Reconnaissance for Radioactive Deposits in Southeastern Alaska, 1952

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

Trace Elements Investigations Report 293

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GEOLOGICAL SURVEY

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and Helmuth Wedow, Jr.

February 1955

Trace Elements Investigations Report 293

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

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RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN SOUTHEASTERN ALASKA, 1952

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

ABSTRACT

Reconnaissance for radioactive deposits in southeastern Alaska in 1952 was centered in three localities:

1) northern part of Prince of Wales Island and parts of adjacent islands

2) Taku Harbor-Point Astley district

3) 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. Here radioactive carbonate-hematite veins occur along the coast for a distance of 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 widths of the veins normally range from less than 1 inch up to 2.5 feet; a few, however, attain widths of 5 to 10 feet.

The most abundant minerals in the veins are dolomite-ankerite and alkali feldspar; smaller 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.

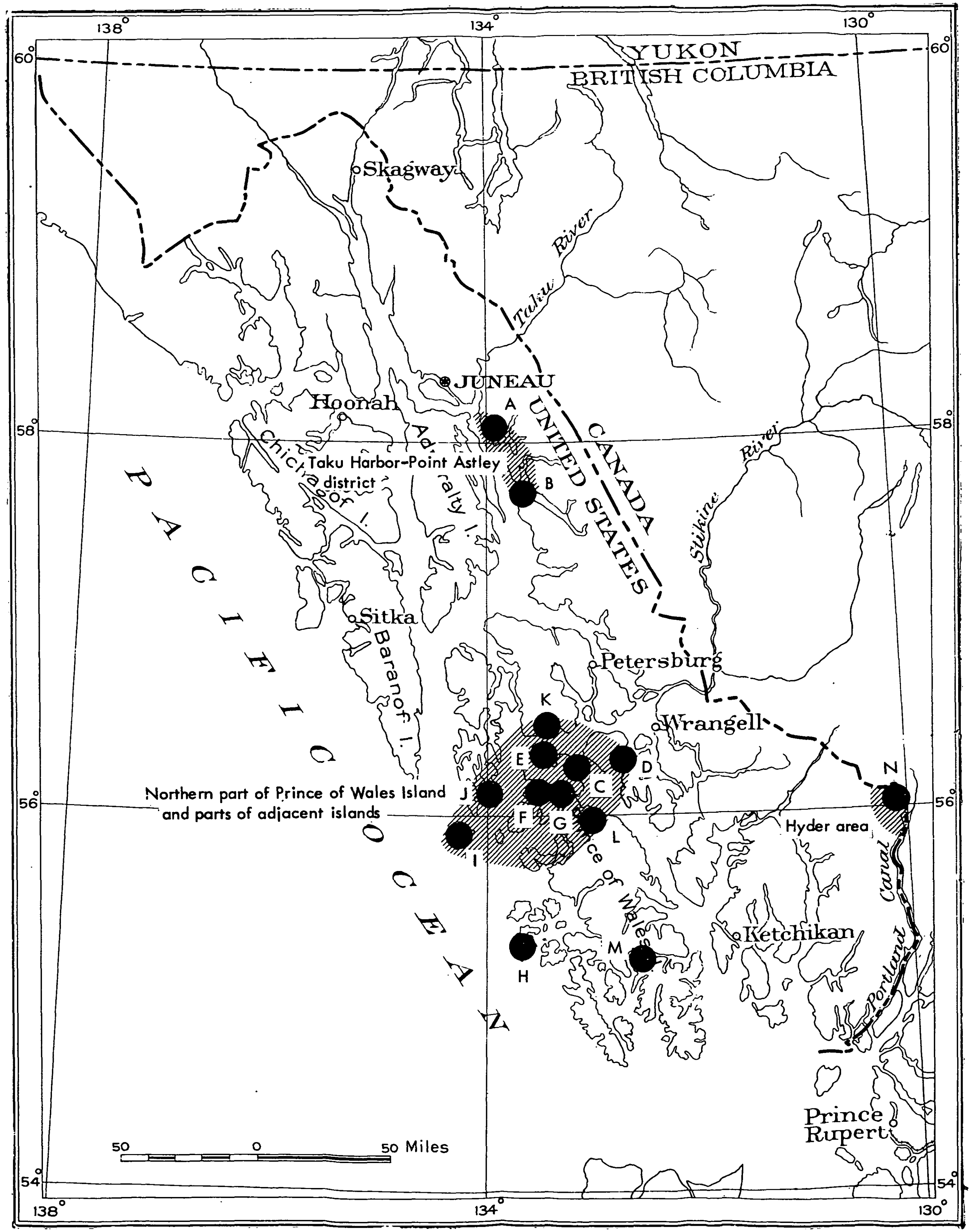
Almost all of the radioactivity is due to thorium contained chiefly in the minerals thorite and monazite. The highest-grade grab sample assayed 0.13 percent equivalent uranium or approximately 0.68 percent equivalent thorium (0.77 percent equivalent thorium dioxide). The average of seven channel samples taken along 100 feet of one of the more radioactive veins was 0.034 percent equivalent uranium or 0.156 percent equivalent thorium (0.178 percent equivalent thorium dioxide).

The rare-earth fluocarbonates parisite and bastnaesite, occur in small amounts in some veins. Four chip-channel samples taken over a distance of approximately 1,150 feet of what is believed to be the highest-grade rare-earth vein averaged 0.79 percent rare-earth oxides over an average width of 7.4 feet, and 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 an area embracing the northern part of Prince of Wales Island and parts of adjacent islands (localities C through M, fig. 1). Brief reconnaissance work in 1951 (Houston, 1952; White and others, 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 (locality C, fig. 1), and further geological work was necessary in order to determine more accurately the grade, mineralogy, and areal extent of these veins.

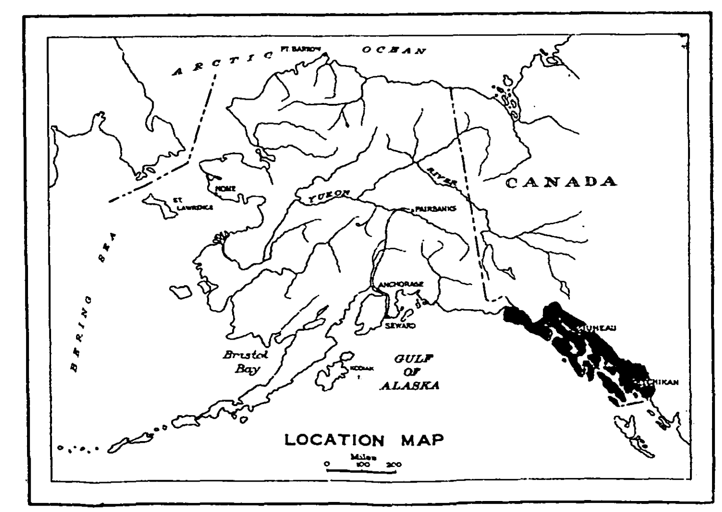
Because the radioactive veins in the vicinity of Salmon Bay occur only in graywacke, those portions of the northern and northwestern coasts of Prince of Wales Island (localities E and G, fig. 1; also see fig. 2) that had also been mapped as graywacke by Buddington (Buddington



EXPLANATION

● Localities examined in 1952

A	Taku Harbor-Port Snettisham area
B	Point Astley
C	Salmon Bay area
D	Round Point, Zarembo Island
E	The "graywacke" area along the north shore of Prince Of Wales Island
F	Shakan molybdenite deposit, Kosciusko Island
G	The "graywacke" area around Shakan and Shipley Bays, El Capitan Passage, Kosciusko and Prince of Wales Islands
H	Baker Island molybdenite prospect
I	Lead deposit on west shore of Egg Harbor, Coronation Island
J	Kuiu Island zinc deposit
K	Totem Bay, Kupreanof Island
L	Lake Bay, Prince of Wales Island
M	Green Monster Mountain, Prince of Wales Island
N	Mountain View property, Hyder area



LOCATION MAP

Figure 1. MAP OF SOUTHEASTERN ALASKA SHOWING LOCALITIES EXAMINED IN 1952

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and Chapin, 1929, pl. 1) were examined. In addition, a number of localities (F, H, I, J, L, and M, fig. 1) on Prince of Wales Island and adjacent islands were visited due to the fact that previously described mineral deposits at those localities contain mineral assemblages similar to those of known uranium deposits elsewhere (Wedow and others, 1951).

Brief reconnaissance examinations were made also in the Taku Harbor-Point Astley district (localities A and B, fig. 1) and in the Hyder area (locality N, fig. 1) to check on reported pitchblende occurrences.

