Mineral Resources of Alaska, 1956

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UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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Reconnaissance for Radioactive Deposits in Southeastern Alaska, 1952

By JOSEPH R. HOUSTON, ROBERT G. BATES, ROBERT S. VELIKANJE, *and* HELMUTH WEDOW, Jr.

MINERAL RESOURCES OF ALASKA

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MINERAL RESOURCES OF ALASKA

RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN SOUTHEASTERN ALASKA, 1952

By Joseph R. Houston, Robert G. Bates, Robert S. Velikanje, and Helmuth Wedow, Jr.

ABSTRACT

Reconnaissance for radioactive deposits in southeastern Alaska in 1952 was centered in three localities: the northern part of Prince of Wales Island and parts of adjacent islands, the Taku Harbor-Point Astley district, and the Hyder area.

Significant concentrations of radioactive minerals were found only in the vicinity of Salmon Bay on the northeastern shore of Prince of Wales Island. In this area radioactive carbonate-hematite veins occur along the coast for about 8 miles. The veins are generally short, irregular, and lenticular, but a few can be traced for more than 300 feet between the low-tide line and the forest cover. The width of the veins normally ranges from less than 1 inch to 2.5 feet; several, however, are 5 to 10 feet wide.

The most abundant minerals in the veins are dolomite-ankerite and alkali feldspar with decreasing amounts of red hematite, specular hematite, pyrite, siderite, magnetite, quartz, chalcedony, and chlorite. Parisite, bastnaesite, muscovite, fluorite, apatite, thorite, zircon, monazite, epidote, topaz, garnet, chalcopyrite, and marcasite have also been identified.

Most of the radioactivity is due to thorium contained chiefly in the minerals thorite and monazite. The highest grade grab sample assayed 0.13 percent equivalent uranium or about 0.64 percent equivalent thorium. The average of 7 channel samples taken along 100 feet of one of the more radioactive veins was 0.034 percent equivalent uranium or 0.16 percent equivalent thorium.

The rare-earth fluocarbonates parisite and bastnaesite, occur in small amounts in some veins. Four chip-channel samples taken from a high-grade rare-earth vein about 1,150 feet long averaged 0.79 percent rare-earth oxides over an average width of 7.4 feet. One high-grade grab sample from this vein assayed 5.0 percent rare-earth oxides.

INTRODUCTION

Most of the reconnaissance for radioactive deposits in southeastern Alaska during the summer of 1952 was centered in the northern part of Prince of Wales Island and parts of adjacent islands (locs. *C* through *M*, fig. 1). Brief reconnaissance work in 1951 (Houston, 1952, p. 13–17) had proved the existence of radioactive carbonate-hematite veins in the vicinity of Salmon Bay on the northeastern shore of Prince of Wales Island (loc. *C*, fig. 1), and further geologic work was necessary to determine more accurately the grade, mineralogy, and areal extent of these veins.

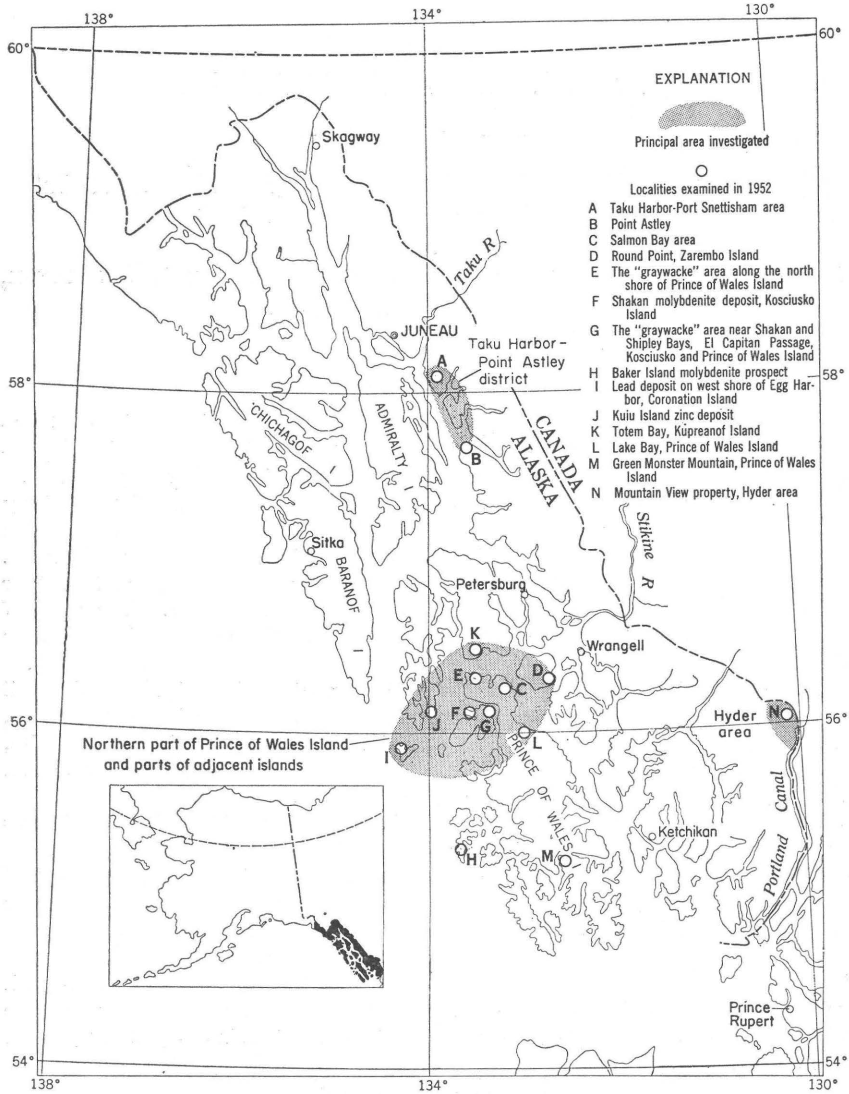

FIGURE 1.—Map of southeastern Alaska showing localities examined in 1952.

Because the radioactive veins in the vicinity of Salmon Bay occur only in graywacke, those parts of the northern and northwestern coasts of Prince of Wales Island (locs. *E* and *G*, fig. 1; pl. 1) that have been mapped as graywacke by Buddington (Buddington and Chapin, 1929, pl. 1) were also examined. In addition, localities *F*, *H*, *I*, *J*, *L*, and *M* (fig. 1), on Prince of Wales Island and adjacent islands were visited because previously described mineral deposits at those localities contain mineral assemblages similar to uranium deposits elsewhere (Wedow and others, 1951).

Brief reconnaissance examinations were made also in the Taku Harbor-Point Astley district (locs. *A* and *B*, fig. 1) and in the Hyder area (loc. *N*, fig. 1) to investigate reported pitchblende occurrences.

Joseph R. Houston, Robert G. Bates, Robert S. Velikanje, and Helmuth Wedow, Jr., geologists, and Eugene D. Michael, geologic field assistant, all of the Geological Survey, made these field investigations. The U. S. Bureau of Mines motor vessel, the "Swan II," was used as a base for the party in the field from early July until about mid-September. Bates and Wedow were with the party for about a month in the early part of the summer. Houston, as chief of the reconnaissance party, was responsible for the preparation of the report.

Special acknowledgment should be made to personnel of the U. S. Bureau of Mines who operated the "Swan II" and to personnel of the laboratories of the Geological Survey at College, Alaska, and Washington, D. C., who made all of the radioactivity, fluorimetric, and chemical analyses and some of the mineral identifications given herein. Mary E. Thompson was the first to identify the rare-earth mineral, parisite, in the samples from the vicinity of Salmon Bay. The writers are also indebted to Arthur E. Glover, engineer-assayer at the Ketchikan assay office of the Alaskan Territorial Department of Mines, for cooperation and aid on the work in the Salmon Bay area.

Qualitative and some semiquantitative determinations of radioactivity were made in the field with standard commercial portable Geiger counters. Some of the counters were modified to accept 2- by 20-inch gamma probes as well as the standard 6-inch beta-gamma probe. The larger probes were used mostly for traversing on foot with both the probe and counter lashed to a packboard (Wedow, 1951, p. 6).

This work was done on behalf of the U. S. Atomic Energy Commission.

NORTHERN PART OF PRINCE OF WALES ISLAND AND PARTS OF ADJACENT ISLANDS

In May 1950, John Wandve of Ketchikan, Alaska, submitted several pounds of reddish rocks to the Ketchikan office of the Alaskan Territorial Department of Mines. Wandve reported that he had collected the specimens at Salmon Bay on the northeastern shore of Prince of Wales Island (loc. *C*, fig. 1). Tests by Arthur E. Glover, Territorial Department of Mines engineer-assayer at Ketchikan, indicated that the average radioactivity of the entire sample was about 0.01 percent equivalent uranium.

In July 1951, Joseph R. Houston and Helmuth Wedow, Jr., geologists, and David L. Norton, geologic field assistant, accompanied by Glover, spent 1½ days in the Salmon Bay area. Houston and Norton returned for 3 days late in August. The results of the work in 1951 have been described by Houston (1952, p. 13–17). Many narrow radioactive carbonate-hematite veins were found in the graywacke of Silurian age near Salmon Bay. The most radioactive sample assayed 0.07 percent equivalent uranium. Tests showed that most of the radioactivity was due to thorium.

In October 1951 Wandve staked two lode claims near the entrance to Salmon Bay. In April and May of 1952, Smith, Pitcher, & Co., also of Ketchikan, prospected in the Salmon Bay area and along the coast to the south. Several new radioactive veins were discovered, and 32 lode claims were recorded.

