COLUMBIUM-, RARE-EARTH-ELEMENT-, AND THORIUM-BEARING VEINS NEAR SALMON BAY, SOUTHEASTERN ALASKA

by J. Dean Warner
Alaska Field Operations Center

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UNITED STATES DEPARTMENT OF THE INTERIOR

Manuel Lujan, Secretary

BUREAU OF MINES

T S Ary, Director

TABLE OF CONTENTS

ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cps	count per second
ft	foot
ft^3/st	cubic foot per short ton
g	gram
gal	gallon
in	inch
kg	kilogram
lb	pound
lb/yd^3	pound per cubic yard
mi	mile
ml	milliliter
MMlb	million pounds
pct	percent
ppm	part per million
st	short ton
yd^3	cubic yard

COLUMBIUM-, RARE-EARTH-ELEMENT-, AND THORIUM-BEARING VEINS NEAR SALMON BAY, SOUTHEASTERN ALASKA

By J. Dean Warner[1]/

ABSTRACT

In 1984 and 1985, the Bureau of Mines investigated radioactive carbonate veins near Salmon Bay, southeastern Alaska, for concentrations of columbium and associated metals. The veins cut units of graywacke, conglomerate, argillite, and limestone and range in width from less than an inch to greater than 10 ft and have a length ranging from less than a hundred to greater than 1,000 ft. Mineralogy of the veins is complex, and includes thorite, the rare-earth-element minerals monazite, parisite, and bastnaesite, and a columbium mineral that is speculated to be columbite. Gangue minerals include ankerite, dolomite, siderite, quartz and albite. More than seventy veins were samples but only three contain elevated metal concentrations along a significant strike length. The three veins contain a combined indicated resource of 340,000 lb Cb, 2.2 MMlb REE, and 11,700 lb Th in 763,000 st of rock. The columbium resource is contained in one of the three veins that averages 840 ppm Cb over a width of 3.4 ft and a length of 1,200 ft. These resources are small compared to columbium, REE, and thorium resources elsewhere in the world.

1/Physical Scientist, Bureau of Mines, Alaska Field Operations Center, Fairbanks, Alaska (now with Nerco Minerals, Inc., Vancouver, Washington).

INTRODUCTION

As part of a project to evaluate occurrences and deposits of certain critical and strategic metals in Alaska, the Bureau of Mines investigated carbonate veins near Salmon Bay, southeastern Alaska, in 1984 and 1985. Although the veins had been previously studied in moderate detail by the U.S. Geological Survey, most of the work had concentrated on radioactive elements and very few analyses for columbium were performed. Bureau investigations, therefore, concentrated on sampling for concentrations of columbium and associated metals. Columbium is considered of critical and strategic importance to the United States because of its use in defense and petroleum-related technologies and because the country is entirely dependent on foreign sources of the commodity (1)[2/]. Although many of the veins were found to contain anomalously high concentrations of columbium, thorium and some rare-earth-elements (REE)[3/], only three contained values uniformly high enough to allow delineation of a small resource.

LOCATION AND LAND STATUS

Salmon Bay is located in the south-central portion of the Petersburg B-4 Quadrangle on northeastern Prince of Wales Island, southeastern Alaska (fig. 1). Radioactive carbonate veins are exposed along more than 6 mi of coastline centered about Salmon Bay and extending southerly from Pt. Colpoys to informally named Pitcher Island near VABM Tick in east-central section, T65S, R79E (fig. 2) This area is on State of Alaska selected land and is closed to mineral entry.

PREVIOUS WORK

In May, 1950, John Wadve of Ketchikan, Alaska, submitted a sample of radioactive hematite-stained carbonate vein material collected at Salmon Bay to the Alaska Territorial Department of Mines in Ketchikan for analyses (2). The sample contained .07 pct equivalent uranium (eU) and spurred interest in the area by the U.S. Geological Survey. A brief follow-up by Houston (2) in 1951, led to the identification of numerous radioactive veins cutting sedimentary rocks along several miles of coastline north and south of Salmon Bay. The veins were found to consist mainly of ankerite, dolomite, and alkali feldspar, with lesser quantities of siderite, hematite, specularite, magnetite, pyrite, quartz, chlorite, white and green (chromium?) muscovite, fluorite, topaz, and the REE fluorocarbonate mineral

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2/Underlined numbers in parenthesis refer to items in the list of references preceeding the appendix at the end of the report.

3/REE include lanthanide elements, atomic numbers 58 to 71, and yttrium, atomic number 39.

