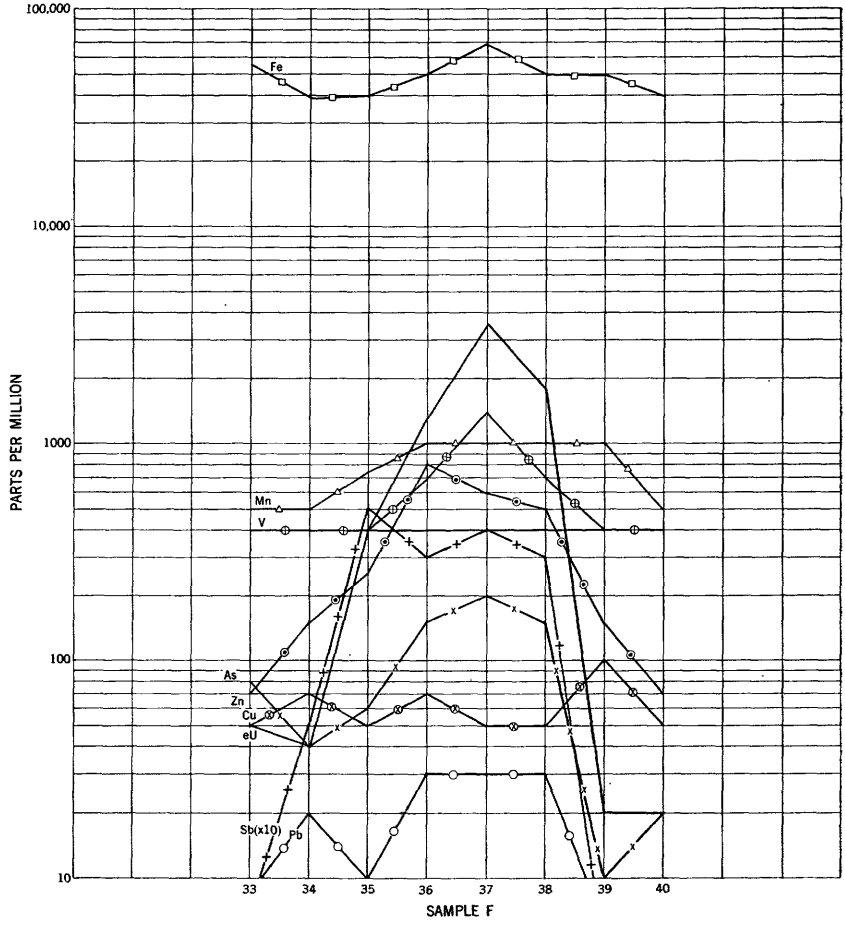


FIGURE 45.—Graph showing variations in amounts equivalent uranium and selected metals in sample taken across Little Johnny vein, at upper pit, Powderhorn district.

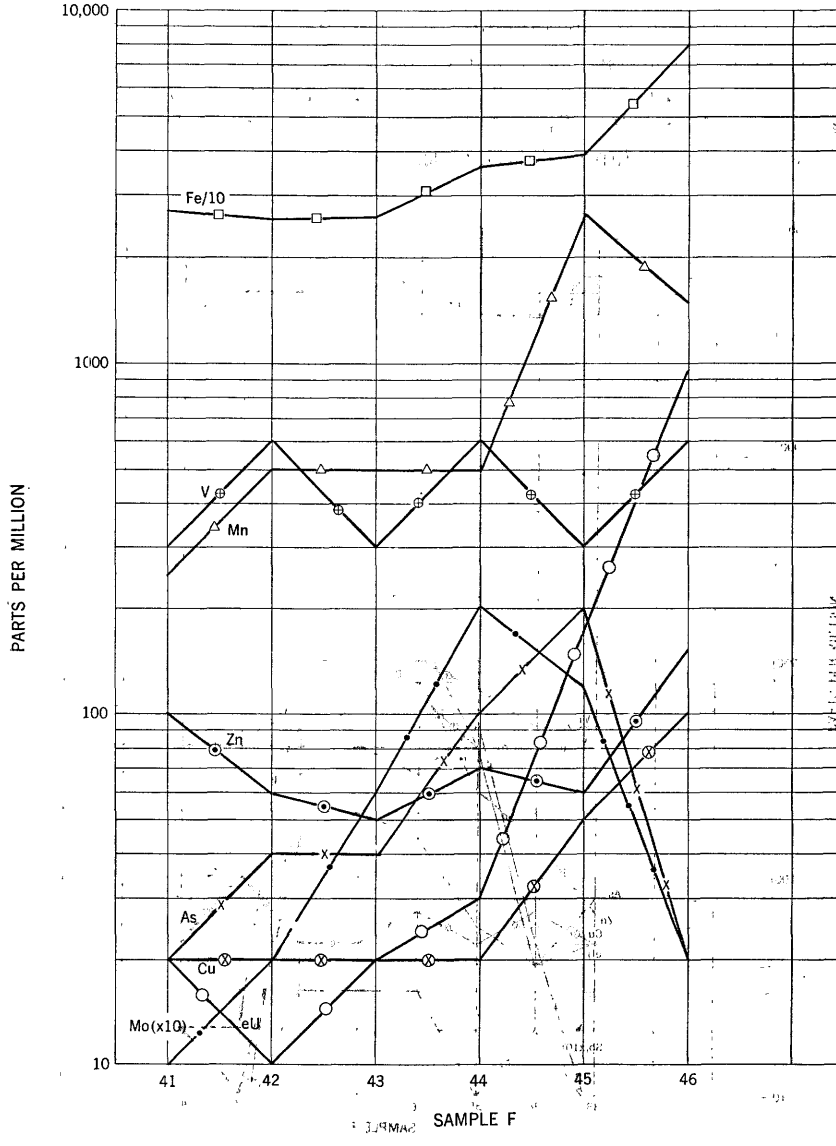


FIGURE 46.—Graph showing variations in equivalent uranium and selected metals in samples taken at 5-foot intervals on wall of cut, Jeanie No. 2 claim, Gunnison County, Colo.