Joseph R. Houston, Robert S. Velikanje, Robert G. Bates, and Helmuth Wedow, Jr., geologists, and Eugene D. Michael, geologic field assistant, were the Geological Survey personnel engaged in these field investigations. The party conducted its operations from aboard the U. S. Bureau of Mines motor vessel, the "Swan II", and was in the field from early July until about mid-September. Bates and Wedow were with the party only 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" for the Survey party and to personnel of the Geological Survey's laboratories 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 semi-quantitative 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. (See Wedow, 1951, p. 6.)

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

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

Introduction

In May 1950, Mr. John Wandve of Ketchikan, Alaska submitted several pounds of reddish rocks to the Ketchikan office of the Alaskan Territorial Department of Mines. Mr. Wandve reported that he had collected the specimens at Salmon Bay on the northeastern shore of Prince of Wales Island (locality C, fig. 1). Tests by Arthur E. Glover, Territorial Department of Mines engineer-assayer at Ketchikan, showed that the average radioactivity of the entire sample was about 0.01 percent equivalent uranium (Glover, 1951, p. 1).

In July 1951, Joseph R. Houston and Helmuth Wedow, Jr., geologists, and David L. Norton, geologic field assistant, of the Geological Survey accompanied by Mr. Glover, spent 1½ days in the Salmon Bay area. Houston and Norton returned for three more days late in August. The results of the work in 1951 have been described by Houston (1952). Many narrow radioactive carbonate-hematite veins were found in the Silurian graywacke around 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 two lode claims were staked near the entrance to Salmon Bay by Mr. Wandve of Ketchikan. In April and May 1952 Smith, Pitcher, and Company, also of Ketchikan, did considerable prospecting in the Salmon Bay area and along the coast to the south. Several new radioactive veins were discovered, and 32 lode claims were eventually 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 during July and August, 1952. Also, because the radioactive veins at Salmon Bay were thought to occur only in the Silurian graywacke, reconnaissance traverses were made along those portions of the northern and northwestern coasts of Prince of Wales Island (fig. 2) that had been mapped as graywacke by Buddington (Buddington and Chapin, 1929, pl. 1). Additional brief examinations were made at several localities on some of the nearby islands to check previously described mineral deposits that were reported to contain mineral assemblages characteristic of known uranium deposits in other parts of the world.

General geology of the northern part of Prince of Wales Island

Very little detailed geologic work has been done in the northern part of Prince of Wales Island. Buddington (Buddington and Chapin, 1929, pl. 1) mapped the coastal areas in reconnaissance fashion; part of his geologic map has been adapted for figure 2 of this report.

Bedded rocks

Ordovician rocks.--The oldest rocks in the area are of early and middle Ordovician age. They consist of a series of well-indurated graywackes with associated dark slates, andesitic volcanics, thin-layered black chert, and layers of conglomerate and limestone.

Silurian rocks.--Overlying the Ordovician rocks, probably unconformably, is a thick series of Silurian sedimentary and volcanic rocks. The oldest Silurian rocks consist of andesitic volcanics and conglomerate with some associated graywacke, black slate, and tuff. These rocks have a thickness of about 3,000 feet. Above them lies a massive, relatively pure limestone. The fresh rock is white; on weathered surface it is grayish or grayish-brown. Numerous small randomly-oriented fractures cut the limestone. These fractures are coated with a thin facing of carbonate that usually weathers out in relief as a network of veinlets. Thick beds of coarse conglomerate and some argillaceous limy layers are interbedded with the limestone. The aggregate thickness of the limestone and conglomerate is about 4,500 feet. About 5,000 feet of reddish-brown, gray, and gray-green graywacke containing a few interbedded conglomerate, graywacke-like sandstone, and shale layers overlies the limestone and is also Silurian in age. Much of the rock on the northern and western coasts of Prince of Wales Island that Buddington mapped as "graywacke" (fig. 2) is actually very limy. The carbonate content of three thin sections ranged from 45 percent to 90 percent. 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

Dioritic 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 the west coast of Prince of Wales Island. Buddington (Buddington and Chapin, 1929, p. 188, 203) gives the following average composition for diorite and "quartzose" diorite from Prince of Wales Island:

Diorite

	Percent
andesine	62
hornblende	26.5
quartz	4
biotite	3
potassium feldspar	2
magnetite	1.5
accessories (chiefly sphene, apatite, and zircon)	1

"Quartzose" diorite

	Percent
andesine	56
hornblende	20
quartz	9
potassium feldspar	6
biotite	4
pyroxene	2.5
magnetite	2
accessories	0.5

Chapin (1919, p. 89), Mertie (1921, p. 118-119), and Robinson (1946, p. 21), who have visited the molybdenite deposit near Shakan on Kosciusko Island (locality F, fig. 1; fig. 2) also report that this intrusive is composed of diorite and quartz diorite. A thin section made from a specimen collected in 1952 near the western contact of this intrusive had the following mineralogic composition:

	Percent
oligoclase-andesine	55
quartz	35
biotite (somewhat altered to chlorite)	5
alkali feldspar	3
hornblende	2
accessories	trace

As geologists have made few, if any, traverses across the northern part of Prince of Wales Island, and prospectors have done little work in that area, there may actually be other outliers of the Coast Range batholith besides the one shown in figure 2.

Lamprohyre and basalt dikes.--Lamprophyre and basalt dikes cut the Paleozoic rocks 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 forest cover to the low-water mark. The dikes generally strike somewhere between northwest and northeast. The most prevalent strike is north-northeast. The lamprophyres are probably older than the basalts, 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.

Structure

Only the broader features of the structural geology of the northern part of Prince of Wales Island are known. The major element is a large northwest-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 anticlinorium. 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

A thick graywacke formation of Silurian age is exposed along the coast for about 3 miles to the northwest and about 5 miles to the southeast of Salmon Bay (fig. 2). Layers of well-indurated shale, graywacke-like 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 Salmon Bay graywacke varies in color from reddish brown to grayish green. The grain size ranges from less than 0.05 mm. to more than 3 mm. The rock is composed of plagioclase, microperthite, orthoclase, chert, quartz, carbonate, and iron oxides with smaller amounts of pyrite, epidote, slate, and volcanic rock fragments. In many places iron oxides are abundant enough to give the rock a deep hematite-red color. The graywacke is well indurated. Usually it occurs in beds ranging from several inches to several feet thick, but in some places no bedding is visible and the graywacke resembles a volcanic rock.

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

Many dikes cut the Salmon Bay graywacke. Their strike ranges from N. 45° W. to N. 65° E., but north-northwest and north-northeast 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 located between Bay Point and Point Colpoys (fig. 3). Three types of dikes have been identified. Albite-biotite lamprophyres and albite-hornblende lamprophyres are the most common type. Fairly fresh-looking basalt dikes rich in carbonate are quite abundant, and 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.

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 formation 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 further west, or they might 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.--Many narrow radioactive carbonate-hematite veins cut the graywacke along the coast for a distance of about 3 miles northwest and 5 miles southeast of Salmon Bay or from the vicinity of the graywacke-limestone contact about 2 miles north of Exchange Cove to the vicinity of Point Colpoys. (See fig. 3.) A few veins also crop out in the larger stream beds west of Salmon Bay. Radioactive veins have been found only in the graywacke. Similar veins in the underlying limestone are not appreciably radioactive.

The veins range in width from a fraction of an inch to several feet, but the average width is only 2-3 inches. Only a few veins are more than a foot wide. Most of them are relatively short; generally only a few feet or a few tens of feet of any given vein are exposed along the beach, but at a few localities a single vein can be followed for more than 300 feet. 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 (figs. 4 and 5). The Paystreak vein strikes N. 3° W. and dips 70° E. It averages 2.4 feet in width. At extreme low tide approximately 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 considerably. The more prominent veins have general strikes of either N. 30-35° W. or north to N. 5° W. (as the Paystreak vein mentioned above). The average dip is about 70° NE.; however, dips ranging from 45° NE. to 40° SW. were noted.

Rare-earth carbonate veins.--In addition to the radioactive veins, wider, essentially 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 up to 10 feet and averages about 5 feet. At one locality just north of a small cove approximately one mile north of the entrance to Salmon Bay (figs. 3 and 6) about 375 feet of a rare-earth carbonate vein is exposed at low tide. This vein strikes N. 35° W. and dips 75° NE. About 5 miles to the south on Pitcher Island (fig. 4) three 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 for 200 to 400 feet along the beach.