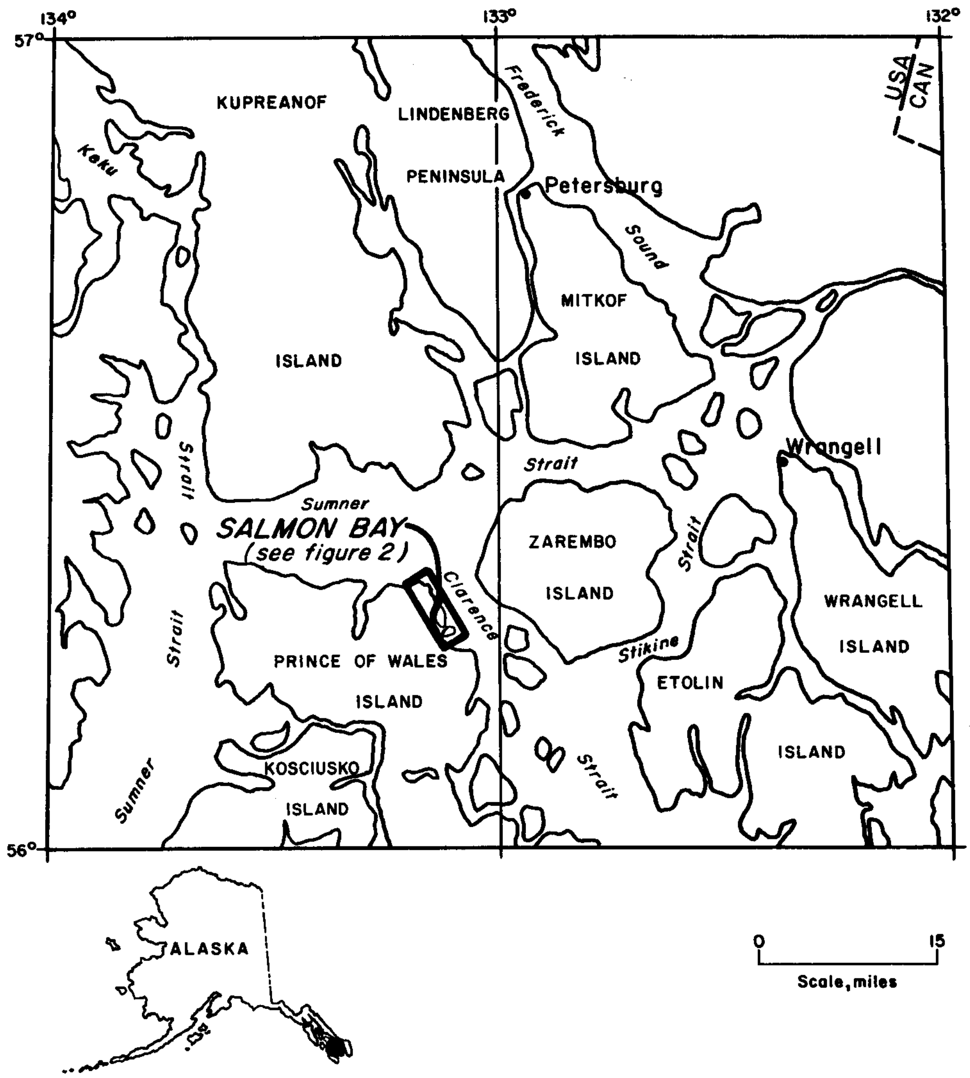

Figure 1.- Location of the Salmon Bay study area.

parisite. Chemical analyses of radioactive samples indicated that thorium is the most abundant radioactive element in the veins.

In 1952, Houston and others (3) investigated the carbonate veins at Salmon Bay in more detail. At that time, Houston found that the veins were generally short and irregular, with widths ranging from 1 to 2.5 ft, but that a few veins ranging from 5 to 10 ft wide could be traced more than 300 ft. Houston subdivided the veins into radioactive thorium-bearing and non-radioactive REE-bearing types and identified several previously unrecognized minerals including bastnaesite, thorite, epidote, chalcopyrite, and monazite. Houston also found an average of .16 pct equivalent thorium (eTh) in 7 channel samples collected along 100 ft of one of the more radioactive veins, referred to as the "Paystreak" vein, for which he calculated a reserve of 70 lb Th per foot of depth. Sampling by Houston also indicated an average of 0.79 pct REE over 7.4 ft in 4 channel-chip samples collected along 1,150 ft of a "high-grade rare-earth vein" 1 mi north of Salmon Bay (3, p.13).

More recently, the carbonate veins at Salmon Bay were briefly described by Eakins, in 1975 (4), and then by Karl, in 1980 (5). Eakins found low uranium values in radioactive samples and reiterated that much of the radioactivity must be due to thorium. Karl collected several samples of carbonate vein material and mafic to felsic dikes and found elevated to anomalously high concentrations of lead, zinc, barium, copper, lanthanum, molybdenum, columbium, strontium, and yttrium.

BUREAU INVESTIGATIONS

Carbonate veins near Salmon Bay were mapped and sampled over a 4-day period in July, 1984, and a 6-day period in July, 1985. Because of the thick forest cover the field investigation was limited to outcrop along more than 6 mi of shoreline extending from Pt. Colpoys, to the north, to Pitcher Island near VABM Tick, to the south (fig 2). A few traverses were also made inland along drainages, but the number of veins appeared to be less in these areas. In order to test the area's potential for beach and offshore placer deposits, four large gravel samples were also collected and concentrated. Post-field investigative methods included petrographic and scanning electron microscope (SEM) studies of selected specimens.

GEOLOGY OF THE VEINS

The carbonate veins near Salmon Bay range in width from a fraction of an inch to 11.0 ft, averaging approximately 1.5 ft over the entire area investigated. The veins generally strike northerly and have near-vertical to steep easterly dips. Although most of the veins are only traceable for a few hundred feet, a few are exposed for more than 1,000 ft of strike length. All but a few of the veins are anomalously radioactive with measurements ranging from slightly above the 60-80 cps local background to a high of near 3,000 cps[4].

4/Total-count gamma-ray radioactivity measured with a Mount Sorpis model SC-132 scintillometer. Use of trade name does not imply endorsement by the Bureau of Mines.

South of Salmon Bay, the near-vertical veins cut north-striking, west-dipping, well-indurated, red to green calcareous graywacke and less-abundant conglomerate. The veins in this area are generally more linear and more radioactive than those north of Salmon Bay and usually have wall rocks of red, hematite-altered graywacke.