Because of the marked interest among private prospectors and because of the brief reconnaissance nature of the 1951 work, the Geological Survey undertook more detailed studies of the Salmon Bay area in July and August 1952. Also, because the radioactive veins at Salmon Bay were thought to be only in graywacke of Silurian age, reconnaissance traverses were made along those parts of the northern and northwestern coasts of Prince of Wales Island (pl. 1) that had been mapped as graywacke by Buddington (Buddington and Chapin, 1929, pl. 1). Additional examinations were made at several localities on some of the nearby islands to investigate previously described mineral deposits that were reported to contain mineral assemblages characteristic of uranium deposits in other parts of the world.

GENERAL GEOLOGY

Little detailed geologic work has been done in the northern part of Prince of Wales Island. Buddington (Buddington and Chapin, 1929, pl. 1) did reconnaissance mapping in the coastal areas; part of his geologic map has been adapted for plate 1 of this report, and most of the geology recorded below has been taken from Buddington's report.

BEDDED ROCKS

The oldest rocks in the area are of Early and Middle Ordovician age. They consist of a series of well-indurated graywacke with associated dark slate, andesitic volcanic rocks, thin-layered black chert, and layers of conglomerate and limestone.

Overlying the rocks of Ordovician age, probably unconformably, is a thick series of sedimentary and volcanic rocks of Silurian age. The oldest rocks consist of andesitic volcanic rocks and conglomerate with some associated graywacke, black slate, and tuff. These rocks are about 3,000 feet thick and are overlain by a massive, relatively pure limestone. The fresh rock is white; on weathered surface it is gray or grayish brown. Many small randomly oriented fractures cut the limestone. These fractures are coated with a thin facing of carbonate that usually weathers into a network of veinlets. Thick beds of coarse conglomerate and limy argillaceous layers are interbedded with the limestone. The aggregate thickness of the limestone and conglomerate is about 4,500 feet. A sequence consisting of about 5,000 feet of reddish-brown, gray, and grayish-green graywacke and containing a few interbedded conglomerate, graywackelike sandstone, and shale layers overlies the limestone. Much of the rock on the northern and western coasts of Prince of Wales Island that Buddington mapped as "graywacke" (Buddington and Chapin, 1929, pl. 1) is actually very limy as indicated by the carbonate content of 45 to 90 percent of 3 thin sections examined. Generally there is a layer of coarse conglomerate 300 to 400 feet thick at the contact between the graywacke and the underlying limestone. The graywacke is the youngest sedimentary formation in the area except for unconsolidated glacial material.

IGNEOUS ROCKS

A small dioritic batholith, apparently an outlier of the Late Jurassic or Cretaceous Coast Range batholith on the mainland, lies just east of Shakan Bay on Prince of Wales and Kosciusko Islands. Buddington (Buddington and Chapin, 1929, p. 188, 203) gives the following average composition for diorite and quartzose diorite (quartz diorite of present authors) from Prince of Wales Island:

Diorite	Percent	Quartzose diorite	Percent
Andesine	62	Andesine	56
Hornblende	26. 5	Hornblende	20
Quartz	4	Quartz	9
Biotite	3	Potassium feldspar	6
Potassium feldspar	2	Biotite	4
Magnetite	1. 5	Pyroxene	2. 5
Accessories (chiefly sphene, apatite, and zircon)	1	Magnetite	2
		Accessories	. 5

Chapin (1919, p. 89), Mertie (1921, p. 118–119), and Twenhofel, Robinson and Gault (1946, p. 21), who have visited the molybdenite deposit near Shakan on Kosciusko Island (loc. *F*, fig. 1; pl. 1) also report that this intrusive mass is composed of diorite and quartz diorite. A thin section made from a specimen collected in 1952 near the western contact of this intrusion had the mineralogic composition shown below:

	Percent		Percent
Oligoclase-andesine	55	Alkali feldspar [1]	3
Quartz	35	Hornblende	2
Biotite (partly altered to chlorite)	5	Accessories	tr

[1] Perthite is the most abundant of the alkali feldspars; lesser amounts of orthoclase, albite, and sodic oligoclase are present.

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As geologists have made few, if any, traverses across the northern part of Prince of Wales Island, and prospectors have done little work in the area, there may actually be other outliers of the Coast Range batholith on Prince of Wales Island besides the one shown in plate 1.

Lamprophyre and basalt dikes cut the rocks of Paleozoic age of northern Prince of Wales Island in many places. They range from a few inches to more than 50 feet in width and many can be traced for several hundred feet from the edge of the low-tide line to the forest cover. The dikes generally strike between northwest and northeast. The most prevalent strike is north-northeast. The lamprophyre dikes are probably older than the basalt, dating possibly from a late phase of the Coast Range orogeny during Cretaceous or early Tertiary time. The basalt dikes are probably of Tertiary age (Buddington and Chapin, 1929, p. 230, 271–272).

STRUCTURE

Only the broader features of the structural geology of the northern part of Prince of Wales Island are known. The major feature is a large northwestward-trending anticlinorium that parallels the Coast Range batholith. Kashevarof Passage on the east side of the island and Port Protection at the northwest corner have been eroded along subsidiary anticlines of this structure. Shakan Bay on the west coast occupies a synclinal trough. There are probably several other minor anticlines and synclines in the area.

SALMON BAY AREA

GEOLOGY

The Salmon Bay area is on the west flank of the north-northwestward-trending Kashevarof anticline. The regional strike averages about N. 15° W. and the dip averages about 45° SW.

A thick graywacke of Silurian age is exposed along the coast for about 3 miles northwest and about 5 miles southeast of Salmon Bay (pl. 1). Layers of well-indurated shale, graywackelike sandstone, and coarse conglomerate are interbedded with the graywacke. The conglomerate is especially abundant near the base of the graywacke formation where it occurs in a layer 300 to 400 feet thick. It is composed of well-rounded pebbles, cobbles, and scattered boulders of a red granitic rock, dark-green greenstone, dark-gray argillite, gray limestone, and a red volcanic rock in a matrix of reddish-brown graywacke.

The graywacke of the Salmon Bay area ranges in color from reddish brown to grayish green. The grains range in size from less than 0.05 to more than 3 millimeters. The rock is composed of plagioclase, microperthite, orthoclase, chert, quartz, carbonate, and iron oxides and contains smaller amounts of pyrite, epidote, slate, and volcanic rock fragments. In many places iron oxides give the rock a deep hematite-red color. The graywacke is well indurated and generally occurs in beds ranging from several inches to several feet in thickness, but in some places no bedding is visible and the graywacke resembles a volcanic rock.

Many dikes cut the graywacke in the Salmon Bay area. Their strikes range from N. 45° W. to N. 65° E., but north-northwesterly and north-northeasterly strikes predominate; the dips are commonly very steep. The widths range from a few inches to as much as 50 feet. The widest dikes are between Bay Point and Point Colpoys (pl. 2). Four types of dikes have been identified. Lamprophyre dikes of albite-biotite and albite-hornblende are the most common types; fairly fresh-looking basalt dikes rich in carbonate are abundant; one phonolite dike has been recognized. The exact age of the dikes is not known. The lamprophyre dikes may have been emplaced during the late stages of the Coast Range orogeny in Cretaceous or early Tertiary time. The other dikes are probably of Tertiary age (Buddington and Chapin, 1929, p. 230, 271–272).

No coarse-grained igneous rocks were observed in the vicinity of Salmon Bay. Traverses to the west up the major streams revealed only more of the graywacke and one small isolated lens of limestone. A few well-rounded pebbles and cobbles of a light-colored hornblende-bearing granitic rock were found in the stream beds. These could have come from an intrusive mass further west, or they may be glacial drift derived from the Coast Range batholith or one of its outlying stocks to the east. A few rounded boulders of granitic rock found along the shore are probably glacial drift from the east or northeast.

VEIN DEPOSITS

RADIOACTIVE CARBONATE-HEMATITE VEINS

For about 3 miles northwest and 5 miles southeast of Salmon Bay many narrow radioactive carbonate-hematite veins cut the graywacke along the coast (pl. 2). A few veins also crop out in the larger stream beds west of Salmon Bay. Radioactive carbonate-hematite veins have been found only in the graywacke. Similar veins in the limestone are not appreciably radioactive.

The largest radioactive vein found to date is the Paystreak vein at the north end of Pitcher Island, about 4 miles southeast of Salmon Bay (fig. 2 and pl. 3). The Paystreak vein strikes N. 3° W. and dips 70° E. It averages 2.4 feet in width. At extreme low tide about 100 feet of the vein is exposed.

The average strike of the radioactive carbonate-hematite veins lies between north and northwest, but individual strikes vary greatly.

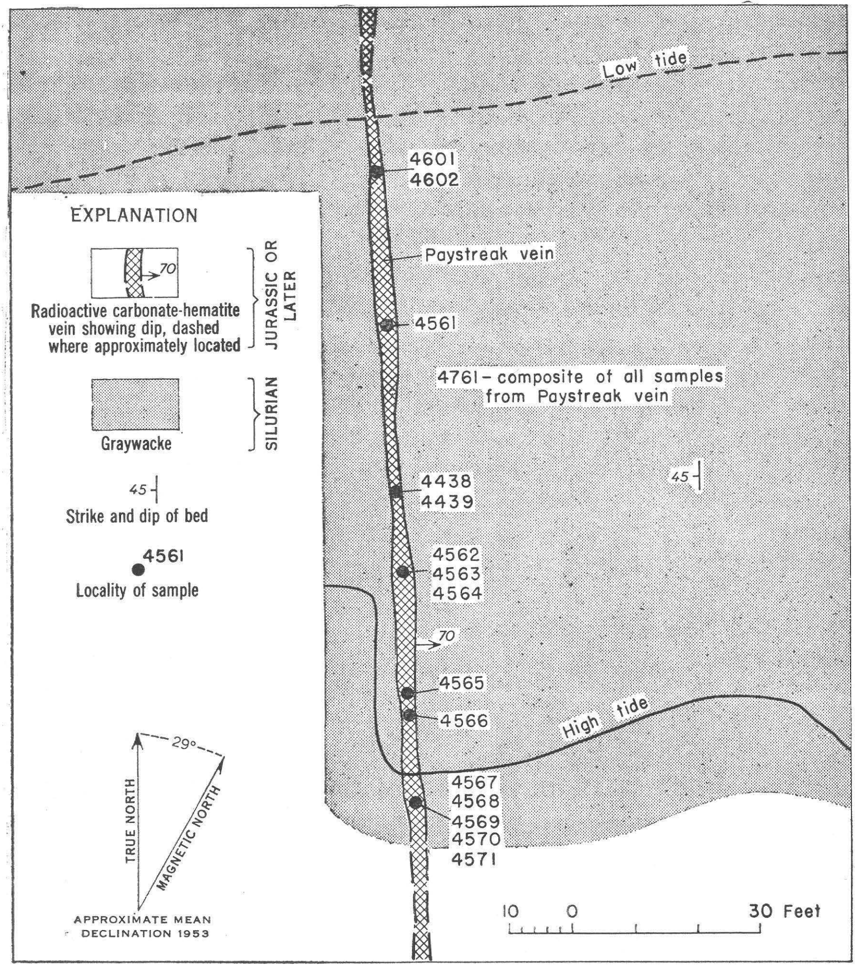

FIGURE 2.—Geologic sketch map of the Paystreak vein, Pitcher Island.