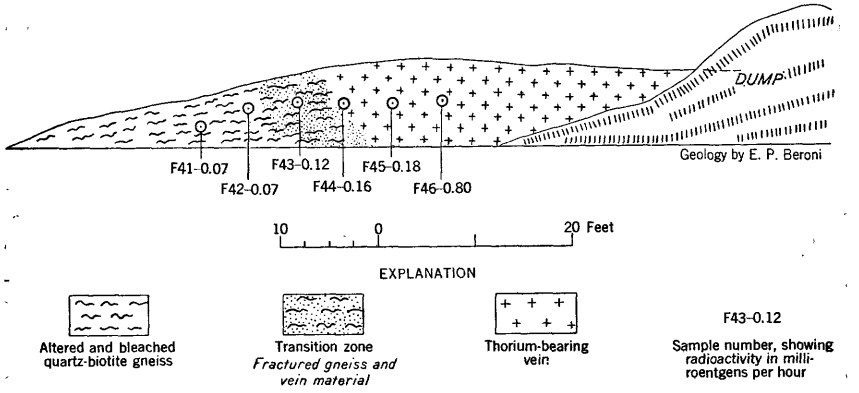


FIGURE 47.—Sketch of southeast wall of bulldozer cut, Jeanie No. 2 claim, Powderhorn district.

Correlation coefficients were determined for zinc, lead, copper, antimony, arsenic, molybdenum, vanadium, manganese, and iron on all 22 samples (table below).

Correlation coefficients, Powderhorn district

[22 samples]

	eU		*eU*
Zn	[1]+0.69	Mo	+0.31
Pb	[1]+.71	V	[2]+.39
Cu	+.15	Mn	[2]+.46
Sb	[1]+.85	Fe	[2]+.54
As	[1]+.61		

[1] Probably significant.
[2] Possibly significant.

CONCLUSIONS

The abundance of red quartz in the samples with a high thorium content indicates, as in the sample from the Haputa ranch area, that submicroscopic thorium-mineral particles may be disseminated throughout the quartz and that they may have formed contemporaneously with it. There is a crude relationship between limonite colors and thorium concentration. In general, the limonite stains change from yellowish or grayish brown through light brown and moderate brown as the vein is approached, to a characteristic moderate to dusky red in the high-thorium vein material. Petrographic studies reveal the presence of hematite pseudomorphs after pyrite in the high-thorium parts of the vein. This suggests a genetic relationship between the thorium ore and sulfide deposits which is also suggested by the relatively high correlation between equivalent uranium and iron, zinc, lead, arsenic, and antimony. The arsenic and antimony apparently are present as minor constituents of the thorium mineral

and do not form separate minerals associated with it. If this is true, it explains both the high correlation of arsenic and antimony with equivalent uranium and their low concentrations.

SUMMARY

The results of this study indicate that preliminary sampling of radioactive-limonite outcrops and geochemical analysis of the samples, followed by the determination of correlation coefficients from the assay data, may reveal important relationships between the radioactive element sought and other elements that may be associated with it. These correlation coefficients may be used in two ways: to eliminate randomly distributed elements and place emphasis on others that seem to show high correlations in further geochemical or geobotanical studies, and to aid, by supplementing petrographic examination, in interpreting the origin and paragenesis of the ore deposits.

The results of petrographic studies of thin and polished sections of selected samples are summarized in table 3.

TABLE 3.—*Petrographic description of thin and polished sections cut from selected samples*

Sample	Locality	Description
F1A-TL-53	Lucky Break iron mine.	Grains of steel-gray hematite surrounded by red hematite rims in banded colloform goethite; numerous small angular quartz fragments in goethite, and cavities filled with chalcedony.
F2-TL-53	do	Similar to F1A but contains less goethite; boundaries between red and gray hematite are commonly gradational and undulating, suggestive of replacement.
F3-TL-53	do	Contains more steel-gray hematite than F2; gray hematite, followed by massive quartz which is embayed by microbreccia of red hematite, late quartz veinlets cut quartz fragments.
F14-TL-53	Diamond J ranch	Angular fragments of quartz, orthoclase, and microcline in matrix of dark-brown goethite, red hematite, and black wad which fills voids in iron oxides and is cut by late quartz veinlets.
F16-TL-53	do	Fewer fragments than F14, wad predominates over hematite and goethite in matrix; some of goethite replaces red hematite, some stains fractures in quartz and may be older than hematite.
F17-TL-53	Haputa ranch area	Small euhedral apatite crystals in early quartz cut by veinlets of late quartz containing voids filled with colloform goethite; few rounded grains of gray hematite in quartz have goethite rims.
F20-TL-53	do	Biotite, hornblende, quartz, and plagioclase with accessory magnetite and apatite are cut by veinlets of rosy quartz and later goethite.
F25-TL-53	do	Altered feldspar fragments in rosy vein quartz contain few grains of thorite; quartz is cut by veinlets of red hematite and later goethite.
F36-TL-53	Powderhorn district	Deep-red quartz with numerous small isometric pseudomorphs of hematite after pyrite; late veinlets of clear quartz cut red quartz.
F44-TL-53	do	Few large quartz grains with late quartz overgrowths in matrix of fine-grained quartz alternating with bands of biotite; goethite coats some quartz grains; few tiny specks of red hematite or thorite in groundmass.
F46-TL-53	do	Red quartz cut by clear quartz veinlets; small hematite pseudomorphs after pyrite in both red and clear quartz; microbreccia of clear quartz and goethite cements fragments of early red quartz.
F49-TL-53	Ouray hot springs	Nodular masses of psilomelane with colloidal banding are cut and partly replaced by dense massive hematite.
F51-TL-53	do	Calcite and goethite with subordinate psilomelane; goethite is younger than psilomelane; small cavities filled with late quartz or barite.

