GEOLOGICAL SURVEY CIRCULAR 321

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

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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

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ABSTRACT

Two hundred and seventy-one prospect pits, mine dumps, or mine workings within the Sugar Loaf and 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 radioactive anomalies were found in pre-Cambrian igneous and metamorphic rocks, 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 is of commercial importance. They are for the most part in nonglaciated 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 concentrations of primary minerals at depth.

INTRODUCTION

Purpose, scope, and acknowledgments

A radioactivity reconnaissance of the St. Kevin mining district, an outlying area immediately to the west, and 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 U. S. Atomic Energy Commission. The reconnaissance was undertaken because in 1951 torbernite was identified in several samples previously collected by Singewald. 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 summer of 1951 by Q. D. Singewald, C. T. Pierson, J. W. Mytton, V. R. Wilmarth, R. C. Vickers, and D. L. Peck.

Examinations for radioactivity 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 most localities that exhibited radioactivity greater than 3 times background count, but only a few were taken at the weakly radioactive localities.

The writers are indebted to J. M. Kleff of Leadville for courtesies extended during the examination of the Lakewood mine, and also to 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, and 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 more than 11,000 feet.

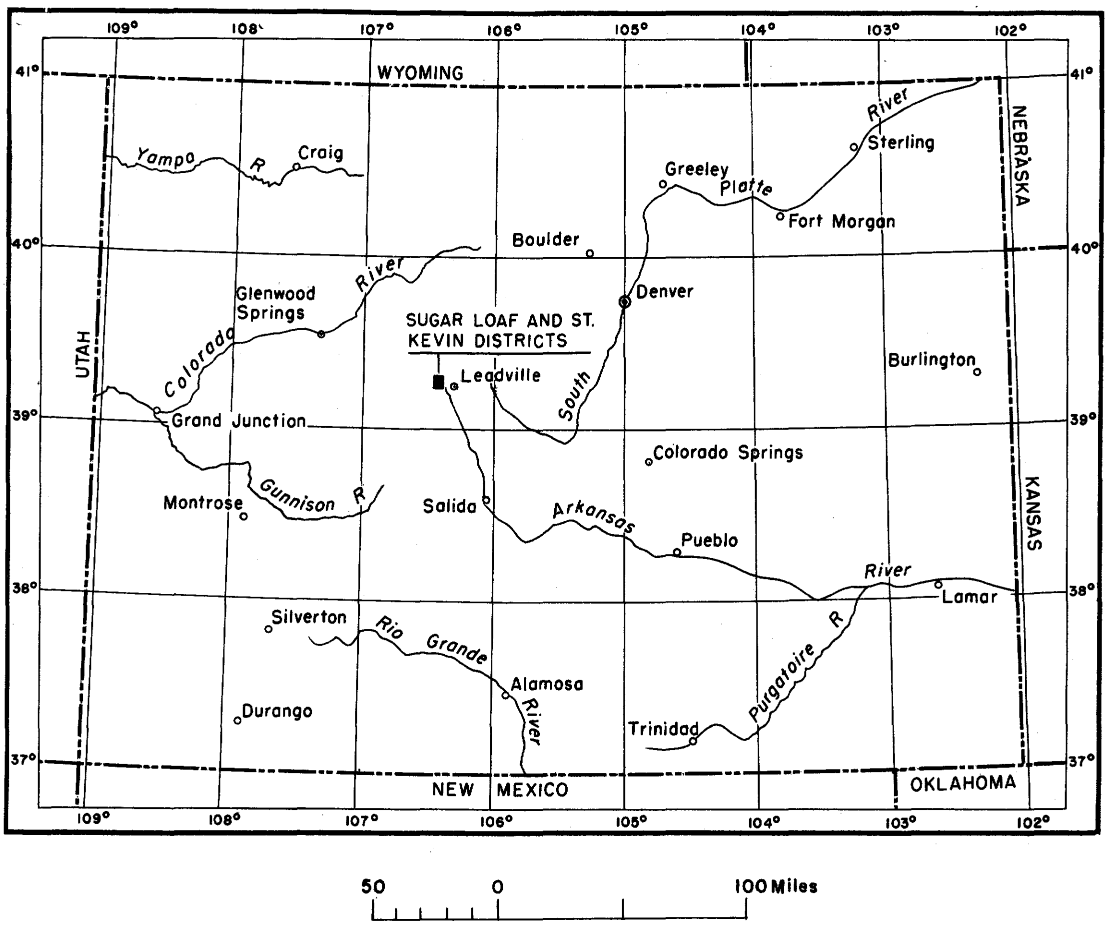

Figure 1.—Index map of Colorado showing location of Sugar Loaf and St. Kevin districts.

