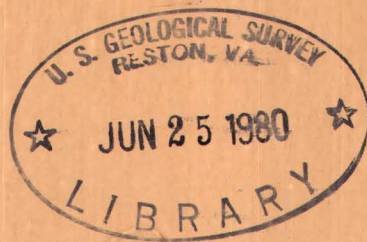


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Occurrences of Uranium- Bearing Minerals in the St. Kevin District, Lake County, Colorado

By C. T. Pierson and Q. D. Singewald



Trace Elements Investigations Report 234

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Geology and Mineralogy

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Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

OCCURRENCES OF URANIUM-BEARING MINERALS IN THE
ST. KEVIN DISTRICT, LAKE COUNTY, COLORADO*

By

C. T. Pierson and Q. D. Singewald

May 1953

Trace Elements Investigations Report 234

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

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

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OCCURRENCES OF URANIUM-BEARING MINERALS IN THE
ST. KEVIN DISTRICT, LAKE COUNTY, COLORADO

By C. T. Pierson and Q. D. Singewald

ABSTRACT

Two hundred and seventy-one prospect pits, mine dumps, or mine workings within the Sugar Loaf-St. Kevin mining districts and vicinity, were tested for radioactivity by the U. S. Geological Survey in 1951 during six weeks of investigation on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. One hundred and twenty-two weak radioactivity anomalies were found in the St. Kevin district and vicinity, and eight slight anomalies were noted in the Sugar Loaf district, which adjoins the St. Kevin district on the south. Most of the radioactivity anomalies were found in igneous and metamorphic rocks of pre-Cambrian age, but some were found in metalliferous veins of Tertiary age. Samples of altered granite or schist contain as much as 0.065 percent uranium, probably in the form of secondary uranium minerals. Samples of vein material contain as much as 0.013 percent uranium, also probably in the form of secondary uranium minerals.

At only a few localities has the identity of the uranium-bearing minerals been determined. Torbernite, associated with turquoise, malachite, and chrysocolla, occurs as disseminations and fracture coatings in altered granite at the Josie May turquoise mine; metatorbernite is disseminated in granite at the Turquoise Chief mine. Commonly the limonite-stained fractures in the altered granite and schist are radioactive; metatorbernite has been

identified in limonite stain at one locality. A uranium-variety of florencite, a hydrous cerium aluminum phosphate, is disseminated in the granite on the dump of a mine just west of the St. Kevin district, and autunite (?) is disseminated in fine-grained, highly silicified rock in the northeastern part of the St. Kevin district.

None of the uranium occurrences are of commercial importance. They are for the most part in non-glaciated terrane, which has been subjected to a very long period of weathering. Thus, chemical leaching within the zone of weathering may have greatly reduced the uranium content of material near the surface, and occurrences of even small quantities of secondary uranium minerals might be related to stronger, primary concentrations at depth.

INTRODUCTION

Purpose, scope, and acknowledgments

A reconnaissance for uranium-bearing minerals in the St. Kevin mining district, in an outlying area immediately to the west, and in the northern part of the adjoining Sugar Loaf mining district, Lake County, Colorado, was made in 1951 by the Geological Survey on behalf of the Division of Raw Materials of the Atomic Energy Commission. The reconnaissance was undertaken because of the identification in 1951 of torbernite in several samples collected by Singewald in 1936. The results of the reconnaissance provide a preliminary appraisal of the frequency, magnitude, and distribution of radioactivity anomalies, and their significance.

The field work was done during the periods of July 20 - August 19, and September 27 - October 23, 1951, by the following members of the Geological

Survey: Q. D. Singewald, four weeks; C. T. Pierson, six weeks; J. W. Mytton, two weeks; V. R. Wilmarth and R. C. Vickers, one day; D. L. Peck, three days. L. R. Page of the Geological Survey, and C. C. Towle, Jr. of the Atomic Energy Commission visited the St. Kevin district on August 1, 1951.

Examinations for uranium-bearing minerals were made of most of the prospect pits, mine dumps, and accessible mine workings in the St. Kevin district and in the region adjoining the district on the west. Fewer tests were made in the Sugar Loaf district because the general level of radioactivity was low.

Samples were taken at nearly all localities that exhibited radioactivity greater than 3 times background count, but only a few samples were taken at the localities of lesser radioactivity.

The writers are indebted to Mr. J. M. Kleff of Leadville for courtesies extended during the examination of the Lakewood Mine, and also to Mr. George S. Casey of Leadville, who generously contributed information and a map of the Wilkesbarre mine.

Geography

The Sugar Loaf and St. Kevin districts (figs. 1 and 2) are separated by Lake Fork Creek, and are on the eastern flank of the Sawatch range, 4 to 7 miles west-northwest of Leadville, the county seat of Lake County. The districts are reached by good secondary roads from Leadville, and, within the districts, most of the mines are accessible by moderately good to poor mountain roads. The relief is about 1,400 feet; altitudes range from about 9,700 feet to over 11,000 feet.

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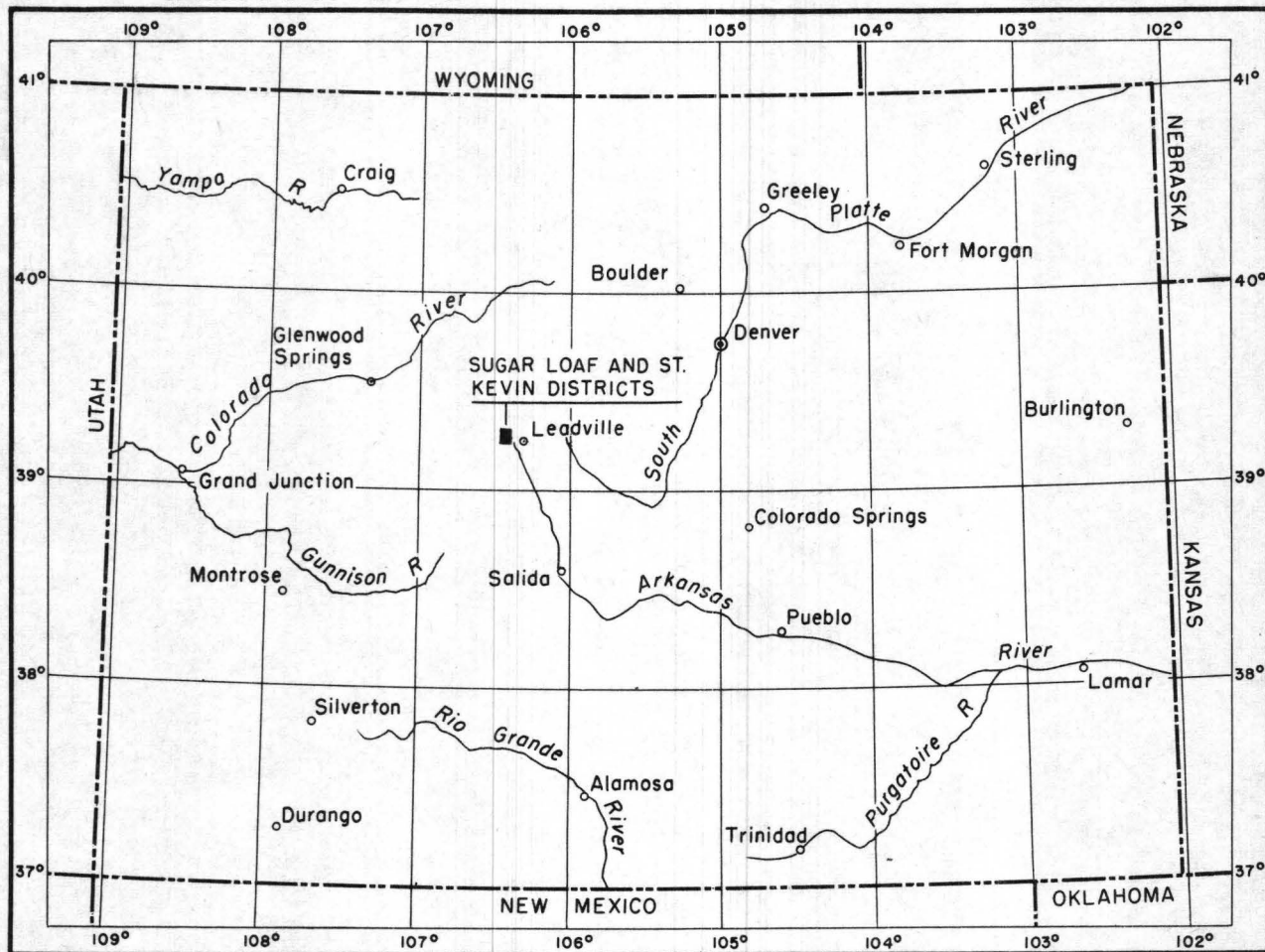