TABLE 3.—*Petrographic description of thin and polished sections cut from selected samples*—Continued

Sample	Locality	Description
F57-TL-53	Yellow Cat area	Subrounded grains of quartz, chert, and limonite-stained altered feldspar in a matrix of dark-brown goethite and cryptocrystalline quartz.
F58-TL-53	do	Quartz grains smaller and more angular, and chert less abundant than in F57, few grains of chalcedony; goethite cement more localized and lighter brown; some red hematite grains; gypsum fills fractures.
F61-TL-53	do	Small rounded grains of quartz and orthoclase cemented by cryptocrystalline quartz; cut by veinlet of brecciated red hematite altering to goethite cemented by late quartz.
F74-TL-53	Silver Cliff mine	Fine- to medium-grained rounded quartz grains in matrix of yellowish-orange goethite replacing calcite; few grains of magnetite and irregular masses of sooty chalcocite.
F75-TL-53	do	Similar to F74, with calcite predominant over goethite; quartz grains are stained red, and a few grains of red hematite are scattered throughout the matrix.
F78-TL-53	do	Large angular quartz grains embedded in a matrix of yellowish-orange to light-brown goethite and green malachite which is younger than goethite; microbreccia of chalcocite and quartz embays quartz grains.

No single element for which geochemical analyses were made showed consistently high correlations with uranium in all of the areas examined (table 4); however, in most of the uranium districts at least one other element appeared to show a significant correlation with uranium. In both thorium districts, on the other hand, high positive correlations were shown between thorium and lead, arsenic, and antimony. A larger number of thorium deposits should be studied in order to determine whether this association is widespread or merely an accidental result of the choice of areas for examination (table 4).

If an element which has distinctively colored alteration products, such as copper, manganese, or cobalt, shows high correlation with uranium or thorium in a given area, then those colors may be useful as field guides to the prospector. The limonite colors observed by the authors did not appear to be particularly useful field guides for uranium. In general, the limonite stains on uranium-bearing outcrops ranged from light yellow brown through moderate brown to dusky brown; rarely were red iron oxides associated with uranium. This in itself does not, however, constitute a useful field guide in most areas because of the prevalence of brown limonite stains on barren outcrops. In the thorium deposits, on the other hand, samples with a high thorium content commonly exhibited a characteristic red color. In some of the deposits, such as the Jeanie No. 2, the color of the limonite stains changes from yellowish or grayish brown through light brown to moderate or dusky brown as the thorium deposit is approached.

Small areas of porous limonite were noted in some of the high-thorium samples from the Powderhorn district, and examination with a hand lens revealed numerous tiny square pits, which are thought

TABLE 4.—*Elements showing significant and possibly significant correlation with radioactive material in the localities examined*

[+, positive correlation; −, negative correlation]

Locality	Probably significant										Possibly significant								
	As	Cu	Fe	Mn	Mo	Ni	Pb	Sb	V	Zn	As	Cu	Fe	Mn	Mo	Ni	Pb	Sb	V
Yellow Cat area, Grand County, Utah	+							+	+					−	+				
Snow-Bonniebell claims, Uintah County, Utah				+									+						
Silver Cliff mine, Niobrara County, Wyo		+								+	+			+	+				
Golden Gate Canyon area, Jefferson County, Colo															+				
Diamond J ranch, El Paso County, Colo		−			−									−					
Ouray hot springs, Ouray County, Colo				+	+					+	+								
Haputa ranch area, Custer County, Colo	+	+					+	+	−							−			
Powderhorn district, Gunnison County, Colo	+		+	+			+	+		+									+

to indicate the former presence of pyrite cubes in these areas. No sponge or boxwork textures were apparent in samples from any of the other localities examined.