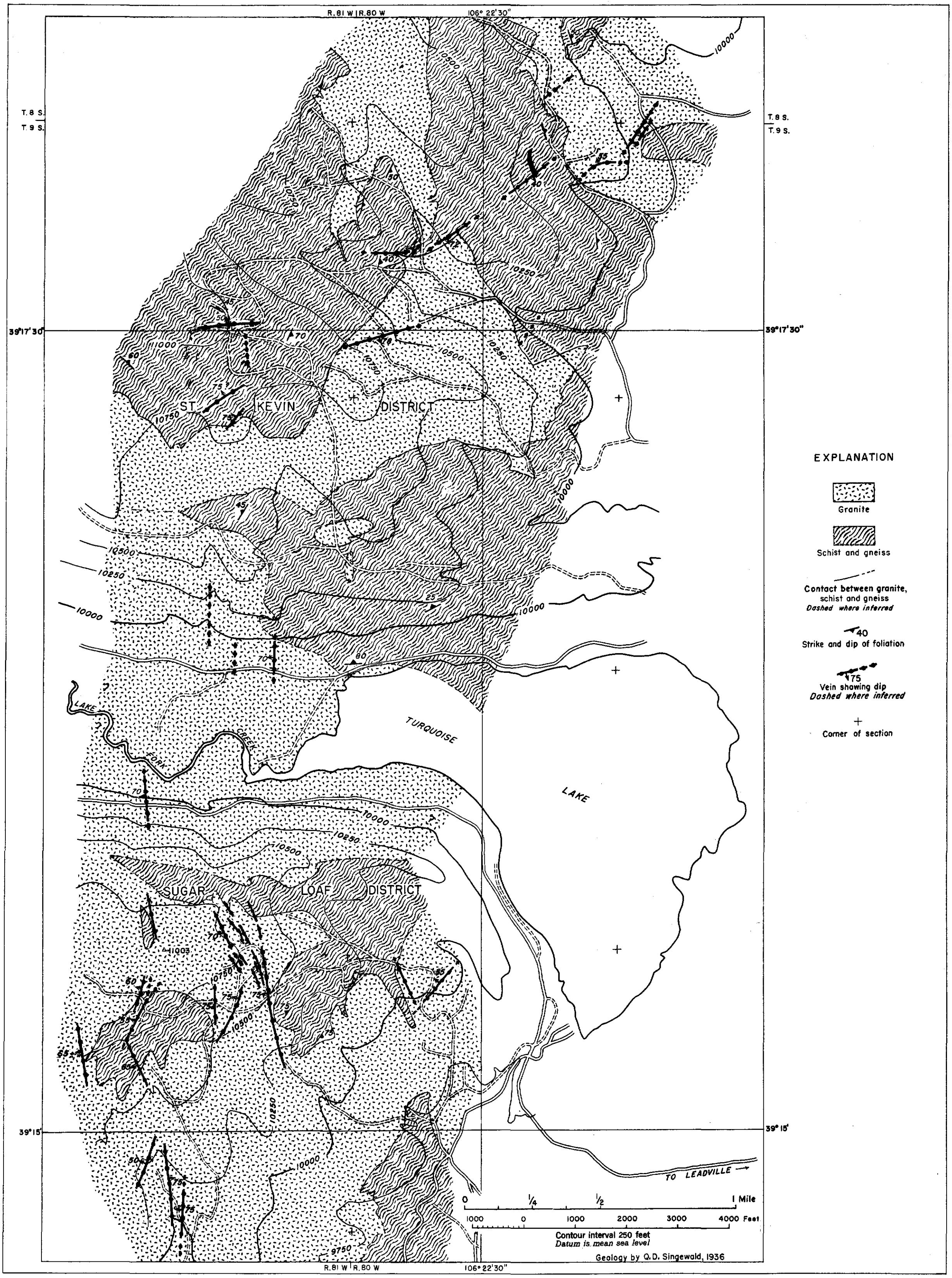

Figure 2. —Generalized geologic map of the Sugar Loaf and St. Kevin district, Lake County, Colorado, showing vein pattern.

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 pre-Cambrian rocks including schist and gneiss of the Idaho Springs formation(?), the Silver Plume(?) granite, and minor pegmatites, 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 nonglaciated; 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 area of the Sawatch Range was folded into a broad, anticlinal arch trending north-northwest, and faulted. Because outcrops are sparse 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 found 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 amounts of 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 and St. Kevin districts and vicinity, 271 prospect pits, mine dumps, or mine workings were tested for radioactivity during 1951. These localities, of which 130 were anomalously radioactive, are shown on figures 3, 4, 5, 6, 7, and 8. The radioactivity

