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RADIOACTIVITY INVESTIGATIONS IN THE SERPENTINE-KOUGAROK AREA SEWARD PENINSULA, ALASKA, 1946

By Robert M. Moxham and Walter S. West

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ABSTRACT

Radioactive minerals in small quantities were found in the bedrock and alluvium within the outcrop area of granite at the head of Serpentine River.

Tests of radioactivity at outcrops of the granite indicate that small amounts of radioactive material is disseminated throughout the mass. Four variants of the normal granite have been recognized: early and late differentiates, and pegmatitic and fine-grained facies. All variants except the early differentiates show radioactivity in excess of the normal granite. The average equivalent uranium content of 29 samples of the granitic variants is 0.008 percent. The heavy-mineral portions of these samples average 0.034 percent equivalent uranium.

The radioactivity of the placer material and bedrock is attributable to zircon, sphene, allanite, hydrogoethite, and two unidentified secondary minerals. Neither the bedrock nor placer deposits contain sufficient radioactive materials to be of present commercial interest.

INTRODUCTION

Investigations in the Serpentine-Kougarok area on the Seward Peninsula, Alaska, in 1946, were made specifically to search for lode and placer deposits of radioactive materials. Two factors were responsible for the selection of this particular area for examination:

1) Two samples from the upper Kougarok area in the Alaskan placer collection were tested for radioactivity in the winter of 1944-45. One sample (labelled Harris Creek, a tributary of the North Fork) showed 1.335 percent equivalent uranium and was among the more highly radioactive samples from all of Alaska (Harder and Reed, 1945, p. 5, 14).

2) Investigations in 1945 at Ear Mountain (Killeen and Ordway, 1946), 45 miles west of the Serpentine-Kougarok area, exposed a small radioactive lode deposit associated with a granitic intrusive similar to the granite at the head of the Serpentine River.

Field work began June 22, 1946 and was terminated September 23, 1946.

GEOGRAPHY

Location and extent of area

The Serpentine-Kougarok area (fig. 1), in the north-central part of the Seward Peninsula in western Alaska, straddles the divide along the east-west axis of the peninsula.

The limits of the area have been chosen arbitrarily to include the headwater portions of the Serpentine, Kougarok, Fish, and Humboldt Rivers and the eastern headwater tributaries of American River.

Nome, on the south coast of the peninsula is approximately 80 miles south of the center of the area.

Physical conditions in the area

Rolling, treeless tundra is prevalent throughout the area. Low ridges with locally steep and rugged peaks lie between the principal drainage basins. Kougarok Mountain, 2,767 feet in altitude, is the highest peak in the region. Tundra extends up the flanks of the hills until the steepness of the slope affords some drainage. Above this level the rocks are generally bare of vegetation and usually disintegrated into a deep talus mantle by severe frost action. The area is treeless, except for a few small stunted willows in some creek bottoms.

Settlements, accessibility, and sources of supply

Nome is the principal source of supplies and the main base for small planes, which are the only convenient means of transportation into the Serpentine-Kougarok area.

The two most frequently used landing fields in the Serpentine-Kougarok area are at Taylor, in the upper part of the Kougarok River valley at the mouth of Taylor Creek, and on Hot Springs Creek at the head of the Serpentine River. At the time the field work was carried out the Serpentine Hot Springs field was generally considered hazardous because of its short runways (about 1,000 feet), rough surface, and the prevalence of crosswinds and downdrafts. The Taylor field was the more frequently used for routine service. Airstrips are also in use at most of the active mining camps, including Keenan's and John Kanari's camps, 4 and 6 miles, respectively, north of Taylor on the Kougarok River; George Bodis' camp on Dick Creek in the Serpentine basin, about 12 miles northwest of Taylor; and at the camp of the North Fork Dredging Co., on North Fork, 5 miles east of the Kougarok River.

Taylor, formerly an active placer-mining camp and center of population in the Serpentine-Kougarok area, was almost completely abandoned during World War II owing to the ban on gold mining. Only one man was working there during the summer of 1946. Taylor can be reached by road from Shelton in the lower Kougarok River valley, the terminus of a narrow gage railway from Nome. Freight for the Kougarok area is also brought in by barge from Teller to Davidson's landing, 25 miles south of Taylor, and then hauled by tractor to the various mining camps.

Serpentine Hot Springs, about 14 miles north of Taylor, can be reached by either tractor or plane. There are no permanent residents in the immediate vicinity.