FIGURE 1—INDEX MAP OF COLORADO SHOWING LOCATION
OF SUGAR LOAF AND ST. KEVIN DISTRICTS

GEOLOGIC SETTING

The geology of the Sugar Loaf and St. Kevin districts has been studied by Singewald (in preparation), and the following is abstracted from his report. The bedrock (fig. 2) is composed mainly of schist and gneiss (Idaho Springs formation ?), granite (Silver Plume ?), and minor pegmatite, all of pre-Cambrian age, but dikes and irregularly shaped bodies of Tertiary igneous rock, tentatively correlated with the White porphyry of the Leadville district, occur locally. Most of the area is non-glaciated; however, Lake Fork Creek occupies a glacial valley. Unconsolidated deposits, consist of moraine, outwash gravel, alluvium, and gravel.

Only the schist and gneiss, mapped as a unit, and the granite, which approaches quartz monzonite in composition, are shown in figure 2. All types of bedrock have been intensely sericitized and locally silicified adjacent to fissures. One important effect of silicification has been the development of chert "dikes" and dike zones, and also of "chert disseminations" consisting of innumerable chert veinlets irregularly distributed through the country rocks.

During the Laramide orogeny the Sawatch Range was folded into a broad, anticlinal arch trending north-northwest, and faulted. Because of the sparse outcrops within the Sugar Loaf and St. Kevin districts, however, the details of the folding cannot be deciphered. The faults in the Sugar Loaf and St. Kevin districts have prevailing trends of north-northwest and east-northeast, and are indicated by veins, chert dikes, and zones of sericitized rock..

The ore deposits of the Sugar Loaf and St. Kevin districts are in composite veins along fissure zones within which the ore forms films,

veinlets, and veins. Silver has been the principal metal produced, although a few of the deposits have been worked for gold, and many contain subordinate zinc and lead. Turquoise occurs in several prospects in the south-central part of the St. Kevin district, but apparently these do not contain silver. Most of the production, which has an estimated value of between 10 and 15 million dollars, came during the last century; the output since that time has been intermittent.

RADIOACTIVITY MEASUREMENTS

In the Sugar Loaf-St. Kevin districts and vicinity, 271 prospect pits, mine dumps, or mine workings were tested for radioactivity during 1951. These localities, of which 130 are anomalously radioactive, are shown on plates 1, 2, and 3, and on figures 3, 4, and 5. The radioactivity, measured with radiation survey meters equipped with 6-inch Geiger-Müller beta-gamma probes, are recorded in table 1 in milliroentgens per hour, a unit of radiation intensity. No data are recorded in table 1 for non-anomalously radioactive localities shown on the illustration.

For each anomalously radioactive locality, both the maximum radioactivity reading obtained on the most radioactive specimen found and the range of background readings are listed in table 1. The maximum readings were obtained by repeated tests during which the probe was held directly against the specimens tested. The background readings were obtained by holding the probe waist-high for about one minute and recording the range of readings.