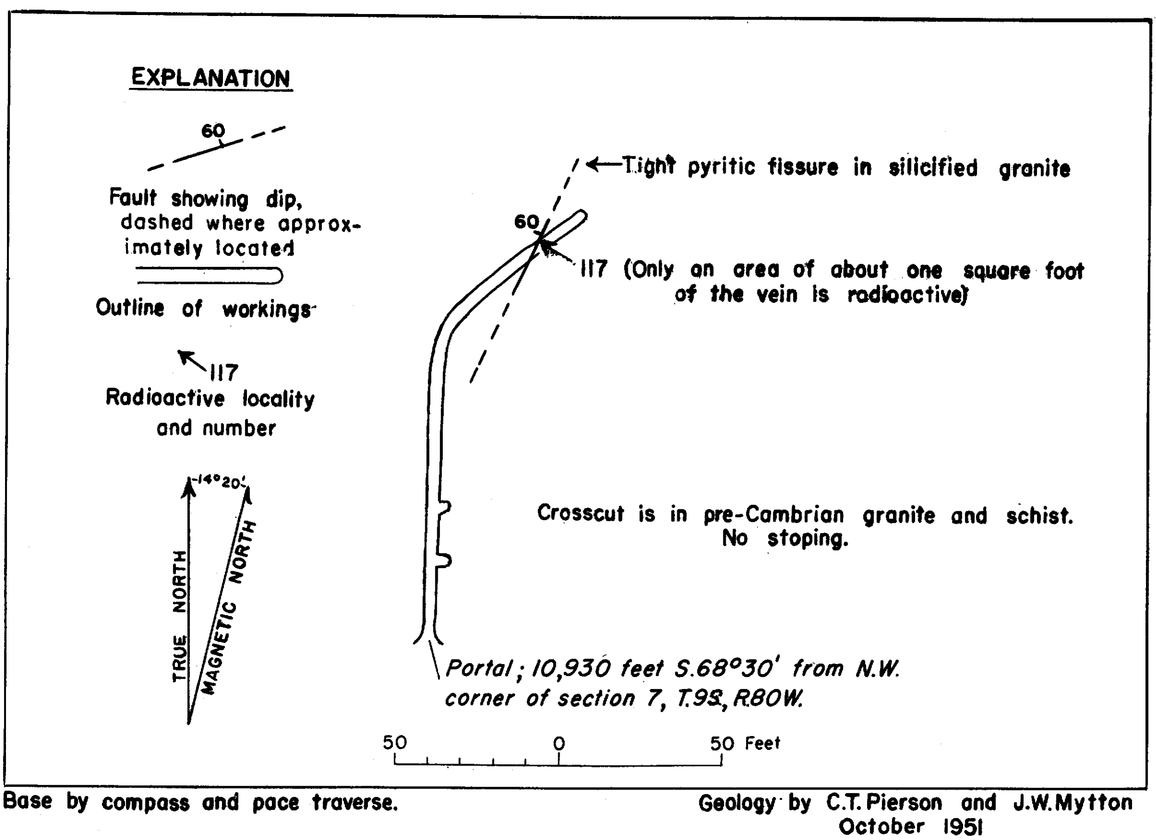

Figure 3.—Map of unnamed adit west of the St. Kevin district, Lake County, Colorado, showing radioactive locality 117.

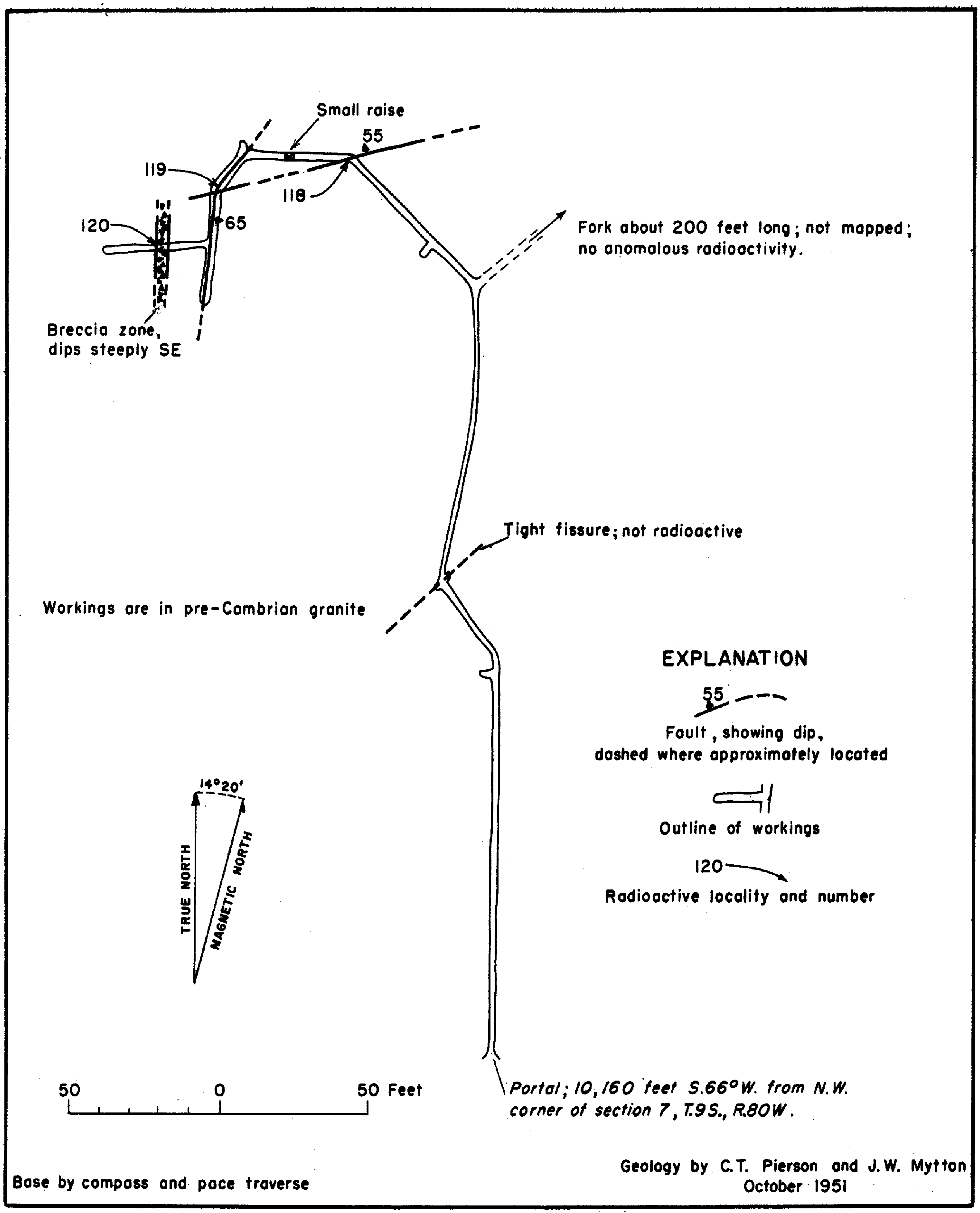

Figure 4. —Map of unnamed adit west of the St. Kevin district, Lake County, Colorado, showing radioactive localities 118, 119, and 120.