GEOLOGY

Earlier reconnaissance investigations in the Serpentine-Kougarok area in 1900, 1901, and 1906 were summarized by Brooks in 1908 (Collier and others, 1908, p. 294-328). Brief statements have been published on some of the lode prospects (Smith, 1908, p. 244; Mertie, 1918, p. 440-442; Brooks, 1922, p. 65). Comments on the placer-mining activities are made in a water-supply paper (Henshaw and Covert, 1908, p. 77-98) and in many of the Geological Survey's reports on the mining industry.[1] The placers of the upper Kougarok River are described in an unpublished report by Shallit (1941).

Three types of bedrock are recognized in the Serpentine-Kougarok area. These are:

1) Two "units" of the Nome group of altered sedimentary rocks of Ordovician and Silurian age.
   - a) Undifferentiated limestone, slate, and schist.
   - b) The Port Clarence limestone, probably mostly Silurian in age.

2) Greenstone of Paleozoic age or younger.

3) Granite and other felsic intrusives of Mesozoic or, in part, perhaps of Tertiary age.

Quaternary unconsolidated silt, sand, and gravel occur as fill of variable depth in the valley bottoms.

Undifferentiated limestone, slate, and schist

In general, the undifferentiated limestone, slate, and schist of the Nome group are exposed in the valley basins, whereas the Port Clarence limestone forms the ridges between the basins. Exceptions to this generalization include parts of Kougarok Mountain and Midnight Mountain and the nearby hills, which are composed of schist. The schist normally consists of quartz and chlorite or muscovite but is locally graphitic.

Port Clarence limestone

The Port Clarence limestone is a massive, crystalline marble in most places. At localities near the limestone-schist contact the limestone shows considerable contortion. Traces of fossils have been retained in a few localities despite the intense metamorphism. Collections made by Collier on Harris Creek were considered to be Niagaran or middle Silurian in age (Collier and others, 1908, p. 76).

Greenstone

Intensely altered mafic intrusive rocks, classified as greenstone by Collier, occur on Washington

[1] Annual summary reports from 1905 to 1942 by A. H. Brooks and P. S. Smith on the mining or mineral industry of Alaska. The numbers of the yearly bulletins may be obtained from "Publications of the Geological Survey".

