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RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN THE DARBY MOUNTAINS, SEWARD PENINSULA, ALASKA, 1948

By Walter S. West

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ABSTRACT

Radioactivity in the southern and eastern parts of the Darby Mountains, Seward Peninsula, Alaska, appears to be directly related to the occurrence of granite. Concentrates from placers derived from areas containing granite are more radioactive than concentrates from placers not derived from the granite and, generally, contain from 0.01 to 0.05 percent equivalent uranium. The radioactivity of these concentrates is largely due to radioactive elements in common accessory minerals in granite, such as sphene, allanite, zircon, and, locally, monazite. Locally, in the Clear Creek-Vulcan Creek area, the headwaters of the Kwiniuk River, and on Golovnin Bay near McKinley Creek, concentrates from placers derived from granitic terrain contain as much as 0.1 percent equivalent uranium. The higher radioactivity of the concentrates from the Clear Creek area and on Golovnin Bay is due chiefly to an unidentified uranium-titanium niobate, whereas the higher radioactivity at the headwaters of the Kwiniuk River is due to thorianite.

INTRODUCTION

The Darby Mountains are situated in the southeastern part of the Seward Peninsula, Alaska (pl. 1). The range has a general north-south trend and extends from Cape Darby on the south to the southeastern portion of the Bendeleben Mountains on the north, a distance of approximately 75 miles. The area is bounded on the west by Golovnin Lagoon, Golovnin Bay, and the Fish River and in general on the east by Norton Bay and the Tubutulik River, although the upper half of the latter river dissects the eastern flank of the mountains.

The area is accessible from Nome, approximately 70 miles to the west, by air to two small airstrips, one located at Golovin on the western side of the Darby Peninsula and the other at White Mountain on the Fish River (outside of area shown on pl. 1) and the Moses Point Civil Aeronautics Authority airfield near the mouth of the Kwiniuk River, 46 miles northeast of Golovin. There are no good harbors along the entire coast. Transportation of supplies within the area must be accomplished by tractor or in part by small boats, as there are no roads.

The Darby Mountains are a relatively low range with the highest peaks seldom rising to more than 3,000 feet above sea level. In the heart of the range, glaciation has produced cirques and steep-sided, U-shaped valleys. Some streams have cut deep valleys. Wave action along the south coast of the Darby Peninsula has produced a rugged coast with high cliffs and a beach so narrow that it is impossible to walk along the shore in many places.

The greater part of the Darby Mountains district is made up of well-rounded tundra- or vegetation-covered hills and mountains. Rock pinnacles, talus, and rock fragments occur on and near the tops of many mountains, but bedrock outcrops are surprisingly scarce.

Previous investigations (Gault, Killeen, West, and others, 1953) in the northeastern part of the Seward Peninsula to the northeast of the Darby Mountains revealed the presence of uranothorianite and several other less radioactive minerals widely distributed, but locally concentrated, in areas underlain by felsic igneous rocks. The purpose of the 1948 reconnaissance in the Darby Mountains was to determine whether similar radioactive minerals also occur in the felsic igneous rocks of this district, and, if present, attempt to discover any sites of high concentration and the bedrock source of such minerals. The reconnaissance was conducted during the summer of 1948 by a field party consisting of W. S. West, geologist, and A. E. Nessett, J. J. Otoyuk, and J. M. Ikleasik, camp assistants. Time permitted only the investigation of the southern and eastern parts of the district. The route followed is indicated by the location of camps, numbered in chronologic order starting at Golovin, on plate 1.

GEOLOGY

The only work of the Geological Survey in the Darby Mountains prior to this investigation was done by two parties; that of Mendenhall (1901), who in 1900 mapped both topographically and geologically the Koyuk River valley and parts of the Darby Mountains on an exploration-reconnaissance scale; and that of Smith and Eakin (1911), who in 1909 mapped the area between Nulato and Council on a similar scale.

The geologic features of the Darby Mountains district as described by Mendenhall (1901) and Smith and Eakin (1911), are discussed briefly below.

Undivided metamorphic rocks

The oldest rocks in the district, which occur mainly along the western flanks of the Darby Mountains, are folded and sheared metamorphic rocks of pre-Silurian and possibly pre-Cambrian age (pl. 1). These rocks consist of quartzose, calcareous, biotitic, chloritic, feldspathic, and graphitic schist and thin limestones. The schist has been cut by greenstone, granite, diorite, and other igneous rocks which have had a share in the metamorphism and obliteration of the original characters of the schist.