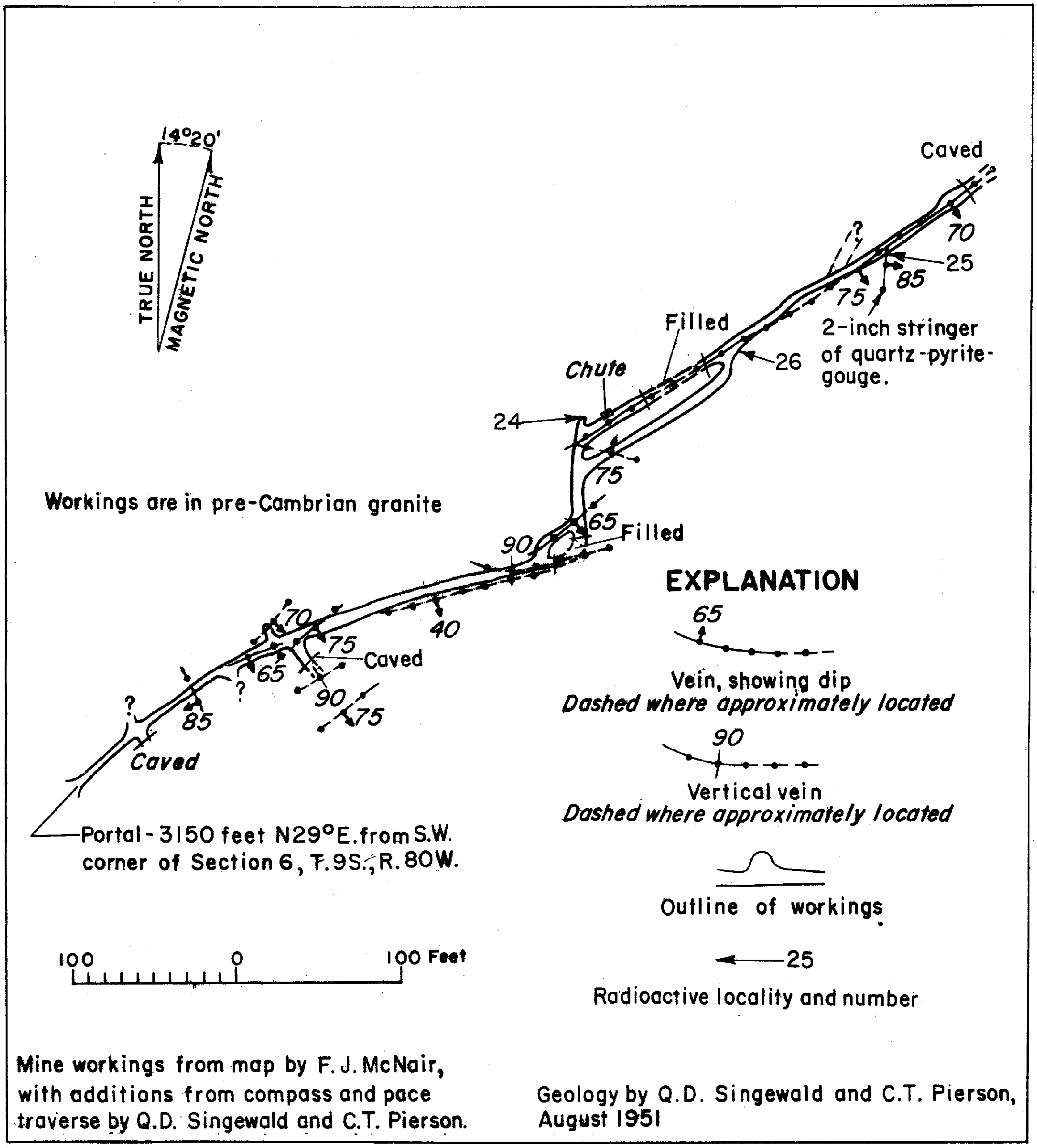

Figure 5. —Map of lower Wilkesbarre adit, St. Kevin district, Lake County, Colorado, showing radioactive localities 24, 25, and 26.

measurements made with portable survey meters equipped with 6-inch beta-gamma tubes, are recorded in table 1 in milliroentgens per hour, a unit of measure of the relative amount of gamma-ray activity. No data are recorded in table 1 for nonanomalously radioactive localities shown in the illustrations.

For each anomalously radioactive locality, 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 tube at waist level for about 1 minute and recording the range of readings.