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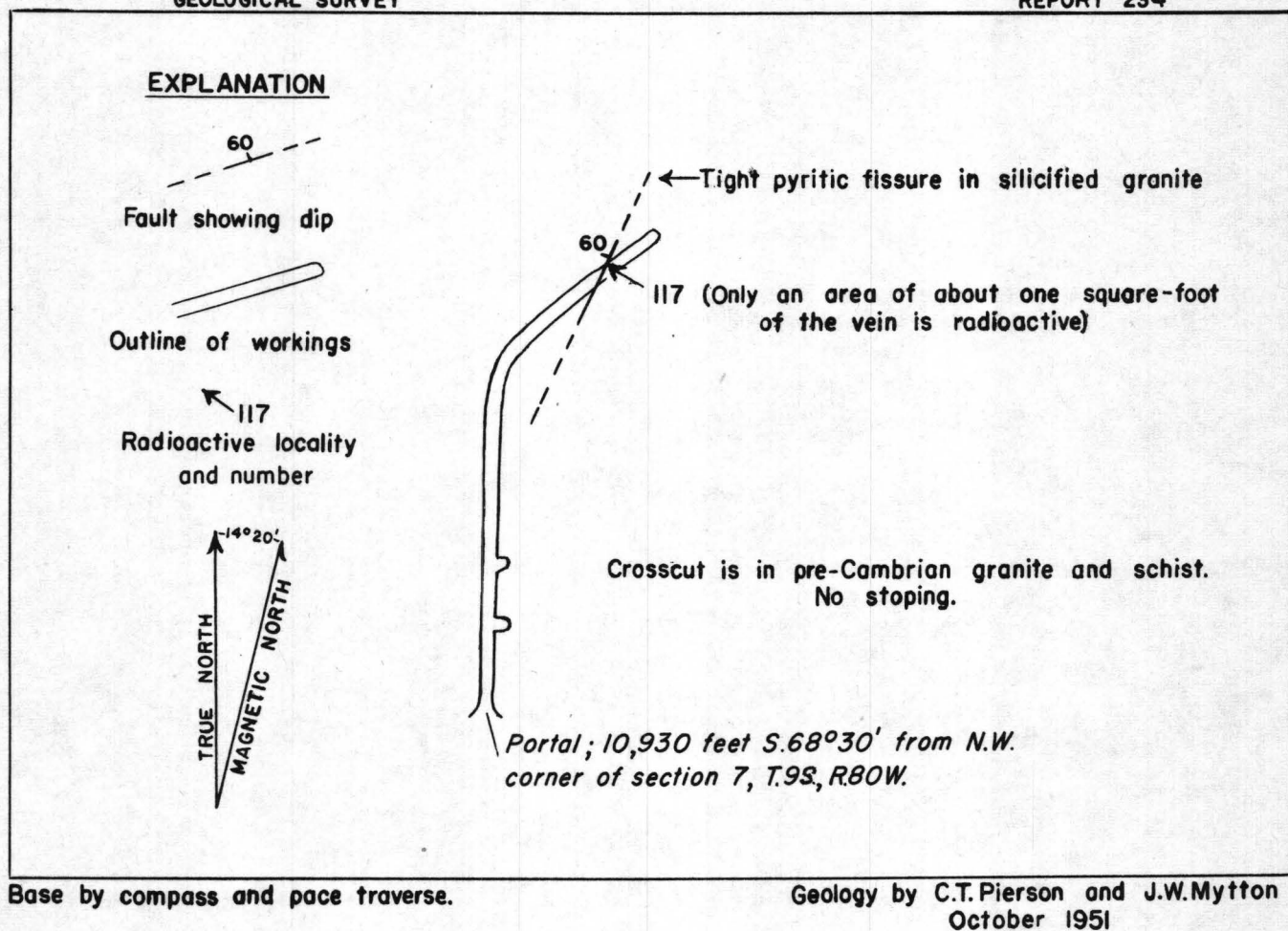
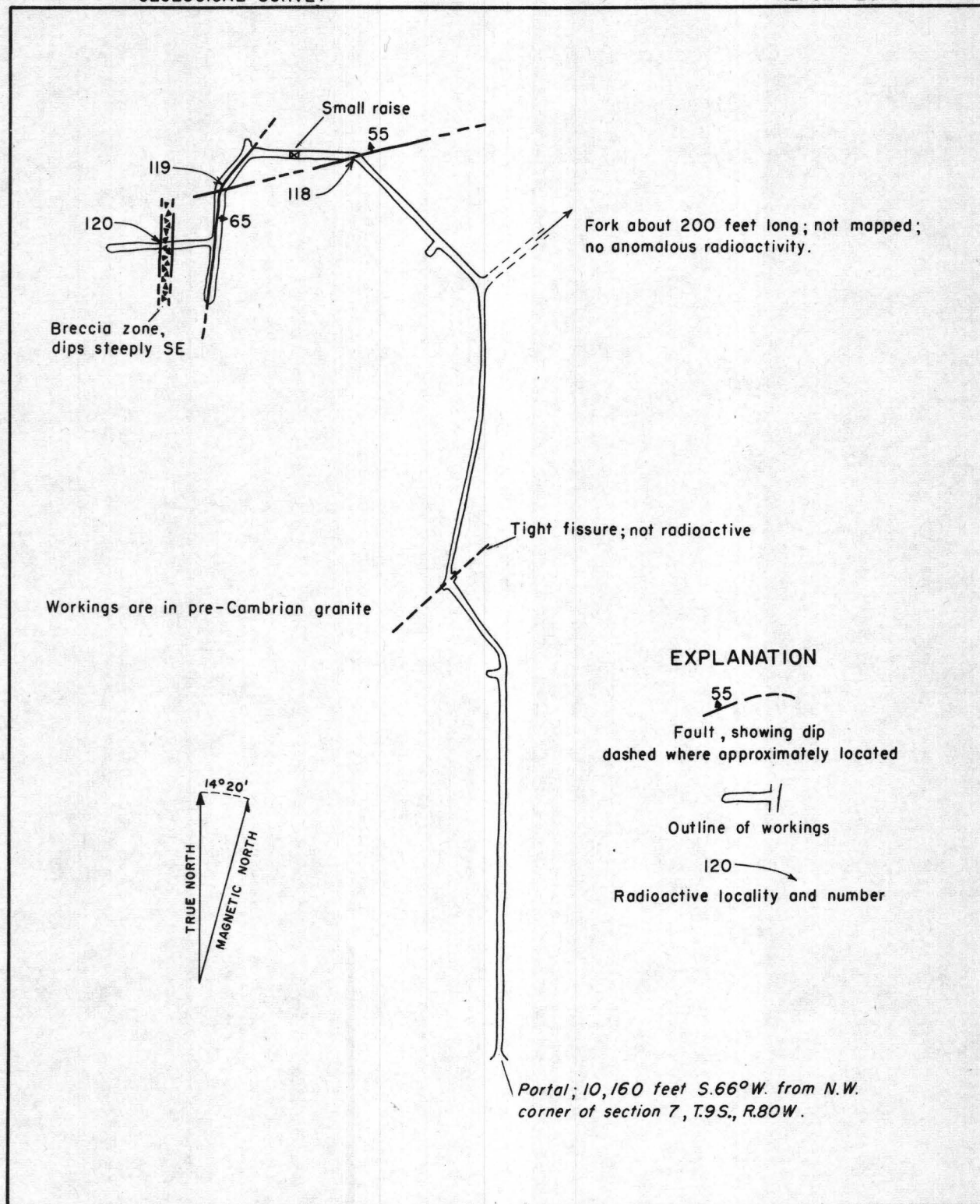


FIGURE 3 — MAP OF UNNAMED ADIT WEST OF THE ST. KEVIN DISTRICT, LAKE COUNTY, COLORADO, SHOWING RADIOACTIVE LOCALITY 117.