Rocks of Paleozoic age

Carboniferous, Devonian, and Silurian rocks are best represented along the eastern flank of the Darby Mountains and are well exposed along the sea coast from the mouth of Iron Creek southwest nearly to Carson Creek. This group of rocks, composed mainly of limestone with subordinate dolomite, black slate, and schist, is complexly folded, faulted, metamorphosed, and cut by intrusives of greenstone, granite, and diorite.

Greenstone and greenstone schist

The post-Carboniferous greenstone and greenstone schist, which occur along the eastern flank of the Darby Mountains, were not observed in place, although greenstone cobbles and pebbles were seen on the bars along the lower course of the Tubutulik River.

Undivided igneous complex

An undivided igneous complex and the granite make up the central core of the Darby Mountains. The undivided igneous complex is believed to belong to one geologic body of pre-Cretaceous age. It is composed mainly of granite, which has undergone varying degrees of metamorphism, but also includes some diorite, greenstone, and several other types of igneous rocks whose characteristics are not sufficiently clear to allow their identification and subdivision.

Granite

The granite, also pre-Cretaceous in age, ranges from even-grained to porphyritic in texture and exhibits considerable variation in mineralogical composition. In the area studied the porphyritic granite is much more abundant than the even-grained. Outcrops usually take the form of knobs and pinnacles on the tops and sides of the mountains. Inclusions of diorite in the porphyritic granite noted especially along the east coast of the Darby Peninsula indicate that the granite is younger than some of the diorites in the undivided igneous complex.

Ungalik conglomerate

The Ungalik conglomerate, the oldest formation of the Cretaceous sedimentary sequence in west-central Alaska, is made up of rounded debris derived from older formations including limestone, schist, igneous rocks, quartz veins, and sandstone. It forms the first main divide east of the Tubutulik River on the extreme eastern flank of the Darby Mountains. One outcrop of this conglomerate was noted along the bank of the lower Tubutulik River.

Basalt

Two isolated outcrops of vesicular basalt of Tertiary age were observed in the area. One lies between the headwaters of Grouse Creek and the Tubutulik River and the other between the third and fourth east tributaries to the Right Branch of Kachauik Creek (pl. 1).

Unconsolidated deposits

The youngest deposits shown on plate 1 are marine and nonmarine water-laid deposits of Quaternary age. No attempt has been made to show the glacial deposits or the widespread deposits of unsorted waste rock that cover practically all of the area not occupied by marine and nonmarine gravels, sands, and silts.

Hot springs

A hot spring, not mentioned in earlier Survey literature, was discovered issuing from granite high on a mountain slope above Clear Creek, a right tributary to the Tubutulik River. The stream formed by this spring constitutes the seventh west tributary to Clear Creek above the creek's mouth (pl. 1). There is another hot spring on the north side of the Kwiniuk River in the vicinity of the mouth of Corral Creek. This spring was not visited, but it also probably issues from granite.

Veins

Quartz and calcite veins and veinlets are abundant in the schistose rocks, and calcite veins are common in the limestones. Quartz veins also occur in the granite and granitoid rocks, but they are much less common than in the schists. Along the beach about 2 miles north of Golovin a large quartz lens 30 by 15 by 10 feet may be seen, but this lens, like practically all the veins and veinlets, contains no sulfides. Half a mile north of this lens vein quartz containing chalcopyrite was found in float along the beach; and chalcopyrite-quartz vein float, stained and incrusted with malachite, was observed on the west bank of the Right Branch of Kachauik Creek about 75 yards upstream from the mouth of the second east tributary. Iron-stained quartz and calcite veins were observed at other localities, and some veins have been reported by prospectors to carry small quantities of gold.

Mineral deposits

No lode mines were operating in the Darby Mountains during 1948. There is evidence that lode prospecting, probably for copper and gold, has been carried on in the past along the coast of Norton Bay between Carson and Walla Walla Creeks, but no deposits of economic importance were discovered. The only lode prospect of any significance in the entire Darby Mountains is a silver-lead prospect on Omilak Creek, a tributary to the Fish River, in the northwestern part of the range. This prospect, which lies outside the area covered in plate 1, was not visited.