Mineralogy of the veins.--A grayish-white carbonate of the dolomite-

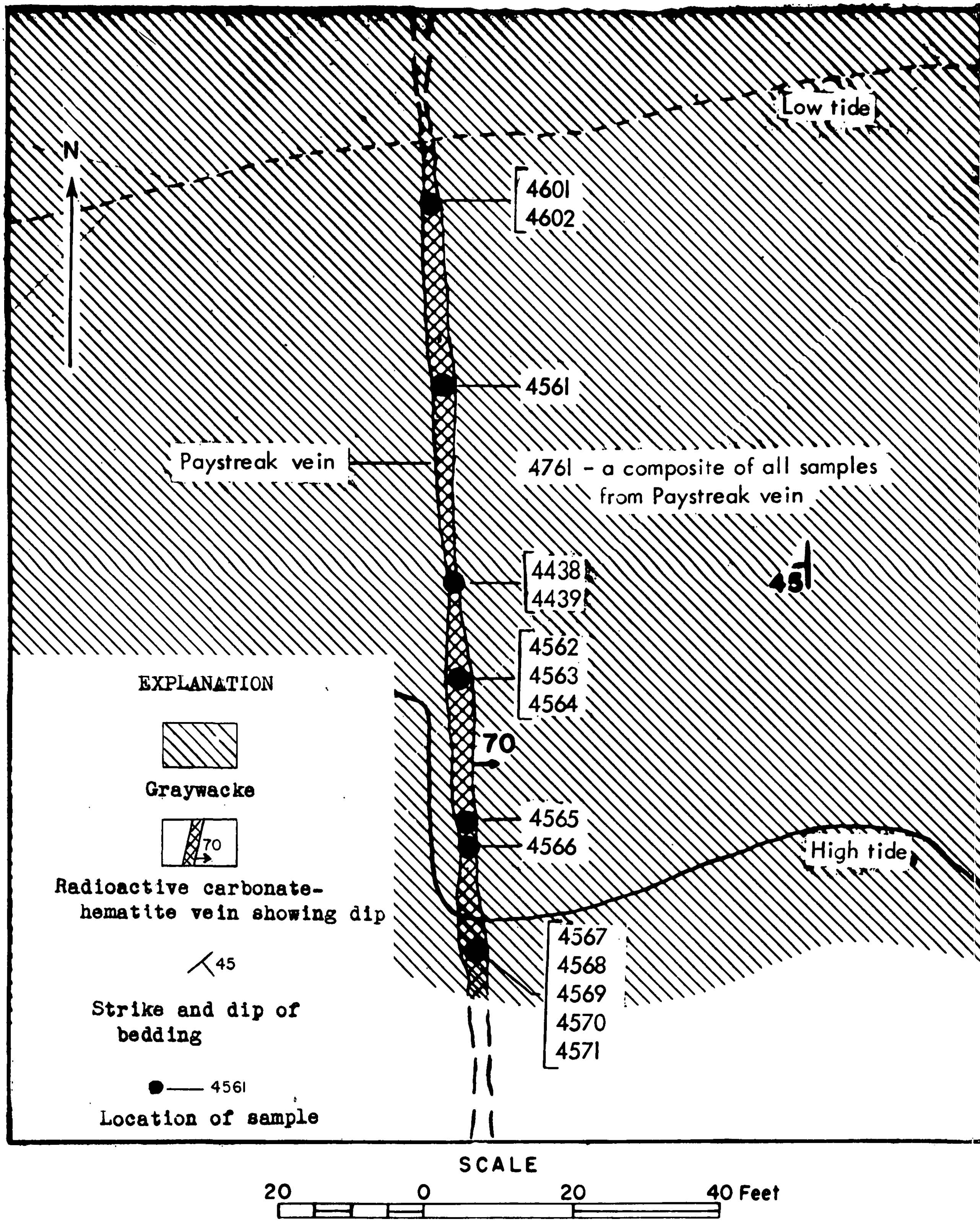
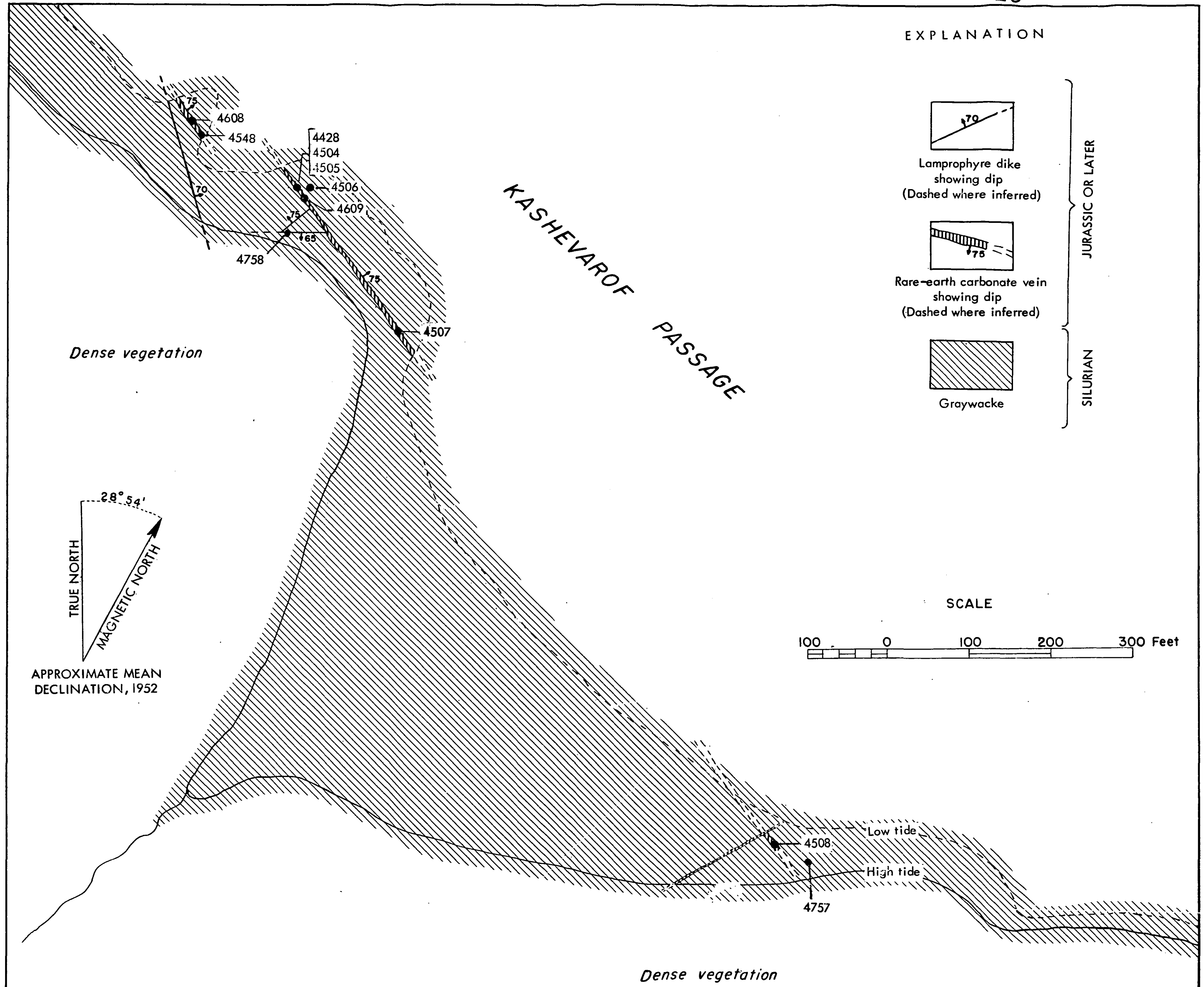


FIGURE 5.--GEOLOGIC SKETCH MAP OF THE PAYSTREAK VEIN, PITCHER ISLAND



Base from sketch map by R. G. Bates, 1952

Geology by R. G. Bates, J. R. Houston, and R. S. Velikanje

FIGURE 6.--GEOLOGIC SKETCH MAP OF THE RARE-EARTH CARBONATE VEIN, ONE MILE NORTH OF SALMON BAY

ankerite series is by far the most abundant mineral in the veins at Salmon Bay. The other main minerals are alkali feldspar, red hematite, specular hematite, and pyrite. Locally siderite and magnetite are abundant. Small amounts of the following minerals, listed in the approximate order of their abundance, have been identified: quartz, chalcedony, chlorite, calcite, parisite, bastnaesite, muscovite, fluorite, apatite, thorite, zircon, monazite, epidote, topaz, garnet, chalcopyrite, and marcasite. (See table 1.)