50 0 50 Feet

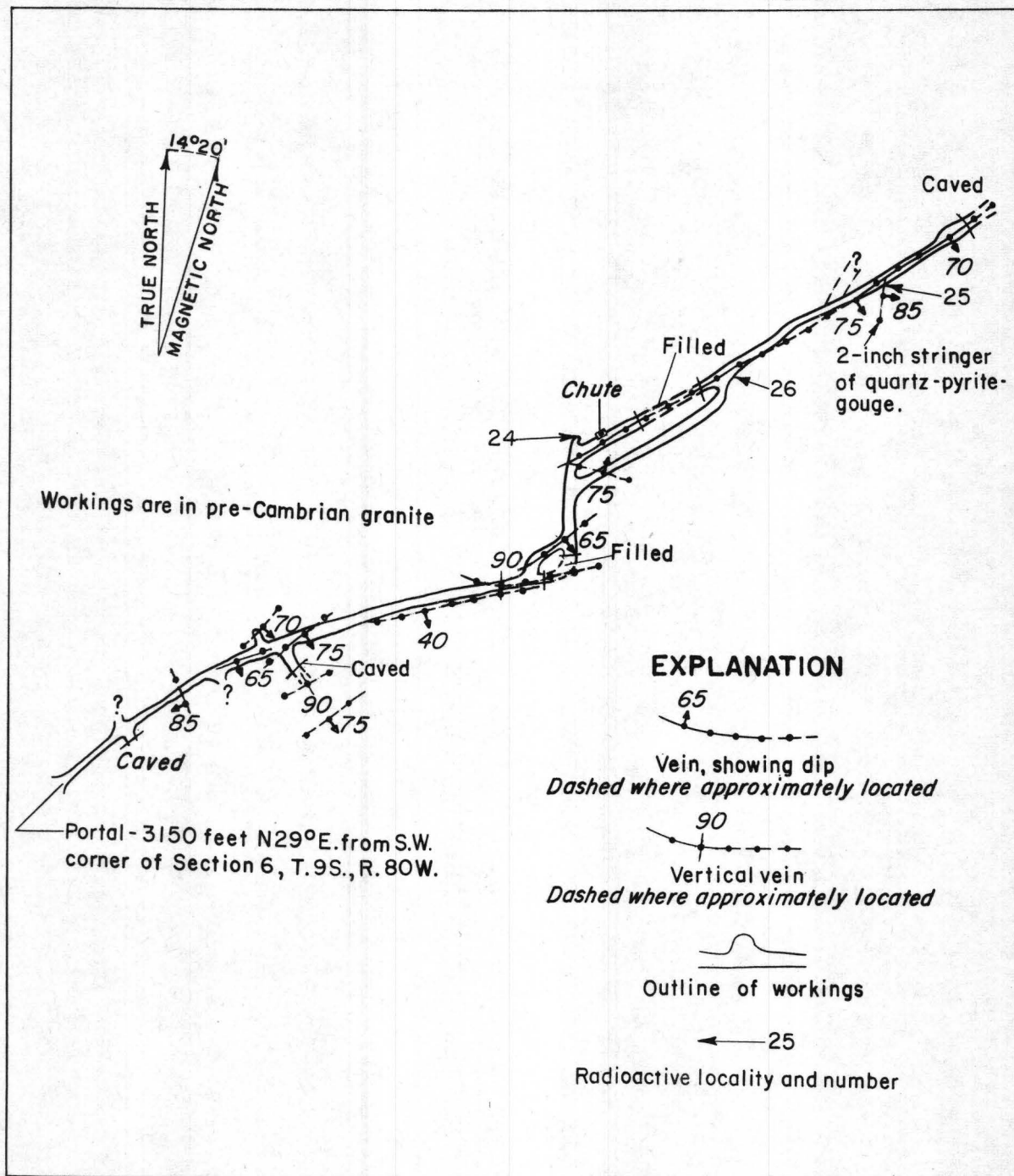


Base by compass and pace traverse

Geology by C.T. Pierson and J.W. Mytton
October 1951

FIGURE 4 — MAP OF UNNAMED ADIT WEST OF THE ST. KEVIN DISTRICT, LAKE COUNTY, COLORADO, SHOWING RADIOACTIVE LOCALITIES 118, 119, AND 120.

50 0 50 Feet



Mine workings from map by F.J. McNair,
with additions from compass and pace
traverse by Q.D. Singewald and C.T. Pierson.

Geology by Q.D. Singewald and C.T. Pierson,
August 1951

FIG. 5 - MAP OF LOWER WILKESBARRE ADIT, ST. KEVIN DISTRICT, LAKE COUNTY, COLORADO, SHOWING RADIOACTIVE LOCALITIES 24, 25 AND 26.

100 0 100 Feet

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity. /

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|--|
| 1 | 0.10 | 0.03-0.06 | - | - | Limonite-stained fractures in fine-grained rock, probably granitized schist from dump of prospect pit. |
| 2 | .10 | .03- .06 | - | - | Do. |
| 3 | .09 | .02- .06 | - | - | Limonite-stained fractures in slightly silicified granite and granitized schist from dump of caved adit. |
| 4 | .10 | .03- .06 | 0.005 | 0.002 | Relatively fresh granite from dump of caved adit. |
| 5 | .12 | .04- .06 | - | - | Limonite-stained fractures in granite from dump of caved shaft. |
| 6 | .30 | .03- .05 | 0.023 | 0.013 | Autunite (?) as disseminations in fine-grained, highly-silicified, limonite-stained rock from out-crop; the freshly broken surfaces of the rock exhibited nearly as much radioactivity as did the limonite-stained surfaces. Spectrographic analysis shows XX. Si; X. Al, Fe; .X Ti, Ca, Mg; .OX Mn, Na, Ba, La, Pb; .OOX Ag, B, Cr, Cu, Ni, Sr, V, Y, Zr; .OOOX Be, Co, Ga, Mo, Sc, Sn. |

/ Chemical, spectrographic, and mineralogical analyses by Washington and Denver Trace Elements Laboratories.

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 7 | 0.13 | 0.05-0.07 | - | - | Limonite-stained, and limonite and manganese-stained fractures in partly weathered granite, which is partly sericitized and silicified. From prospect trench. |
| 8 | .10 | .05- .07 | - | - | Limonite-stained fractures in granite from dump of Amity Shaft. |
| 9 | .12 | .03- .06 | - | - | Limonite-stained fractures in granitized schist from dump of caved adit. |
| 10 | .13 | .03- .07 | - | - | Limonite-stained surface of fragment of intensely sericitized and silicified granite transected by veinlets of vuggy quartz with very minor sulfide minerals; also Mn-stained surfaces of granite. From dump of caved shaft or prospect pit. |
| 11 | .20 | .03- .06 | 0.019 | 0.008 | Fracture coatings and disseminations in highly silicified and sericitized granite. Limonite and manganese stain is common, and pyrite and galena occur in vuggy quartz. From dump of Huckleberry shaft. The material presumably came from within the vein or the walls adjoining it, but is not ore. No uranium minerals identified. Spectro-graphic analysis shows XX. Si; X. Al, Fe; .X Ti, Ca, Mg, Pb, Zn; .OX Mn, Na, Ag, Ba; .00X B, Cr, Cu, Mo, Ni, Sr, V, Y, Zr; .000X Be, Ga, Sc. |