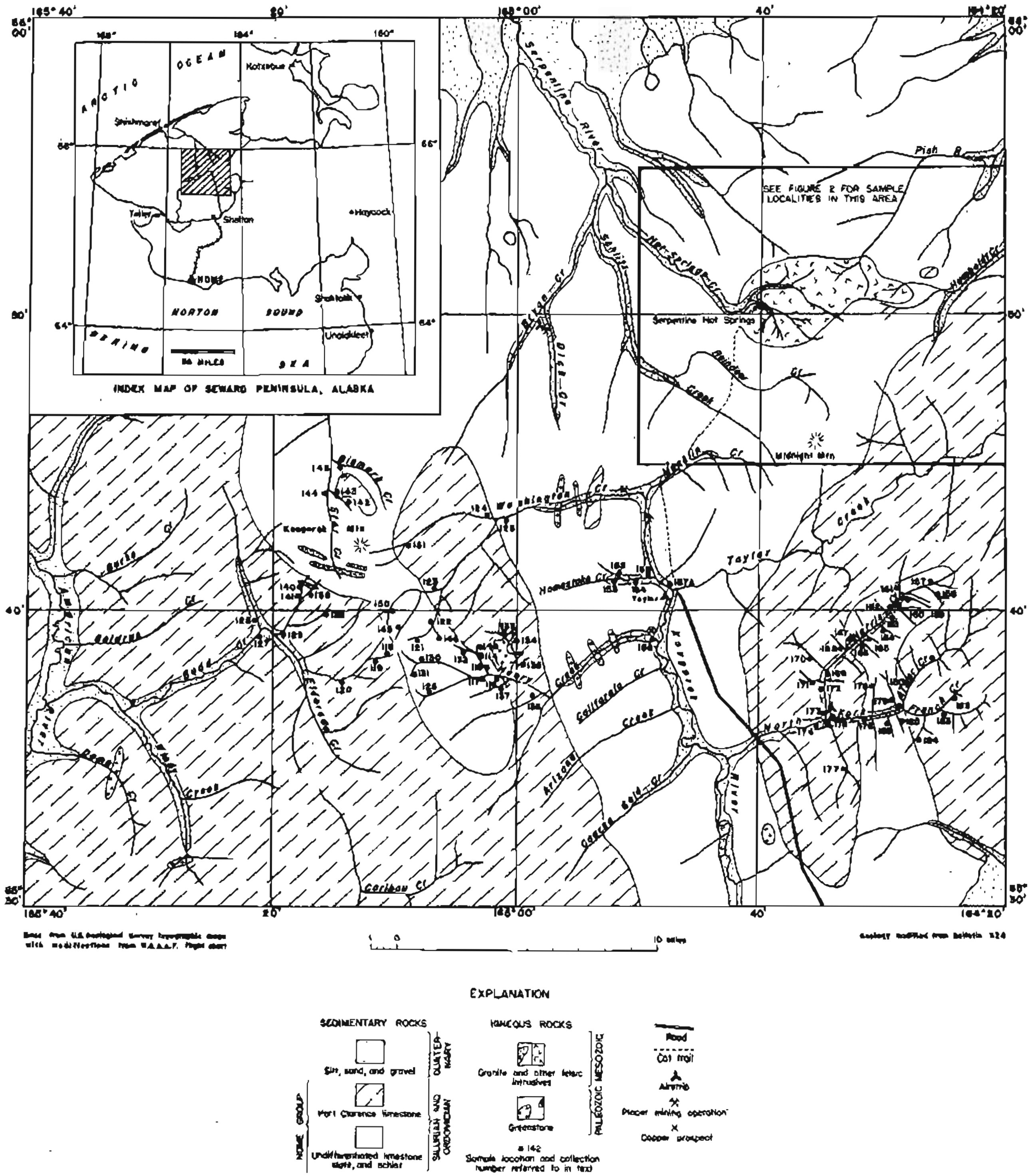

Figure 1.—Geologic sketch map of the Serpentine-Kougarok area, Seward Peninsula, Alaska, showing sample localitie[s]

and Henry Creeks, tributaries of the upper Kougarok River, and in the valley of the Kougarok south of Coarse Gold Creek. The greenstone on Henry Creek contains crystals of actinolite and garnet but lacks the schistose characteristic of this rock type in other localities.

Granite at Serpentine Hot Springs and other felsic intrusives

In the vicinity of Serpentine Hot Springs, a granitic stock of Mesozoic or Tertiary age is exposed over a roughly oval area (fig. 2). The long axis of the oval is about 6 miles in length, extending in an east-west direction. Serpentine Hot Springs is slightly west of the center of the granite area, the larger part of which is within the headwater drainage of Hot Springs and Humboldt Creeks, and the Fish River. Pinnacles formed by weathering along well-developed joint systems make the outcrop area rather conspicuous.

The normal granite is a coarse, light-colored rock composed chiefly of quartz, orthoclase, and biotite. Locally it encloses rounded masses, up to a foot in diameter, containing a much greater proportion of biotite. They probably represent partly assimilated inclusions of an early mafic magmatic differentiate or border phase.

The stock has been transected by three types of intrusive material or differentiates of the granite:

1) Pegmatitic quartz-muscovite veins.

2) Fine-grained, felsic dikes similar to the granite in composition.

3) Dark-colored, tabular, dike-like masses similar in composition to the earlier mafic differentiates.

Probably all of the three types listed are related in time of emplacement and magmatic source and represent phases in consolidation of the magma. The variants are generally very irregular and difficult to trace for any distance. The contacts may be either sharp or gradational. Few of the dikes exceed several inches in thickness, and the thicker portions are generally lens-shaped. Vugs are present in some of the pegmatites and are lined with quartz, mica, and tourmaline crystals.

Although these granitic variants are present in many parts of the area, the greatest number occur in the pinnacles on the flanks and summit of the low hill on the northeast side of the south fork of Hot Springs Creek. Vugs and irregular banding are well developed in a pegmatite that transects a pinnacle near the summit of the hill at the locality where samples 86-88 were collected (fig. 2). The pegmatite consists of a central zone up to 4 inches in width composed of quartz, muscovite, and tourmaline, and irregular zones on both sides composed of layers of fine-grained, felsic material a few inches in width. A biotite-rich zone, about 5 feet in length and several inches wide, occurs in the normal granite along one margin of the vein. In a second pinnacle, 30 feet distant, the probable continuation of the same dike contains a vug 2 feet in diameter lined with quartz crystals up to 2 inches in length and books of mica.

Rhyolitic intrusives of small size were found by earlier surveys on the summit and southwest slopes of Kougarok Mountains, 18 miles west of Serpentine Hot Springs.

MINERALIZATION, LODE PROSPECTS, AND PLACER GOLD MINING

A small amount of placer cassiterite occurs in the gravels of Humboldt Creek and has been reported from Mascot Gulch, a headwater tributary of the Kougarok, and from Dick Creek, a tributary of the Serpentine River. An unverified report suggests that cassiterite may occur also in Budd and Windy Creeks, tributaries to American River. Scheelite, said to have been obtained from Homestake Creek, a tributary entering the Kougarok River from the west at Taylor, was shown to the writers by a prospector. Cinnabar has been recognized in some gravels of the lower Kougarok River valley, and a small amount was seen in concentrates panned from a shallow gully in the south side of the eastern fork of Hot Springs Creek.