North of Salmon Bay, the veins cut and sometimes are concordant to a sequence of folded argillite, limestone, and conglomerate. The conglomerate contains rounded limestone clasts although the angular nature of some of the clasts gives them an appearance of a sedimentary breccia. North of Salmon Bay, the veins still generally strike north, however, some have quite irregular attitudes. No veins were observed cutting limestone. A west-striking high-angle fault likely underlies and juxtaposes the different rock units and veins along Salmon Bay.

Numerous generally north-striking lamprophyre dikes cut the sedimentary rocks near Salmon Bay. The lamprophyre dikes show close association with some of the veins (see for example, figs 3 and 4). Lamprophyre dikes are especially common near Bay Point, north of Salmon Bay, where some dikes appear to have metasomatically altered carbonate clasts in the adjacent conglomerate unit. The alteration is characterized by a broad zone of slightly radioactive rock and by the development of secondary biotite. In the southerly portion of the area investigated, especially near Pitcher Island (fig.5), many of the mafic (lamprophyre?) dikes have been sheared and altered to a mixture of carbonate, quartz, and green (chromium?) mica. These dikes average 5.5 ft wide and are non-radioactive.

Unaltered basalt dikes are also common along the shoreline near Salmon Bay. No crosscutting relationships of the basalt dikes with the carbonate veins were observed.

MINERALOGY AND PETROGRAPHY OF THE VEINS

SEM and petrographic studies were conducted on samples from Salmon Bay in order to correlate vein texture and mineralogy with trace-element contents. The veins are quite variable in texture and mineralogy. Typically, they consist of buff-colored, coarsely crystalline ankeritic dolomite with patches of siderite and minor amounts of quartz, and altered albite. Sooty or specular hematite or limonite is found in orange weathering veinlets and disseminations within the veins. Other veins are distinctly more siliceous and are composed mostly of white- to deep-red-colored hematite-stained finely crystalline quartz.

Some of these veins contain coarse, brecciated carbonate fragments, euhedral to rounded apatite crystals, plagioclase laths, traces of disseminated and veinlet pyrite, fluorite, molybdenite, and disseminated microscopic-sized grains of chalcopyrite, thorite, and zircon. Where present, sulfide minerals are most commonly concentrated along vein selvages. A few of the veins also exhibit a distinct foliation at the microscopic scale due to the preferred orientation of recrystalized quartz.

Two REE-bearing (mainly Ce and La) minerals were identified by SEM study of one specimen[5/]. A positive identification is impossible

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5/SEM analysis by J. Sjoberg, Bureau of Mines, Reno Research Center, Reno, NV.