A coal deposit, not previously mentioned in Survey literature, was found to crop out on the right headwater fork of the left branch of Grouse Creek, a tributary to the Tubutulik River. This deposit appears to have an east-west extent of more than 1 mile, and the outcrop from stream level to the top of the bank varies from 10 to 15 feet in thickness although the depth of the coal below the level of the stream is not known. The coal is probably a high-grade lignite and may possibly rank as high as subbituminous C coal.

There is no evidence of any recent placer mining in the district, and no one was prospecting during the summer of 1948. The only old placer-gold operation observed was on Grouse Creek. In the past, gold prospecting has been done on Vulcan, Chukajak, and Admiral Creeks, all tributaries to the Tubutulik River.

RADIOACTIVITY INVESTIGATIONS

The instrument used for field radiometry in the Darby Mountains in 1948 was a standard commercial model of a portable survey meter with a 6-inch beta-gamma probe. Because the greater part of the district is covered with vegetation—mostly tundra—and talus, direct radiometric testing of outcrops was of necessity limited in scope, and the low sensitivity of the probe rendered the instrument ineffectual for traversing. To study effectively distribution of radioactive minerals in the district the greater part of the field work was directed, therefore, to the collection of concentrates from slopewash and the gravels of stream and beach deposits in a effort to determine whether radioactive minerals were being concentrated in placers formed by the deposition of material eroded from rocks in the various drainage areas. Thus, local concentrations of radioactive minerals could be found, the ultimate source of which could then be discovered by trenching to bedrock at selected localities.

In the course of the season 248 concentrates were collected from 215 sites of stream gravels, 20 sites of beach gravels, and 13 sites in slopewash. Each concentrate from stream and beach gravels was panned from about 50 pounds of sand and gravel, and each slopewash concentrate was panned from approximately 100 pounds of disintegrated rock material. The locations of these concentrates are shown on plate 1. Each of these concentrates was tested for radioactivity in the field to determine whether additional concentrates should be taken in any given drainage area. For consistency in expressing the radioactivity of these concentrates, each sample was further concentrated in the laboratory by separating the light- and heavy-mineral fractions with bromoform (sp gr 2.89). As preliminary tests showed that essentially all the radioactive minerals occur in the heavy-mineral fraction, the equivalent uranium content of each heavier-than-bromoform fraction was then determined by radiometric analysis. To concentrate further the radioactive minerals for mineralogic study the heavier-than-bromoform fractions of selected concentrates were subdivided into light and heavy subfractions by using methylene iodide (sp gr 3.3), as again preliminary scanning of the samples indicated that essentially all the radioactive minerals have a relatively high specific gravity.

In addition to the above technique of testing areas by studying the heavy-mineral content of its placers, the writer collected numerous rock samples, mostly float rock from talus slopes and stream gravels.

However, as the radioactivity of none of these samples was estimated to exceed 0.003 percent equivalent uranium when tested with the portable survey meter, they were not examined in more detail.

The distribution of radioactivity in the southern and eastern parts of the Darby Mountains is discussed by area in the following pages.

Kachauik Creek-Cheenik Creek area

The rocks in the drainage basins of Kachauik and Cheenik Creeks (pl. 1) include two bodies of granite, which appear to be the source rocks of the radioactive minerals in the concentrates collected from the area. The distribution of radioactivity in a total of 46 concentrate samples (nos. 2884-2889, pl. 1) obtained in the area is as follows:

Range in equivalent-uranium content (percent)	Number of samples
< 0.01	25
0.01 to 0.02	14
> 0.02 (maximum 0.028)	7

All the concentrates containing 0.01 percent or more equivalent uranium are from those parts of the two main streams or their tributaries which drain the granite bodies. The concentrates that contain more than 0.02 percent equivalent uranium have an average concentration ratio of about 380 to 1.

The mineral subfraction of sample 2839, greater than 3.3 specific gravity, selected as typical of the radioactive concentrates from the Kachauik Creek-Cheenik Creek area, contains, in decreasing order of abundance, hornblende, sphene, garnet, and zircon and traces of magnetite, ilmenite, and olivine. Although the radioactive minerals in this sample were not specifically identified, it is likely that the radioactive elements occur chiefly in the sphene and zircon.