The largest veins, such as the Paystreak, have general strikes of either N. 30°–35° W. or north to N. 5° W. A third strike trend lies between N. 30°–60° E. The N. 30°–35° W. and the N. 30°–60° E. veins were perhaps emplaced along a complementary set of shear fractures resulting from the compressive forces that formed the north-northwestward trending Prince of Wales anticlinorium during the Coast Range orogeny. The average dip is about 70° NE.; however, dips range from 45° NE. to 40° SW. The veins range in width from a fraction of an inch to several feet, but the average width is 2 to 3 inches. Few veins are more than a foot wide, most are relatively short. Generally only a few feet or a few tens of feet of any given vein is exposed along the beach, but at a few localities individual veins can be traced for more than 300 feet.

RARE-EARTH CARBONATE VEINS

In addition to the radioactive veins, wider nonradioactive carbonate-hematite veins containing small amounts of rare-earth fluocarbonates occur in the graywacke of the Salmon Bay area. The width of these veins ranges from a few inches to 10 feet and averages about 5 feet. Just north of a small cove about 1 mile north of the entrance to Salmon Bay (fig. 3 and pl. 2) about 375 feet of a rare-earth carbonate vein is exposed at low tide. This vein strikes N. 35° W. and dips 75° NE. To the south on Pitcher Island (pl. 3), 3 rare-earth carbonate veins are exposed between the high- and low-tide lines. These veins strike about N. 60° E. and dip 60°–65° SE. They can be traced foı 200 to 400 feet along the beach.

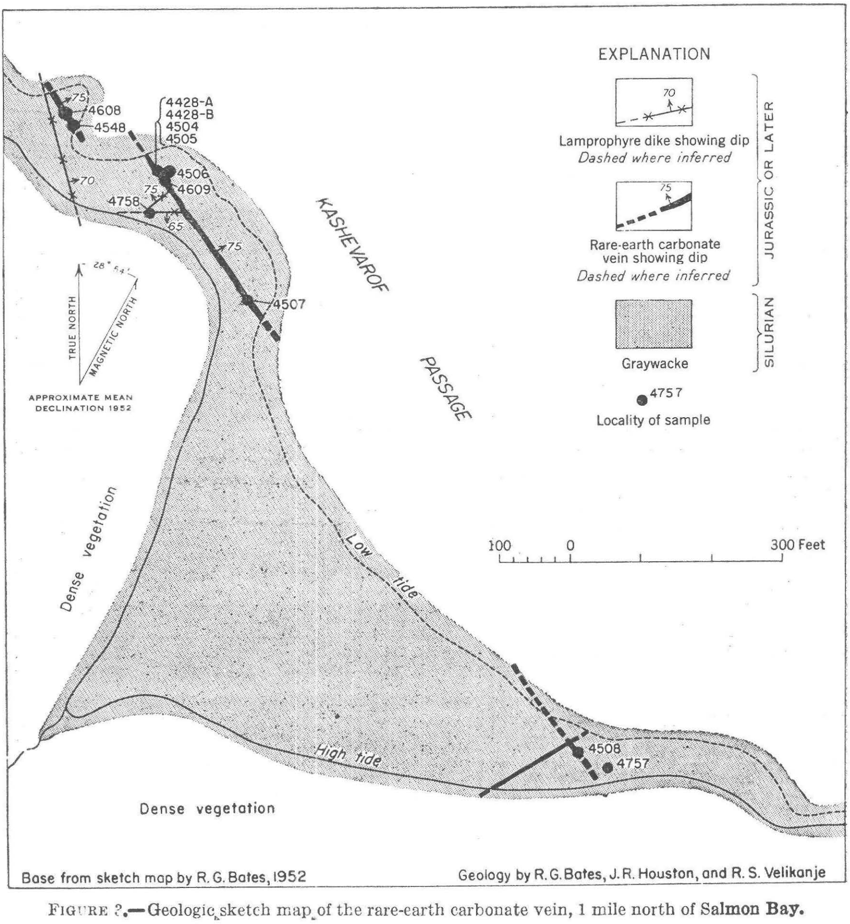

FIGURE 3.—Geologic sketch map of the rare-earth carbonate vein, 1 mile north of Salmon Bay.

MINERALOGY

A grayish-white carbonate of the dolomite-ankerite series is the most abundant mineral in the veins at Salmon Bay. Other minerals present in appreciable amounts are alkali feldspar, red hematite, specular hematite, and pyrite. Locally siderite and magnetite are abundant. Small amounts of the following minerals, listed in decreasing order of abundance, have been identified: quartz, chalcedony, chlorite, calcite, parisite, bastnaesite, muscovite, fluorite, apatite, thorite, zircon, monazite, epidote, topaz, garnet, chalcopyrite, and marcasite (table 1).

TABLE 1.—*Minerals found in the Salmon Bay veins*

[Mineralogic analyses, Mary E. Thompson, Joseph R. Houston, and Richard Kellagher; spectrographic analyses, Charles S. Annell, J. N. Stich, and Katherine E. Valentine; powder X-ray work, Evelyn Cisney]

Mineral	Occurrence, abundance, and remarks
Dolomite-ankerite, $Ca(Fe,Mg,Mn)(CO_3)_2$	In all veins; makes up about 80 percent of most veins and as much as 99 percent of some veins. Omega indices on 10 different specimens ranged from 1.720 to 1.732, values which are in the ankerite end of the dolomite-ankerite group (Palache and others, 1951, p. 211). However, carbonate from some samples was identified as dolomite and ferroan dolomite by mineralogists of the U. S. Geological Survey Trace Elements laboratory in Washington, D. C.
Feldspar, alkalic, $(K,Na)AlSi_3O_8$	The second most abundant vein mineral; makes up about 10 percent of most veins, but is absent in other veins; perthite is the most common type; orthoclase, albite and sodic oligoclase are also present; some feldspar is slightly sericitized.
Hematite, red Fe_2O_3	Small amounts in most veins, usually as narrow bands or as dark reddish-brown radioactive layers along vein walls; probably mixed with other unidentified red iron oxides.
Hematite, specular, Fe_2O_3	Small amounts in most veins, usually as narrow black bands, also as platy aggregates.
Pyrite FeS_2	In all veins, usually in striated cubes less than 1 mm thick. A few cubes are as much as 7 mm thick; apparently a late-stage mineral.
Siderite, $FeCO_3$	Small amounts in many veins; abundant locally, especially near the entrance to Salmon Bay.
Magnetite, $Fe^{+2}Fe^{+3}{}_2O_4$	Small amounts is many veins, locally abundant.
Quartz and chalcedony, SiO_2	Irregular; many veins contain no quartz; generally concentrated near the edges of the veins.
Chlorite, $(Fe,Mg)_2Al(OH)_6(Fe,Mg)_3(AlSi_3O_{10})(OH)_2$.	Rare; fills cracks in some veins; apparently a late-stage alteration product.
Calcite, $CaCO_3$	Rare; most of the carbonate is ankerite.
Parisite, $(Ce,La)_2Ca(CO_3)_3F_2$	Small amounts in many veins; most abundant in the wide, rare-earth carbonate veins; apparently a late-stage mineral usually occurring as a filling in small vugs or along postvein fractures in the carbonate.
Bastnaesite, $(Ce,La)(CO_3)F$	Rare; identified in the Paystreak vein on Pitcher Island; a late-stage mineral.
Muscovite, $K(Al,Cr)_2(AlSi_3O_{10})(OH,F)_2$	Small amounts in many veins but not common; the green (chromian) variety occurs in small but conspicuous concentrations.
Fluorite, CaF_2	Rare; local concentrations of purple fluorite conspicuous in a few veins; more rarely white.

TABLE 1.—*Minerals found in the Salmon Bay veins*—Continued

Mineral	Occurrence, abundance, and remarks
Apatite, $Ca_5(F,Cl,OH)(PO_4)_3$	Rare; radioactive apatite indentified in sample 4437 (pl. 2).
Thorite $ThSiO_4$	Trace amounts in most radioactive veins; generally in narrow veinlets.
Zircon, $ZrSiO_4$	Rare; trace amounts in some radioactive veins; generally radioactive.
Monazite, (Ce, La, Y, Th)(PO_4)	Rare; trace amounts in some radioactive veins.
Epidote, $Ca_2(Al,Fe)_3(SiO_4)_3(OH)$	Rare; apparently a late-stage alteration product.
Topaz, $Al_2(SiO_4)(OH,F)_2$	Very rare; a few acicular grains were found in the heavy-mineral fraction of sample 4422 from Fishery Island (pl. 2).
Garnet, $(Ca,Mn,Fe,Mg)_3(Al,Fe)_2(SiO_4)_3$	Very rare; found only in sample 4440 from West Island (pl. 2).
Chalcopyrite, $CuFeS_2$	Very rare; identified in sample 4580 (pl. 2) from small island ½ mile west of Pitcher Island.
Marcasite, FeS_2	Very rare; identified in sample 4437 from Salmon Bay (pl. 2).