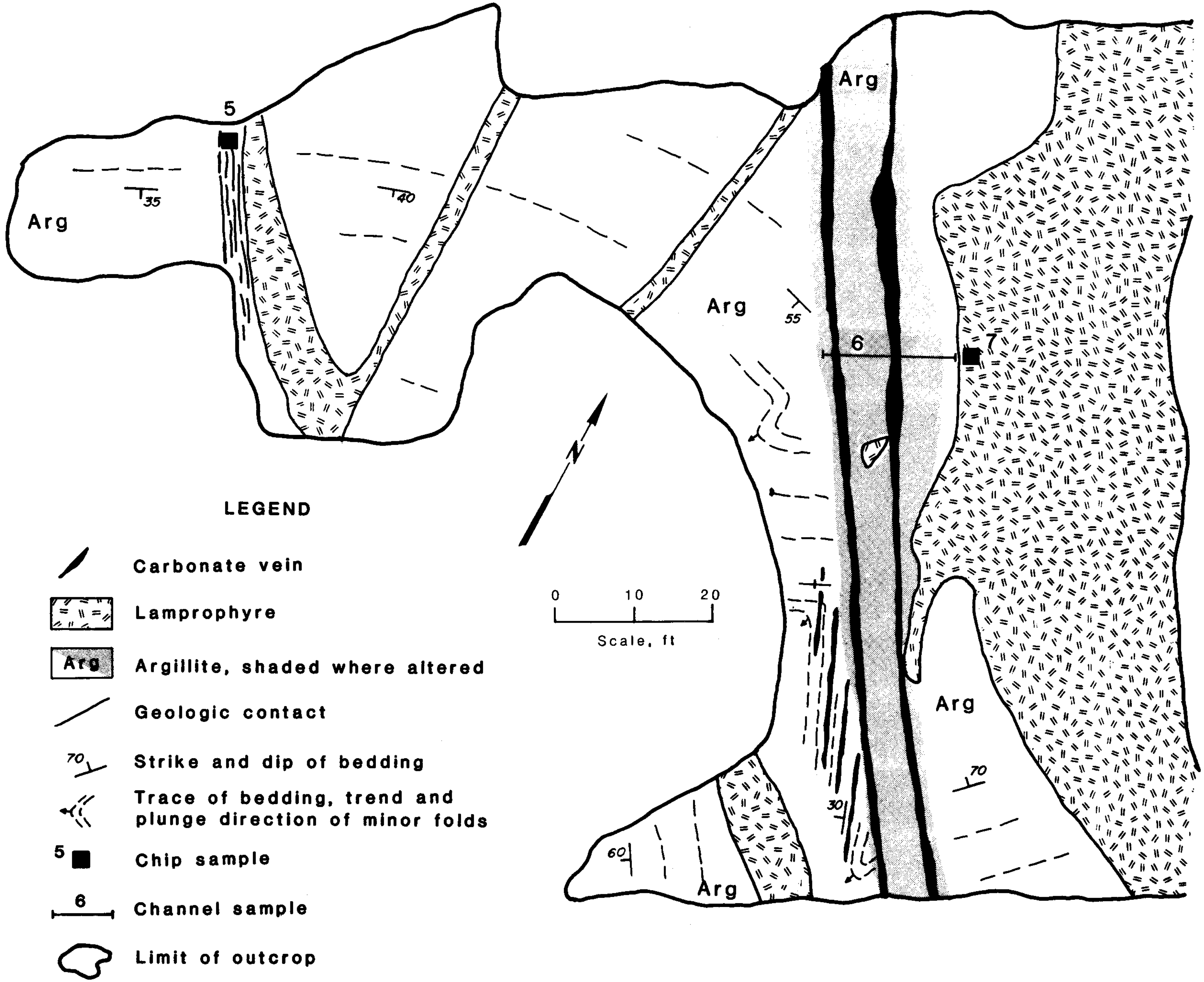

Figure 3.- Map of carbonate veins and lamprophyre dikes in area north of Salmon Bay