McKinley Creek-Bryan Creek area

In the McKinley Creek-Bryan Creek area (pl. 1) a small body of granite occurs in the headwaters of Bryan Creek and an even smaller body appears in a sea cliff on Golovnin Lagoon about midway between the mouths of Cheenik and McKinley Creeks. Six concentrates (nos. 2893-2898) were taken in the vicinity of the granite at the head of Bryan Creek. The radioactivity of these concentrates, which have concentration ratios of 500—1,000 to 1, ranges from 0.009 to 0.015 percent equivalent uranium. The radioactive minerals in these samples were not identified but probably are one or more of the common accessory minerals in the granite. Sample 2890, a concentrate taken from a small unnamed stream, not shown in plate 1, contains 0.016 percent equivalent uranium. As this stream probably heads in the edge of the granite on upper Bryan Creek and the radioactivity and concentration ratio is about the same as the samples from Bryan Creek, it is likely that the radioactive minerals are the same as those in the samples from Bryan Creek.

The material in the slopewash concentrate (sample 2891) taken at the granite on the coast between Cheenik and McKinley Creeks probably is derived mostly from a mineralized zone near the contact between the granite and the older igneous complex (pl. 1). The heavier-than-bromoform fraction contains 0.074 percent equivalent uranium. The minerals of specific gravity greater than 3.3 are chiefly magnetite, with lesser amounts of sphene and topaz and minor amounts of allanite, hematite, ilmenite, hornblende, biotite, scheelite, and an unidentified uranium-titanium niobate mineral. The uraniferous niobate is the chief radioactive mineral, although radioactive elements in the allanite, hematite, and sphene doubtless contribute to the total radioactivity of the sample.

Portage Creek-Cape Darby area

Between Portage Creek and Cape Darby 24 concentrate samples (nos. 2899-2922, pl. 1) were collected to determine whether radioactive minerals were being eroded from the rocks along the numerous short streams and sea cliffs in the area. The distribution of radioactivity in these samples follows:

Range in equivalent-uranium content (percent)	Number of samples
< 0.01	17
0.01 to 0.02	2
> 0.02	5

Data on the concentrates from this area containing 0.01 percent or more equivalent uranium are given as follows:

Sample no.	Location	Percent equivalent uranium	Concentration ratio
2899	Portage Creek, near mouth	0.022	650:1
2900	Portage Creek, right tributary.	.034	550:1
2905	Golovnin Lagoon beach near Mission Creek.	.015	75:1
2909	do	.015	130:1
2910	do	.030	30:1
2918	Unnamed stream entering Golovnin Lagoon about 3½ miles south of Mission Creek.	.035	6,400:1
2921	Golovnin Lagoon sea cliff about 4½ miles south of Mission Creek.	.049	1,200:1

The mineralogic composition of selected radioactive samples from the Portage Creek-Cape Darby area is given in table 1. As in the Kachauik Creek-Cheenik Creek area the more radioactive samples are concentrates in which the material has been derived chiefly from granite.

In this area the radioactivity is due to the presence of radioactive elements in allanite, hematite, and monazite as well as sphene and zircon. Of particular note is the slopewash concentrate (sample 2918) from the small granite mass about 4 miles south of Mission Creek which contains chiefly hematite and topaz. The material from which this concentrate was obtained consisted largely of disintegrated rock from a contact zone between the younger granite and the older intrusives, in this case a metamorphosed granitic rock. The possibility that the radioactive elements, particularly

Table 1.—Mineralogic composition of selected radioactive heavy-mineral subfractions (specific gravity greater than 3.3) of concentrates from the Portage Creek-Cape Darby area

[X indicates presence of mineral; Tr. indicates presence of only traces of the mineral; zero indicates mineral not present]

Mineral	Sample no.				Mineral	Sample no.			
	2900	2910	2918	2921		2900	2910	2918	2921
Fluorite	X	0	0	Tr.	Topaz	0	0	X	0
Hematite	Tr.	X	X	X	Epidote	0	X	0	Tr.
Ilmenite	Tr.	X	0	X	Allanite	X	0	0	Tr.
Spinel	0	X	0	0	Staurolite	0	X	0	0
Magnetite	X	X	0	X	Biotite	0	0	0	Tr.
Rutile	0	X	0	0	Sphene	X	X	0	0
Hornblende	X	0	0	0	Monazite	0	0	0	X
Garnet	X	X	0	X	Scheelite	0	0	0	Tr.
Olivine	0	Tr.	0	0	Powellite	0	Tr.	0	0
Zircon	X	X	Tr.	X					

uranium, in this area were introduced hydrothermally in a late stage of the consolidation of the granite magmas is suggested by the occurrence of fluorite and topaz.