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

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

The grain size of the various vein minerals varies from less than 0.05 mm. to more than 1 cm. Most of the carbonate grains are 1 to 3 mm. across.

Thorite, monazite, zircon, and apatite are the only radioactive minerals that have been identified from the Salmon Bay veins, and these minerals occur only in traces. Many radioactive zones contain only carbonate, feldspar, pyrite, and red hematite.

A zone of reddish-brown hematitic alteration occurs along the walls of many of the veins. Also, many small open fissures are intensely stained with hematite or other red iron oxides or both. Some of the altered zones have a glazed, slag-like appearance. They are usually less than 1 inch wide. Generally the hematitic zones are more radioactive

Table 1.--Minerals found in the Salmon Bay veins[1/]

Mineral	Occurrence, abundance, and remarks
Dolomite-ankerite $Ca(Fe,Mg,Mn)(CO_3)_2$	Occurs 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 definitely in the ankerite end of the dolomite-ankerite group (Palache et al. 1951, p. 211). However, carbonate from some samples was identified as dolomite and ferroan dolomite by mineralogists of the U. S. Geological Survey's Washington Trace Elements Laboratory
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 some 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	Occurs in 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	Occurs in small amounts in most veins, usually as narrow black bands, also as platy aggregates
Pyrite FeS_2	Occurs in all veins, usually in striated cubes less than 1 mm. on a side, a few cubes are as much as 7 mm. on a side; apparently a late-stage mineral
Siderite $FeCO_3$	Occurs in small amounts in many veins; abundant locally, especially near the entrance to Salmon Bay
Magnetite $FeFe_2O_4$	Present in small amounts in many veins, locally abundant
Quartz and chalcedony SiO_2	Irregular; many veins contain no quartz; generally concentrated near the edges of the veins

Table 1.--Minerals found in the Salmon Bay veins--Continued

Mineral	Occurrence, abundance, and remarks
Chlorite $(Fe,Mg)_2Al(OH)_6(Fe,Mg)_3(AlSi_3O_{10})(OH)_2$	Rather rare; fills cracks in some veins; apparently a late-stage alteration product
Calcite $CaCO_3$	Rare; most of the carbonate is ankerite
Parisite $(Ce,La)_2Ca(CO_3)_3F_2$	Present in 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 post-vein 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 occur in many veins but it is not common; the green (chromian) variety occurs in small but conspicuous concentrations.
Fluorite CaF_2	Rare; local concentrations of purple fluorite are conspicuous in a few veins; more rarely white in color
Apatite $Ca_5(F,Cl,OH)(PO_4)_3$	Rare; radioactive apatite was identified in sample 4437 (fig. 3)
Thorite $ThSiO_4$	Traces occur in most radioactive veins; generally occurs in narrow veinlets
Zircon $ZrSiO_4$	Rare; traces occur in some of the radioactive veins; generally radioactive
Monazite $(Ce,La,Y,Th)(PO_4)$	Rare; traces occur in some of the radioactive veins

Table 1.--Minerals found in the Salmon Bay veins--Continued

Mineral	Occurrence, abundance, and remarks
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 (fig. 3)
Garnet $(Ca,Mn,Fe,Mg)_3(Al,Fe)_2(SiO_4)_3$	Very rare; found only in sample 4440 from West Island (fig. 3)
Chalcopyrite $CuFeS_2$	Very rare; identified in sample 4580 (fig. 3) from small island 1/2 mile northwest of Pitcher Island
Marcasite FeS_2	Very rare; identified in sample 4437 from Salmon Bay (fig. 3)

1/ Mineralogy by Mary E. Thompson, Joseph R. Houston, and Richard Kellagher
Spectrographic analyses by Charles S. Annell, J. N. Stich, John J. Matzko, and Katherine E. Valentine
Powder X-ray work by Evelyn Cisney

than the carbonate vein filling. A less intense reddish-brown coloration due to 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, $(Ce, La)_2 Ca(CO_3)_3F_2$ and bastnaesite, $(Ce, La)(CO_3)F$ occur in small amounts in some of the veins. Parisite is especially abundant in a wide vein located about 1 mile north of the mouth of Salmon Bay (fig. 6). The parisite has a light yellowish-brown to grayish-brown color. It is a rather late-stage mineral, generally occurring along post-vein fractures in the carbonate vein filling. Locally it lines small vugs as earthy, sub-rounded grains about 0.5 mm. in diameter.

Pertinent data concerning the Salmon Bay vein minerals are summarized in table 1.

Radioactivity data.--Most of the veins at Salmon Bay show some radioactivity. The equivalent-uranium content of 95 samples from the Salmon Bay area was determined in the laboratory; in addition selected samples were analyzed for uranium, uranium oxide, equivalent thorium, and thorium dioxide. (See table 2.) Sample locations are shown on figures 3, 4, 5, and 6.

The maximum equivalent-uranium content on unconcentrated vein material from Salmon Bay analyzed by the Geological Survey is 0.13 percent (sample 4443, fig. 3). 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.

Table 2.--Data on the radioactivity of samples from the Salmon Bay area

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) (percent) 3/	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) 3/
4089	Grab from carbonate vein; Fishery Island, Salmon Bay (fig. 3)	0.017	<0.001	---	0.09 4/	---
4090	do.	.07	.003	---	.26 1/	---
4092	do.	.001	---	---	---	---
4093	do.	.007	<.001	---	.04 4/	---
4095	do.	.013	<.001	---	.07 4/	---
4403-A	do.	.014	---	---	---	---
-B	(Non-magnetic fraction of 4403-A)	.020	---	---	---	---
-C	(Magnetic fraction of 4403-A)	.006	---	---	---	---
4422-A	Grab from carbonate vein; Fishery Islad, Salmon Bay (fig. 3)	.022	---	---	---	---
-B	(Fraction of 4422-A less than 2.9 sp. gr.)	.008	---	---	---	---
-C	(Fraction of 4422-A between 2.9 and 3.3 sp. gr.)	.020	---	---	---	---
-D	(0.7 - 0.9 ampere Frantz portion of fraction of 4422-A greater than 3.3 sp. gr.)	.160	---	---	---	---
-E	(1.1 ampere Frantz portion of fraction of 4422-A greater than 3.3 sp gr.)	.007	---	---	---	---
4428-A	Grab from carbonate vein; small bay 1 mile north of Salmon Bay (fig. 6)	.003	.001	---	.01 4/	---
4428-B	do.	.002	.001	---	.005 4/	--