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TABLE 5.—*Description and analyses of samples from the Yellow Cat area*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (parts per million)												
				eU	U	Zn	Pb	Cu	Ni	Co	Sb	As	Mo	V	Mn	Fe
F54-TL-53	Cactus Rat claim, bench: Surface to 1-ft depth.	Vertical channel.[1]	Light-gray barren arkosic conglomerate.	30	<20	200	<10	20	<10	<10	1	10	8	300	750	50,000
F55-TL-53	1- to 2-ft depth	do.[1]	Light-gray medium-grained cross-bedded sandstone.	20	<20	20	<10	20	<10	<10	2	10	8	600	500	20,000
F56-TL-53	2- to 3-ft depth	do.[1]	do	120	210	100	<10	50	50	50	1	20	12	1,500	750	32,000
F57-TL-53 [2]	3- to 4-ft depth	do.[1]	Pale yellowish-gray fine-grained sandstone with limonite coating fractures.	120	110	50	<10	50	15	<10	3	100	200	(3)	250	30,000
F58-TL-53 [2]	4- to 5-ft depth	do.[1]	Same as F57, with less limonite stain.	1,100	700	<10	<10	20	<10	<10	10	600	500	(3)	250	38,000
F59-TL-53	5- to 6-ft depth	do.[1]	Light-brown medium-grained sandstone impregnated with limonite.	80	50	40	<10	20	<10	<10	4	150	200	<300	500	32,000
F60-TL-53	6- to 7-ft depth	do.[1]	Light-brown and medium-gray arkosic conglomerate.	240	300	100	<10	20	<10	<10	4	150	32	<300	1,000	39,000
F61-TL-53 [2]	Cactus Rat claim, 2 ft west of F56.	Selected grab.	Carbonaceous material in a "trash pocket," with limonite-stained sandstone.	1,200	2,000	70	<10	<10	<10	<10	3	150	32	10,000	250	33,000
F80-TL-53	Allor No. 2 claim	Grab	Light-brown fine-grained sandstone with gray-brown clay partings.	400	430	500	<10	70	<10	50	1	130	12	600	<200	10,000
F81-TL-53	Cactus Rat claim, above F54.	Float	Reddish-brown mudstone of the Brushy Basin with black manganese stain on surface.	10	<20	50	<10	20	<10	<10	<1	<10	8	<300	500	17,000
F82-TL-53	Flat Top claim	Grab	Light-buff fine-grained sandstone with light-brown to moderate-brown limonite coatings.	40	<20	70	<10	<10	<10	<10	2	150	500	600	<200	11,000
F83-TL-53	do	do	Light-brown medium-grained arkosic sandstone with patches of carnotite and dark-brown limonite.	2,400	2,500	50	<10	<10	<10	<10	4	100	150	1,500	<200	14,000
F84-TL-53	Allor No. 2 claim	do	Pale-brown medium-grained sandstone with carnotite(?) and moderate-brown limonite coating fractures.	1,200	1,600	600	<10	70	<10	50	2	200	80	1,500	<200	13,000

[1] Samples F54-TL-53 through F60-TL-53 are 1-ft segments of a 7-ft channel sample taken vertically through the upper (no. 1) sand of the Salt Wash sandstone member; they are listed from the top downward.

[2] See table 3 for petrographic description.

[3] Concentration indeterminate because of interference.

TABLE 6.—*Description and analyses of samples from the Snow-Bonniebell claims*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)									
				eU	U	Zn	Pb	Cu	Sb	As	Mo	Mn	Fe
F62-TL-53	Bonniebell No. 3 claim	Grab	Light-gray medium-grained sandstone with bands of dark yellowish-orange limonite.	190	220	20	<10	<10	1	20	<1	<200	10,000
F63-TL-53	2 ft north of F65	1-ft channel	Pale yellowish-brown laminated siltstone.	20	<20	20	<10	<10	2	40	<1	<200	22,000
F64-TL-53	1 ft south of F65	do	Pale-brown laminated siltstone	20	<20	50	20	50	<1	30	100	<200	7,000
F65-TL-53	East wall of opencut	10-in. channel	Medium-brown and black laminated siltstone. Limonite seam.	130	170	100	<10	130	3	250	1,000	<200	49,000
	Fault zone, ½ mile east-northeast of opencut, south end:												
F66-TL-53	1 ft south of fault	1-ft channel	Very light-gray medium-grained sandstone.	40	<20	20	<10	20	<1	<10	6	<200	6,000
F67-TL-53	Fault zone	do	Light-brown fine-grained sandstone with dusky-brown limonite coating.	310	480	20	<10	50	<1	10	3	750	19,000
F69-TL-53	1 ft north of fault	do	Pale yellowish-brown fine-grained sandstone stained with dark yellowish-orange limonite.	250	380	150	<10	50	<1	10	2	500	13,000
F70-TL-53	2 ft north of fault	do	do	120	170	40	<10	50	<1	10	3	750	20,000
F71-TL-53	3 ft north of fault	do	Dark yellowish-brown fine-grained sandstone with thin dusky yellowish-brown claystone partings.	180	340	50	<10	50	<1	<10	1	750	14,000
F72-TL-53	4 ft north of fault	do	Very light-gray to yellowish-gray medium-grained sandstone.	30	<20	40	<10	50	<1	<10	3	250	13,000
F68-TL-53	North end: Fault zone	Grab	Yellowish-brown fine- to medium-grained sandstone with dusky-brown limonite and yellow-green uranium mineral.	790	1,200	20	<10	50	1	10	8	750	28,000

TABLE 7.—*Description and analyses of samples from the Silver Cliff mine*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)												
				eU	U	Zn	Pb	Cu	Ni	Co	As	Sb	Mo	V	Mn	Fe
F74-TL-53 [1]	Through fracture zone 50 ft west of portal.	1-ft channel	Light-brown to medium-brown fine-grained quartzite.	160	190	400	500	3,000	40	10	150	4	6	1,500	500	17,000
F75-TL-53 [1]	1 ft north of F74.	do	Pale-red fine-grained quartzite with small dark-reddish-brown spots.	30	<20	70	20	180	<10	10	40	<1	6	1,000	250	17,000
F76-TL-53	1 ft south of F74.	do	Grayish-orange-pink fine-grained quartzite with sparse dark-gray chert pebbles.	30	<20	130	<10	700	<10	10	40	<1	1	300	250	14,000
F77-TL-53	10 ft above F74, in red zone.	Grab	Dark reddish-brown fine-grained quartzite.	60	<20	70	<10	150	30	<10	40	1	<1	300	500	94,000
F78-TL-53 [1]	Dump	do	Dark-brown and brilliant-green fine-grained sandstone.	550	920	600	1,000	35,000	15	20	100	2	3	1,500	500	22,000

[1] For petrographic description see table 3.