A locality is considered to be anomalously radioactive if the ratio of the maximum radioactivity reading to the maximum background reading is greater than 1.3:1. The values of the ratios for the localities tested range from 1:1 (locality 26) to 125:1 (locality 52). Each locality has been assigned to one of three ratio groups. A few localities, 21, 36, 61, described in table 1 as having a slight feeble, or doubtful anomalous radioactivity, but for which no radioactivity readings

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

[Chemical and spectrographic analyses by Geological Survey Trace Elements laboratories]

Locality no.	Maximum radioactivity reading (mr per hr)	Background reading (mr per hr)	Equivalent uranium (percent)	Uranium (percent)	Occurrences of the radioactive minerals and results of mineralogical and spectrographic 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	.023	.013	Autunite(?) as disseminations in fine-grained, highly silicified, limonite-stained rock from outcrop; 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; 0.X Ti, Ca, Mg; 0.0X Mn, Na, Ba, La, Pb; 0.00X Ag, B, Cr, Cu, Ni, Sr, V, Y, Zr; 0.000X Be, Co, Ga, Mo, Sc, Sn.
7	.13	.05- .07	---	---	Limonite-stained, and limonite- and manganese-stained fractures in partly weathered granite that 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 manganese-stained surfaces of granite. From dump of caved shaft or prospect pit.
11	.20	.03- .06	.019	.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. Spectrographic analysis shows XX. Si; X. Al, Fe; 0.X Ti, Ca, Mg, Pb, Zn; 0.0X Mn, Na, Ag, Ba; 0.00X B, Cr, Cu, Mo, Ni, Sr, V, Y, Zr; 0.00X Be, Ga, Sc.
12	.12	.03- .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, and siliceous vein material from dump of adit not 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.

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

Locality no.	Maximum radioactivity reading (mr per hr)	Background reading (mr per hr)	Equivalent uranium (percent)	Uranium (percent)	Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses
17	0.16	0.03-0.04	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; 0.0X Mn, Mg, Na, Ba, Cu, Pb; 0.00X Ag, B, Cr, Ga, Ni, Sc, V, Y, Zn; 0.000X Be, Co, Sr.
18	.11	.04- .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	.013	.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; 0.X Ti, Ca, Mg; 0.0X Mn, Na, Ba, Pb, Zn; 0.00X B, Co, Cr, Cu, La, Ni, Sc, Sr, V, Y, Zr; 0.000X Ag, Be, Ga.
24	.16	.09- .14	.014	.013	Intensely altered granite intermixed with gouge, and stained by limonite; forms footwall of Arty and Snow vein zone exposed by lower Wilkesbarre adit; radon gas present. No uranium minerals identified.
25	.16	.14	.014	.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 partly granitized schist from dump of shaft; there is a relatively small amount of anomalously radioactive material in dump.
31	.08	.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 radio-activity.	.03- .05	---	---	Limonite-stained fractures in intensely sericitized granite from dump of shallow prospect pit sunk in schist and granite. (Schist is common rock of dump.)
37	.12	.03- .05	---	---	Pale-yellow, limonite-stained, intensely altered rock, probably from or adjacent to 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	.011	.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	.050	.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 hydrothermally 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.
43	.08	.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- .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.
50	.12	.03- .05	.007	.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	.043	.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; 0.X Na; 0.0X Ti, Mn, Ca, Mg, Ba; 0.00X B, Cr, Cu, Ga, Mo, Ni, Pb, Sc, Sr, V, Y, Zr; 0.000X 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.

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

Locality no.	Maximum radioactivity reading (mr per hr)	Background reading (mr per hr)	Equivalent uranium (percent)	Uranium (percent)	Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses
54	0.08	0.01-0.05	0.004	<0.001	Limonite-stained crushed rock and gouge along minor fissure in hanging wall, several inches away from vein; Lakewood mine.
55	.12	.03- .07	---	---	Gossan, 1 foot thick, exposed in place just east of portal, upper Griffin adit.
56	.16	.03- .06	.024	.015	Breccia composed of chert and silicified granite fragments, 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	.010	.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; 0.X Ti, Mg, Pb; 0.0X Mn, Ca, Na, Ag, Ba, Cr, Cu, La; 0.00X B, Ni, Sc, V, Y, Zr; 0.000X 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.
62-64	.40	.02- .05	.085	.065	Metatorbernite(?) in limonite and manganese-stained fracture coatings and as disseminations(?) in granite from dumps of three small prospect pits, Griffin vein zone. Spectrographic analysis of sample shows XX. Si; X. Al, Fe; 0.X Ca, Mg, Na, Ba; 0.0X Ti, Mn, Pb, Sr, U; 0.00X B, Cr, Cu, Mo, V, Y, Zr; 0.000X 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	.010	.007	Limonite-stained fractures in schist from dump of shallow prospect pit sunk into schist and granite.
72	.14	.02- .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 throughout 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(?).
80	.15	.02- .08	---	---	Limonite films on fractures in granite and in partly 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	.004	.001	Turquoise and chrysocolla(?) coat fractures in granite exposed by trench.
84	.16	.03- .05	---	---	Iron-stained fractures in granite from western part of bull-dozer-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	.005	.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.
88	.08	.03- .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	---	---	Do.
92	.11	.02- .04	---	---	Limonite-stained fractures in granite from dump of prospect pit.
93	.15	.02- .08	.005	.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 radioactivity.
96	.40	.02- .08	.010	.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.
98	.16	.01- .06	.011	.006	Disseminations and fracture coatings in muscovite-chlorite schist from dump of shallow prospect pit, which also contains granite.
99	.19	.01- .06	.004	.002	Limonite-stained, slickensided surfaces in chloritic schist which came from within or nearby a prospect pit.
100	---	---	---	---	Dump of pit: doubtful anomalous radioactivity.
101	---	---	---	---	Do.
102-105[1]	([1])	([1])	([1])	([1])	([1])
106	.14	.03- .07	.005	.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 limonitic gossan, slightly manganese-stained. From dump of shaft.
110	.40	.02- .10	.017	.009	Metatorbernite(?) disseminated in granite exposed by opencut, Turquoise Chief mine. Spectrographic analysis shows XX. Si; X. Al, Fe; 0.X Ca, Mg, Na; 0.0X Ti, Mn, Ba, Cu, La; 0.00X B, Cr, Ni, Pb, Sr, V, Y, Zr; 0.000X Ag, Be, Co, Ga, Sc, Sn.
111	.07	.02- .04	.007	.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.