Several copper prospects have been staked in the vicinity of Kougarok Mountain, but evidence of development work was seen only at the Ward property between Bismark and Star Creeks, 2 miles north of the northern end of Kougarok Mountain. Several trenches have been dug at the Ward prospect, and an adit, now caved a short distance from the portal, reveals several veins of malachite and azurite about 2 inches thick near a limestone-schist contact.

Gold-quartz lodes are reported to have been exposed by placer mining at the headwaters of the Kougarok River, but none have been worked commercially.

Placer-gold deposits have been found in many parts of the drainage basins of the area. The placers have been mined on Dick Creek, Humboldt Creek, some tributaries of the American River, and in the Kougarok basin. The major part of the production has been from the Kougarok and its tributaries.

The Kougarok district ranked second in gold production on the Seward Peninsula before World War II, surpassed only by the Nome district (Smith, 1941, p. 59). Dredges accounted for the largest output, but many smaller hydraulic workings also contributed to it. Gold mining was at a standstill during the war owing to the ban on all but very small operations.

Mining in the upper Kougarok River valley has centered around Taylor, where a number of bulldozer-hydraulic operations were active during the prewar period. Most of the other workings were within a short distance of Taylor on the main stream, but many of the upper tributaries have been worked sporadically in the past, some nearly to their sources. In 1946, the operations in the upper Kougarok River valley, above the mouth of North Fork, were as follows: John Kanari, 6 miles north of Taylor; the Kougarok Consolidated Placers, Inc., 4 miles north of Taylor, where dredging had not yet been resumed, but drilling was in progress; Jim Carroll at Taylor; Sam Godfrey at the mouth of Henry Creek, 2 miles south of Taylor;