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) (percent) 3/	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) 3/
4437	Grab from carbonate vein; Salmon Bay (fig. 3)	0.029	0.002	---	0.14 4/	---
4438	Wall rock adjacent to vein; Paystreak vein, Pitcher Island (fig. 5)	.002	.001	---	.005 4/	---
4439	Channel from carbonate vein; Paystreak vein (fig. 5)	.046	.001	---	.20 1/	---
4440	Channel from carbonate vein; West Island (fig. 3)	.029	.003	---	.14 4/	---
4441	Fine-grained dike rock; small island about 3/4 mile northwest of Pitcher Island (fig. 3)	.007	.003	---	.02 4/	---
4442	Coarse-grained dike rock; large island between Fishery Island and Pitcher Island (fig. 3)	.005	.001	---	.02 4/	---
4443	Hematite-rich wall rock; Fishery Island, Salmon Bay (fig. 3)	.130	.002	---	.46 1/	---
4492-A	Hematitic limestone; Exchange Island (fig. 3)	.001	---	---	---	---
-B	(Fraction of 4492-A greater than 2.9 sp. gr.; conc. ratio 1:1)	.003	---	---	---	---
4493-A	Grab from carbonate vein; Prince of Wales Island, about 3/4 mile north of Exchange Cove (fig. 3)	.001	---	---	---	---
-B	(Fraction of 4493-A greater than 2.9 sp. gr.; conc. ratio 1.3:1)	.004	---	---	---	---
4494-A	Altered fracture zone in graywacke; Exchange Island (fig. 3)	.001	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) [1]	Uranium (percent) [2]	Uranium oxide (U_3O_8) (percent) [3]	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) [3]
4494-B	(Fraction of 4494-A greater than 2.9 sp. gr.;conc. ratio 3.2:1)	0.005	---	---	---	---
4495-A	Iron-stained zone in graywacke; Exchange Island (fig. 3)	.002	---	---	---	---
-B	(Fraction of 4495-A greater than 2.9 sp. gr.; conc. ratio 2:1)	.003	---	---	---	---
4496-A	Hematitic limy breccia zone; West Island (fig. 3)	< .001	---	---	---	---
-B	(Fraction of 4496-A greater than 2.9 sp. gr.; conc. ratio 1:1)	.002	---	---	---	---
4497-A	Grab from carbonate vein; small cove on Prince of Wales Island west of Thorne Island (fig. 2)	< .001	---	---	---	---
-B	(Fraction of 4497-A greater than 2.9 sp. gr.; conc. ratio 1:1)	< .001	---	---	---	---
4498-A	Grab from carbonate vein; Thorne Island (fig. 2)	< .001	---	---	---	---
-B	(Fraction of 4498-A greater than 2.9 sp. gr.; conc. ratio 21:1)	.001	---	---	---	---
4499-A	Grab from carbonate vein; Thorne Island (fig. 2)	< .001	---	---	---	---
-B	(Fraction of 4499-A greater than 2.9 sp. gr.; conc. ratio 1:1)	< .001	---	---	---	---
4500-A	Grab from carbonate vein; Thorne Island (fig. 2)	< .001	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) (percent) 3/	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) 3/
4500-B	(Fraction of 4500-A greater than 2.9 sp. gr.; conc. ratio 1.2:1)	<0.001	---	---	---	---
4501-A	Mafic dike rock; Thorne Island (fig. 2)	.002	---	---	---	---
-B	(Fraction of 4501-A greater than 3.3 sp. gr.; conc. ratio 55:1)	.001	---	---	---	---
4502-A	Grab from carbonate vein; Marker vein, Pitcher Island (fig. 4)	.053	---	---	---	---
-B	(Fraction of 4502-A greater than 2.9 sp. gr.; conc. ratio 1.3:1)	.056	---	---	---	---
-C	(Fraction of 4502-A greater than 3.3 sp. gr.; conc. ratio 40:1)	.103	---	---	---	---
4503-A	Grab from carbonate vein; southeast side of Pitcher Island (fig. 4)	.038	---	---	---	---
-B	(Fraction of 4503-A greater than 2.9 sp. gr.; conc. ratio 1.2:1)	.039	---	---	---	---
4504	Chip-channel across carbonate vein; small bay 1 mile north of Salmon Bay (fig. 6)	.002	---	---	---	---
4505	Chip-channel across carbonate vein; small bay 1 mile north of Salmon Bay (fig. 6)	.002	---	---	---	---
4506	Grab of altered zone adjacent to vein; same location as 4505	.006	---	---	---	---
4507	Chip-channel across carbonate vein; same location as 4505	.002	---	---	---	---
4508	do.	.002	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) 3/ (percent)	Equivalent thorium (percent)	Thorium dioxide (ThO_2) 3/ (percent)
4546	Grab of wall rock along barren fracture; West Island (fig. 3)	0.003	---	---	---	---
4547	Grab from carbonate vein; West Island (fig. 3)	.009	---	---	---	---
4548	Grab from carbonate vein; small bay 1 mile north of Salmon Bay (fig.6)	< .001	---	---	---	---
4549	Grab from fluorite-bearing carbonate vein; south of Bay Point (fig. 3)	< .001	---	---	---	---
4550	Grab from carbonate vein; west of Point Colpoys (fig. 3)	.002	---	---	---	---
4551	Grab from carbonate vein; Bay Point (fig. 3)	.006	---	---	---	---
4561	Channel across carbonate vein; Paystreak vein (fig. 5)	.035	---	---	0.16 1/	---
4562	Channel across wall rock adjacent to vein; Paystreak vein (fig. 5)	.003	---	---	---	---
4563	Channel across carbonate vein; Paystreak vein (fig. 5)	.036	---	---	.16 1/	---
4564	Channel across wall rock adjacent to vein; Paystreak vein (fig. 5)	.002	---	---	---	---
4565	Channel across carbonate vein; Paystreak vein (fig. 5)	.020	---	---	.11 1/	---
4566	do.	.030	---	---	.17 1/	---
4567	Channel across wall rock adjacent to vein; Paystreak vein (fig. 5)	.002	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) [1/]	Uranium (percent) [2/]	Uranium oxide (U_3O_8) (percent) [3/]	Equivalent thorium (percent)	Thorium dioxide (ThO_2) [3/] (percent)
4568	Channel across wall rock adjacent to vein; Paystreak vein (fig. 5)	0.003	---	---	---	---
4569	Channel across carbonate vein; Paystreak vein (fig. 5)	.036	---	---	0.17 [1/]	---
4570	do.	.014	---	0.001	.07 [6/]	0.08
4571	do.	.049	---	.001	.23 [6/]	.26
4572	Channel across carbonate vein; Marker vein, Pitcher Island (fig. 4)	.083	---	.002	.42 [6/]	.48
4573	Channel across wall rock inclusion; Marker vein (fig. 4)	.002	---	---	.013 [1/]	---
4574	Channel across carbonate vein; Marker vein (fig. 4)	.057	---	.004	.29 [6/]	.35
4575	Channel across wall rock inclusion; Marker vein (fig. 4)	.006	---	---	.028 [1/]	---
4576	Channel across carbonate vein; Marker vein (fig. 4)	.037	---	---	.17 [1/]	---
4577	do.	.026	---	.004	.11 [6/]	.13
4579	Grab from carbonate vein; small island about 1/2 mile northwest of Pitcher Island (fig. 3)	.011	---	---	---	---
4581	Channel across wall rock adjacent to vein; southeast side of Pitcher Island (fig. 4)	.005	---	---	---	---
4582	Channel across carbonate vein; southeast side of Pitcher Island (fig. 4)	.064	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) (percent) 3/	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) 3/
4583	Channel across wall rock adjacent to vein; southeast side of Pitcher Island (fig. 4)	0.005	---	---	---	---
4584	Chip-channel across carbonate vein; southeast side of Pitcher Island (fig. 4)	.002	---	---	---	---
4585	do.	.003	---	---	---	---
4586	Chip-channel along carbonate vein; southeast side of Pitcher Island (fig. 4)	.004	---	---	---	---
4601	Channel across carbonate vein; Paystreak vein (fig. 5)	.035	---	---	---	---
4602	Channel across wall rock adjacent to vein; Paystreak vein (fig. 5)	<.001	---	---	---	---
4603	Chip-channel along carbonate vein; northwest side of Pitcher Island (fig. 4)	<.001	---	---	---	---
4604	Chip-channel across carbonate vein; northwest side of Pitcher Island (fig. 4)	<.001	---	---	---	---
4605	Chip-channel along carbonate vein; northwest side of Pitcher Island (fig. 4)	<.001	---	---	---	---
4606	Chip-channel across carbonate vein; northwest side of Pitcher Island (fig. 4)	<.001	---	---	---	---
4608	Chip-channel across carbonate vein; small bay 1 mile north of Salmon Bay (fig. 6)	<.001	---	---	---	---
4609	Grab from carbonate vein; small bay 1 mile north of Salmon Bay (fig. 6)	.001	---	---	---	---

Table 2.--Data on the radioactivity of samples from the Salmon Bay area--Continued

Sample no.	Type and location of sample	Equivalent uranium (percent) 1/	Uranium (percent) 2/	Uranium oxide (U_3O_8) (percent) 3/	Equivalent thorium (percent)	Thorium dioxide (ThO_2) (percent) 3/
4610	Grab from feldspathic dike; south of Bay Point (fig. 3)	0.005	---	---	---	---
4759	Hematitic wall rock adjacent to radioactive fracture; Fishery Island, Salmon Bay (fig. 3)	.065	---	---	---	---
4761	Composite from Paystreak vein, Pitcher Island (fig. 5)	.033	---	---	0.16 5/	0.18
4762	Composite from Marker vein, Pitcher Island (fig. 4)	.057	---	---	.26 5/	.30

1/ Radiometric assay - By Mary E. Thompson, Paul D. Benson, Joseph R. Houston, and Benjamin A. McCall

2/ Fluorimetric assay - By Mary E. Thompson, Paul D. Benson H. Kramer, and Audrey C. Pietsch

3/ Chemical analysis - By Jesse J. Warr and Harry Levine

4/ Calculated from the equivalent uranium by subtracting the chemical uranium and multiplying the remainder by the conversion factor of 5.22

5/ Calculated from the ThO_2 content by multiplying by the conversion factor of 0.8788

6/ Average of results obtained using methods described in 4/ and 5/.