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

Locality no.	Maximum radioactivity reading (mr per hr)	Background reading (mr per hr)	Equivalent uranium (percent)	Uranium (percent)	Occurrences of the radioactive minerals and results of mineralogical and spectrographic analyses
114	0.06	0.02-0.04	---	---	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; 0.X Ti; Mn, Ca, Mg, Na; 0.0X Ba, Cr, La, Pb, V, Zn; 0.00X B, Mo, Ni, Sc, Sn, Sr, Zr, Y; 0.000X Ag, Be, Co, Cu, Ga.
116	.19	.02- .08	.004	.001	Limonite-stained films on fractures in granite, and disseminations in silicified White porphyry and jasperoid from dump of prospect pit.
117	.90	.04	.069	.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 of sample shows XX. Si; X. Al, Fe; 0.X Pb; 0.0X Ti, Mn, Ca, Na, Ba, Cu, Zn; 0.00X Ag, B, Ga, Sn, Sr, V, Zr; 0.000X Mg, Cr, Ni.
119	.18	.09	---	---	Pyritic veinlets exposed by adit.
120	.18	.09	---	---	Breccia zone in granite, 6 feet thick; exposed by adit.
121	.20	.03- .04	.034	.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[2]	([2])	([2])	([2])	([2])	
128	.12	.03- .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.

[1]See 106.
[2]See 122.