Norton Bay coastal area between Cape Darby and the Kwiniuk River

Twenty-seven concentrates (samples 2923-2946 and 2963-2965, pl. 1) were taken in the coastal area along Norton Bay between Cape Darby and the mouth of the Kwiniuk River. These include three samples from the area of a granite at the head of the Kwiniuk River, which extends to within several miles of the coast about 13 miles north of Cape Darby (pl. 1). Most of the concentrates were collected in the vicinity of several small granite bodies that occur along the coast in the vicinity of Carson Creek. The radioactivity data of the 27 concentrates are summarized as follows:

Range in equivalent-uranium content (percent)	Number of samples
< 0.01	15
0.01 to 0.02	7
> 0.02	5

Pertinent data on the heavy-mineral fractions of samples containing more than 0.02 percent equivalent uranium follows:

Sample no.	Location	Percent equivalent uranium	Concentration ratio
2927	Creek between Norton Bay, 2.8 miles south of Carson Creek.	0.021	410:1
2929	Creek between Norton Bay, 0.6 mile south of Carson Creek.	.024	560:1
2937	Carson Creek	.024	380:1
2963	Headwaters Kwiniuk River, second right tributary below headwater forks.	.029	350:1
2965	Headwaters of Kwiniuk River.	.039	410:1

Although the radioactive minerals in the concentrates from the Norton Bay coastal area were not identified (except for one concentrate from the head of the Kwiniuk River), the fact that the locations of the more radioactive samples are directly related to location of the granites suggests that the bulk of the radioactivity is due to common accessory minerals of the granite, such as zircon and sphene. However, because of the proximity of these granites to those on the west side of Darby Peninsula in the vicinity of Mission Creek, it is also possible that such minerals as allanite and monazite might also be found in these concentrates. If present, these minerals would contribute to the radioactivity of the samples.

Sample 2965 from the granite area near the head of the Kwiniuk River (pl. 1), contains, in decreasing order of abundance, hornblende, sphene, zircon, garnet, hematite, magnetite, epidote, olivine, and thorianite. The thorianite is the chief radioactive mineral; however, the zircon and sphene are slightly radioactive. Although the bedrock occurrence of the thorianite is most likely as an accessory mineral in the granite, the proximity of the contact between the granite and metamorphosed sedimentary rocks, including limestone, suggests that the thorianite may well have been derived from altered rocks in the contact zone.

Kwiniuk River

The Kwiniuk River crosses a large belt of granite about halfway to its headwaters (pl. 1). Unfortunately the investigation of this granite area could not be completed because of the onset of cold weather in the fall. However, some 16 concentrates (samples 2947-2962) were taken along the Kwiniuk, and a few of its tributaries, between its mouth and the belt of granite. The equivalent-uranium content of the heavy-mineral fractions (specific gravity greater than 2.89) of these concentrates are given as follows:

Sample no.	Percent equivalent uranium	Concentration ratio	Remarks
2947	0.003	1,080:1	
2948	.008	120:1	
2949	.008	250:1	
2950	.015	180:1	
2951	.011	310:1	
2952	.018	210:1	
2953	.002	610:1	Right-limit tributary.
2954	.012	240:1	
2955	.006	330:1	Left-limit tributary.
2956	.004	240:1	Do.
2957	.015	180:1	
2958	.011	250:1	
2959	.013	210:1	
2960	.015	230:1	
2961	.017	230:1	Left-limit tributary.
2962	.017	180:1	

As seen in the previous tabulation and on plate 1 the equivalent uranium content of the samples has a fairly general increase in upstream order with the radioactivity confined almost entirely to concentrates from the main stream. Although the equivalent uranium content of the concentrates is not as relatively high when compared to other concentrates from the district, the general increase upstream suggests that higher values might be obtained in the granite belt, which is believed to be the chief source of the radioactive minerals. The heavy minerals in sample 2961, which was obtained from a small tributary draining a small part of the granite along its contact with adjacent sedimentary rocks of Paleozoic age (pl. 1), are chiefly sphene, hornblende, allanite, apatite, hematite, and garnet; also found were traces of spinel, scheelite, powellite, magnetite, epidote, rutile, pyrite, and chalcopyrite. The radioactivity of the sample is ascribed mostly to thorium in the allanite, although it is likely that some of the other minerals, such as the sphene and hematite, are also radioactive. The presence of traces of scheelite, powellite, and chalcopyrite suggests that at least some of the minerals in the concentrate were derived from some type of lode at or near the contact between the granite and the limestone and shale of Paleozoic age. It is possible, therefore, that some, if not all, of the radioactive minerals might also have been derived from a lode source rather than have originated as accessory minerals in the granite.