Thirteen fluorimetric analyses (samples 4089, 4090, 4093, 4095, 4428-A, 4428-B, and 4437 through 4443, table 2) were made for uranium at the Geological Survey's laboratory in Washington, D. C. The maximum uranium content of these samples was 0.003 percent. Five samples (4570, 4571, 4572, 4574, and 4577, table 2) were analyzed chemically for uranium oxide (U_3O_8); the maximum uranium-oxide content of these samples did not exceed 0.004 percent. As these results indicated that almost all the radioactivity was due to thorium, the same five samples analyzed for uranium oxide and having equivalent-uranium contents ranging from 0.014 to 0.083 percent were analyzed chemically for thorium dioxide (ThO_2). The ratio -- percent ThO_2 : (percent eU - percent U) -- was calculated for each of the five samples. The ratios ranged from 5.40 to 6.53 and averaged 5.93. Thus, if any given equivalent-uranium assay on the Salmon Bay samples is multiplied by this factor (5.93), the result will represent the approximate amount of thorium dioxide in the sample. Because the ratio -- Th : ThO_2 -- equals 0.8788, any given Salmon Bay equivalent-uranium assay can be expressed as equivalent thorium by substituting in the following formulae:

$$\text{eTh (percent)} = \text{eU (percent)} \times 0.8788 \times 5.93$$

$$\text{or} \quad \text{eTh (percent)} = \text{eU (percent)} \times 5.22$$

where eTh is equivalent thorium and eU is equivalent uranium.

Because of the short, lenticular, irregular nature of most of the Salmon Bay veins, no calculations of average grade or total reserves were made. However, 100 feet of the Paystreak vein on Pitcher Island (figs. 4 and 5) was sampled accurately enough to warrant a grade and reserve calculation; these calculations are given in the next section of this report.

In addition to radioactivity measurements made in the field on the ground and on samples in the laboratory, an attempt was made by Bates and Wedow to determine whether the radioactivity of the Marker and Paystreak veins on Pitcher Island (fig. 4) 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 northeast end of Pitcher Island (fig. 4) where the Marker and Paystreak veins are located was flown successively at 100-foot, 50-foot, and 20-foot heights above the beach with the instrument carried in a 4-place fixed-wing aircraft on floats. No ratemeter readings above background were obtained at the 100-foot 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 slighty greater than the maximum limit of fluctuation in the ratemeter readings for background. Because of flying hazards at both the 50-foot and 20-foot levels (maximum height of timber on island is close to 100 feet), no attempt was made to make more than one run at each of the two lower levels. Because of the greater sensitivity of a portable scintillometer it is likely that such an instrument adapted for airborne traversing with light fixed-wing aircraft could detect significant variations in radioactivity over the beach on Pitcher Island at the safer 100-foot level of flying.

Reserve calculations for a 100-foot section of the Paystreak vein, Pitcher Island.--Because of the low grade and short, lenticular, irregular nature of the Salmon Bay radioactive carbonate-hematite veins, no attempts at systematic sampling were made except on Pitcher Island (figs. 3, 4, and 5). There, slightly more than 100 feet of the Paystreak vein, averaging 2.4 feet in width, is exposed at low water. A 100-foot portion of this vein was sampled accurately enough to warrant a grade and reserve calculation. (See fig. 5.)

First, the grade was calculated in terms of percent equivalent uranium and was found to average 0.034 percent (table 3). However, an expression of the average grade in terms of equivalent uranium actually has little meaning because almost all of the radioactivity is due to thorium. Therefore, grade calculations were also made in terms of percent equivalent thorium and were found to average 0.156 percent (table 4). In these calculations no provisions were made for possible wall-rock dilution. A tonnage-volume factor of 10.9 was used.

Reserves of thorium and thorium dioxide per foot of depth (down the dip) were calculated for the 100-foot portion of the vein. There are approximately 68.6 pounds of thorium or 78.1 pounds of thorium dioxide per foot of depth for the 100-foot portion of the vein sampled. (See table 5.)

It is impossible to say just how far the Paystreak vein extends beyond the 100-foot sampled portion. The dense forest cover on Pitcher Island prevents the tracing of the vein, either visually or by radioactivity surveying, 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 (fig. 4); 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 continuing under water for a distance of about 40 feet at extreme low tide. However, at least another 50 feet of comparable width and grade

Table 3.--Calculation of the average equivalent-uranium content of a 100-foot portion of the Paystreak vein, Pitcher Island 1/

Sample no. (fig. 5)	Width (feet)	Distance between samples (feet)	Distance of influence (feet)	Area of influence (square feet)	Assay equivalent uranium (percent) 2/	Area-assay product equivalent-uranium content
4601	2.0	24.2	24.2	48.4	0.035	1.69
4561	2.8	24.2 26.0	25.1	70.28	.035	2.46
4439	1.7	26.0 13.0	19.5	33.15	.046	1.52
4563	3.1	13.0 19.6	16.3	50.53	.036	1.82
4565	2.0	19.6 3.2	11.4	22.8	.020	0.46
4566	1.8	3.2 14.0	8.6	15.48	.030	.46
4569 4570 3/ 4571	3.3	14.0 14.0	14.0	46.2	.026 4/	1.20
Avg. width= 2.4 ft.				286.84		9.61

Average grade = $\frac{9.61}{286.84}$ = 0.034 percent equivalent uranium

1/ Format after Parks, 1949, p. 66

2/ Radiometric assay

3/ Sample 4569 assayed 0.036 percent eU over 1.0 ft.
Sample 4570 assayed 0.014 percent eU over 1.8 ft.
Sample 4571 assayed 0.049 percent eU over 0.5 ft.

4/ Weighted average of samples 4569, 4570, and 4571

Table 4.--Calculation of the average equivalent-thorium content of a 100-foot portion of the Paystreak vein, Pitcher Island 1/

Sample no. (fig. 5)	Width (feet)	Distance between samples (feet)	Distance of influence (feet)	Area of influence (square feet)	Assay equivalent thorium (percent)	Area-assay product equivalent-thorium content
4601	2.0	24.2	24.2	48.4	0.17 2/	8.23
4561	2.8	24.2 26.0	25.1	70.28	.16 3/	11.25
4439	1.7	26.0 13.0	19.5	33.15	.20 3/	6.63
4563	3.1	13.0 19.6	16.3	50.53	.16 3/	8.09
4565	2.0	19.6 3.2	11.4	22.8	.11 3/	2.51
4566	1.8	3.2 14.0	8.6	15.48	.17 3/	2.63
4569 4570 4/ 4571	3.3	14.0 14.0	14.0	46.2	.12 5/	5.54
Avg. width = 2.4 ft.				286.84		44.88

Average grade = $\frac{44.88}{286.84}$ = 0.156 percent equivalent-thorium

1/ Format after Parks, 1949, p. 66

2/ Calculated from the equivalent uranium by substracting an estimated 0.002 percent for chemical uranium and multiplying the remainder by the conversion factor of 5.22

3/ Radiometric assay

4/ Sample 4569 assayed 0.17 percent eTh over 1.0 ft.
Sample 4570 assayed 0.07 percent eTh over 1.8 ft.
Sample 4571 assayed 0.23 percent eTh over 0.5 ft.

5/ Weighted average of samples 4569, 4570, and 4571

Table 5.--Reserves of thorium dioxide per foot of depth in a 100-foot portion of the Paystreak vein, Pitcher Island

Average specific gravity of the Paystreak vein material = 2.94

2.94 x 62.4 = 183.5 pounds of unbroken ore per cubic foot

$\frac{2000}{183.5}$ = 10.9 cubic feet of ore per ton

Average width of the Paystreak vein = 2.4 feet

Length of the Paystreak vein sampled - 100 feet

Area of vein sampled = 2.4 x 100 = 240 square feet

(practically the same result is obtained if the areas of the individual blocks between the samples are calculated separately).

Tons of ore per foot of depth = $\frac{240}{10.9}$ = 22 tons

Average grade (table 6) = 0.156 percent equivalent thorium

0.156 percent x 22 tons = 0.03432 tons equivalent thorium per foot of depth (down the dip)

0.03432 tons x 2,000 = 68.6 pounds equivalent thorium per foot of depth (down the dip)

68.6 pounds ÷ 0.8788 = 78.1 pounds of thorium dioxide per foot of depth (down the dip) can be inferred, and there might be several hundred feet more.

Rare-earth oxide data.--As 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 6; the location of the samples analyzed are shown on figures 3, 4, 5, and 6. One vein about 1 mile north of the entrance to Salmon Bay was particularly high in parisite. Four chip-channel samples 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. (See table 6 and fig. 6.)

Genesis of the veins.--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 Salmon Bay graywacke served as a fairly competent rock, maintaining open-spaces much better than the dikes.