Table 1.-- Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 12 | 0.12 | 0.03-0.05 | - | - | Limonite-stained fractures in granitized schist from dump of prospect pit. |
| 13 | .08 | .04 | - | - | Disseminations (?) in relatively fresh granite-float near bedrock source. Hydrothermally altered granite and schist anomalously radioactive. |
| 14 | .08 | .03- .04 | - | - | Limonite-stained fractures in silicified granite from adit dump. |
| 15 | .08 | .03- .04 | - | - | Limonite-stained fractures in silicified granite from shaft dump. |
| 16 | .08 | .03- .04 | - | - | Limonite-stained fractures and disseminations in silicified granite from shaft dump. Relatively fresh granite-float nearby read 0.10. |
| 17 | .16 | .03- .04 | 0.008 | 0.004 | Black, sooty coatings on fractures in pyritized, silicified granite and pyritic, siliceous vein material from adit dump. Vugs of the vein material contain quartz, galena, and sphalerite (?). No uranium minerals identified. Spectrographic analyses shows XX. Si; X. Al, Fe; .X Ti, Ca, K, Zn; .OX Mn, Mg, Na, Ba, Cu, Pb; .OOX Ag, B, Cr, Ga, Ni, Sc, V, Y, Zn; .OOOX Be, Co, Sr. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 18 | 0.11 | 0.04-0.05 | - | - | Soft clay and limonite-stained fractures in highly-weathered, silicified and sericitized granite, exposed by a glory-hole. |
| 19 | .10 | .03- .06 | - | - | Limonite-stained granitic debris from dump of shallow prospect pit. |
| 20 | .09 | .03- .06 | - | - | Limonite-stained fractures in granite from dump of upper Wilkesbarre adit; vein-material on dump not anomalously radioactive. |
| 21 | - | - - | - | - | Dump of caved adit: doubtful anomalous radioactivity. |
| 22 | .18 | .03- .06 | 0.013 | 0.008 | Vein material and gouge from dump of lower Wilkesbarre adit. |
| 23 | .20 | .03- .06 | .018 | .013 | Disseminations (?) in fine-grained, intensely altered rock, probably from the vein-zone; from dump of lower Wilkesbarre adit. No uranium minerals identified. Spectrographic analysis shows XX. Si; X. Al, Fe; .X Ti, Ca, Mg; .OX Mn, Na, Ba, Pb, Zn; .OOX B, Co, Cr, Cu, La, Ni, Sc, Sr, V, Y, Zr; .OOOX Ag, Be, Ga. |
| 24 | .16 | .09- .14 | .014 | .013 | Intensely altered granite intermixed with gouge, and stained by limonite; forms foot-wall of Arty and Snow vein zone; exposed by lower Wilkesbarre adit; radon gas present. No uranium minerals identified. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 25 | 0.16 | 0.14 | 0.014 | 0.002 | Quartz, pyrite, and gouge from 2 inch-thick stringer in hanging wall of Arty and Snow vein zone; exposed by lower Wilkesbarre adit. Radon gas caused the exceptionally high background reading. |
| 26 | .13 | .13 | .009 | .005 | Chip-channel sample of crushed and gouge-permeated granite across 5-foot zone of hanging-wall of Arty and Snow vein zone, lower Wilkesbarre adit. Considerable amount of radon gas present. |
| 27 | .08 | .03- .04 | - | - | Silicified granite cut by quartz-pyrite-sphalerite veinlets; from adit dump. Silicified granite, schist, and pyritic vein material from dump not anomalously radioactive. |
| 28 | .08 | .04 | - | - | Disseminations (?) in relatively fresh granite from outcrop. |
| 29 | .11 | .03- .06 | - | - | Pegmatitic rock with smooth, limonite-stained surfaces. From dump of prospect pit sunk into pegmatite which grades into schist. |
| 30 | .11 | .03- .06 | - | - | Limonite-stained surfaces of partially granitized schist from dump of shaft; there is a relatively small amount of anomalously radioactive material in dump. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|--|
| 31 | 0.08 | 0.04 | - | - | Disseminations (?) in friable, limonite-stained granite from dump of lower Griffin adit. Vein material not anomalously radioactive. |
| 32 | .05 | .04 | - | - | Pyritic, siliceous vein material from adit-dump feebly radioactive; granite and schist not anomalously radioactive. |
| 33 | .08 | .04 | - | - | Fracture coatings and disseminations (?) in granite and schist from dump of shaft. |
| 34 | .09 | .04 | - | - | Limonite-stained fracture coatings and disseminations (?) in fairly fresh granite and schist from dump of Rosse Tunnel. Pyritic-siliceous vein material not anomalously radioactive. |
| 35 | .07 | .03- .04 | - | - | Disseminations (?) in relatively fresh granite from dump of Grand View shaft. Hydrothermally altered granite, pyritized granite, relatively fresh schist, and pyritic vein quartz not anomalously radioactive. |
| 36 | Feeble anomalous radioactivity | .03- .05 | - | - | Limonite-stained fractures in intensely sericitized granite from dump of shallow prospect pit sunk in schist and granite. (Schist is prevailing rock on dump). |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 37 | 0.12 | 0.03-0.05 | - | - | Pale-yellow, limonite-stained, intensely altered rock, probably from within or adjacent to the St. Kevin vein. From dump of inaccessible shaft. Highly-altered schist fragments from the same dump gave weaker readings; pyrite-quartz vein material not anomalously radioactive. |
| 38 | .18 | .03- .05 | 0.011 | 0.009 | Limonite-stained, rather porous, intensely silicified granite from dump of caved shaft. |
| 39 | .12 | .04- .06 | - | - | Limonite-stained fractures in granite from dumps of several closely clustered shallow prospect pits. |
| 40 | .20 | .05 | 0.050 | 0.028 | No uranium mineral identified. The uranium is associated with the biotite of coarse-grained, altered granite from dump of shallow pit in granite, schist, and jasperoid. Disequilibrium caused by excess radium; no thorium present. |
| 41 | .08 | .04 | - | - | Disseminations (?) in weathered but hydro-thermally unaltered granite from shaft dump. Limonite-stained fractures in the granite are slightly more radioactive than unstained surfaces. |
| 42 | .07 | .04 | - | - | Disseminations (?) in somewhat altered granite from dump of shallow pit. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|--|
| 43 | 0.08 | 0.04 | - | - | Disseminations (?) in moderately fresh granite from dump of prospect pit. Limonite-stained fractures in granite are slightly more radioactive than fresher surfaces. |
| 44 | .07 | .05 | - | - | Disseminations (?) in saussuritized granite from shallow trench. |
| 45 | .10 | .03-0.04 | - | - | Hematite and goethite-stained fractures in silicified granite from dump of shaft. Siliceous vein material not anomalously radioactive. |
| 46 | .12 | .03- .04 | - | - | Hematite-stained fractures in granite from dump of adit. |
| 47 | .10 | .03- .04 | - | - | Hematite and goethite-stained fractures in silicified granite from dump of shaft. Siliceous vein material not anomalously radioactive. |
| 48 | .08 | .04- .05 | - | - | Disseminations (?) in pyritized granite; iron-stained, silicified granite; and pyritic, siliceous vein material. From dump of adit. |
| 49 | .10 | .04- .05 | - | - | Disseminations (?) in pyritized, silicified granite from dump of adit. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|--|
| 50 | 0.12 | 0.03-0.05 | 0.007 | 0.001 | Relatively fresh granite from outcrop; radioactivity readings upon freshly broken surfaces nearly as high (0.06-0.10) as on manganese-stained surfaces (0.06-0.12). |
| 51 | .08 | .03- .04 | - | - | Limonite-stained fractures in silicified granite from adit dump. |
| 52 | 5.00 | .03- .04 | 0.043 | 0.018 | No uranium mineral identified. Uranium is associated with black fracture coatings in pyritic vein quartz from dump of caved adit. X-ray powder pattern of coating matches quartz and hydromica patterns. Spectrographic analysis shows XX. Si, X. Al, Fe, K; .X Na; .OX Ti, Mn, Ca, Mg, Ba; .00X B, Cr, Cu, Ga, Mo, Ni, Pb, Sc, Sr, V, Y, Zr; .000X Ag, Co. Disequilibrium caused by excess radium; no thorium detected. |
| 53 | .08 | .04 | - | - | Tight, unpyritized fissure in granite exposed in adit. Copper-stained White porphyry, silicified granite, and silicic vein material on dump not anomalously radioactive. Some relatively unaltered granite on dump read 0.07. |
| 54 | .08 | .01- .05 | 0.004 | <0.001 | Limonite-stained crushed rock and gouge along minor fissure in hanging wall, several inches away from vein; Lakewood mine. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 55 | 0.12 | 0.03-0.07 | - | - | Gossan, 1 foot thick, exposed in place just east of portal, upper Griffin adit. |
| 56 | .16 | .03- .06 | 0.024 | 0.015 | Breccia composed of chert and silicified granite fragments, and cemented by silica and limonite; from dump of workings west of upper main Griffin adit. No uranium minerals identified. |
| 57 | .17 | .02- .05 | - | - | Limonite-stained surface in very intensely altered granite from shaft dump. (Probably from footwall of vein). |
| 58 | .15 | *.02- .05 | 0.010 | 0.007 | Limonite-stained fractures and disseminations in sericitized, fine-grained hybrid rock from dump of shaft, Griffin vein zone. Spectrographic analyses shows XX. Si; X. Al, Fe; .X Ti, Mg, Pb; .OX Mn, Ca, Na, Ag, Ba, Cr, Cu, La; .OOX B, Ni, Sc, V, Y, Zr; .OOOX Be, Ga, Sn, Sr. |
| 59 | .13 | .02- .06 | - | - | Limonite-stained fractures in granite from dump of prospect pit. |
| 60 | .13 | .02- .06 | - | - | Limonite-stained fractures in granite from dump of shaft. |
| 61 | - | - | - | - | Dump of small pit; slight anomalous radioactivity. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 62-64 | 0.40 | 0.02-0.05 | 0.085 | 0.065 | Metatorbernite (?) in limonite and manganese-stained fracture coatings and as disseminations (?) in granite from dumps of three small prospect pits, Griffin vein zone. (Sample analysed was No. 64). Spectrographic analysis shows XX. Si; X. Al, Fe; .X Ca, Mg, Na, Ba; .0X Ti, Mn, Pb, Sr, U; .00X B, Cr, Cu, Mo, V, Y, Zr; .000X Ag, Be, Ga, Ni, Sc. Disequilibrium caused by excess radium; no thorium detected. |
| 65 | - | - | - | - | Dump of large pit; doubtful anomalous radioactivity. |
| 66 | .14 | .02- .08 | - | - | Limonite-stained fractures in granite from dump of small trench. |
| 67 | .09 | .02- .05 | - | - | Limonite-stained fractures in schist from dumps of two shallow prospect pits in schist and granite. |
| 68 | .09 | .02- .05 | - | - | Limonite-stained fractures in schist from dump of shallow prospect pit. |
| 69 | .13 | .02- .08 | - | - | Limonite-stained fractures in granite and schist from dump of shallow prospect pit. |
| 70 | .16 | .02- .08 | - | - | Limonite-stained fractures in granite and schist from dump of shallow prospect pit. |
| 71 | .19 | .02- .08 | 0.010 | 0.007 | Limonite-stained fractures in schist from dump of shallow prospect pit sunk into schist and granite. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 72 | 0.14 | 0.02-0.08 | - | - | Crumbled granite from dump of shallow prospect pit. |
| 73 | .09 | .02- .05 | - | - | Limonite-stained fractures in granite from dump of prospect pit. |
| 74 | .13 | .02- .08 | - | - | Maximum reading on freshly broken granite was 0.11; limonite-stained fractures gave readings of 0.13. Both from dump of shallow prospect pit. |
| 75 | .13 | .02- .08 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |
| 76-1 | .12 | .03- .05 | - | - | Weathered, moderately dark granite exposed along abandoned road. Radioactive through-out zone 50 feet thick. |
| 76-2 | .13 | .02- .05 | - | - | Limonite-stained fractures and disseminations (?) in dark-colored granite from dump of shaft. |
| 77 | .11 | .04- .06 | - | - | Limonite-stained surface of one block of silicified granite float in abandoned road. |
| 78 | .10 | .04- .06 | - | - | Unconsolidated granular material at surface, derived from granite in abandoned road. |
| 79 | .14 | .03- .08 | - | - | Limonite-stained fractures in granite from dump of caved shaft (?). |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 80 | 0.15 | 0.02-0.08 | - | - | Limonite films on fractures in granite and in partially silicified White porphyry from dumps of two shallow prospect pits, near caved shaft. |
| 81 | .17 | .03- .05 | - | - | Limonite-stained fractures in granite from dump of prospect pit. |
| 82 | .14 | .03- .08 | - | - | Limonite-stained fractures in granite from dump of prospect pit. |
| 83 | .16 | .02- .10 | 0.004 | 0.001 | Turquoise and chrysocolla (?) coat fractures in granite exposed by trench. |
| 84 | .16 | .03- .05 | - | - | Iron-stained fractures in granite from western part of bulldozer-cut 200 feet long. Turquoise found in middle part of cut. |
| 85 | Not recorded | - | - | - | Visible torbernite on surfaces of granite from two shallow pits. |
| 86 | .08 | .03- .04 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |
| 87 | 1.00 | .02- .10 | 0.005 | 0.002 | Disseminations and fracture coatings of visible torbernite associated with turquoise, malachite, and chrysocolla in granite, schist, and hybrid granite from dump of Josie May shaft. |