Tubutulik River area

The drainage basin of the Tubutulik River is underlain by a large variety of rock types (pl. 1). The most significant feature, however, is a wide belt of granite along the western side of the area that is a continuation of the granite belt crossing the Kwiniuk River to the south. Of a total of 114 concentrates (samples 2966-2990, 2992-2998, and 3000-3002, 3004, 3081 (pl. 1), 41 contain between 0.01 and 0.02 percent equivalent uranium, and 34 contain more than 0.02 percent equivalent uranium up to a maximum of about 0.1 percent equivalent uranium. The radioactivity of the concentrates from the Tubutulik River and its tributaries is confined entirely to samples in which at least part of the original material concentrated was derived from granitic rocks (pl. 1). In general, the equivalent-uranium content of the concentrates increases as the streams are ascended to and within the granite. The data on the concentrates from the Tubutulik River area that contain more than 0.02 percent equivalent uranium are given below; these samples are arranged in order of location from south to north, rather than in upstream order, in an attempt to show more precisely the relationship of the radioactivity of the concentrates to the belt of granite.

Sample no.	Location	Percent equivalent uranium	Concentration ratio
3020	Seventh west tributary of Clear Creek, near hot spring.	0.038	375:1
3021	----do----------	.022	200:1
3009	Third west tributary of Clear Creek.	.022	425:1
2983	Second west tributary of Clear Creek.	0.086	1,100:1
2984	----do----------	.023	400:1
2987	----do----------	.027	1,750:1
2988	----do----------	.067	2,200:1
2989	----do----------	.054	1,050:1
2990	----do----------	.027	475:1
2992	----do----------	.104	1,850:1
2993	----do----------	.079	1,450:1
2994	----do----------	.060	750:1
2995	----do----------	.066	1,900:1
2996	----do----------	.065	1,550:1
2997	----do----------	.040	1,500:1
2982	Clear Creek----------	.022	---
2974	First west tributary of Clear Creek.	.023	600:1
2975	----do----------	.023	925:1
2979	----do----------	.023	4,000:1
3028	Vulcan Creek----------	.048	275:1
3029	----do----------	.027	127:1
3030	----do----------	.042	825:1
3031	----do----------	.044	1,850:1
3032	----do----------	.043	1,450:1
3033	----do----------	.067	1,050:1
3034	----do----------	.023	725:1
3035	----do----------	.025	450:1
3052	Rock Creek----------	.036	2,250:1
3072	First south tributary of Tubutulik River above Rock Creek.	.024	1,450:1
3075	Big Creek----------	.023	1,200:1
3077	First northeast tributary of Tubutulik River above Grouse Creek.	.046	---
3078	Second northeast tributary of Tubutulik River above Grouse Creek.	.055	1,500:1
3064	Grouse Creek----------	.076	2,750:1

From the above tabulation it is apparent that three major centers of abnormal radioactivity occur in the Tubutulik River area. These centers are on the second west tributary of Clear Creek, on Vulcan Creek, and in the area between Grouse Creek and the Tubutulik River. The mineral composition of representative concentrates from these areas are given in table 2. For comparison, the mineral composition for radioactive concentrates of the seventh and first west tributaries of Clear Creek, Rock Creek, and Big Creek are also given.

Review of the above mineral lists suggests that some of the radioactivity in all the concentrates is due to radioactive elements in such minerals as hematite, allanite, and sphene. It is likely that the zircon also is radioactive. Of the more radioactive samples, namely those containing more than 0.06 percent equivalent uranium, only one (that from Grouse Creek) is not from the area between the second west tributary of Clear Creek and Vulcan Creek. The higher radioactivity in the Clear Creek-Vulcan Creek samples is attributed primarily to the presence of an as yet unidentified uraniferous titanium niobate mineral or minerals. The heavy-mineral fractions (specific gravity greater than 2.89) of samples 2983, 2996, and 3033 were estimated to contain as much as 5 to 10 percent of the niobate mineral or minerals. Qualitative spectrographic analyses of the niobates from these three

Table 2.—Mineralogic composition of heavy-mineral subfractions (specific-gravity greater than 3.3) of concentrates from the Tubutulik River area

[X indicates presence of mineral; Tr. indicates presence of only traces of the mineral; zero indicates mineral not present]