The two most prominent directions of strike of the veins mentioned previously (N.30°W.-N.35°W. and N.-N.5°W.) are supplemented by a third strike trend lying between N.30°E. and N.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-northwest-trending Prince of Wales anticlinorium during the Coast Range orogeny.

Table 6.--Data[1] on the rare-earth oxide content of carbonate-vein samples from the Salmon Bay area

Sample no.	Location of sample	Type of sample	Equivalent uranium (percent)	Rare-earth oxides (percent) [2]
4428-A	Vein about 1 mile north of Salmon Bay (fig. 6)	High-grade grab	0.003	5.0
-B	do.	do.	.002	1.2
4504	do.	2.0 ft. chip-channel from hanging-wall portion of vein	.002	.73
4505	do.	4.0 ft. chip-channel from foot-wall portion of vein (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. 5)	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 (fig. 4)	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

Table 6.--Data[1] on the rare-earth oxide content of carbonate-vein samples from the Salmon Bay area--Continued

Sample no.	Location of sample	Type of sample	Equivalent uranium (percent)	Rare-earth oxides (percent) [2]
4608	Vein about 1 mile north of Salmon Bay (fig. 6)	6.5 ft. chip-channel across vein	0.001	0.78
4609	do.	High-grade grab	.001	1.95
4610	Feldspathic dike about 1/2 mile south of Bay Point	Grab	.005	0.07

1/ Equivalent-uranium analyses by Mary E. Thompson and John J. Matzko.

2/ 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.

At one locality on the southeast shore of Pitcher Island (fig. 4) a narrow radioactive carbonate-hematite vein appears to cut one of the wider, essentially 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 (fig. 2). 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. This is especially true with the wide rare-earth carbonate vein located about 1 mile north of Salmon Bay (fig. 6). Here and in one or two other localities carbonate veins were observed cutting 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. 6) 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 are believed to be "genetically related to the differentiation of an alkaline magma" (Olson and Sharp, 1951, p. 803). The lamprophyre dikes at Salmon Bay could be associated with alkalic rocks which have not yet been exposed by erosion. Also, because the region immediately west of Salmon Bay has never been mapped geologically, it is possible that there are some undiscovered alkalic intrusives near the carbonate veins. Thin sections from three different lamprophyre dikes in the area showed the following mineralogical composition:

Sample 4757 (fig. 6)

	Percent
albitic plagioclase	49
carbonate	21
altered hornblende	19
epidote	5
pyrite	3
iron oxides	3
analcite	trace

Sample 4758 (fig. 6)

	Percent
brown and green biotite	48
albitic plagioclase	28
carbonate	22
ilmenite	2
apatite	trace

Sample 4760 (fig. 3)

	Percent
hydrobiotite and "sericitic" material	51
biotite	25
albitic plagioclase	15
carbonate	6
opaques (magnetite, pyrite, ilmenite)	3
analcite	trace

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 (fig. 4). Megascopically the rock is dark, fresh-looking, and 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 (fig. 4)

	Percent
plagioclase (average An_{50})	45
carbonate	35
magnetite	14
chloritic material	6
quartz	trace
olivine(?)	trace

A thin section of rock sample 4441 (fig. 3) collected by Glover from a dike located on a small island a short distance northwest of Pitcher Island was examined by Richard Kellagher of the Geological Survey's 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 narrower, more radioactive carbonate veins are genetically associated with one of these sets of dikes while the wider, essentially 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" are closely associated with these veins (Christman, and others, 1953, p. 1). However, the relationship between the dikes and the thorium veins is thought to be "purely structural" (Christman, and others, 1953, 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 hydrothermally redistributed sedimentary limestones. The association of alkalic lamprophyres, phonolites, olivine basalts, and dike-like 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 limestones derived from the relatively pure limestone that underlies the graywacke in the vicinity of Salmon Bay (fig. 2). 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 the mineralogy section of this report (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 post-vein fractures in the carbonate and as small, subround aggregates in vugs. Another feature that is also definitely hydrothermal is the widespread hematitic alteration adjacent to most of the veins.

Extensive detailed mapping along the shore of Prince of Wales Island from Point Colpoys to Exchange Cove (fig. 3) at low tide would undoubtedly solve many of the problems concerning the origin of the carbonate veins and their relationship to the different dikes. But such an undertaking would hardly be practical because work could be carried on effectively only during the few hours of low water on those days of the month when the tides were at a maximum.

Summary and conclusions

The surface portions 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, it does not seem probable that they would show any significant increase in uranium tenor with depth. The thorium is contained in minerals into whose structures uranium enters only to a very limited extent. So, unless some undetected radioactive mineral which 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 on northern Prince of Wales Island and adjacent islands

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 (localities E and G, fig. 1; also see fig. 2) that had been mapped as graywacke by Buddington (Buddington and Chapin, 1929, pl. 1). Only a small portion 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 portable Geiger counters. A few barren calcite veins were found in the graywacke, some epidote-garnet-calcite veinlets were encountered near igneous contacts, and 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" (fig. 2) 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 "Shakan batholith" (fig. 2) or to similar smaller intrusives, a number of mineral deposits definitely known to be related to these intrusives were examined. These deposits included the molybdenum prospect at Shakan, Kosciusko Island (locality F, fig. 1), a zinc prospect near Point St. Albans, Kuiu Island (locality J, fig. 1), an old lead prospect on Egg Harbor, Coronation Island (locality I, fig. 1), and the Baker Island molybdenum prospect (locality 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 (locality K, fig. 1) was examined to determine if the northwest-trending veins at Salmon Bay continued on the north side of Sumner Strait (fig. 2). 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 (locality 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 (locality L, fig. 1) and Green Monster Mountain (locality M, fig. 1) to determine whether copper deposits at these localities showed any significant radioactivity. Field measurements and analyses of samples, however, indicated that the copper occurrences tested do not contain more than 0.001 percent equivalent uranium.

The radioactive studies in the outlying areas mentioned above indicate that the areal extent of the radioactive carbonate-hematite veins is probably limited to the Salmon Bay graywacke area 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; and no appreciable radioactivity has yet been found in carbonate veins that occur in limestone or carbonate-rich wall rocks in the northern part of Prince of Wales Island.

The restriction of the radioactive veins to the Salmon Bay graywacke 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 which they could be deposited. The graywacke itself probably played no part in localizing the veins other than serving as a fairly competent rock that maintained open fractures.

TAKU HARBOR-POINT ASTLEY DISTRICT

Brief reconnaissance examinations were carried out at Point Astley, a copper prospect (locality B, fig. 1) and the sites of reported pitchblende occurrences in the vicinity of Taku Harbor, Limestone Inlet, and Port Snettisham (locality A, fig. 1) were examined briefly in the course of travel from Juneau to the Salmon Bay area.

The country rocks in these fields 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.-N.30°W. and dip about 70°E.-NE. 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 7) taken across a 2-foot portion of this zone assayed 0.006 percent equivalent uranium. No radioactive minerals were identified.

Reconnaissance with portable Geiger counters in the vicinity of reported pitchblende occurrences at Taku Harbor, Limestone Inlet, and Port Snettisham, (locality 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 7) was 0.003 percent.

HYDER AREA

The Hyder area (locality N, fig. 1 and fig. 7) 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; and the famous Premier mine, located only a mile northeast of the boundary in British Columbia produced gold, silver, copper, lead, and zinc for many years. All of these deposits have mineral assemblages somewhat similar to those found in uranium lodes in other parts of the world.

The area investigated is underlain by greenstones, tuffaceous graywacke, volcanic breccia, slate, argillite, quartzite, and limestone belonging to the Bear River formation of the Jurassic(?) Hazelton group

Table 7.--Data on the radioactivity of samples from the Taku Harbor-Point Astley district, the islands adjacent to northern Prince of Wales Island, and the Hyder area.