Table 1.—Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.—Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 88 | 0.08 | 0.03-0.04 | - | - | Limonite-stained fractures in granite from dumps of three shallow prospect pits. |
| 89 | .08 | .03- .04 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |
| 90 | .08 | .03- .04 | - | - | Limonite-stained fractures in granite from dump of shallow pit. |
| 91 | .13 | .02- .08 | - | - | Limonite-stained fractures in granite from dump of shallow pit. |
| 92 | .11 | .02- .04 | - | - | Limonite-stained fractures in granite from dump of prospect pit. |
| 93 | .15 | .02- .08 | 0.005 | 0.001 | Pyritic, limonite-stained, silicified granite from dump of caved shaft. |
| 94 | .12 | .02- .08 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |
| 95 | - | - | - | - | Dump of pit: doubtful anomalous radio-activity. |
| 96 | .40 | .02- .08 | 0.010 | 0.005 | Limonite-stained fractures in schist exposed by prospect pit, which also exposes granite. |
| 97 | .11 | .02- .08 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-------------------|---|-----------------------------------|------------------------------|-------------------|---|
| 98 | 0.16 | 0.01-0.06 | 0.011 | 0.006 | Disseminations and fracture-coatings in muscovite-chlorite schist from dump of shallow prospect pit, which also contains granite. |
| 99 | .19 | .01- .06 | 0.004 | 0.002 | Limonite-stained, slickensided surfaces in chloritic schist which came from within or nearby a prospect pit. |
| 100 | - | - | - | - | Dump pit: doubtful anomalous radioactivity. |
| 101 | - | - | - | - | Dump pit: doubtful anomalous radioactivity. |
| 102-105 (see 106) | | | | | |
| 106 | .14 | .03- .07 | 0.005 | 0.001 | Films on fractures in both granite and amphibolite (?) from dumps of several shallow prospect pits. (Composite sample 102-105). |
| 107 | .11 | .03- .06 | - | - | Limonite-stained fractures in granite from dump of caved adit. |
| 108 | .09 | .03- .06 | - | - | Unconsolidated granular material at surface; derived from granite. |
| 109 | .13 | .03- .05 | - | - | Small chunks of soft limonite-gossan, slightly Mn-stained. From dump of shaft. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|--|
| 110 | 0.40 | 0.02-0.10 | 0.017 | 0.009 | Metatorbernite (?) disseminated in granite exposed by open cut, Turquoise Chief mine. Spectrographic analysis shows XX. Si; X. Al, Fe; .X Ca, Mg, Na; .OX Ti, Mn, Ba, Cu, La; .OOX B, Cr, Ni, Pb, Sr, V, Y, Zr; .OOOX Ag, Be, Co, Ga, Sc, Sn. |
| 111 | .07 | .02- .04 | 0.007 | 0.004 | Turquoise (?) and chrysocolla (?) coatings on fractures in granite from dump of caved adit. |
| 112 | .07 | .02- .04 | - | - | Limonite-stained fractures in granite from dump of shallow prospect pit. |
| 113 | .08 | .02- .04 | - | - | Iron-stained surface of granite fragment from dump of prospect pit. |
| 114 | .06 | .02- .04 | - | - | Granite exposed by trench-like erosion of about 60 feet of old road. |
| 115 | .30 | .03- .06 | 0.021 | 0.014 | Limonite-stained, weathered schist from dump of shallow prospect pit. Goethite contains the uranium. Spectrographic analysis shows XX. Si; X. Al, Fe; .X Ti; Mn, Ca, Mg, Na; .OX Ba, Cr, La, Pb, V, Zn; .OOX B, Mo, Ni, Sc, Sn, Sr, Zr, Y; .OOOX Ag, Be, Co, Cu, Ga. |
| 116 | .19 | .02- .08 | 0.004 | 0.001 | Limonite-stained films on fractures in granite, and disseminations in silicified White porphyry and jasperoid from dump of prospect pit. |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses |
|-------------------|---|-----------------------------------|------------------------------|-------------------|---|
| 117 | 0.90 | 0.04 | 0.069 | 0.003 | Disseminations in pyritized, silicified granite from tight fissure exposed by adit. No uranium mineral identified. Disequilibrium caused by excess radium; no thorium detected. |
| 118 | 1.00 | .09 | .015 | .005 | Disseminations in silicified granite from footwall of a pyritic vein 1 foot wide, about 3 feet from the vein. (Vein material 0.15-0.18 mr. per hr.); exposed by adit. No uranium mineral identified. Spectrographic analysis shows XX. Si; X. Al, Fe; .X Pb; .OX Ti, Mn, Ca, Na, Ba, Cu, Zn; .OOX Ag, B, Ga, Sn, Sr, V, Zr; .OOOX Mg, Cr, Ni. |
| 119 | .18 | .09 | - | - | Pyritic veinlets exposed by adit. |
| 120 | .18 | .09 | - | - | 6-foot thick breccia zone in granite; exposed by adit. |
| 121 | .20 | .03- .04 | 0.034 | 0.004 | Florencite, the uranium-bearing mineral, occurs as disseminations in pyritized granite from adit dump. |
| 122 | .15 | .03- .08 | .005 | <.001 | Limonite-stained fractures in sericitized granite from several dumps and exposures along road. (Composite of 123-127). |
| 123-127 (see 122) | | | | | |