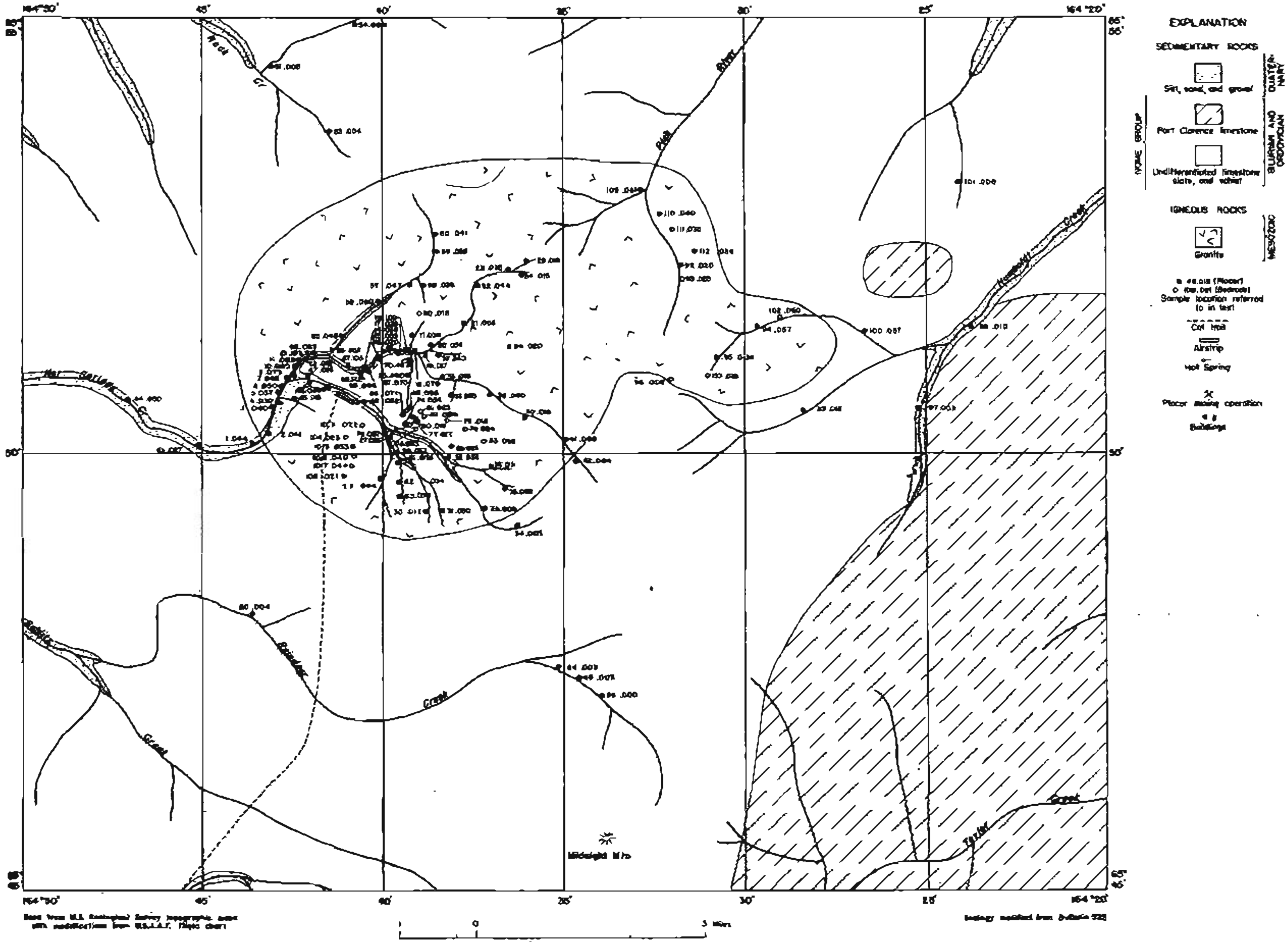

Figure 2.--Geologic sketch map of the Serpentine-Hot Springs area, Seward Peninsula, Alaska, showing sample localities.

and the North Fork Dredging Co., operating a dredge at the mouth of Harris Creek. In the upper Serpentine River valley, George Bodis was working near the mouth of Dick Creek, 12 miles northwest of Taylor. Near the mouth of Budd Creek, a tributary of American River, Dodson had resumed mining, but his camp was not visited. Mining had not yet been resumed at the Walsh camp on Humboldt Creek, about 8 miles east of Serpentine Hot Springs.

Placer deposits in the Kougarok River valley occur both in the gravels of the present streams and in those on benches at two or more levels. The more conspicuous benches are at altitudes of 25 and 50 feet above the present stream. The benches are discontinuous and somewhat difficult to recognize because of erosion and soil creep. The bench gravels average 10 to 20 feet in thickness. Drilling at the dredge site of the Kougarok Consolidated Placers, Inc., in 1946, showed the stream gravels to be 18 feet thick. All of the gravels are characteristically barren of gold except within a few inches of bedrock.

RADIOACTIVE MINERAL INVESTIGATIONS

Field studies

At the time the field work was undertaken the portable radiation equipment available from commercial sources was relatively crude. The field instrument used in this investigation was constructed by the Geological Survey and utilized a 3-inch glass-walled gamma tube housed in a cylindrical brass probe. It was necessary to use this tube for both outcrop testing and semiquantitative assaying. By present-day standards the counter would be considered inadequate for the type of work in which it was applied. Semiquantitative assays of bedrock samples were made in the field by comparison with a standard containing a known percentage of equivalent uranium.

Heavy-mineral concentrates were panned from surface gravels of nearly all the major drainages in an effort to determine whether the placer deposits contained sufficient radioactive material to constitute a source of supply. In addition, a study of the radioactivity and mineral constituents of such samples helped in the search for bedrock deposits. The samples represent surface gravel only, except those obtained from placer mines. Care was taken, however, to remove the uppermost well-washed gravel and to take samples at such depths that the sand and clay formed a tight matrix between the pebbles and retarded the downward movement of the heavy minerals.

Laboratory studies

Bedrock and placer samples were further concentrated in the laboratory for mineralogical study and for determining to what degree the radioactive material could be concentrated. The small quantity of material which would not pass through a 20-mesh sieve was rejected after scanning for radioactive mineral fragments. Samples were split into fractions of greater and less than 2.89 specific gravity. From some selected samples the minerals heavier than 3.3 specific gravity were removed. Measurement of the equivalent uranium content of the plus 2.89 specific gravity fractions was made with a laboratory beta counter.

Distribution of radioactive material

Radioactive material was found in significant quantities in gravel or bedrock only in the area of intrusive granitic rock outcropping in the vicinity of Hot Springs Creek at the head of the Serpentine River and adjacent east-flowing drainage.

Data concerning the bedrock samples are given in table 1, and the data on the placer or gravel samples are listed in table 2.

Samples of the placer deposits of Budd and Eldorado Creeks (eastern tributaries of American River), the upper Kougarok River and its tributaries, and the headwater tributaries of the Serpentine River, excluding Hot Springs Creek, did not show sufficient radioactivity to be detected with the field counter, although a few of the heavy-mineral fractions of these samples are slightly radioactive. However, the investigation was not carried far enough into the American and Goodhope River basins to entirely eliminate these placer areas; likewise, no work was done on the Kougarok River or its tributaries downstream from North Fork.

One dredge concentrate was collected from the Kougarok Consolidated Placers, Inc. The material was derived from gravel on the east side of the Kougarok River between the mouths of Taylor and Homestake Creeks. No appreciable radioactivity was noted.