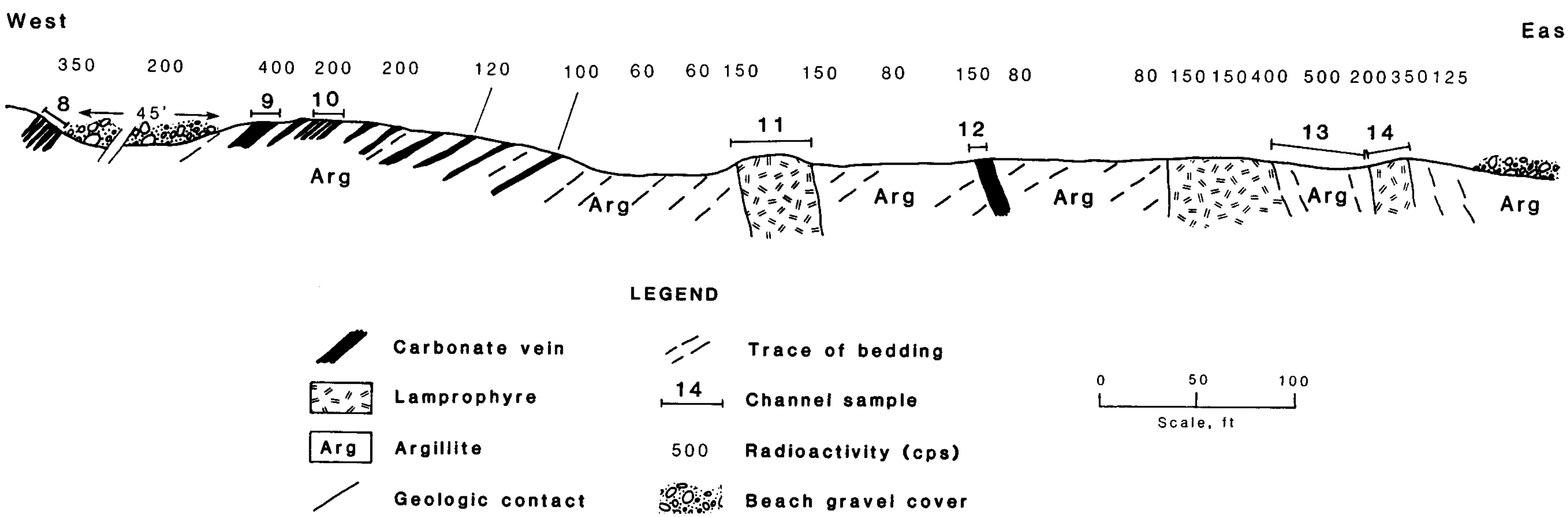

Figure 4. - Profile across beach outcrops in an area north of Salmon Bay

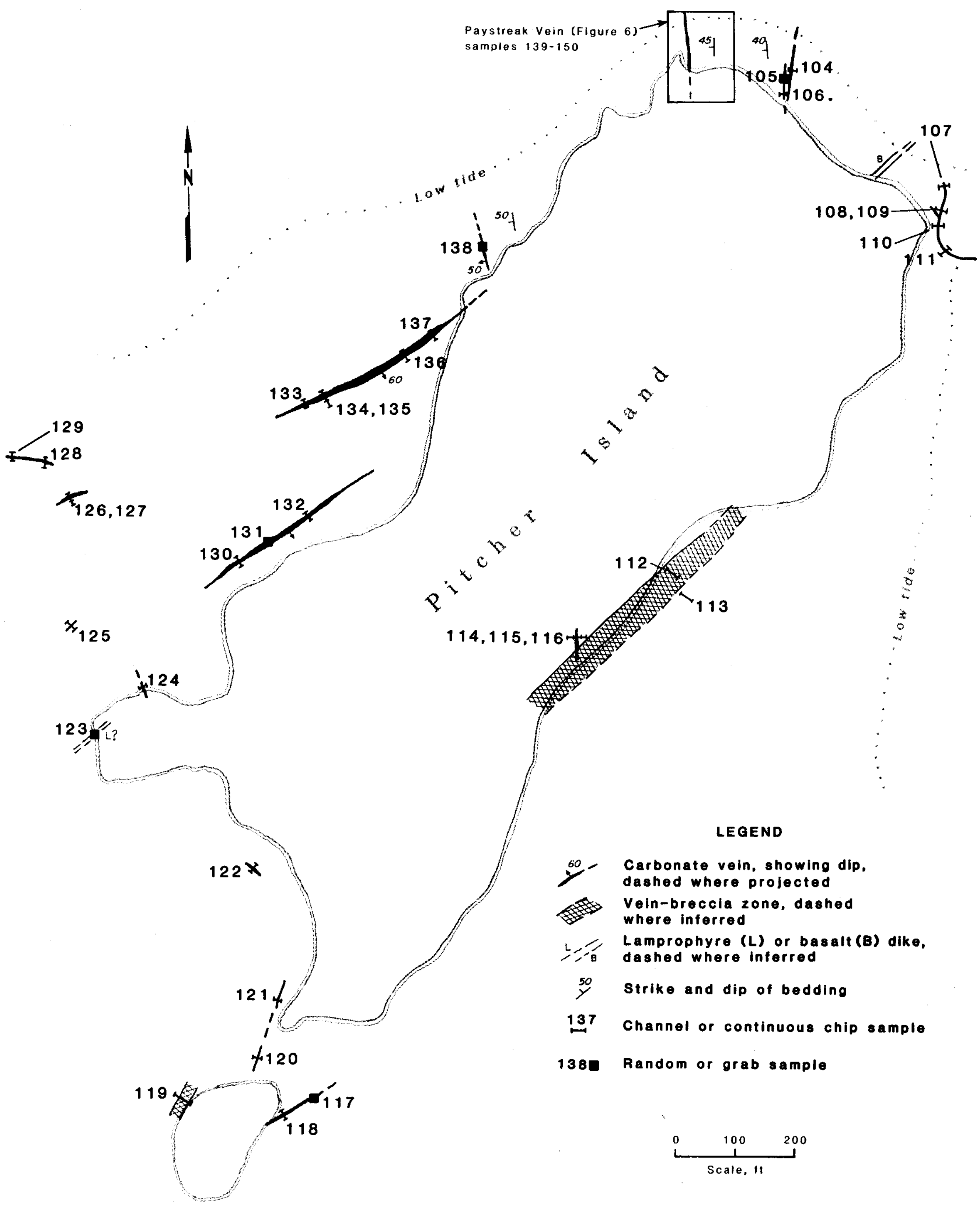

Figure 5. - Geologic and sample location map of Pitcher Island

because of the inability of the SEM used to detect carbon or oxygen, but the two minerals differ mainly in their calcium contents and are likely carbonates. This suggests that the two minerals are bastnaesite [(Ce, La) $(Co_3)F$] and parasite [(Ce, La)$_2Ca(Co_3)_3F_2$]. both of which were previously identified by Houston (2, 3). In the specimen studied, these two minerals are intergranular in nature forming matrix surrounding elongated magnetite prisms, rounded apatite grains, and disseminated thorite and chalcopyrite.

Although no columbium-bearing phase was identified during this investigation, the lack of correlation between concentrations of columbium and those of tantalum, titanium, thorium, uranium, or REE, with which columbium is often associated in nature, suggests that columbium is present in a simple oxide mineral such as columbite [(Fe, Mn)Cb_2O_6].

ROCK SAMPLING

Methods

One-hundred and forty-six rock samples were collected for analyses at Salmon Bay (fig.2, 3, 4, 5, 6, and appendix A and B). Most of these samples were collected during investigations in 1984 and 1985. Some samples, however, were also collected by Tom Pittman, Mining Engineer with the Bureau, during a brief reconnaissance in the area conducted in 1960. Generally, all of the samples consisted of channels or continuous chips across a vein or wall rock, as noted in Appendix A, however, a few also consisted of rock chips gathered at random across an outcrop of interest or were high-graded from a particular portion of a vein. Most of the samples weighed from 2 to 4 lb.

Samples were sent to a commercial laboratory for preparation and pulps were forwarded to the Bureau's Research Center in Reno, Nevada, for analyses. Columbium, and in some cases tantalum and tin were analyzed by x-ray fluorescence, thorium was analyzed by radiometric techniques, uranium was analyzed by fluorimetry, and REE plus a suite of 42 elements were analyzed by emmission spectrographic techniques. In some samples molybdenum and tungsten were also analyzed by atomic absorbtion and colorimetric techniques, respectively. Note that emission spectrographic analyses are subject to a wide range of error, particularly for REE. Random check analyses by x-ray fluorometric procedures indicate reported REE values are significantly low (appendix B).

The results of analyses presented in appendices A and B include only those elements present in elevated concentrations in some samples. Sample descriptions are also presented in the appendices. The veins were systematically investigated for levels of radioactivity with a gamma-ray scintillometer. Radioactivity levels over both the vein and wall rock were generally recorded so that a later comparison with analytical results could be made.