TABLE 8.—*Description and analyses of samples from the Golden Gate Canyon area*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)							
				eU	U	Cu	Pb	Zn	As	Sb	Mo
F87-TL-53	2½ ft west of vein zone near Buckman adit.	6-in. channel	Medium dark-gray fresh hornblende gneiss.	20	<20	100	20	100	10	2	3
F88-TL-53	1½ ft west of vein near Buckman adit.	do	Moderate yellowish-brown iron-stained hornblende gneiss.	50	20	50	20	150	10	3	6
F89-TL-53	Vein zone near Buckman adit.	3-in. channel	Pale yellowish-brown bleached silicified hornblende gneiss.	8,200	10,700	250	70	200	20	10	16
F90-TL-53	1½ ft east of vein near Buckman adit.	6-in. channel	Medium dark-gray fresh hornblende gneiss.	20	<20	50	30	250	10	4	1
F91-TL-53	2 ft east of vein, Union Pacific prospect.	1-ft channel	Light-brown to dark yellowish-orange altered gneiss.	110	120	1,300	20	500	250	100	26
F92-TL-53	1 ft east of vein, Union Pacific prospect.	do	Moderate-brown to grayish-orange altered gneiss.	50	30	300	20	400	70	50	12
F93-TL-53	Vein zone, Union Pacific prospect.	do	Dark yellowish-orange altered gneiss, heavily coated with limonite.	320	200	4,000	300	900	1,000	500	20
F94-TL-53	1 ft west of vein, Union Pacific prospect.	do	Light-brown to dark-yellowish-orange altered gneiss.	100	50	3,000	600	500	800	500	32
F95-TL-53	2 ft west of vein, Union Pacific prospect.	do	do	150	60	2,000	500	500	400	250	20
F96-TL-53	3 ft west of vein, Union Pacific prospect.	do	do	50	20	2,000	300	700	500	250	20

TABLE 9.—*Semiquantitative spectrographic analyses of samples from the Golden Gate Canyon area* [1]

[Analyst, R. G. Havens]

Sample	Si	Al	Fe	Ti	Mn	Ca	Mg	Na	K	Ag	As
F87-TL-53	XX.	X.	X.+	0.X	0.X−	X.−	X.−	X.−	X.−	0	0
F88-TL-53	XX.	X.+	X.+	.X	.0X+	X.−	.X+	X.−	.X+	0	0
F89-TL-53	X.+	X.	X.+	.X−	.X	X.+	X.	X.−	X.−	Tr.	0
F90-TL-53	XX.	X.+	XX.	.X+	.X−	X.	X.	X.−	X.−	0	0
F91-TL-53	XX.	X.+	X.+	.X+	.X−	.X+	.X+	X.−	X.−	Tr.	0
F92-TL-53	XX.	X.+	X.+	.X+	.0X+	.X+	.X+	X.−	X.−	.000X−	0
F93-TL-53	XX.	X.+	XX.	.X+	.0X	.X	.X−	.X+	X.+	.00X	Tr.
F94-TL-53	XX.	X.+	X.+	.X	.X−	.X−	.0X+	.X	X.+	.00X−	Tr.
F95-TL-53	XX.	X.+	XX.	.X+	.X−	.X+	.X	.X+	X.+	.000X	0
F96-TL-53	XX.	X.+	X.+	.X+	.X−	.X+	.X+	.X+	X.	.000X−	0

Sample	Ba	Be	Bi	Co	Cr	Cu	Mo	Nb	Ni
F87-TL-53	0.00X+	0	0	0.000X+	0.000X+	0.0X−	0	0	0.000X
F88-TL-53	.0X+	0	0	.00X−	.00X−	.00X+	Tr.	0	.000X+
F89-TL-53	.00X+	.000X	Tr.	.000X−	.000X+	.0X+	Tr.	0	.000X+
F90-TL-53	.0X−	0	0	.00X	.000X+	.00X−	Tr.	0	.000X+
F91-TL-53	.0X+	.000X	0	.00X	.000X	.X−	.00X	0	.000X+
F92-TL-53	.0X	.000X	0	.00X	.000X+	.X−	.00X−	0	.000X
F93-TL-53	.0X	.000X	.0X−	.00X−	.000X+	.X	.00X+	.00X−	.00X−
F94-TL-53	.0X	0	.0X	.00X−	.00X−	.X	.00X+	.00X−	.000X+
F95-TL-53	.0X+	.000X+	.00X+	.00X	.000X+	.X−	.00X+	.00X	.000X+
F96-TL-53	.0X−	.000X	0	.00X	.000X−	.X−	.00X	.00X−	.000X+