Grain counts on thin sections made from three Salmon Bay veins gave the following average mineralogic composition:

	Percent		*Percent*
Carbonate	81	Quartz and chalcedony	2
Alkali feldspar [1]	11	Pyrite	2
Iron oxides	3	Chlorite	1

[1] Perthite is the most abundant of the alkali feldspars with lesser amounts of orthoclase, albite, and sodic oligoclase.

The grain size of the vein minerals ranges from less than 0.05 millimeter to more than 1 centimeter; however, most of the carbonate grains are 1 to 3 millimeters across.

Thorite, monazite, zircon, and apatite are the only radioactive minerals that have been identified from the Salmon Bay veins, and these occur only in traces. There are many radioactive zones in which the radioactive mineral or minerals could not be determined. These zones contain only carbonate, feldspar, pyrite, and red hematite.

Hematite and other red iron oxides stain intensely many small open fissures which cut the graywacke almost parallel to the carbonate veins. There are also reddish-brown hematitic alteration zones along the walls of many of the veins. Some of the altered zones have a glazed, slaglike appearance; most of them are less than 1 inch wide. Generally the hematitic zones are more radioactive than the carbonate-vein filling. A less intense reddish-brown coloration caused by smaller amounts of red iron oxides is common in much of the graywacke country rock around Salmon Bay. The dark-red hematitic zones adjacent to the veins were undoubtedly formed by hydrothermal solutions, but much of the lighter red coloration in the surrounding graywacke is due to iron oxides that were either present in the original rock or formed by the oxidation of pyrite.

The rare-earth fluocarbonates, parisite and bastnaesite, occur in small amounts in some of the veins. Parisite is especially abundant in a wide vein about 1 mile north of the mouth of Salmon Bay (pl. 2 and fig. 3). The parisite is light yellowish brown to grayish brown. It is a late-stage mineral, generally occurring along postvein fractures in the carbonate vein filling. Locally, it lines small vugs as earthy subrounded grains about 0.5 millimeter in diameter.

RADIOACTIVITY DATA

Most of the veins at Salmon Bay show some radioactivity. The equivalent-uranium content of 74 samples from the Salmon Bay area was determined in the laboratory; selected samples were also analyzed for uranium, uranium oxide, equivalent thorium, and thorium dioxide (table 2). Sample localities are shown on figures 2 and 3, and on plates 1, 2, and 3.

The maximum equivalent-uranium content of unconcentrated vein material from Salmon Bay analyzed by the Geological Survey is 0.13 percent (sample 4443, pl. 2). This sample was collected by a prospector from a hematite-rich zone of wall rock adjacent to a carbonate vein. It contained hematite, albite, orthoclase, and some small veinlets of thorite.

Twelve samples (4089, 4090, 4093, 4095, 4428–A and –B, and 4437–4443, table 2) that were analyzed fluorimetrically for uranium (U) showed a maximum uranium content of only 0.003 percent. Five other samples (4570, 4571, 4572, 4574, and 4577, table 2) that were analyzed chemically for uranium oxide (U_3O_8) showed a maximum uranium content of only 0.004 percent. The equivalent uranium content (eU) of these 5 samples as determined by radiometric assay ranged from 0.014 to 0.083 percent, indicating that most of the radioactivity was due to thorium. Thus, it seemed advisable to express the assay data in terms of percent equivalent thorium (eTh) rather than percent equivalent uranium.

TABLE 2.—*Data on radioactivity of samples from Salmon Bay area*

Sample	Locality	Type	Analyses (percent)				
			Equivalent uranium [1]	Uranium [2]	Uranium oxide (U_3O_8)	Equivalent thorium	Thorium dioxide (ThO_2) [3]
4089	Carbonate vein, Fishery Island, Salmon Bay (pl. 2).	Grab	0.017	<0.001		[4] 0.084	
4090	do	do	.07	.003		[5] .26	
4092	do	do	.001				
4093	Carbonate vein, Prince of Wales Island, about 0.7 miles north of Salmon Bay (pl. 2).	do	.007	<.001		[4] .03	
4095	Carbonate vein, Pt. Colpoys, Prince of Wales Island (pl. 2).	do	.013	<.001		[4] .06	
4403–A	Carbonate vein, Fishery Island, Salmon Bay (pl. 2).	do	.014				
B	do	Nonmagnetic fraction of 4403–A.	.020				
C	do	Magnetic fraction of 4403–A.	.006				
4422–A	Carbonate vein, Fishery Island, Salmon Bay (pl. 2).	Grab	.022				
B	do	Fraction of 4422–A less than 2.9 sp gr.	.008				
C	do	Fraction of 4422–A between 2.9 and 3.3 sp gr.	.020				
D	do	Moderately magnetic portion of fraction of 4422–A greater than 3.3 sp gr.	.160				
E	do	Slightly magnetic portion of fraction of 4422–A greater than 3.3 sp gr.	.007				
4428–A	Carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	Grab	.003	.001		[4] .01	
B	do	do	.002	.001		[4] .005	
4437	Carbonate vein, Salmon Bay (pl. 2).	do	.029	.002		[4] .14	
4438	Wall rock adjacent to Paystreak vein, Pitcher Island (fig. 2).	do	.002	.001		[4] .005	
4439	Paystreak vein, Pitcher Island (fig. 2).	Channel	.046	.001		[5] .20	
4440	Carbonate vein, West Island (pl. 2).	do	.029	.003		[4] .13	
4441	Fine-grained dike rock, small island about ¾ mile northwest of Pitcher Islands (pl. 2).	Grab	.007	.003		[4] .02	
4442	Coarse-grained dike rock, large island between Fishery and Pitcher Island (pl. 2).	do	.005	.001		[4] .02	
4443	Hematite-rich wall rock, Fishery Island, Salmon Bay (pl. 2).	do	.130	.002		[4] .64	
4492–A	Hematitic limestone, Exchange Island (pl. 2).	do	.001				
B	do	Fraction of 4492–A greater than 2.9 sp gr; concentration ratio [6] 1:1.	.003				

See footnotes at end of table.

TABLE 2.—*Data on radioactivity of samples from Salmon Bay area*—Continued

Sample	Locality	Type	Analyses (percent)				
			Equivalent uranium [1]	Uranium [2]	Uranium oxide (U_3O_8)	Equivalent thorium	Thorium dioxide (ThO_2)[3]
4493-A	Carbonate vein, Prince of Wales Island, about ¾ mile north of Exchange Cove (pl. 2).	Grab	0.001				
4493-B	do	Fraction of 4493-A greater than 2.9 sp gr; concentration ratio [6] 1.3:1.	.004				
4494-A	Altered fracture zone in graywacke, Exchange Island (pl. 2).	Grab	.001				
B	do	Fraction of 4494-A greater than 2.9 sp gr; concentration ratio [6] 3.2:1.	.005				
4495-A	Iron-stained zone in graywacke, Exchange Island (pl. 2).	Grab	.002				
B	do	Fraction of 4495-A greater than 2.9 sp gr; concentration ratio [6] 2:1.	.003				
4496-A	Hematitic limy breccia zone, West Island (pl. 2).	Grab	<.001				
B	do	Fraction of 4496-A greater than 2.9 sp gr: concentration ratio [6] 1:1.	.002				
4497-A	Carbonate vein, small cove on Prince of Wales Island west of Thorne Island (pl. 1).	Grab	<.001				
B	do	Fraction of 4497-A greater than 2.9 sp gr; concentration ratio [6] 1:1.	<.001				
4498-A	Carbonate vein, Thorne Island.	Grab	<.001				
B	do	Fraction of 4498-A greater than 2.9 sp gr; concentration ratio [6] 21:1.	.001				
4499-A	Carbonate vein, Thorne Island (pl. 1).	Grab	<.001				
B	do	Fraction of 4499-A greater than 2.9 sp gr; concentration ratio [6] 1:1.	<.001				
4500-A	do	Grab	<.001				
B	do	Fraction of 4500-A greater than 2.9 sp gr; concentration ratio [6] 1.2:1.	<.001				
4501-A	Mafic dike rock, Thorne Island (pl. 1).	Grab	.002				
B	do	Fraction of 4501-A greater than 3.3 sp gr: concentration ratio [6] 55:1.	.001				
4502-A	Marker vein, Pitcher Island (pl. 3).	Grab	.053				
B	do	Fraction of 4502-A greater than 2.9 sp gr; concentration ratio [6] 1.3:1.	.056				
C	do	Fraction of 4502-A greater than 3.3 sp gr; concentration ratio [6] 40:1.	.103				

See footnotes at end of table.