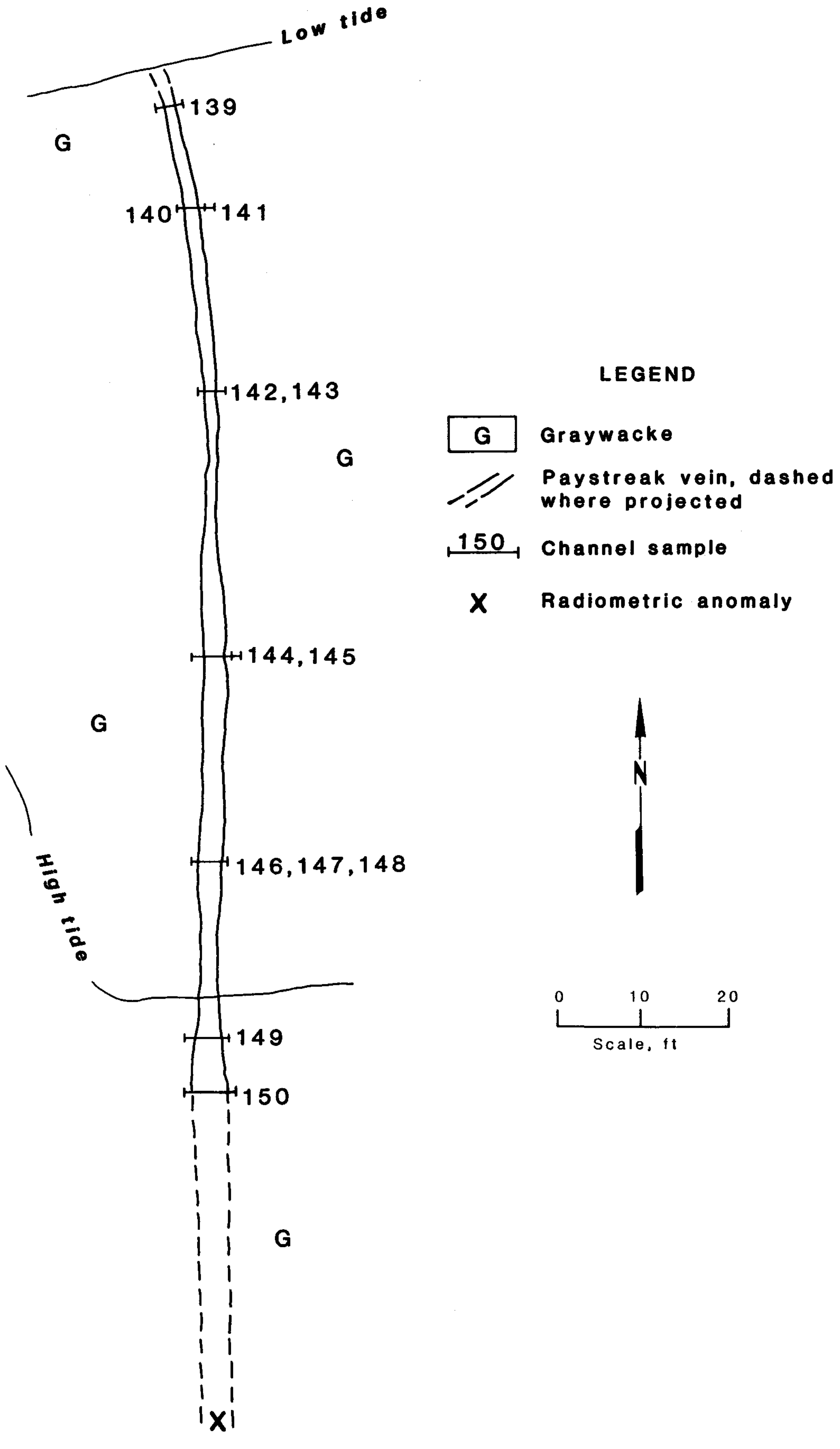

Figure 6. - Sketch map of Paystreak vein, Pitcher Island

Results

The carbonate veins near Salmon Bay contain sporadically high concentrations of columbium (to 2760 ppm), thorium (to 2105 ppm), uranium (to 33 ppm), barium (to 2.0 pct), molybdenum (to 160 ppm), lead (to 700 ppm), phosphorus (to 5.0 pct), strontium (to 0.3 pct), titanium (to 1.0 pct), zirconium (to 0.5 pct), and REE (to 3.0 pct). High values of one element, however, are generally not correlative to that of any other. In contrast to what is reported by Houston and others (3), the Bureau investigation found that almost all of the veins near Salmon Bay are radioactive and that no mutually exclusive relationship exists between thorium and REE contents. In agreement with Houston (3) and Eakins (4), however, this investigation indicates the level of radioactivity is proportional to the thorium content of the veins and must be due largely to thorium contained mainly in thorite and monazite.

Very few of the veins contain elevated metal values over their entire lengths. Exceptions include: 1) the vein near Bay Pt. (samples 19, 20, 21, 22, and 23) which contains a weighted average of 850 ppm Cb, but only .01 pct REE over a width of 3.4 ft and a length of 1,200 ft, 2) the vein approximately 1 mi north of Salmon Bay (sample 46, 47, 49 and 52) which contains a weighted average of 0.2 pct REE, but only 67 ppm Cb over a width of 8.0 ft and a length of 1,300 ft, and 3) the "Paystreak vein" on Pitcher Island (figs. 5 and 6), which contains a weighted average of 1,670 ppm Th and 0.13 pct REE, but only 100 ppm Cb over a width of 2.6 ft and a length of 180 ft.

GRAVEL SAMPLING

Methods

Four gravel samples (29, 74, 75, and 76) ranging in volume from approximately 0.05 to 0.06 yd^3 were collected from the mouth of Salmon Bay and from the small cove just south of Bay Point (fig. 2) in order to investigate the area's potential for columbium-bearing beach and offshore placer deposits. Samples were collected from 1- to 2-ft-deep pits dug near the high-tide line, or in the case of sample 74, from the bottom of Salmon Bay, approximately 70 ft below the low-tide elevation. The samples were then screened in the field to minus-10 or, in some cases, minus-16 mesh and pre-concentrated by panning to a volume of approximately 0.001 yd^3. In the laboratory, samples were further reduced by panning to a standard volume of approximately 10 ml, microscopically examined for mineralogy, dried, and weighed. Concentrates were sent to a commercial laboratory for preparation and then forwarded to the Bureau's Reno (NV) Research Center for analyses by methods similar to those employed on rock samples.