Sample	Pb	Sb	Sc	Sr	U	V	Y	Yb	Zn	Zr
F87-TL-53	0.0X−	0	0.00X−	0.0X−	0	0.00X	0.00X	0.000X−	0	0.00X+
F88-TL-53	Tr.	0	.00X	.0X−	0	.00X	.00X+	.000X+	0	.0X−
F89-TL-53	.0X−	0	.00X	.0X−	.X+	.00X+	.0X−	.00X	0	.0X−
F90-TL-53	.00X−	Tr.	.00X	.0X	0	.0X−	.00X	.000X	0	.0X−
F91-TL-53	.00X	0	.00X	.0X	0	.0X−	.00X+	.000X+	Tr.	.0X−
F92-TL-53	.0X	0	.00X	.0X−	0	.0X−	.00X	.000X+	.0X	.0X−
F93-TL-53	.0X−	.0X	.00X	.0X−	0	.0X−	.00X+	.000X+	Tr.	.0X−
F94-TL-53	.0X+	.0X	.00X−	.00X+	0	.0X−	.00X+	.000X+	Tr.	.0X−
F95-TL-53	.0X+	.0X−	.00X	.0X−	0	.0X	.00X+	.000X+	Tr.	.0X−
F96-TL-53	.00X+	0	.00X	.0X−	0	.0X−	.00X	.000X	.0X	.0X−

[1] Looked for but not found: P, B, Cd, Ce, Ge, La, Nd, Sn, Au, Dy, Er, Gd, Hf, Hg, In, Ir, Li, Os, Pd, Pt, Re, Rh, Ru, Sm, Ta, Th, Tl, Te, W.

See Introduction, p. 340, for explanation of values given in table.

TABLE 10.—*Description and analyses of samples from the Diamond J ranch*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)											
				eU	U	Zn	Pb	Cu	Ni	Co	Sb	As	Mo	Mn	Fe
F4-TL-53	Top of cliff near north end of deposit.	1-ft channel	Moderate grayish-brown coarse sandstone and arkose.	60	50	150	50	50	<10	10	<1	60	3	25,000	165,000
F5-TL-53	1 ft below F4	do	Pale-brown very coarse sandstone	70	50	150	<10	20	<10	<10	1	40	1	1,500	165,000
F6-TL-53	2 ft below F4	do	Moderate yellowish-brown to dusky-brown very coarse sandstone.	140	50	140	<10	20	<10	<10	1	<10	6	2,500	155,000
F7-TL-53	3 ft below F4	do	Dark yellowish-orange to light-brown medium-coarse sandstone.	230	130	120	<10	20	<10	<10	<1	<10	3	1,000	105,000
F8-TL-53	4 ft below F4	do	Dark yellowish-orange coarse sandstone and arkose.	210	140	60	<10	20	<10	<10	<1	40	1	1,000	48,000
F9-TL-53	5 ft below F4	do	Dark yellowish-brown to grayish-brown coarse sandstone and arkose.	100	70	130	<10	50	<10	<10	1	40	3	7,500	190,000
F10-TL-53	Near F9	Grab	Moderate-brown arkose with dusky-brown coating.	300	180	130	<10	20	<10	<10	1	80	1	1,500	230,000
F11-TL-53	Cliff at east end of deposit.	1-ft channel	Moderate yellowish-brown to grayish-brown coarse arkose.	120	70	120	<10	20	<10	<10	1	100	1	5,000	150,000
F12-TL-53	25 ft west of F11 and 25 ft east of F7.	do	do	140	70	120	<10	20	<10	<10	1	80	3	15,000	165,000
F13-TL-53	Fracture coating 1½ ft west of F8.	Grab	Moderate-brown to dusky-brown coarse arkose.	130	50	100	<10	20	<10	<10	<1	20	6	7,500	190,000
F14-TL-53 [1]	West end of deposit, 25 ft west of F7.	1-ft channel	Dusky-brown coarse sandstone and arkose.	130	100	130	<10	<10	<10	<10	1	<10	<1	10,000	165,000
F15-TL-53		Random chip	Grayish-brown to dusky-brown coarse sandstone with dusky-brown radioactive fracture coating.	300	140	120	<10	<10	<10	<10	<1	<10	<1	10,000	105,000
F16-TL-53 [1]		do	Moderate-brown to dusky-brown arkose with dusky-brown radioactive fracture coating.	1,300	60	180	<10	<10	15	<10	1	30	3	2,000	190,000

[1] For petrographic description see table 3.

TABLE 11.—*Semiquantitative spectrographic analyses of samples from the Lucky Break iron mine* [1]

[Analyst, R. G. Havens]

Sample	Si	Al	Fe	Ti	Mn	Ca	Mg	Na	K	Ag	As	B
F1-TL-53	XX.	X.+	X.−	0.X	0.0X	0.0X+	0.X	0.X−	X.−	0	0	0.0X−
F1A-TL-53	XX.	X.	XX.	.X	.00X−	.0X+	.X	.X−	X.−	0	0	.00X+
F2-TL-53	XX.	X.−	XX.	.X−	.X−	.0X	.X−	.0X+	.X+	0	0	.00X
F3-TL-53	XX.	X.−	XX.	.X−	.0X−	.0X	.X−	.0X+	.X+	0	0	.00X