TABLE 2.—*Data on radioactivity of samples from Salmon Bay area*—Continued

Sample	Locality	Type	Analyses (percent)				
			Equivalent uranium [1]	Uranium [2]	Uranium oxide (U_3O_8)	Equivalent thorium	Thorium dioxide (ThO_2)[3]
4503-A	Carbonate vein, southeast side of Pitcher Island (pl. 3).	Grab	0.038				
B	do	Fraction of 4503-A greater than 2.9 sp gr; concentration ratio [6] 1.2:1.	.039				
4504	Carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	Chip-channel	.002				
4505	do	do	.002				
4506	Altered zone adjacent to carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	Grab	.006				
4507	Carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	Chip-channel	.002				
4508	do	do	.002				
4546	Wall rock along barren fracture, West Island (pl. 2).	Grab	.003				
4547	Carbonate vein, West Island (pl. 2).	do	.009				
4548	Carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	do	<.001				
4549	Fluorite-bearing carbonate vein, south of Bay Point (pl. 2).	do	<.001				
4550	Carbonate vein, west of Point Colpoys (pl. 2).	do	.002				
4551	Carbonate vein, Bay Point (pl. 2).	do	.006				
4561	Paystreak vein, Pitcher Island (fig. 2).	Channel	.035			[5] 0.16	
4562	Wall rock adjacent to Paystreak vein (fig. 2).	do	.003				
4563	Paystreak vein, Pitcher Island (fig. 2).	do	.036			[5] .16	
4564	Wall rock adjacent to Paystreak vein (fig. 2).	do	.002				
4565	Paystreak vein, Pitcher Island (fig. 2).	do	.020			[5] .11	
4566	do	do	.030			[5] .17	
4567	Wall rock adjacent to Paystreak vein (fig. 2).	do	.002				
4568	do	do	.003				
4569	Paystreak vein, Pitcher Island (fig. 2).	do	.036			[5] .17	
4570	do	do	.014		0.001	[7] .07	0.08
4571	do	do	.049		.001	[7] .23	.26
4572	Marker vein, Pitcher Island (pl. 3).	do	.083		.002	[7] .41	.48
4573	Wall rock inclusion, Marker Vein (pl. 3).	do	.002			[5] .013	
4574	Marker vein, Pitcher Island (pl. 3).	do	.057		.004	[7] .29	.35
4575	Wall rock inclusion, Marker vein (pl. 3).	do	.006			[5] .028	
4576	Marker vein, Pitcher Island (pl. 3).	do	.037			[5] .17	
4577	do	do	.026		.004	[7] .11	.13
4579	Carbonate vein, small island about ½ mile northwest of Pitcher Island (pl. 2).	Grab	.011				

See footnotes at end of table.

TABLE 2.—*Data on radioactivity of Samples from Salmon Bay area*—Continued

Sample	Locality	Type	Analyses (percent)				
			Equivalent uranium [1]	Uranium [2]	Uranium oxide (U_3O_8)	Equivalent thorium	Thorium dioxide (ThO_2)
4581	Wall rock adjacent to vein, southeast side of Pitcher Island (pl. 3).	Channel	0.005	------	------	------	------
4582	Carbonate vein, southeast side of Pitcher Island (pl. 3).	do	.064	------	------	------	------
4583	Wall rock adjacent to vein, southeast side of Pitcher Island (pl. 3).	do	.005	------	------	------	------
4584	Carbonate vein, southeast side of Pitcher Island (pl. 3).	Chip-channel	.002	------	------	------	------
4585	do	do	.003	------	------	------	------
4586	do	Chip-channel (along the vein).	.004	------	------	------	------
4601	Paystreak vein, Pitcher Island (fig. 2).	Channel	.035	------	------	------	------
4602	Wall rock adjacent to Paystreak vein (fig. 2).	do	<.001	------	------	------	------
4603	Carbonate vein, northwest side of Pitcher Island (pl. 3).	Chip-channel (along the vein).	<.001	------	------	------	------
4604	do	Chip-channel	<.001	------	------	------	------
4605	do	Chip-channel (along the vein).	<.001	------	------	------	------
4606	do	Chip-channel	<.001	------	------	------	------
4608	Carbonate vein, small bay 1 mile north of Salmon Bay (fig. 3).	do	<.001	------	------	------	------
4609	do	Grab	.001	------	------	------	------
4610	Feldspathic dike, south of Bay Point (pl. 2).	do	.005	------	------	------	------
4759	Hematitic wall rock adjacent to radioactive fracture, Fishery Island, Salmon Bay (pl. 2).	do	.065	------	------	------	------
4761	Paystreak vein, Pitcher Island (fig. 2).	Composite	.033	------	------	[8] 0.16	0.18
4762	Marker vein, Pitcher Island (pl. 3).	do	.057	------	------	[8] .26	.30

[1] Radiometric assay by Benjamin A. McCall.
[2] Fluorimetric assay by Mary E. Thompson, Paul D. Benson, H. Kramer, and Audrey C. Pietsch.
[3] Chemical assay by Jesse J. Warr and Harry Levine.
[4] Calculated from the equivalent-uranium content by subtracting the chemical uranium and multiplying the remainder by a conversion factor of 5.
[5] Radiometric assay by Benjamin A. McCall, using thorium standards.
[6] Concentration ratio is the concentration by weight effected by removal of minerals lighter than the heavy-liquid medium used; approximate specific gravity of bromoform 2.9, methylene iodide 3.3.
[7] Average of results obtained using methods described in ([4]) and ([5]).
[8] Calculated from the ThO_2 content by multiplying by the conversion factor of 0.8788.

Thorium assays can be made by the conventional wet chemical analysis for thorium dioxide (ThO_2) or by radiometric analysis using thorium standards. The 5 samples (4570, 4571, 4572, 4574, and 4577, table 2) that were analyzed chemically for uranium oxide and radiometrically for equivalent uranium were also analyzed chemically for thorium dioxide. The ratio, percent ThO_2:(percent eU—percent U), was calculated for each of the 5 samples. These ratios ranged from 5.40 to 6.53 and averaged 5.93. So if any given equivalent-uranium assay is multiplied by 5.93 the result will represent the approximate amount of thorium dioxide in the sample. Inasmuch as the ratio $Th:ThO_2=0.8788$, 5.93×0.8788, or 5.22, is an average factor for converting equivalent-uranium assays to equivalent thorium.

Another method of thorium assay is to determine the thorium radiometrically using thorium standards. Ten Salmon Bay samples (4090, 4439, 4561, 4563, 4565, 4566, 4569, 4573, 4575, and 4576) were assayed radiometrically for equivalent thorium, using thorium standards, and for equivalent uranium using uranium standards. The ratio of equivalent thorium to equivalent uranium in this group of samples ranged from 3.54 to 6.50 and averaged 4.75, as compared to an average ratio of 5.22 determined by comparing equivalent-uranium assays with wet-chemical assays for thorium dioxide. These conversion ratios depend on many factors and are only approximate at best, so the number 5 was used as an average conversion factor for the Salmon Bay samples. This factor was used in computing some of the equivalent-thorium values in table 2 of this report by substituting uranium values in the following formula:

$$\text{percent eTh}=(\text{percent eU}-\text{percent U})\times5$$

The percent uranium (chemical assay) should be subtracted from the percent equivalent uranium (radiometric assay) before multiplying by the conversion factor. But because the amount of uranium in the Salmon Bay samples is small (0.004 percent or less), it can be neglected for all practical purposes, and the following formula can be used:

$$\text{percent eTh}=\text{percent eU}\times5$$

In addition to radioactivity measurements made in the field and in the laboratory, Bates and Wedow made an attempt to determine whether the radioactivity of the Marker and Paystreak veins on Pitcher Island (pl. 3) could be detected from the air. The equipment used in the airborne attempt consisted of a gang of six 2- by 40-inch gamma tubes connected in parallel and powered by a standard commercial Geiger counter modified to accept such a probe (Wedow, 1951). The instrument was carried in a 4-place aircraft equipped with floats. Flights over the localities of the veins on the northeast beach of Pitcher Island were made at 100-, 50-, and 20-foot altitudes, successively. No ratemeter readings above background were obtained at the 100- and 50-foot levels, and only a very slight increase was noted at the 20-foot level. This slight increase, however, may have no significance, because it was about equal to or only slightly greater than the maximum limit of fluctuation in the ratemeter readings for background. Because of flying hazards at both the 50- and 20-foot levels (maximum height of timber on island is about 100 feet), only one run was made at each of the two lower levels. A more sensitive instrument, such as a scintillation counter adapted for airborne traversing, probably could detect significant variations in radioactivity over the beach on Pitcher Island at the safer 100-foot level of flying.

CALCULATION OF RESERVES IN 100-FOOT SECTION OF THE PAYSTREAK VEIN

Because of the low grade and the short, lenticular, irregular nature of the Salmon Bay radioactive carbonate-hematite veins, no attempts at systematic sampling were made except on Pitcher Island where a 100-foot section of the Paystreak vein, exposed at low tide, could be sampled accurately enough to warrant a grade and reserve calculation (fig. 2).

First, the grade was calculated in terms of percent equivalent uranium and was found to average 0.03 percent (table 3). However, an expression of the average grade in terms of equivalent uranium actually has little meaning because most of the radioactivity is due to thorium. Therefore, grade calculations were also made in terms of percent equivalent thorium and were found to average 0.16 percent (table 3). In these calculations no provisions were made for possible wall-rock dilution.