The reconnaissance of Harris Creek failed to reveal any placer material along the creek's course comparable in radioactivity to that shown by the older sample from the Alaskan placer collection. Unfortunately, all of this original sample from Harris Creek was used in chemical analysis. The original sample may represent an extremely local concentration or a sluice concentrate from gravel immediately above bedrock at one of the older placer workings, or the sample may have been incorrectly labeled and actually taken at another locality.

Both "units" of the Nome group were examined in a number of localities with no radioactivity being apparent. The greenstone was tested at the outcrop area on Kougarok Mountain. The results were negative. The felsic rocks on Kougarok Mountain were not found in place. Placer samples from the drainage basin in which float from these rocks was found failed to show significant radioactivity.

No radioactive minerals were found at the Ward copper prospect located on the north flank of Kougarok Mountain. Laboratory tests of the ore taken a few feet from the portal were negative.

The locations of all samples collected in the Serpentine Hot Springs area are shown in figure 2. In the symbols used for sample localities on figure 2, for example, 93.023, the figures preceding the decimal points are the field collection numbers of the samples. The figures including and following the decimal points represent the percent of equivalent uranium, in the heavy-mineral fractions. Data relating to samples 118 through 184 have been omitted from figure 1 and the tables because of their insignificant radioactivity.

Bedrock deposits of radioactive material.–The granite in much of the Serpentine-Hot Springs area probably contains disseminated accessory minerals which are slightly radioactive, for gamma counts on all outcrops are above the average background count. Four samples of the granite from widely separated localities averaged 0.005 percent equivalent uranium. The crushed material was separated with methylene iodide, and a very small quantity of heavy minerals was obtained. The small amount of heavy residue prevented a quantitative determination of the equivalent uranium content, but qualitative radiation tests indicate slight radioactivity. A sample of disintegrated granitic material collected from a sidehill wash, concentrated by the removal of the lighter minerals through creep action, contained 0.004 percent equivalent uranium as determined in the field. The heavy-mineral fraction of this sample was found to contain 0.06 percent equivalent uranium.

As stated above, four facies of the normal granite have been recognized. Samples of three, the pegmatites and fine-grained felsic and late mafic differentiates, all show radioactivity in excess of the granite, whereas outcrop tests of the early differentiates failed to indicate any concentration of radioactive minerals. The most radioactive unconcentrated sample (no. 82) of lode material is of the pegmatitic variety and contains 0.032 percent equivalent uranium. The average of 20 samples of the pegmatitic facies of the normal granite indicates that this facies contains an average of about 0.009 percent equivalent uranium.

The sample of fine-grained felsic intrusive (no. 86) showing the greatest radioactivity contains 0.015 percent equivalent uranium. The average content of the three samples of felsic dikes is 0.009 percent equivalent uranium. The most radioactive sample of the mafic dike material (no. 105) contains 0.011 percent equivalent uranium. The average of the three sites sampled is 0.008 percent equivalent uranium.

Radioactive material in the alluvium.–The radioactivity of most of the concentrates is sufficient to be readily recognizable with a portable survey meter. The content of radioactive material in these concentrates panned from the gravel in the Serpentine-Hot Springs area ranges from 0.000 to 0.017 percent equivalent uranium. As the degree of concentration obtained by panning is purely arbitrary and differs for each sample, the percent equivalent uranium of the semiconcentrates is not given in table 2.

Further concentration of these samples in bromoform yielded heavy-mineral fractions containing 0.003 to 0.84 percent equivalent uranium. The average equivalent uranium content of the heavy fractions of the 74 samples is 0.064 percent. The increase in tenor of radioactive material effected by heavy-liquid separations indicates roughly the amount of beneficiation of the original gravel that might be obtained by the most efficient gravity methods under ideal conditions. The concentration ratio, that is, the weight of the original gravel to that of the heavy-mineral fraction, gives a rough estimate of the amount of heavy minerals in the gravel that might be recovered at each sample locality. The concentration ratio averages 758 to 1. Assuming that 1 cubic yard of gravel weighs 3,100 pounds, the heavy-mineral content averages 4 pounds per cubic yard of gravel.

The amount of radioactive material in the unconcentrated gravel is too low to be determined with a counter, but may be computed from the concentration ratios and the equivalent uranium content of the heavy-mineral fractions (see table 2).

Radioactive minerals

Radioactivity in the gravel and bedrock originates from radioactive elements associated with the following minerals: zircon ($ZrSiO_4$), sphene ($CaTiSiO_5$), allanite (an hydrous silicate of Ca, Fe, Al, Ce, La, and Di), hydrogoethite ($3Fe_2O_3 \cdot 4H_2O$), and two unidentified secondary minerals.