Results

Analytical results and descriptions are presented in the appendix with rock sample analyses. The concentrates contain slightly to moderately anomalously high concentrations of columbium, thorium, uranium, titanium, and barium, and in some cases, lead, zinc, phosphorus, and zircomium. Columbium and thorium grades in the samples, however, are low and do not exceed 0.0005 lb/yd^3. Unlike the case for rock samples, higher columbium concentrations in the gravel samples correlate positively with higher titanium concentrations. Also, higher thorium concentrations occur in those concentrate samples containing higher zirconium values suggesting that thorium is contained in the zirconium-bearing mineral zircon as well as in thorite and monazite.

RESOURCES

Resource classifications were made according to guidelines set forth in the joint U.S. Bureau of Mines - U.S. Geological Survey publication, "Principles of a Resource/Reserve Classification for Minerals" (7). "Indicated resources" are calculated here for those veins containing metal tenor uniform enough to allow reasonable certainty of continunity between sample stations.

A small indicated resource can be calculated for three veins that were found to contain elevated metal concentrations over their entire sampled lengths. Assuming mineralization continues at depth for one-half the strike length with a grade equivalent to the weighted average and at an estimated tonnage factor of 12 ft^3/st: 1) the vein near Bay Pt. contains indicated resources of approximately 340,000 lb Cb within 200,000 st of rock, 2) the vein south of Bay Pt. contains indicated resources of approximately 2.2 MMlb REE within 560,000 st of rock, and 3) the "Paystreak vein" near VABM Tick, contains indicated resources of approximately 11,700 lb Th and 9,100 lb REE within 3,500 st of rock. Estimates of REE resources may be low (c.f. appendix). Although the width of the veins, the competency of the wall rocks, and the vein's location on tidewater suggest they would be amenable to mining, these resources are relatively small and low-grade compared to resources of columbium, REE, or thorium located elsewhere in the United States and the world.

No significant placer resources were delineated by gravel samples collected near Salmon Bay.

DISCUSSION

The carbonate veins at Salmon Bay can be compared to radioactive thorium-bearing carbonate dikes and veins located at Powderhorn, Colorado (7,8) and in the Lemitar Mountains of central New Mexico (9). Veins in all three areas are tabular, with widths ranging from less than an inch to greater than 10 ft and lengths ranging from a few hundred to over 1,000 ft. and are characterized by enrichment in barium, columbium, phosphorus, REE, strontium, titanium, and thorium. Veins in all of the areas are also enriched in light REE minerals (including bastnaesite, cerite, synchysite, or parisite), sulfide minerals (including pyrite, sphalerite, chalcopyrite, molybdenite, and galena), and radioactive minerals (including thorite, monazite, and possibly radiogenic zircon). Gangue minerals for all of the areas include variable amounts of the carbonate minerals ankerite, dolomite, calcite, and siderite, in addition to alkali feldspar, chlorite, apatite, quartz, magnetite, hematite, limonite, barite, and other minerals. Columbite has also been identified in veins at Powderhorn and is speculated to be present at Salmon Bay, based on the lack of correlation between values of columbium and those of other elements that are associated with columbium in more complex minerals.

Unlike Salmon Bay, the veins at Powderhorn show a spatial association to a complex of alkalic rocks and carbonatite (7, 8). No alkalic rocks were identified at Salmon Bay, although a phonolite (extrusive equivalent of nepheline syenite) dike was reported by Houston (2) and lamprophyre dikes, which are abundant near Salmon Bay, are often associated with alkalic complexes. By analogy, a mass of alkalic rocks, not yet identified, may exist in the Salmon Bay area. As at Powderhorn, these alkalic rocks offer an additional exploration target for possible commercial concentrations of thorium, REE, columbium, or other metals. It should be noted, however, that no alkalic complex is directly associated with carbonate veins and dikes in the Lemitar Mountains of New Nexico (9).

Houston (3) suggests the carbonate veins at Salmon Bay may actually be carbonatites, which are carbonate rocks of magmatic origin. The close spatial and probable temporal link of the veins to the lamprophyre dikes and the carbonate-rich nature of the sedimentary rocks cut by the veins, however, alternatively suggest that a plausible origin for the veins would be mobilization of carbonate minerals and trace-elements from the sedimentary rocks or lamprophyre dikes during intrusion of the lamprophyre dikes.

SUMMARY

Radioactive carbonate veins near Salmon Bay cut a sequence of graywacke, shale, limestone and conglomerate along more than 6 mi of coastline on northeastern Prince of Wales Island, southeastern Alaska. The veins range from a fraction of an inch to greater than 10 ft wide and less than a hundred to greater than 1,000 ft long and are composed dominantly of ankeritic dolomite, siderite, and quartz, with lesser amounts of albite, hematite, limonite, apatite, pyrite, fluorite, chalcopyrite, magnetite, molybdenite, chlorite, white and green (chromium?) mica, topaz, parisite, bastnaesite, monazite, epidote and thorite. The veins are also characterized by locally anomalously high concentrations of thorium, columbium, strontium, titanium, REE, and barium. Radioactivity, which ranges from slightly above background to a few thousand cps, is due almost entirely to thorium in thorite and monazite, and to a lesser extent to thorium in zircon. A columbium mineral was not identified but the lack of a correlation between titanium, REE or radioactive-element concentrations and those of columbium in rock samples suggests the presence of trace amounts of a simple oxide mineral such as columbite [(Fe, Mn)Cb_2O_6].