Table 1.--Radioactivity anomalies, Sugar Loaf, St. Kevin mining districts and vicinity.--Continued

| Locality number | Maximum radio-activity reading in mr. per hr. | Background reading in mr. per hr. | Equivalent uranium (percent) | Uranium (percent) | Occurrences of the radioactive minerals and results of mineralogical and spectro-graphic analyses |
|-----------------|---|-----------------------------------|------------------------------|-------------------|---|
| 128 | 0.12 | 0.03-0.05 | - | - | Granite from dump of prospect pit. |
| 129 | .09 | .03- .04 | - | - | Manganese-stained fractures in silicified granite from shaft dump. Limonite-stained, silicified granite; pyritized, silicified granite; and pyritic, siliceous vein material not anomalously radioactive. |
| 130 | .08 | .03- .04 | - | - | Iron and manganese-stained fractures in silicified granite from shaft dump. Granitized schist and silicic vein material not anomalously radioactive. |

A locality is considered to be anomalously radioactive if the ratio of the maximum radioactivity reading to the maximum background reading is equal to or greater than 1.3. The range of ratios for localities tested is 1.0 - 124.9. Each locality has been assigned to one of three ratio groups (pls. 1, 2, and 3). A few localities, e.g. 21, 36, and 61, described in table 1 as having slight, feeble, or doubtful anomalous radioactivity, but for which no radioactivity readings are recorded, are shown on plates 1 and 2 as belonging to the second category (weak anomalous radioactivity). Localities 24, 25, and 26, where the ratios are low because of the unusually high background readings caused by radon gas, are assigned to the third category (stronger anomalous radioactivity). Locality 85, for which radioactivity readings are not recorded, is also assigned to the third category because of the presence of torbernite in some of the specimens.

Besides providing a quick visual method of distinguishing between non-anomalously radioactive localities, and the two categories of anomalously radioactive localities, the foregoing ratios give a rough indication of the percent equivalent uranium existing at localities where this percentage has not been determined by laboratory analysis. As indicated below, the percentages of equivalent uranium for twenty-four of the thirty-three localities for which laboratory analyses are available fall into two distinct groups when arranged according to the magnitude of their associated ratios.

Associated ratiosPercent equivalent uranium

1.3 - 3.0

0.004 - 0.013; 13 localities,
excluding 56 (0.024)

Greater than 3.0

Greater than 0.013; 11
localities, excluding 99
(0.004), 87 (0.005), 17
(0.008), 96 (0.010), and
38 (0.011).

Note: Localities 24, 25, and 26 do not fall into the above groups because of the unusually high background readings caused by radon gas.

THE URANIUM OCCURRENCES

Uranium minerals in the St. Kevin district and vicinity are found in metalliferous veins of Tertiary age and as disseminations and fracture coatings in pre-Cambrian igneous and metamorphic rocks that were hydrothermally altered in advance of vein formation. Descriptions of the occurrences are found in table 1.

Anomalous radioactive vein material was found in the St. Kevin district at eleven mine dumps (e.g. loc. 11, Huckleberry vein; and loc. 37, St. Kevin vein), and, also, at several places within the few underground workings now accessible (e.g. loc. 24 to 26, Arty and Snow vein zone; and 117 and 119, unnamed veins). The radioactive vein material consists of gouge and intensely sericitized and silicified granite transected by veinlets of vuggy quartz containing minor amounts of sulfide minerals. Samples of the vein material contain as much as 0.013 percent uranium, but the radioactive mineral, which probably is secondary, has not been identified. Vein material, however, is low in radioactivity at some localities where radioactivity anomalies were found on fracture coatings of wall rock (e.g. loc. 13, 20, 31, and 34).

Torbernite, associated with turquoise, malachite, and chrysocolla, occurs as disseminations and fracture coatings in altered granite at the Josie May turquoise mine (loc. 87) in the south-central part of the St. Kevin district. At locality 85, near the Josie May mine, torbernite is found on surfaces of granite from two shallow prospect pits. Metatorbernite is disseminated in granite at the Turquoise Chief mine (loc. 110).

Disseminations of radioactive minerals are present at several places in the St. Kevin district, most commonly in sericitized granite (e.g. loc. 13, 16, 28, 31), but at a few localities (e.g. 33, 98) in schist. The uranium minerals in most of the disseminated occurrences have not been identified, but autunite (?), metatorbernite, and uranium-bearing florencite have been identified at localities 6, 64, and 121, respectively. These and perhaps also other secondary uranium minerals probably account for most or all of the radioactivity anomalies resulting from disseminated uraniferous minerals.

The limonite-stained fractures in weathered granite and schist from the dumps of many of the mines and small prospect pits in the St. Kevin district are anomalously radioactive (e.g. 1, 7, 39). Except for metatorbernite at locality 64, uranium minerals that could account for the radioactivity have not been identified.