The small size of the zircon crystals prevented hand picking sufficient material for a quantitative analysis of its activity. However, a magnetic separation of sample 18 yielded a nearly pure zircon fraction which was tested semiquantitatively with a laboratory beta counter and showed approximately 0.15 percent equivalent uranium. Sodium-fluoride flux tests for uranium (Northrup, 1945) on this fraction were negative so that the radioactivity is thought to be due to thorium, although fluorescence due to any uranium present may have been inhibited by the relatively high percentage of zirconium.

Spectrographic analyses of hand-picked samples of allanite and sphene show 0.1 and 0.03 percent thorium, respectively. These figures are approximate, as they are close to the limit of sensitivity for the method used. Uranium was not detected spectrographically, and sodium-fluoride flux tests for uranium on these two minerals were also negative.

The three secondary minerals, hydrogoethite and two unidentified, react positively for uranium in sodium-fluoride flux. Spectrographic analysis indicates a content of somewhat less than 1 percent. No thorium was detected.

Field outcrop tests, as well as the laboratory studies, of the normal granite indicate the presence of minor amounts of radioactive accessory minerals rather evenly distributed throughout the mass. The widespread occurrence of zircon and sphene in the streams draining the outcrop area of the intrusive supports this conclusion. Allanite, which is less common and present in smaller amounts, is also an accessory mineral in the normal granite, although perhaps more irregularly disseminated.

The radioactivity of the pegmatitic facies of the granite is due primarily to hydrogoethite and two other secondary minerals as yet unidentified. X-ray and spectrographic studies of these two minerals were inconclusive in suggesting the nature of the primary minerals from which they may have been derived. The major constituent elements of one of the secondary minerals are Cu, Ag, and Pb; traces of Be and Fe are present. The other mineral consists mainly of

Al, Ca, Fe, Ag, Cu, Pb, and Si. The hydrogeothite contains traces of Cu, Ag, Be, and Si, in addition to the major constituent, Fe.

The radioactive part of the heavy-mineral fraction of the fine-grained acidic intrusives is composed chiefly of zircon and sphene with lesser amounts of allanite, whereas the radioactive heavy portion of the biotitic variant is composed primarily of allanite with only a few grains of zircon.

Mineralogical studies of the placer samples indicate that the radioactivity is due principally to zircon and sphene, both of which are present in all of the concentrates. Allanite is present in many of the samples, and hydrogoethite and the two unidentified secondary minerals occur in a somewhat smaller percentage of the concentrates. Although these minerals usually constitute a minor portion of the heavy minerals in comparison to the zircon and sphene, they doubtless add considerably to the radioactivity in many samples.

Thorium-uranium content.-The relative amounts of thorium and uranium in the gravel and bedrock deposits are dependent upon the nature of the mineral constituents. As shown above, the radioactivity of the placer deposits is primarily due to thorium-bearing zircon, sphene, and allanite, and to a lesser extent to secondary minerals containing uranium. The radioactivity of the normal granite, the fine-grained felsic intrusives, and the biotite-rich material is also due to the presence of thorium-bearing minerals. The secondary minerals of the pegmatitic facies contain uranium but thorium is not in quantities detectable by spectrographic analysis.

CONCLUSIONS

The investigations in the Serpentine-Kougarok area failed to reveal either placer or bedrock deposits of radioactive material in quantities of present commercial interest. Although the field studies were necessarily restricted in their scope, the results do not indicate further work to be warranted at the present time.

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Table 1.--Data on bedrock samples, granite area in vicinity of Serpentine Hot Springs

Sample locality no.	eU content of crushed sample (percent)	eU content heavy-mineral concentrate[1] (percent)	Concentration ratio (weight of the original sample to heavy minerals)	Type of material
74	0.016	0.034	2.0	Quartz-muscovite-tourmaline vein.
75	.019	.057	3.3	Same vein no. 74; 8 feet distant.
76	.008	.033	5.6	Quartz-muscovite vein.
77	.006	.017	2.3	Do.
78	.004	.018	5.0	Do.
79	.016	.024	2.7	Quartz-muscovite tourmaline vein.
80	.005	.011	3.4	Quartz-muscovite vein.
81	.007	.025	19.5	Do.
82	.032	.096	9.5	Do.
83	.004	.039	17.9	Biotite-rich granitic differentiate.
84	.004	.020	4.5	Do.
85	.009	.021	1.9	Fine-grained felsic vein.
86	.015	.071	150.5	Do.
87	.004	.070	42.0	Do.
88	.004	.036	4.6	Quartz-muscovite-tourmaline vein.
90	.007	.021	110.0	Fine-grained felsic vein.
93	.012	.023	6.9	Quartz-muscovite vein.
96	.000	.009	2.3	Do.
102	.002	.060	214.0	Disintegrated granite from sidehill water.
103	.004	.022	16.4	Quartz-muscovite vein.
104	.000	.023	8.5	Iron-stained zone in granite.
105	.011	.033	4.4	Biotite-rich granitic differentiate.
106	.004	.040	15.4	Quartz-muscovite-tourmaline vein.
107	.012	.044	7.5	Quartz-muscovite vein.
108	.000	.021	7.0	Iron-stained zone in granite.
110	.007	.040	14.7	Iron-stained quartz vein in granite.
111	.008	.035	6.8	Quartz-muscovite vein.
112	.009	.034	9.6	Do.
113	.008	.018	16.5	Do.