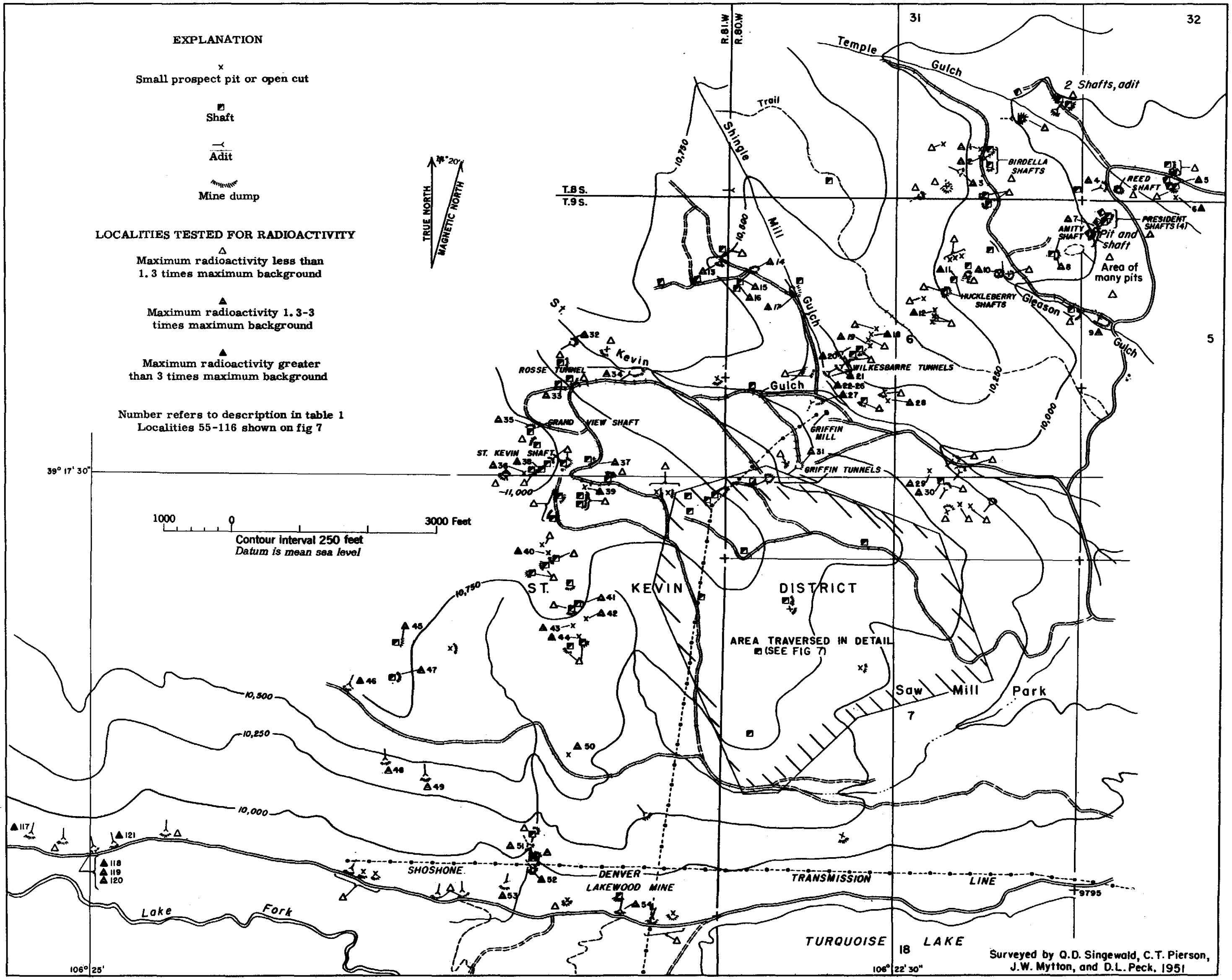

Figure 6. —Localities tested for radioactivity in the St. Kevin district and vicinity, Lake County, Colorado.

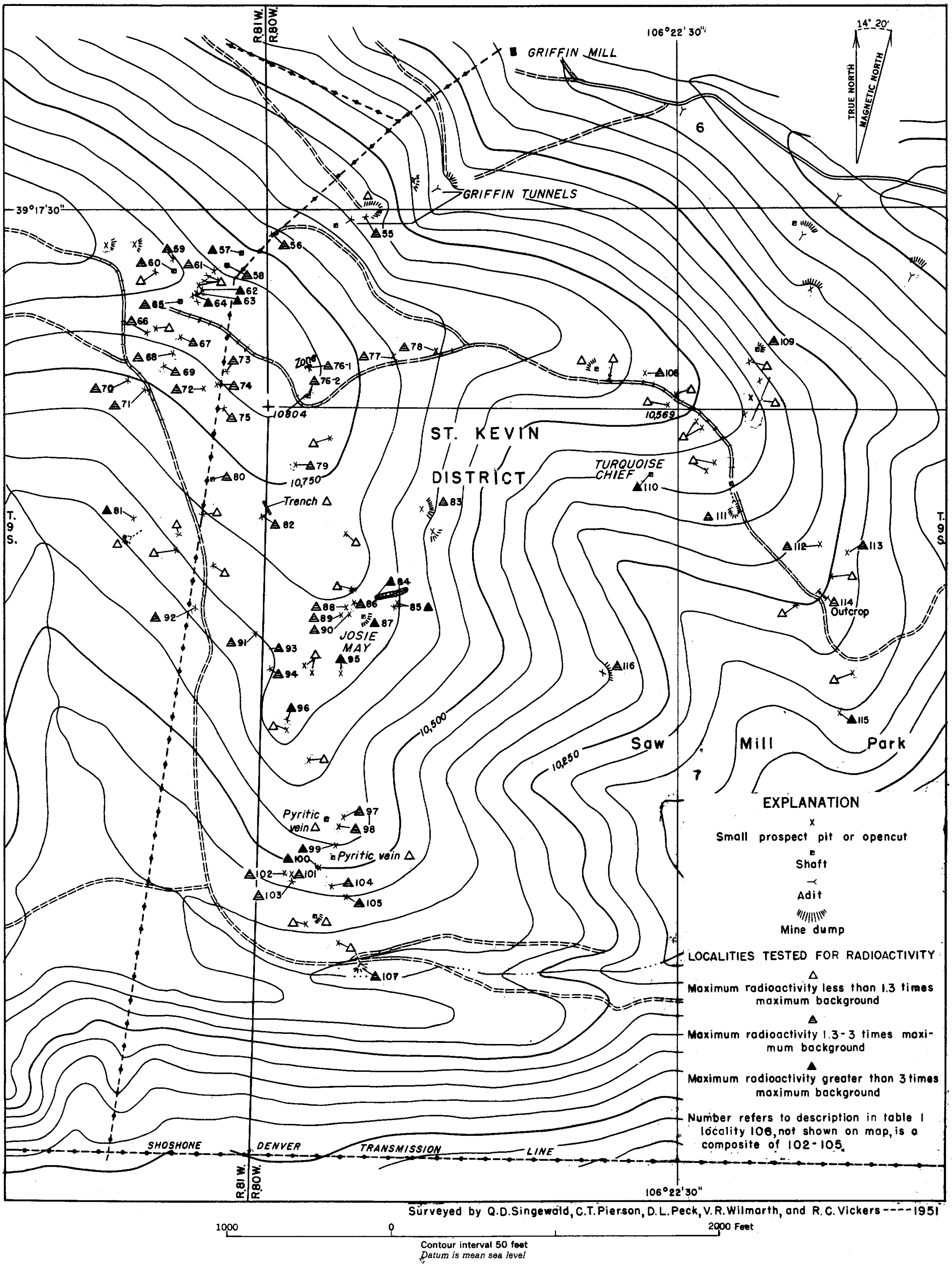

Figure 7. --Localities tested for radioactivity in part of St. Kevin district, Colorado, traversed in detail.