Sample	Ba	Be	Bi	Ce	Co	Cr	Cu	Ga	La	Mo	Nb	Nd
F1-TL-53	0.0X+	0	0	0	0.00X−	0.00X+	0.00X−	0.000X	0	0	0	0
F1A-TL-53	.0X	0	0	0	.000X+	.00X	.000X−	.000X	0	.00X	Tr.	0
F2-TL-53	.0X−	.000X	0	0	.0X−	.00X	.00X+	Tr.	0	.00X	Tr.	0
F3-TL-53	.0X−	.000X	0	0	.00X	.00X	.00X	Tr.	0	.00X	Tr.	0

Sample	Ni	Pb	Sb	Sc	Sr	Th	U	V	Y	Yb	Zn	Zr
F1-TL-53	0.00X+	Tr.	0	0.000X+	0.0X−	0	0	0.0X−	0.000X+	0.000X−	0	0.0X
F1A-TL-53	.00X	Tr.	0	.00X−	.0X−	0	0	.00X	0	.000X−	0	.0X
F2-TL-53	.0X	Tr.	0	.00X−	.00X	0	0	.00X	.00X	.000X	.X−	.0X−
F3-TL-53	.00X+	Tr.	0	.00X−	.00X−	0	0	.00X−	.00X−	.000X	.0X	.0X−

[1] See Introduction, p. 340, for explanation of values.

TABLE 12.—*Description and analyses of samples from the Ouray hot springs tufa deposit*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)										
				eU	U	Zn	Pb	Co	Sb	As	Mo	V	Mn	Fe
F49-TL-53 [1]	Tufa deposit about 250 ft southeast of the bridge.	Grab	Black and light-brown porous tufa	1,300	<20	500	<10	10	4	1,000	100	(2)	300,000	50,000
F50-TL-53	do	do	Moderate yellowish-brown porous laminated tufa.	80	<20	150	50	10	3	150	1	<300	20,000	13,000
F51-TL-53 [1]	do	do	Dark yellowish-brown porous tufa	20	<20	50	<10	<10	3	150	<1	<300	10,000	13,000
F52-TL-53	Tufa deposit 50 ft north of the bridge.	do	Dark yellowish-orange less porous tufa.	90	<20	500	<10	<10	100	2,000	20	(2)	5,000	300,000
F53-TL-53	do	do	Black and moderate-brown less porous tufa.	280	<20	150	20	<10	4	400	6	600	350,000	34,000

[1] For petrographic description see table 3.
[2] Concentration indeterminate because of interference.

TABLE 13.—*Description and analyses of samples from the Haputa ranch area*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)											
				eU	Zn	Pb	Cu	Ni	Co	As	Sb	Mo	V	Mn	Fe
F17-TL-53 [1]	Vein on Rare Earth Special No. 1 claim.	Grab	Light-brown and dark reddish-brown silicified vein material.	630	2,500	50	70	15	30	10	2	32	300	7,500	230,000
F18-TL-53	1 ft south of shear zone, cut above drill hole Ha-8, Haputa ranch.	1-ft channel.	Dark yellowish-brown altered amphibolite, with dark yellowish-orange limonite coating fractures.	50	200	<10	70	50	<10	30	1	<1	1,500	1,500	82,000
F19-TL-53	South wall of shear zone, 1 ft north of of F18.	do	Similar to F18 but locally impregnated with moderate-red hematite(?) or thorite.	60	180	20	70	40	<10	20	1	<1	3,000	1,000	88,000
F20-TL-53 [1]	2 ft north of F18	do	Altered amphibolite, stained with dusky-brown and yellowish-orange limonite cut by pale reddish-brown siliceous veinlets.	40	150	<10	130	30	<10	10	<1	<1	1,500	1,000	88,000
F21-TL-53	3 ft north of F18	do	Dark yellowish-brown and light-brown brecciated altered amphibolite.	260	500	100	70	60	10	30	<1	3	600	2,000	72,000
F22-TL-53	4 ft north of F18	do	Dusky-brown to moderate yellowish-brown and dark reddish-brown altered amphibolite with slickenside surfaces.	930	800	500	70	50	<10	40	1	1	1,500	1,500	60,000
F23-TL-53	5 ft north of F18	do	Moderate yellowish-brown silicified altered amphibolite.	540	400	2,000	50	30	<10	30	2	6	600	1,500	96,000
F24-TL-53	6 ft north of F18	do	Dark yellowish-orange altered amphibolite.	1,400 [2] (6,300)	200	500	100	30	20	60	3	1	600	1,500	52,000
F25-TL-53 [1]	North wall of shear zone 7 ft north of F18.	do	Dusky-brown vein filling and amphibolite breccia, with local spots of moderate red to dusky-red thorite(?).	3,800 [2] (18,000)	400	2,500	100	30	10	40	2	1	600	1,500	105,000
F26-TL-53	Wall rock 8 ft north of F18.	do	Moderate yellowish-brown altered amphibolite.	40	100	50	70	15	10	<10	<1	<1	3,000	1,000	96,000
F86-TL-53	Prospect pit east of drill hole Ha-8.	Grab	Light-gray, moderate-brown, and dark reddish-brown vein breccia with bladed texture in some fragments.	36,000 [2] (127,000)	150	50	150	<10	<10	80	5	<1	600	500	90,000

[1] For petrographic description see table 3.
[2] Chemically determined thorium.