Although primary uranium minerals have not been found, it is probable that the uranium minerals in vein material in the St. Kevin district formed as a result of supergene alteration of primary pitchblende. The secondary uranium minerals that coat fractures may have resulted from the supergene redistribution of primary uranium minerals in the igneous rocks, fresh samples of which (loc. 4 and 50) contain as much as 0.007 percent equivalent

uranium, and 0.002 percent uranium; yet these occurrences are mostly restricted to rocks that were hydrothermally altered during Tertiary time, and therefore the secondary uranium minerals may be derived from pitchblende that was deposited by hydrothermal solutions.

The uranium occurrences in the St. Kevin district are largely in non-glaciated terrane, which has been subjected to a very long period of weathering; and accordingly nearly all the rocks containing the uranium are weathered. Thus, chemical leaching within the zone of weathering probably has greatly reduced the uranium content of material near the surface, and occurrences of even small quantities of secondary uranium minerals might be related to stronger concentrations at depth. However, if stronger concentrations are present at depth, their size and grade may be much less than would be required for exploitation.

Data from which to estimate the depth to unweathered rock are exceedingly meager. Complete oxidation probably extends to depths ranging from a few feet to not more than 60 feet throughout the district, but partial oxidation along selected fractures may extend several hundred feet deeper.

All the analysed samples from the Sugar Loaf-St. Kevin districts and vicinity are in a state of disequilibrium, that is the percent equivalent uranium is greater than the percent uranium. In some samples as at localities 40, 52, 64, and 117, the differences are relatively large. Laboratory analyses show that the difference between total radioactivity and the radioactivity due to uranium is caused by surplus radium and other daughter products of uranium. As Phair and Levine (1952) have shown in their studies of the leaching of pitchblende, the most probable cause for this disequilibrium is the leaching of uranium by supergene processes.

UNPUBLISHED REPORTS

Phair, George, and Levine, Harry, 1952, Notes on the differential leaching of uranium, radium, and lead from pitchblende in H_2SO_4 solutions:
U. S. Geol. Survey Trace Elements Inv. Rept. 262 (TEI-262, 1952, U. S. Atomic Energy Comm., Tech. Inf. Service, Oak Ridge, Tenn.)

Singewald, Q. D., Sugar Loaf and St. Kevin mining districts, Lake County, Colorado, with a section on Petrography of the bedrock by John G. Broughton, U. S. Geol. Survey Bull., in preparation.

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SUMMARY AND SUGGESTIONS FOR PHYSICAL EXPLORATION

An abundance of radioactivity anomalies that disclosed traces of uranium-bearing minerals, and that yielded selected samples which assayed more than 0.01 percent uranium, indicates widespread uranium mineralization throughout part of the St. Kevin district. Most of the occurrences are in weathered rock, at or very close to the surface, in non-glaciated terrane where much of the original uranium probably was leached during long-continued weathering. Thus, although none of the known occurrences may now be regarded as ore, further prospecting is warranted. Potentialities can be evaluated adequately only by means of physical exploration because the covering of soil and float rock limits the collection of data by reconnaissance methods to scattered prospect pits and mine dumps. However, more reconnaissance for radioactivity should be done before physical exploration is undertaken.

The Geological Survey has no plans for further work in the Sugar Loaf and St. Kevin districts at this time. If in the future, however, it is desirable to resume work in the area, the following localities are considered most favorable for further investigations by reconnaissance and by physical exploration.

Exploration in the vicinity of the prospect pits listed in table 2 probably can best be accomplished by surface trenching to delineate the radioactive zones, supplemented by diamond core drilling to determine the extent and grade of the zones at depth. The trenching, guided by frequent checks with a radiation meter, could be accomplished by dynamite-bulldozer

methods to depths of 8 to 10 feet. The first step at mine localities listed in table 3 would be to follow known leads by means of drifting, cross-cutting, raising, and sinking.

Table 2.—Surface localities at which physical exploration is suggested. (Listed in order of preference.)

| Locality number | Ratio—/ | Equivalent uranium (percent) | Uranium (percent) | Remarks |
|-----------------|---------|------------------------------|-------------------|--------------------|
| 110 | 4.0 | .017 | .009 | Metatorbernite (?) |
| 64 | 8.0 | 0.085 | 0.065 | Metatorbernite (?) |
| 58 | 3.0 | .010 | .007 | — |
| 115 | 5.0 | .021 | .014 | — |
| 87 | 10.0 | .005 | .002 | Torbernite |
| 85 | — | — | — | Torbernite |
| 6 | 6.0 | 0.023 | 0.013 | Autunite (?) |
| 81 | 3.4 | — | — | — |
| 98 | 2.7 | 0.011 | 0.006 | — |
| 96 | 5.0 | .010 | .005 | — |
| 99 | 3.2 | .004 | .002 | — |

/ Ratio of maximum radioactivity to maximum background count.

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Table 3.—Mine localities suggested for physical exploration. (Listed in order of preference)

| Locality number | Ratio [/] | Equivalent uranium (percent) | Uranium (percent) | Remarks |
|----------------------|--------------------|------------------------------------|----------------------|--|
| 117 (See fig. 3.) | 22.5 | 0.069 | 0.003 | Tight fissure with attitude N. 25° E., 60° NW; 124 feet N. 15° E. from portal of adit located 10,930 feet S. 68° 30' W. from NW corner of sec. 7, T. 9 S., R. 80 W. |
| 24 (See fig. 5.) | 1.1 (radon gas) | .014 | .013 | Footwall of vein exposed by short cross-cut; 380 feet N. 54° E. from portal of lower Wilkesbarre adit located 3,150 feet N. 29° E. from SW corner of sec. 6, T. 9 S., R. 80 W. |
| 25 (See fig. 5.) | 1.1 (radon gas) | .014 | .002 | Hanging wall of vein 590 feet N. 56° 30' E. from portal of lower Wilkesbarre adit. |
| 26 (See fig. 5.) | 1.0 (radon gas) | .009 | .005 | Hanging wall of vein 482 feet N. 57° E. from portal of lower Wilkesbarre adit. |
| 87 | 10.0 | .005 | .002 | Torbernite on dump of Josie May mine located 1,380 feet S. 24° 30' E. of the NW corner of sec. 7, T. 9 S., R. 80 W. Mine will have to be unwatered. |

[/] Ratio of maximum radioactivity to maximum background countOFFICIAL USE ONLY

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Table 3.--Mine localities suggested for physical exploration. (Listed in order of preference)--Continued

| Locality number | Ratio | Equivalent uranium (percent) | Uranium (percent) | Remarks |
|----------------------|-------|------------------------------------|----------------------|--|
| 118 (See fig. 4.) | 11.1 | .015 | .005 | Footwall of pyritic vein striking N. 75° E., and dipping 55° NW; 300 feet N. 8° W. from portal of adit located 10,160 feet S. 66° W. from NW corner of sec. 7, T. 9 S., R. 80 W. |
| 119 (See fig. 4.) | 2.0 | -- | -- | Pyritic veinlet strike ranging from N. 7° E. to N. 38° E. and dipping 65° SE; 303 feet N. 17° 30' W. from portal of adit of locality 118. |
| 120 (See fig. 4.) | 2.0 | -- | -- | Breccia zone striking N. 1° E. and dipping steeply SE. 293 feet N. 23° W. from portal of adit of locality 118. |

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