TABLE 3.—*Calculation of average equivalent-uranium and equivalent-thorium content of a 100-foot section of the Paystreak vein, Pitcher Island* [1]

Sample (fig. 5)	Width (W) (feet)	Distance between samples (D) (feet)	Distance of influence $\frac{D_1}{2}+\frac{D_2}{2}=d$ (feet)	Area of influence W×d=A (square feet)	Equivalent uranium assay (percent eU) [2]	Area-assay product (A×percent eU)	Equivalent thorium assay (percent eTh)	Area-assay product (A×percent eTh)
4601	2.0	24.2	24.2	48	0.035	0.017	[3] 0.17	0.082
4561	2.8	26.0	25.1	70	.035	.025	[4] .16	.11
4439	1.7	13.0	19.5	33	.046	.015	[4] .20	.066
4563	3.1	19.6	16.3	51	.036	.018	[4] .16	.082
4565	2.0	3.2	11.4	23	.020	.005	[4] .11	.025
4566	1.8	14.0	8.6	15	.030	.005	[4] .17	.026
4569 [5], 4570 [5], 4571 [5]	3.3	14.0	14.0	46	[6] .028	.013	[6] .14	.064
Total				286 Σ(A)		0.098 Σ(A×percent eU)		0.46 Σ(A×percent eTh)

[1] Method modified after Parks (1949, p. 66).
[2] Radiometric assay, using uranium standards.
[3] Calculated from the equivalent-uranium assay by subtracting an estimated 0.002 percent for chemical uranium and multiplying the remainder by the conversion factor of 5.
[4] Radiometric assay, using thorium standards.
[5] Sample:

	eU (percent)	eTh (percent)	Width (feet)
4569	0.036	0.17	1.0
4570	.014	.07	1.8
4571	.049	.23	.5

[6] Weighted average of samples 4569, 4570, and 4571.

$$\text{Average grade, equivalent uranium} = \frac{\Sigma(\text{A}\times\text{percent eU})}{\Sigma\text{A}} = \frac{0.098}{286} = 0.0003 = 0.03 \text{ percent eU.}$$

$$\text{Average grade, equivalent thorium} = \frac{\Sigma(\text{A}\times\text{percent eTh})}{\Sigma\text{A}} = \frac{0.46}{286} = 0.0016 = 0.16 \text{ percent eTh.}$$

Reserves of thorium and thorium dioxide per foot of depth (down the dip) were calculated for the 100-foot section of the vein. The average specific gravity of the Paystreak vein is 2.94. This gives 10.9 cubic feet of mineralized rock per ton or 22 tons per foot of depth. There are, therefore, about 70 pounds of thorium or 80 pounds of thorium dioxide per foot of depth for the 100-foot section of the vein sampled.

The extent of the Paystreak vein beyond the 100-foot sampled section is unknown. The dense forest cover on Pitcher Island prevents the tracing, either visually or by radioactivity surveying, of the vein to the south. No sign of the vein along its projected strike could be seen on the beach on the southeast side of the island (pl. 3); hence it is evident that the Paystreak vein does not extend for more than 730 feet to the south. Nothing is known about the northward extension of the vein, except that it can be seen under water for about 40 feet at extreme low tide; however, at least another 50 feet of comparable width and grade can be inferred, and there may be several hundred feet more.

RARE-EARTH OXIDE DATA

Because many of the Salmon Bay veins contain parisite or bastnaesite or both, chemical analyses for rare-earth oxides were made on several samples. The rare-earth oxide analyses are listed in table 4;

TABLE 4.—*Data on rare-earth oxide content of carbonate-vein samples from the Salmon Bay area*

[Equivalent-uranium analyses, Mary E. Thompson and John J. Matzko]

Sample	Location of sample	Type of sample	Equivalent uranium (percent)	Rare-earth oxides (percent)[1]
4428-A	Vein about 1 mile north of Salmon Bay (fig. 3).	High-grade grab	0.003	5.0
-B	do	do	.002	1.2
4504	do	2.0-ft chip-channel from hanging-wall	.002	.73
4505	do	4.0-ft chip-channel from footwall (a continuation of sample 4504).	.002	.67
4507	do	7.0-ft chip-channel across vein	.002	.83
4508	do	10.0-ft chip-channel across vein	.002	.84
4601	Paystreak vein, Pitcher Island (fig. 2).	2.0-ft channel across vein	.035	.36
4602	do	Channel across wall rock adjacent to vein.	<.001	.09
4603	Vein on northwest side of Pitcher Island (pl. 3).	Chip-channel along vein	<.001	.09
4604	do	Chip-channel across vein	<.001	.19
4605	do	Chip-channel along vein	<.001	.29
4606	do	4.5-ft chip-channel across vein	<.001	.72
4608	Vein about 1 mile north of Salmon Bay (fig. 3).	6.5-ft chip-channel across vein	<.001	.78
4609	do	High-grade grab	.001	1.95
4610	Feldspathic dike about ½ mile south of Bay Point.	Grab	.005	.07

[1] Includes ThO_2 which in these samples is negligible except for sample 4601 which contains about 0.2 percent ThO_2 as calculated from the equivalent-uranium analysis.

the localities of the samples analyzed are shown in figures 2 and 3, and plates 2 and 3. One vein about 1 mile north of the entrance to Salmon Bay was particularly high in parisite. Five chip-channel samples (4504, 4505, 4507, 4508, and 4608) were taken across this vein at irregular intervals along a strike distance of about 1,150 feet. They average 0.79 percent rare-earth oxides for the average vein width of 7.4 feet. One high-grade grab sample from the vein assayed 5.0 percent rare-earth oxides (table 4 and fig. 3).

GENESIS

Most of the Salmon Bay veins have sharp, clean walls; wall-rock inclusions are not abundant, but they do occur locally. A few veins show alternating narrow bands of vein material and wall rock. Some of the veins have an en echelon arrangement. There is evidence of some replacement, but open-space filling appears to have been the dominant process involved in the introduction of the vein fillings. The restriction of the radioactive veins to the graywacke at Salmon Bay is probably due to the fact that magmas and hydrothermal solutions of the proper composition existed in that area at a time when there were fractures in the graywacke in which the mineralized solutions could be deposited. The graywacke probably played no part in localizing the veins other than serving as a fairly competent rock that maintained open spaces much better than the other rock types in the area.

At one locality on the southeast shore of Pitcher Island (pl. 3) a narrow radioactive carbonate-hematite vein appears to cut one of the wider nonradioactive rare-earth fluocarbonate veins, suggesting that the radioactive veins are younger than the rare-earth veins.

Lamprophyre, basalt, and phonolite dikes are the only igneous rocks exposed in the Salmon Bay area. The nearest plutonic rocks are of dioritic composition and are almost 10 miles to the west-southwest (pl. 1). There are some Tertiary volcanic rocks on Zarembo Island 4 to 6 miles northeast of Salmon Bay.

Many of the carbonate veins are closely associated with the lamprophyre dikes. The wide rare-earth carbonate vein located about 1 mile north of Salmon Bay (fig. 3) and one or two other carbonate veins cut lamprophyre dikes. The veins commonly pinch down to an inch or less in width through the dike, then widen out again to their normal width in the graywacke. Several lamprophyre dikes (fig. 3) end abruptly against the carbonate veins. Probably the lamprophyre dikes and the wide rare-earth carbonate veins are genetically related although no definite evidence for this has been found. The lamprophyre dikes, in turn, may be genetically related to a phase of the Late Jurassic or Cretaceous intrusive rocks (Buddington and Chapin, 1929, p. 230).

The Salmon Bay rare-earth fluocarbonate veins have some similarity to the rare-earth fluocarbonate deposits at Mountain Pass, San Bernardino County, Calif. The California deposits probably are genetically related to the "differentiation of an alkaline magma from shonkinite to syenite to granite with a carbonate-rich end product containing the rare elements" (Olson, Shawe, Pray, and Sharp, 1954, p. 1). The lamprophyre dikes at Salmon Bay may be associated with alkalic rocks which have not yet been exposed by erosion. Inasmuch as the region immediately west of Salmon Bay has never been mapped geologically, it is possible that there are also some undiscovered alkalic intrusive rocks near the carbonate veins. Thin sections from three different lamprophyre dikes in the area showed the following mineralogic composition:

Sample 4757 (fig. 3)

	Percent		*Percent*
Albitic plagioclase	49	Pyrite	3
Carbonate	21	Iron oxides	3
Altered hornblende	19	Analcite	tr
Epidote	5		

Sample 4758 (fig. 3)

	Percent		*Percent*
Brown and green biotite	48	Ilmenite	2
Albitic plagioclase	28	Apatite	tr
Carbonate	22		

Sample 4760 (pl. 2)

	Percent		*Percent*
Hydrobiotite and "sericitic" material	51	Carbonate	6
Biotite	25	Opaques (magnetite, pyrite, ilmenite)	3
Albitic plagioclase	15	Analcite	tr

In addition to the lamprophyre dikes some basalt dikes occur in the Salmon Bay area. About 70 feet of one such dike is exposed on Pitcher Island between the Paystreak and Marker veins (pl. 3). Megascopically the rock is dark and fresh looking; it effervesces in hydrochloric acid. A thin section (sample 4578) shows a poorly defined diabasic texture. Plagioclase in lath-shaped crystals and ferroan dolomite (Palache and others, 1951, p. 211) are the main constituents. The original ferromagnesian minerals have been completely altered, but the original presence of olivine is strongly indicated. The rock is probably an olivine basalt that has undergone considerable deuteric alteration. The mode is as follows:

Sample 4578 (pl. 3)

	Percent		Percent
Plagioclase (average An_{50})	45	Chloritic material	6
Carbonate	35	Quartz	tr
Magnetite	14	Olivine(?)	tr

A thin section of rock sample 4441 (pl. 2) collected by Glover from a dike on a small island a short distance northwest of Pitcher Island, was examined by Richard Kellagher of the Geological Survey laboratory in Washington, D. C. Kellagher identified the rock as an aegirite-analcite phonolite consisting chiefly of sanidine, analcite, and aegirite with small amounts of leucite and sodalite. No other phonolite dikes were recognized in the area, but more detailed studies would probably disclose some.

The relation of these basalt and phonolite dikes to the carbonate-hematite veins is obscure. Perhaps the narrow radioactive carbonate veins are genetically associated with one of these sets of dikes while the wider nonradioactive rare-earth fluocarbonate veins are related to the lamprophyre dikes.

Thorium-bearing veins somewhat similar to the Salmon Bay veins have been discovered recently along shear zones in the Wet Mountains of Colorado. "Pre-mineralization basic dikes" (Christman, and others, 1953, p. 1) are closely associated with these veins; however, the relationship between the dikes and the thorium veins is thought to be "purely structural" (idem, p. 6).

The so-called carbonate-hematite veins at Salmon Bay may actually be carbonatites, that is, carbonate-rich rocks derived from a carbonate magma or from carbonate hydrothermally redistributed from sedimentary limestone beds. The association of lamprophyres, phonolites, olivine basalts, and dikelike carbonatite bodies is entirely logical from a petrogenic standpoint, although authorities do not agree on the exact processes involved. Rock assemblages having similar bulk chemical compositions have been described from several parts of the world (Turner and Verhoogen, 1951, p. 334–342; Barth, 1952, p. 213–216; Hatch, Wells, and Wells, 1949, p. 241–243).