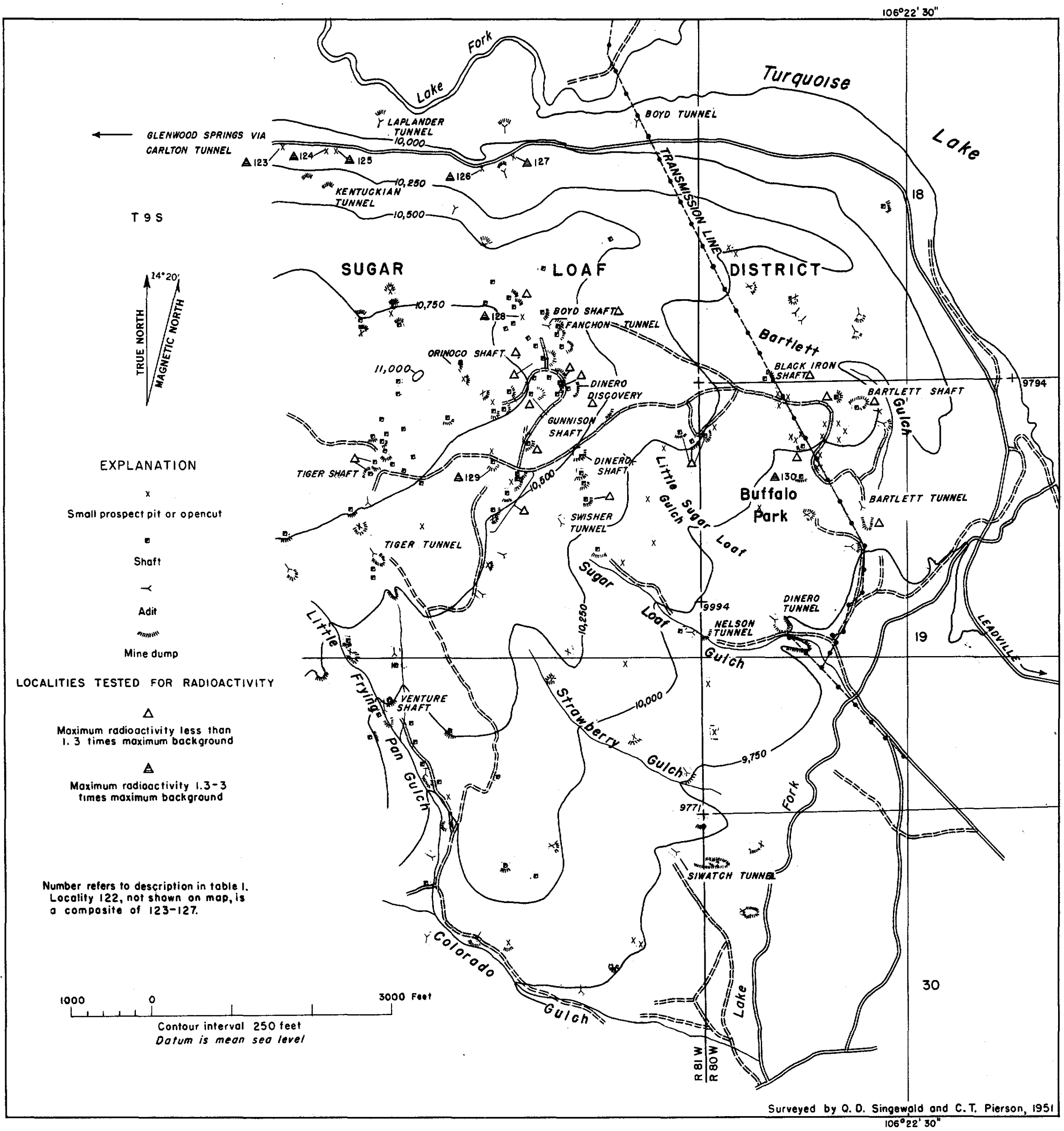

Figure 8. —Localities tested for radioactivity in the Sugar Loaf district, Lake County, Colorado.

are recorded, are shown on figures 6 and 7 as belonging to the second ratio group (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 nonanomalously 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 24 of the 33 localities for which laboratory analyses are available fall into two distinct groups when arranged according to the magnitude of their associated ratios.

Associated ratios	Percent equivalent uranium
1.3:1-3.0:1	0.004-0.013; 13 localities, excluding 56 (0.024).
Greater than 3.0:1	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.

Anomalously radioactive vein material was found in the St. Kevin district at 11 mine dumps (locality 11, Huckleberry vein; and locality 37, St. Kevin vein) and, also, at several places within the few underground workings now accessible (localities 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 (localities 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 (locality 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 (locality 110).

Disseminations of radioactive minerals are present at several places in the St. Kevin district, most commonly in sericitized granite (localities 13, 16, 28, 31), but at a few localities (localities 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 (localities 1, 7, 39). Except for metatorbernite at locality 64, uranium minerals that could account for the radioactivity have not been identified.

Although no primary uranium minerals have 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 (localities 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 nonglaciated terrane that 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 of primary minerals 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 some fractures may extend to depths of several hundred feet.

All the analysed samples from the Sugar Loaf-St. Kevin districts and vicinity are in a state of disequillibrium, 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 of this disequillibrium 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: TEI-262, 1952, U. S. Atomic Energy Comm., Tech. Inf. Service, Oak Ridge, Tenn.

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

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