Sample no.	Location	Type of sample	Equivalent uranium (percent)
	Taku Harbor - Point Astley area		
4552	East side of Taku Harbor (locality A. fig. 1) about 100 yds. south of cannery dock	Grab sample of massive sulfide float	< 0.001
4553	From mineralized zone, east side of Taku Harbor (locality A, fig. 1) about 150 yds. south of cannery dock	Grab sample of sulfide from mineralized zone	< .001
4554	From a narrow vein about 100 yds. south of sample 4553	Grab sample of sulfide vein material	.001
4555	North side of Limestone Inlet (locality 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 (locality B, fig. 1), from a short adit driven across a mineralized zone 10-15 feet wide.	Grab sample from a 2 ft. portion of a mineralized zone	.006
	Islands adjacent to northern Prince of Wales Island		
4559	Round Point, Zarembo Island (locality D, fig. 3)	Grab sample of granite	.004
4726	McGill zinc prospect, southeast side of Kuiu Island about $1\frac{1}{2}$ miles north of Pt. St. Albans (locality J, fig. 1)	Grab sample of sphalerite-bearing vein material	.001
4729	Shakan molybdenite prospect, Kosciusko Island (locality F, fig. 1)	Grab sample of molybdenite-bearing vein material	.004

Table 7.--Data on the radioactivity of samples from the Taku Harbor-Point Astley district, the islands adjacent to northern Prince of Wales Island, and the Hyder area--Continued

Sample no.	Location	Type of sample	Equivalent uranium (percent)
4734	Baker Island molybdenite prospect (locality H, fig. 1)	Grab sample of granite containing molybdenite-bearing quartz veinlets	0.001
4737	Northwest corner of Edua Bay, Kosciusko Island (south of locality F, fig. 1)	Grab sample of iron-stained, argillaceous limestone	.001
4739	From the middle of Totem Bay, Kupreanof Island (locality K, fig. 1)	Grab sample of "dacite" country rock	.003
4741	The Lake Bay copper prospect, Prince of Wales Island (locality L, fig. 1)	Grab sample of pyrite-chalcopyrite vein	.001
4742	Green Monster Mountain, Prince of Wales Island (locality M, fig. 1)	Grab sample of chalcopyrite-bearing contact metamorphic ore	<.001
	Hyder area (fig. 7)		
4743	Canyon Vein, Mountain View property, Hyder area	Grab sample of vein material	.004
4745	Station 59 & 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 (U.S.G.S. 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

Table 7.--Data on the radioactivity of samples from the Taku Harbor-Point Astley district, the islands adjacent to northern Prince of Wales Island, and the Hyder area--Continued

Sample no.	Location	Type of sample	Equivalent uranium (percent)
4748	Near footwall of Silver Falls Vein, about 100' - 150' above the upper Silver Falls tunnel, Mountain View property, Hyder area	Grab sample of vein material	0.005
4749	Surface out in the Ruby Silver Vein, Mountain View property, Hyder area (locality N, fig. 1)	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 elevation of about 5000 feet on "Hyder Lead Mountain", south side of the West Fork of Texas Creek, Hyder area (locality N, fig. 1)	Grab sample from vein outcrop	<.001
4754	Surface cut in the gray copper vein, Mountain View property, Hyder area	Grab sample from vein outcrop	<.001

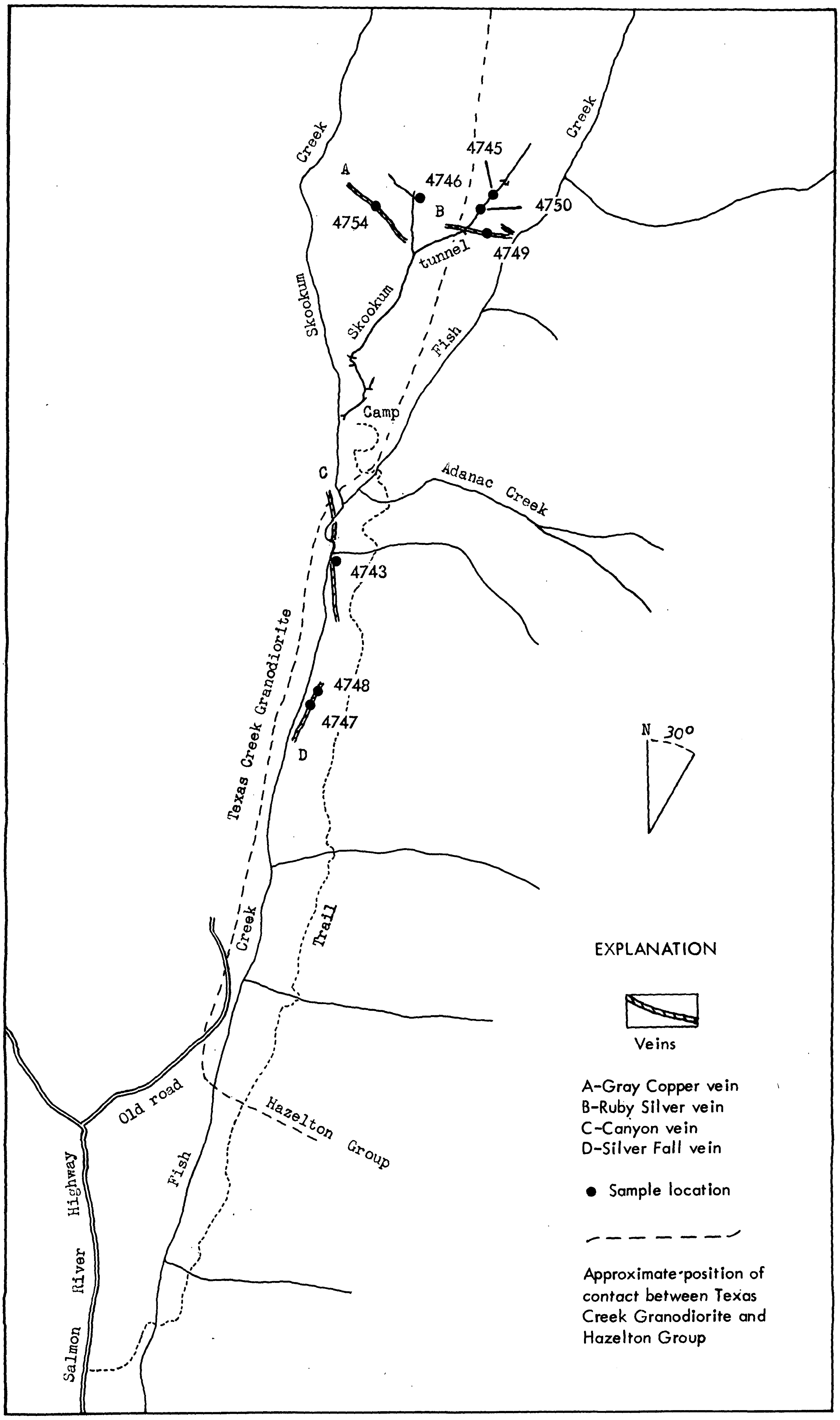


FIGURE 7.--SAMPLE LOCATION MAP OF THE MOUNTAIN VIEW PROPERTY, HYDER AREA, ALASKA.

1,000 0 1,000 2,000 3,000 feet

75282

(Buddington and Chapin, 1929). These rocks are intruded by the Texas Creek granodiorite of late Jurassic or Cretaceous age.

The ore deposits on the Mountain View property are located near the contact of the granodiorite and the Hazelton group. They consist of mesothermal fissure veins containing: 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, had detected radioactivity anomalies on the Mountain View property (West and Benson, 1954). 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, 1954) with special emphasis on the Mountain View property which is located about 5 miles north of the village of Hyder. No deposits of commercial interest were located although radioactive material was found 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 the definite presence of uranium; and 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. This sample was reported to have assayed 0.7 percent equivalent uranium oxide. Because of Fowler's report on the pitchblende occurrence, a brief reconnaissance of the Canyon vein and the underground workings on the Mountain View property was made in 1952.

No appreciably radioactive material could be detected in the Canyon vein. The maximum assay of the samples collected from this vein was only 0.004 percent equivalent uranium (sample 4743, table 7, fig. 7). One slightly radioactive spot 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 7, fig. 7) assayed 0.035 percent equivalent uranium. No uranium mineral could be identified. The radioactivity apparently emanates from molybdenite, pyrrhotite, and pyrite. Chemical tests by the U. S. Geological Survey's Washington laboratory have shown that traces of uranium are present in these sulfides 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 occurs 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). Three other deposits showing similar mineralization occur in southern British Columbia. In all four of these occurrences molybdenite is the sulfide most commonly associated with the uraninite (Stevenson, 1951, p. 362).

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 autunite, but the coating is not appreciably radioactive. The fluorescent mineral was identified optically as opal (silicon dioxide) by the Survey's Washington Laboratory. The fluorescence is probably due to a slight trace of some uranium present as an impurity in the opal.

The surface croppings of the Ruby Silver vein on the Mountain View property contain thin coatings of a yellow stain similar in color to some of the secondary uranium minerals. Samples of this material collected by Mr. Arthur O. Moa, manager of the Mountain View property, were studied by the Survey's laboratory in Washington. The coatings are not appreciably radioactive when tested with a Geiger counter. An X-ray diffraction pattern gave spacings similar to the line spacings 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.

Samples assaying as much as 0.035 percent equivalent uranium were found in the Hyder area in 1952.

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