[1] Specific gravity +2.89.

Table 2.--Data on placer samples, granite area in vicinity of Serpentine Hot Springs

Sample locality no.	eU content gravels in place (percent)	Heavy-mineral concentrate (+2.89 sp gr) eU content (percent)	Concentration ratio (weight original gravels to heavy-mineral fraction)
HOT SPRINGS CREEK AND TRIBUTARIES (all samples in order downstream)			
Main right-limit tributary of north fork			
60	0.00011	0.041	378:1
59	.00015	.058	382:1
58	.00008	.036	448:1
57	.00011	.047	414:1
56	.00006	.050	852:1
55	.00009	.046	529:1
26	.00016	.052	334:1

Table 2.--Data on placer samples, granite area in vicinity of Serpentine Hot Springs--Continued

Sample locality no.	eU content gravels in place (percent)	Heavy-mineral concentrate (+2.89 sp gr) eU content (percent)	Concentration ratio (weight original gravels to heavy-mineral fraction)
HOT SPRINGS CREEK AND TRIBUTARIES--Continued			
Southeast headwater branch of the north fork			
42	0.00010	0.041	404:1
41	.00002	.008	514:1
40	.00001	.018	1,350:1
39	.00004	.040	1,031:1
91	.00015	.178	1,169:1
38	.00004	.015	389:1
Minor tributary gulches near junction northeast and southeast headwater branches of north fork			
73	0.00118	0.840	711:1
70	.00072	.463	635:1
71	.00009	.039	445:1
Northeast headwater branch of the north fork			
25	0.00002	0.016	895:1
24	.00002	.015	645:1
23	.00005	.035	705:1
22	.00007	.044	674:1
21	.00009	.053	587:1
20	.00002	.054	3,400:1
37	.00190	.260	137:1
19	.00001	.017	1,260:1
North from below junction of headwater branches to main right-limit tributary			
18	0.00011	0.070	630:1
72	.00011	.100	929:1
17	.00007	.028	391:1
16	.00007	.070	952:1
15	.00004	.052	1,226:1
69	.00001	.006	421:1
14	.00004	.036	856:1
68	.00022	.112	508:1
67	.00039	.103	264:1
South fork Hot Springs Creek			
35	0.00005	0.069	1,473:1
36	.00003	.031	1,226:1
32	.00002	.032	1,432:1
34	.00000	.003	728:1
33	.00000	.005	835:1
31	.00008	.050	670:1
30	.00002	.012	544:1
29	.00028	.064	225:1
63	.00008	.038	502:1
62	.00009	.034	375:1
61	.00007	.036	544:1
28	.00024	.062	262:1
27	.00005	.036	750:1
48	.00013	.052	392:1
46	.00006	.044	805:1
47	.00003	.018	613:1

Table 2.--Data on placer samples, granite area in vicinity of Serpentine Hot Springs--Continued

Sample locality no.	eU content gravels in place (percent)	Heavy-mineral concentrate (+2.89 sp gr) eU content (percent)	Concentration ratio (weight original gravels to heavy-mineral fraction)
HOT SPRINGS CREEK AND TRIBUTARIES--Continued			
Left-limit gully of Hot Springs Creek below forks			
45	0.00000	0.015	2,520:1
Downstream from junction of main right-limit tributary and north fork			
66	0.00021	0.086	409:1
13	.00046	.108	236:1
12	.00011	.062	564:1
11	.00027	.082	308:1
10	.00014	.060	420:1
9	.00018	.079	428:1
7	.00016	.068	427:1
6	.00004	.030	867:1
5	.00008	.037	495:1
4	.00004	.030	740:1
3	.00015	.040	259:1
2	.00015	.041	265:1
1	.00016	.044	278:1
43	.00003	.027	787:1
44	.00007	.050	667:1
FISH RIVER AND TRIBUTARIES			
92	0.00001	0.020	1,940:1
109	.00001	.031	2,835:1
101	.00001	.008	702:1
Humboldt Creek and tributaries			
95	0.00004	0.038	1,086:1
94	.00012	.057	456:1
100	.00006	.037	637:1
99	.00000	.016	2,021:1
97	.00002	.009	462:1
98	.00002	.010	438:1

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