TABLE 14.—*Description and analyses of samples from the Powderhorn district*

[Analysts: H. E. Crowe, R. F. DuFour, S. P. Furman, J. N. Rosholt, J. L. Siverly, and James Wahlberg]

Sample	Locality	Type	Description	Analyses (ppm)											
				eU	Zn	Pb	Cu	Ni	Co	Sb	As	Mo	V	Mn	Fe
F27-TL-53	Across Little Johnny vein, 2,000 ft west of ridge crest.	1-ft channel.	Dark yellowish-orange altered quartz-biotite gneiss.	1,200 [1] (5,500)	200	400	20	10	<10	3	80	32	1,500	500	70,000
F28-TL-53	1 ft south of F27	do	Moderate reddish-brown and black silicified quartz-biotite gneiss.	50	180	<10	20	<10	<10	1	20	1	300	500	62,000
F29-TL-53	2 ft south of F27	do	Light-brown and pale yellowish-brown altered quartz-biotite gneiss.	40	130	<10	40	<10	<10	<1	30	<1	600	250	37,000
F30-TL-53	1 ft north of F27	do	Moderate yellowish-brown quartz-biotite gneiss with dark yellowish-orange fracture coatings.	40	100	<10	20	<10	<10	1	20	1	600	1,000	51,000
F31-TL-53	2 ft north of F27	do	Altered gneiss with dark yellowish-orange, dark yellowish-brown, and dark reddish-brown, stains.	180	150	100	20	<10	<10	1	80	<1	5,000	1,500	72,000
F32-TL-53	Little Johnny vein, 25 ft east of F27.	2-ft channel.	Fractured silicified gneiss with dark reddish-brown and light-brown stains.	40	200	20	20	<10	<10	1	<10	6	<300	500	46,000
F33-TL-53	2 ft north of Little Johnny vein, 250 ft west of ridge crest.	1-ft channel.	Light-gray gneiss with dark yellowish-brown stains on fracture surfaces.	50	70	<10	50	<10	<10	1	80	2	300	500	56,000
F34-TL-53	1 ft south of F33	do	Moderate-brown silicified gneiss	40	150	50	70	<10	<10	2	40	8	300	500	39,000
F35-TL-53	2 ft south of F33	do	Moderate-red, light-brown, and dark yellowish-orange slightly porous vein material.	400	250	500	50	<10	<10	1	60	8	300	750	40,000
F36-TL-53 [2]	3 ft south of F33	do	Dusky-red vein material with dark yellowish-orange coatings, some of which are slightly porous.	1,300	800	300	70	15	<10	3	150	12	600	1,000	50,000
F37-TL-53	4 ft south of F33	do	do	3,500 [1] (16,000)	600	400	50	<10	<10	3	200	12	1,500	1,000	69,000
F38-TL-53	5 ft south of F33	do	do	1,800	500	300	50	<10	<10	3	150	1	600	1,000	51,000
F39-TL-53	6 ft south of F33	do	Light-gray silicified gneiss (wall rock) with light-brown to moderate yellowish-brown coatings.	20	150	<10	100	<10	<10	<1	10	<1	300	1,000	49,000
F40-TL-53	7 ft south of F33	do	Medium-gray to dark-gray gneiss (wall rock) cut by dark reddish-brown veinlets and coated with light-brown stains.	20	70	<10	50	<10	<10	<1	20	<1	300	500	40,000

See footnotes at end of table.

TABLE 14.—*Description and analyses of samples from the Powderhorn district*—Continued

Sample	Locality	Type	Description	Analyses (ppm)											
				eU	Zn	Pb	Cu	Ni	Co	Sb	As	Mo	V	Mn	Fe
F41-TL-53	20 ft north of vein, opencut on Jeanie No. 2 claim.	Grab	Yellowish-gray altered biotite gneiss cut by light-brown veinlets, altering to moderate yellowish-brown.	20	100	<10	20	<10	<10	<1	20	1	300	250	27,000
F42-TL-53	5 ft south of F41	do	Similar to F41 but veinlets are moderate yellowish brown.	10	60	<10	20	<10	<10	<1	40	2	600	500	26,000
F43-TL-53	10 ft south of F41	Grab	Light-brown to moderate-brown stained silicified gneiss.	20	50	50	20	<10	<10	<1	40	6	300	500	26,000
F44-TL-53 [2]	15 ft south of F41	do	Moderate-brown stained gneiss	30	70	20	20	<10	<10	1	100	20	600	500	36,000
F45-TL-53	20 ft south of F41	do	Moderate reddish-orange, black, dark yellowish-orange, and brown silicified gneiss and vein breccia, slightly porous locally.	170	60	<10	50	<10	<10	1	200	12	<300	2,500	39,000
F46-TL-53 [2]	Jeanie No. 2 claim 25 ft south of F41.	do	Moderate reddish-orange to moderate-red siliceous vein breccia in a moderate-brown slightly porous matrix.	950	150	20	100	15	<10	3	20	2	600	1,500	80,000
F79-TL-53	Little Johnny claim	do	Medium bluish-gray fresh quartz-biotite gneiss (country rock) with light-brown to moderate-brown fracture coatings.	10	200	50	150	<10	<10	<1	<10	1	300	750	45,000
F85-TL-53	Upper pit, Jeanie No. 2 claim.	do	Moderate reddish-orange and dusky-red silicified vein breccia in porous dark yellowish-orange to moderate-brown matrix.	90	130	20	100	15	<10	1	40	1	<300	1,000	31,000

[1] Chemically determined thorium.
[2] For petrographic description see table 3.

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