The Salmon Bay veins could be interpreted as mobilized or hydrothermally redistributed sedimentary limestone beds derived from the relatively pure limestone that underlies the graywacke in the vicinity of Salmon Bay (pl. 1) or from the limy graywacke itself. Such an origin would require some outside source of magnesium and iron for the dolomite-ankerite that constitutes about 80 percent of the veins. Also, aluminum, silicon, sodium, and potassium in excess of the small amounts carried in the relatively pure limestone would be required for the alkali feldspar which makes up about 10 percent of the veins. The remaining 10 percent of the Salmon Bay veins consists of iron oxides and sulfides and small amounts of many other minerals listed in table 1. A hydrothermal origin for these minerals seems probable. The pyrite in particular appears to be hydrothermal. Almost invariably it occurs in small striated cubes that apparently were formed by late-stage replacement solutions. The rare-earth fluocarbonates appear to be definitely hydrothermal. They are late-stage minerals occurring along postvein fractures in the carbonate and as small, subrounded aggregates in vugs. Another feature that is also definitely hydrothermal is the widespread hematitic alteration adjacent to most of the veins.

Detailed geologic mapping along the shore of Prince of Wales Island from Point Colpoys to Exchange Cove (pl. 2) at low tide would undoubtedly solve many of the problems concerning the origin of the carbonate veins and their relationship to the different dikes.

SUMMARY AND CONCLUSIONS

The surface of the radioactive carbonate-hematite veins in the vicinity of Salmon Bay contain only traces of uranium. Most of the radioactivity is due to thorium contained in the minerals thorite and monazite. Red hematite, zircon, and apatite also contain small amounts of thorium. The thorium content of the veins is too low to be of commercial interest at the present time.

Judging from the surface mineralogy of these veins, the authors do not think it probable that the veins would show any significant increase in uranium tenor with depth. The thorium is contained in minerals into whose crystal structure uranium enters to only a very limited extent. So, unless some undetected radioactive mineral that forms an isomorphous series between a pure thorium end member and a pure uranium end member is present, there is little likelihood of an increase in uranium content with depth.

The rare-earth fluocarbonate veins are low grade and relatively small. They rank far below the California deposits in both grade and tonnage, and at the present time they offer no commercial possibilities.

OTHER AREAS EXAMINED

The radioactive carbonate veins at Salmon Bay occur only in graywacke. Similar veins in the underlying limestone are not appreciably radioactive. Therefore, in order to exhaust all possibilities, radioactivity traverses were made along those parts of the northern and northwestern coasts of Prince of Wales Island (loc. *E* and *G*, fig. 1; also see pl. 1) that had been mapped as graywacke by Buddington (Buddington and Chapin, 1929, pl. 1). Only a small part of this work was done on foot. The greater part was conducted by cruising close to the shore in a skiff. If any signs of the hydrothermal hematitic alteration common to the veins at Salmon Bay or other evidence of possible mineralization were seen the party went ashore and made a radioactivity examination with Geiger counters. A few barren calcite veins were found in the graywacke; some epidote-garnet-calcite veinlets were found near igneous contacts; one small galena-bearing veinlet was found near Tokeen on Marble Island. None of the samples collected assayed greater than 0.001 percent equivalent uranium. It should be pointed out that most of the rock in this area that was mapped as graywacke (pl. 1) by Buddington is actually very limy. Three thin sections made from specimens collected from the "graywacke" areas on the northern and western shores of Prince of Wales Island contained from 45 to 90 percent carbonate.

As the Salmon Bay veins may be related genetically to the batholith near Shakan (pl. 1) or to similar smaller intrusive masses, a number of mineral deposits definitely known to be related to these masses were examined. These deposits included the molybdenum prospect at Shakan, Kosciusko Island (loc. *F*, fig. 1), a zinc prospect near Point St. Albans, Kuiu Island (loc. *J*, fig. 1), an old lead prospect at Egg Harbor, Coronation Island (loc. *I*, fig. 1), and the Baker Island molybdenum prospect (loc. *H*, fig. 1). No radioactivity in excess of 0.004 percent equivalent uranium was found at any of these localities.

Four other outlying areas were also examined briefly. The shoreline of Totem Bay, Kupreanof Island (loc. *K*, fig. 1) was examined to determine if the northwestward-trending veins at Salmon Bay continued on the north side of Sumner Strait (pl. 1). No evidence of the thorium-bearing veins was found. Samples of the andesite country rock on the shore of Totem Bay assayed only 0.003 percent equivalent uranium. A brief examination was made also in the vicinity of Round Point, Zarembo Island (loc. *D*, fig. 1) to discover if any radioactive mineral deposits were associated with a small granitic intrusive there; only small epidote veinlets were found. The granite at Round Point assayed 0.004 percent equivalent uranium. Finally, brief examinations were made at Lake Bay (loc. *L*, fig. 1) and Green Monster Mountain (loc. *M*, fig. 1) to determine whether copper deposits at these localities showed any significant radioactivity. Field measurements and analyses of samples indicated that the copper deposits tested do not contain more than 0.001 percent equivalent uranium.

The studies mentioned above indicate that the radioactive carbonate-hematite veins of the graywacke area at Salmon Bay do not extend beyond the region along the northeast coast of Prince of Wales Island between Exchange Cove and Point Colpoys. It is not likely that the area extends very far inland to the west because the graywacke is succeeded in that direction by massive, relatively pure limestone; no appreciable radioactivity has been found in carbonate veins that occur in limestone or carbonate-rich wall rocks on the northern part of Prince of Wales Island.

TAKU HARBOR-POINT ASTLEY DISTRICT

In the course of travel from Juneau to the Salmon Bay area brief reconnaissance examinations were made at a copper prospect near Point Astley (loc. *B*, fig. 1), and at the sites of reported pitchblende occurrences in the vicinity of Taku Harbor, Limestone Inlet, and Port Snettisham (loc. *A*, fig. 1).

The country rocks in these localities include green schist, green, gray, and black slaty phyllite, and minor amounts of limestone and schistose chert. These rocks were intruded by quartz diorite of the Jurassic or Cretaceous Coast Range batholith (Buddington and Chapin, 1929, pl. 1).

At Point Astley metallic minerals occur in lenticular replacement veins that strike N. 0°–30° W. and dip to the east about 70° parallel to the schistosity of the country rock. The veins contain pyrite, sphalerite, bornite, pyrrhotite, galena, chalcopyrite, malachite, covellite, and chalcocite in a gangue of quartz, carbonate, and impregnated schist. Buddington and Chapin (1929, p. 327) reported traces of native silver from this locality.

Slight radioactivity was noted at one point in a short adit driven through a mineralized zone 10 to 15 feet wide. Sample 4558 (table 5) taken across a 2-foot part of this zone assayed 0.006 percent equivalent uranium. No radioactive minerals were identified.

Reconnaissance with Geiger counters in the vicinity of reported pitchblende occurrences at Taku Harbor, Limestone Inlet, and Port Snettisham (loc. *A*, fig. 1) revealed no appreciable radioactivity. No metallic minerals were observed except at the Taku Harbor locality where pyrite and arsenopyrite occur in a breccia zone and in the adjacent country rock. The maximum equivalent-uranium content (samples 4555 and 4556, table 5) was 0.003 percent.

HYDER AREA

The Hyder area (loc. *N*, figs. 1 and 4) at the head of Portland Canal is very highly mineralized. Several marginal gold-silver-copper-lead-zinc-tungsten properties have been exploited on the American side of the international boundary line; the famous Premier mine, only a mile northeast of the boundary in British Columbia, produced gold, silver, copper, lead, and zinc for many years. All these deposits have mineral assemblages somewhat similar to those found in uranium lodes in other parts of the world.

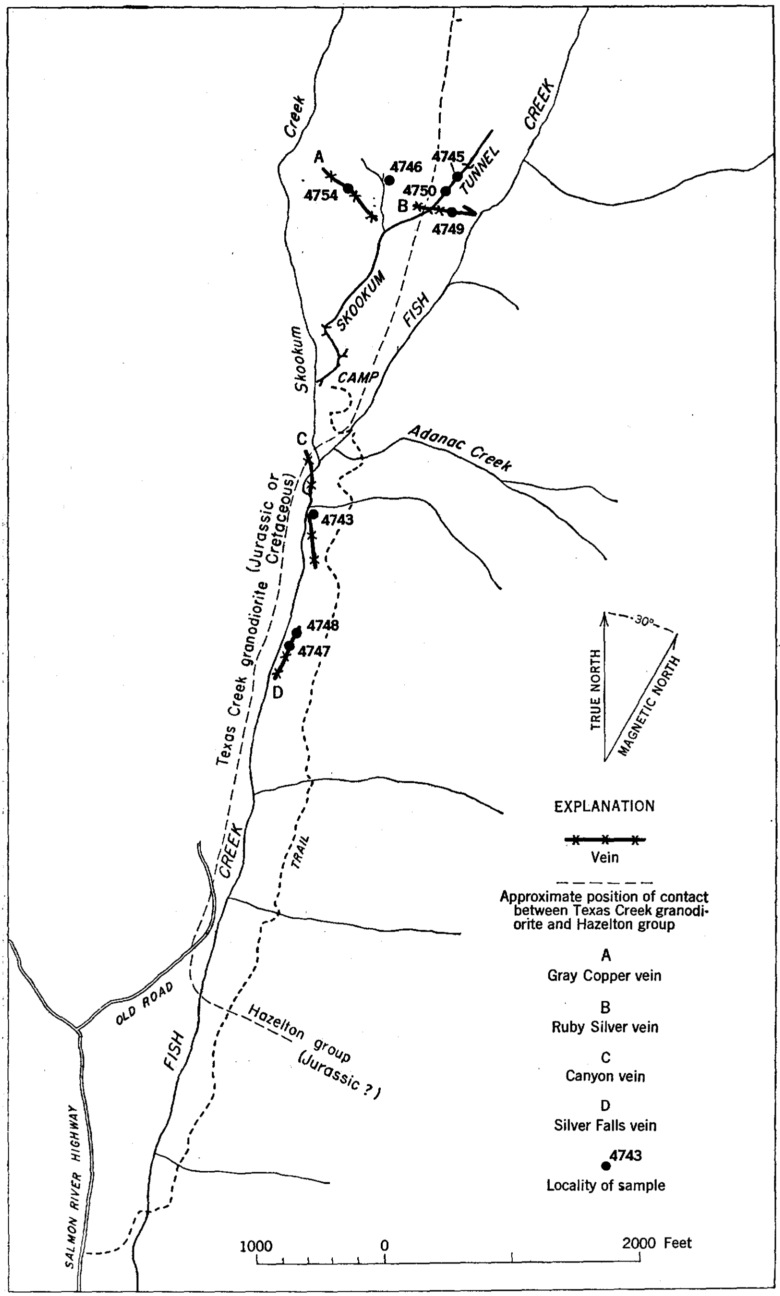

FIGURE 4.—Sample location map of the Mountain view property, Hyder area.