Mineral	Sample no.													
	3020	2983	2992	2993	2995	2996	2974	3028	3033	3052	3075	3077	3078	3064
Pyrrhotite	0	0	0	0	0	0	0	0	0	0	Tr.	0	0	0
Pyrite	Tr.	0	X	0	0	X	Tr.	Tr.	X	0	Tr.	0	0	0
Hematite	0	X	0	X	X	X	0	X	X	X	X	0	X	0
Ilmenite	Tr.	X	0	X	X	0	X	X	0	X	X	X	X	X
Magnetite	X	0	0	X	X	X	X	X	X	X	0	X	X	X
Cassiterite	0	Tr.	0	0	0	0	0	0	0	0	0	0	0	0
Rutile	0	0	0	0	0	0	0	Tr.	0	0	Tr.	0	X	0
Anatase	Tr.	0	0	0	0	Tr.	Tr.	Tr.	Tr.	X	Tr.	0	X	0
Hornblende	0	0	0	0	0	0	X	Tr.	0	0	0	0	0	0
Garnet	0	X	0	0	0	0	0	Tr.	0	X	X	0	0	X
Olivine	0	0	0	0	0	0	0	0	0	0	X	0	0	0
Zircon	X	0	Tr.	0	0	X	0	X	X	0	Tr.	0	0	0
Topaz	X	X	X	0	0	X	X	0	0	X	0	0	0	0
Kyanite	0	0	0	0	0	0	0	Tr.	0	X	0	0	0	0
Epidote	0	0	0	0	0	0	0	X	0	X	X	0	X	0
Allanite	X	X	X	X	X	X	Tr.	0	Tr.	X	X	0	0	0
Staurolite	0	0	0	0	0	0	0	X	0	0	0	0	0	0
Biotite	0	0	0	0	0	0	Tr.	0	0	0	0	0	0	0
Sphene	X	X	X	X	Tr.	X	X	X	X	X	X	X	X	X
Niobate minerals[1]	0	X	Tr.	Tr.	0	X	0	0	X	0	0	0	0	0
Apatite	0	0	0	0	0	0	0	X	0	0	0	0	0	0
Scheelite	0	Tr.	0	0	0	0	0	0	0	0	0	0	0	0
Powellite	0	0	0	0	0	0	0	0	0	0	Tr.	0	0	0
Wulfenite	0	0	0	0	0	0	0	0	0	0	0	0	Tr.	0

[1]Unidentified minerals that contain chiefly niobium, titanium, calcium, and uranium.

samples showed that the chief elements in the mineral are niobium, uranium, titanium, and calcium. Traces of silicon and iron were also found. In only one of the samples was a niobate mineral thorium bearing.

The relatively high radioactivity of the sample from Grouse Creek is ascribed to the occurrence of a large amount of sphene and the relatively high concentration ratio.

SUMMARY AND CONCLUSIONS

The widespread cover of vegetation, mostly tundra and talus, in the Darby Mountains necessitated the use of a placer-sampling technique to evaluate adequately the potentialities of the district for radioactive materials. Field studies and the radiometric analysis and mineralogic study of the heavy-mineral fractions of numerous concentrates from placers of the district showed that essentially all the radioactive minerals in the district occur in, or were derived from, bodies of felsic igneous rocks, chiefly granite.

The most common and widespread radioactive minerals are sphene, allanite, hematite, and zircon. These minerals, with the possible exception of the hematite, probably are all primary accessory minerals in the granite. Locally in the Clear Creek-Vulcan Creek area and near the mouth of McKinley Creek, abnormally high radioactivity of concentrates derived from the granite appears to be due to the presence of a uraniferous titanium niobate mineral. Monazite was identified in one concentrate from the east shore of Golovnin Bay between Cape Darby and Portage Creek. Thorianite is the chief radioactive mineral in a concentrate from the head of the Kwiniuk River.

Although it is likely that the uranium- and thorium-bearing minerals in the southern and eastern parts of the Darby Mountains are largely disseminated in the granite, local concentrations of the radioactive elements may have formed through hydrothermal activity in a late stage of consolidation of the granite magmas. This is suggested by the common association of topaz and, locally, fluorite with the radioactive minerals. The association of topaz and traces of cassiterite with the uraniferous niobate mineral in the Clear Creek-Vulcan Creek area suggests also that these minerals may be genetically related to lode tin occurrences or pegmatitic phases of the granite.

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