TABLE 5.—*Data on radioactivity of samples from the Taku Harbor-Point Astley district, the islands adjacent to northern Prince of Wales Island, and the Hyder area*

Sample	Location	Type of sample	Equivalent uranium (percent)
	Taku Harbor-Point Astley area		
4552	East side of Taku Harbor (loc. *A*, fig. 1) about 300 ft. south of cannery dock.	Grab sample of massive sulfide float.	<0.001
4553	From mineralized zone, east side of Taku Harbor (loc. *A*, fig. 1) about 450 ft. south of cannery dock.	Grab sample of sulfide from mineralized zone.	<.001
4554	From a narrow vein about 300 ft. south of sample 4553.	Grab sample of sulfide vein material.	.001
4555	North side of Limestone Inlet (loc. *A*, fig. 1) about midway between the mouth and the head of the inlet.	Grab sample of fine-grained granitic dike.	.003
4556	do	do	.003
4557	do	do	.002
4558	Point Astley (loc. *B*, fig. 1), from a short adit driven across a mineralized zone 10–15 ft. wide.	Grab sample from a 2-ft. section of a mineralized zone.	.006
	Islands adjacent to northern Prince of Wales Island		
4559	Round Point, Zarembo Island (loc. *D*, fig. 1)	Grab sample of granite	0.004
4726	McGill zinc prospect, southeast side of Kuiu Island about 1½ miles north of Point St. Albans (loc. *J*, fig. 1).	Grab sample of sphalerite-bearing vein material.	.001
4729	Shakan molybdenite prospect, Kosciusko Island (loc. *F*, fig. 1).	Grab sample of molybdenite-bearing vein material.	.004
4734	Baker Island molybdenite prospect (loc. *H*, fig. 1).	Grab sample of granite containing molybdenite-bearing quartz veinlets.	.001
4737	Northwest corner of Edna Bay, Kosciusko Island (south of loc. *F*, fig. 1).	Grab sample of iron-stained, argillaceous limestone.	.001
4739	From the middle of Totem Bay, Kupreanof Island (loc. *K*, fig. 1).	Grab sample of "dacite" country rock.	.003
4741	The Lake Bay copper prospect, Prince of Wales Island (loc. *L*, fig. 1).	Grab sample of pyrite-chalcopyrite vein.	.001
4742	Green Monster Mountain, Prince of Wales Island (loc. *M*, fig. 1).	Grab sample of chalcopyrite-bearing contact metamorphic ore.	<.001
	Hyder area (fig. 4: loc. *N*, fig. 1)		
4743	Canyon vein, Mountain View property, Hyder area.	Grab sample of vein material	0.004
4745	Stations 59 and 90, Skookum tunnel, Mountain View property, Hyder area.	Grab sample from Skookum tunnel.	.004
4746	Southeast end of the drift on the Gray Copper vein (USGS station 21), Skookum tunnel, Mountain View property, Hyder area.	Grab sample of vein material (unconcentrated).	.035
4747	Upper Silver Falls tunnel, Mountain View property, Hyder area.	Grab sample of fluorescent material.	.006
4748	Near footwall of Silver Falls vein, about 100–150 ft. above the upper Silver Falls tunnel, Mountain View property, Hyder area.	Grab sample of vein material	.005
4749	Surface cut in the Ruby Silver vein, Mountain View property, Hyder area.	Grab sample of thin yellow coating from outcrop of vein.	.003
4750	Near the floor of the Skookum tunnel between stations 55 and 60–25, Mountain View property, Hyder area.	Grab sample of fluorescent material.	.004
4753	Bankovich prospect at an altitude of about 5,000 ft. on "Hyder Lead Mountain", south side of the West Fork of Texas Creek, about 9 miles west of Mountain View property, Hyder area.	Grab sample from vein outcrop	<.001
4754	Surface cut in the Gray Copper vein, Mountain View property, Hyder area.	do	<.001

Investigations were centered on the Mountain View property which is about 5 miles north of Hyder. The area immediately surrounding this property is underlain by the Texas Creek granodiorite of Jurassic or Cretaceous age that intrudes greenstone, tuffaceous graywacke, volcanic breccia, slate, argillite, quartzite, and limestone of the Hazelton group of Jurassic(?) age (Buddington and Chapin, 1929).

The ore deposits on the Mountain View property are near the contact of the granodiorite and the Hazelton group. They consist of mesothermal fissure veins containing in decreasing order of abundance: pyrite, galena, sphalerite, pyrrhotite, molybdenite, scheelite, arsenopyrite, magnetite, specular hematite, tetrahedrite, proustite, chalcopyrite, chalmersite, marcasite, anglesite, malachite, azurite, covellite, and "limonite." The gangue consists of quartz, calcite, barite, ankerite, sericite, and chlorite.

Early in the summer of 1949, Howard M. Fowler, a former mining engineer for the Territorial Department of Mines, detected radioactivity anomalies on the Mountain View property. Later in the summer of 1949, W. S. West and P. D. Benson of the U. S. Geological Survey, who were based in southeastern Alaska, conducted a radiometric reconnaissance in the Hyder district (West and Benson, 1955) with special emphasis on the Mountain View property. No deposits of commercial interest were found although radioactive material is widely distributed on the Mountain View mining property. The maximum equivalent-uranium assay on unconcentrated material was 0.049 percent on a sample from the Skookum tunnel of the Mountain View mine. No primary uranium minerals could be identified. Chemical analyses, however, showed definite uranium; thin coatings of a yellowish stain, tentatively identified as uranium sulfate, were found at one locality. Positive qualitative tests for uranium were obtained from pyrrhotite, molybdenite, pyrite, galena, iron oxides, and a few other minerals.

During the summer of 1950 Howard M. Fowler collected a pitchblende-bearing sample from the Canyon vein on the Mountain View property. Because this sample was reported to have assayed 0.7 percent equivalent uranium oxide, a brief reconnaissance of the Canyon vein and the underground workings on the Mountain View property was made by the authors in 1952.

No appreciably radioactive material was detected in the Canyon vein. The maximum assay of the samples from this vein was only 0.004 percent equivalent uranium (sample 4743, table 5, fig. 4). One slightly radioactive area found by West and Benson in 1949 in the Skookum tunnel at the southeast end of the drift on the Gray Copper vein was rechecked in the 1952 investigation. An unconcentrated sample from this locality (sample 4746, table 5; fig. 4) assayed 0.035

percent equivalent uranium. No uranium mineral was identified. The radioactivity apparently emanated from molybdenite, pyrrhotite, and pyrite. Chemical tests by the U. S. Geological Survey laboratory have shown that these sulfides contain traces of uranium and that the molybdenite is the most radioactive. In this connection it is interesting to note that very fine grained uraninite has been described from the Victoria deposit near Hazelton, British Columbia about 100 miles southeast of the Hyder area. The uraninite is in microscopic grains associated with molybdenite, gold-bearing arsenopyrite, cobalt sulfarsenides, and hornblende in lenticular hydrothermal veins a few inches to 4 feet wide (Stevenson, 1951, p. 353, 362). Three other deposits showing similar mineralization occur in southern British Columbia. In all four of these places, Stevenson found that molybdenite is the sulfide most commonly associated with the uraninite.

A dark-green fluorescent coating was noted underground in several places near the bottom of the walls of the Skookum tunnel and the upper Silver Falls tunnel. The color of the fluorescence is similar to that of the uranium mineral autunite, but the mineral is not appreciably radioactive. The fluorescent mineral from the Skookum and Silver Falls tunnels was identified optically as opal (silicon dioxide) by the Geological Survey laboratory in Washington, D. C. The fluorescence is probably due to a trace of uranium present as an impurity in the opal. Fluorescent silica containing traces of uranium has been described from the Virgin Valley in northwestern Nevada (Staatz and Bauer, Jr., 1951, p. 2) and from the Monument Valley area in Utah. It has been identified in several other localities in the Western United States. The color of the fluorescence ranges from pale yellowish green to deep green as the uranium content increases.

The surface outcrops of the Ruby Silver vein on the Mountain View property have thin coatings of a yellow stain similar in color to some of the secondary uranium minerals. Samples of this material collected by Arthur O. Moa, manager of the Mountain View property, were studied by the Geological Survey laboratory. The coatings are not appreciably radioactive when tested with a Geiger counter. An X-ray diffraction pattern gave d-spacings similar to those for hydromica and the clay mineral kaolinite. Similar material collected by West and Benson in 1949 gave positive qualitative tests for uranium and was tentatively identified as a secondary uranium sulfate. It was impossible to collect enough of this material for positive identification.

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