Rock sampling indicates that only three veins contain columbium, REE, or thorium mineralizaton over significant strike lengths. A vein at Bay Pt., 1 mi north of Salmon Bay, contains a weighted average of 850 ppm Cb over a width of 3.4 ft and length of 1,200 ft. A vein just south of Bay Pt. contains a weighted average of 0.2 pct REE over a width of 8.0 ft and a length of 1,300 ft. The "Paystreak vein" on Pitcher Island, south of Salmon Bay near VABM Tick, contains a weighted average of 1670 ppm Th and 0.13 pct REE over a width of 2.6 ft and a length of 180 ft. These three veins contain combined indicated resources of approximately 340,000 lb Cb, 2.2 MMlb REE, minimal estimate, and 11,700 lb Th within approximately 763,000 st of rock. These resources are relatively small and low-grade compared to columbium, REE, and thorium resources located elsewhere in the United States and the world.

Gravel samples collected from beach and offshore indicate that some of the sediments near Salmon Bay are slightly enriched in columbium, uranium, and thorium, but grades of the gravel samples are too low to be considered resources.

The veins near Salmon Bay show similarities in morphology, mineralogy, and trace-element composition to thorium-bearing veins in the Powderhorn District, Colorado and in the Lemitar Mountains of central New Mexico. By analogy, a mass of alkalic rocks may be present at Salmon Bay. These rocks offer an additional exploration target for potentially economic concentrations of thorium, columbium, REE, and other metals.

Although it has been suggested that the carbonate veins near Salmon Bay are actually carbonatites, their close spatial and temporal link to lamprophyre dikes and the carbonate-rich nature of the sedimentary units that they cut alternatively suggest the veins originated from the mobilization of carbonate minerals and trace-elements during intrusion of the lamprophyre dikes.

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APPENDIX A

LIST OF EXPLANATIONS

B	Background
C	Continuous chip sample
Ch	Channel sample
CR	Random chip sample
D	Detected
H	High grade sample
L	Less than detection
N	Not applicable
ND	Not determined

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Th	U	Pct Ba	Mo	P	Pb	Sr	Ti	Zn	Zr	Rare-Earth Elements, Pct Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE[2]
1.....	H.....	N	2400	< 50	1025	1.1	.1	L	3.0	L	.2	.2	.02	.005	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
2.....	H.....	N	200-450	160	235	<.5	.04	L	L	L	.1	.4	.01	L	L	L	L	L	L	L	L	L	L	L	L	D	D	L	L
3.....	Ch....	3.7	ND	50	< 30	<.5	.2	.01	L	L	.09	.09	.03	L	L	L	L	L	L	L	.004	L	L	L	L	.01	L	L	.004
4.....	H.....	N	ND	90	195	.63	1.0	L	4.0	.01	.1	.6	.03	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
5.....	CR....	.0	150-200	60	90	.74	.2	L	L	L	.01	.2	.004	.01	L	L	L	D	L	L	.09	L	L	L	L	.001	D	L	.094
6.....	Ch....	14.5	400-1500	< 50	185	1.6	.2	L	L	L	.02	L	.02	L	L	L	L	D	L	L	.02	L	L	L	L	.004	D	L	.024
7.....	CR....	20.0	250-500	170	85	1.5	.7	L	L	L	.05	.9	.008	L	L	L	L	D	L	L	.04	L	L	L	L	.004	D	L	.044
8.....	Ch....	2.2	200-350	220	< 30	4.6	.8	L	L	L	.07	.8	.02	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
9.....	C.....	5.0	to 500	420	70	11.0	.8	L	L	L	.002	.1	.004	L	D	L	L	D	L	L	.02	L	L	L	L	.002	D	L	.022
10....	Ch....	.6	ND	< 50	< 30	.51	.2	L	L	L	.02	.3	.009	L	L	L	L	L	L	L	.04	L	L	L	L	.01	D	L	.05
11....	Ch....	1.3	to 500	< 50	80	< .5	.2	L	L	L	.03	.3	.03	L	L	L	L	L	L	L	L	L	L	L	L	.01	D	L	.01
12....	C.....	1.3	ND	160	45	.51	1.0	L	2.0	L	.1	.1	.01	L	L	L	L	L	L	L	.09	L	L	L	L	.004	D	L	.094
13....	CR....	N	ND	< 50	130	.69	1.0	L	3.0	L	.1	.2	.02	L	L	L	L	L	L	L	.09	L	L	L	L	.004	D	L	.094
14....	Ch....	1.2	ND	< 50	110	< .5	2.0	L	4.0	L	.1	.2	.03	L	L	L	L	L	L	L	.04	L	L	L	L	.01	D	L	.05
15....	CR....	6.0	350-650	< 50	125	.58	.6	L	L	.008	.02	.2	.009	.009	D	L	L	L	L	L	.02	L	L	L	L	D	D	L	.02
16....	CR....	1.5	353-500	< 50	260	.81	.07	L	L	L	.008	.4	.01	L	L	L	L	L	L	L	L	L	L	L	L	.01	D	L	.01
17....	CR....	8.0	170-200	80	< 30	2.8	.5	L	L	L	.05	.8	.01	L	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
18....	C.....	1.2	200-500	2760	45	33	.09	.016	L	L	.01	.4	L	L	L	L	L	L	L	L	.009	L	L	L	L	.002	D	L	.011
19....	C.....	4.5	250-350	600	40	5.5	.2	L	L	L	.003	.1	L	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
20....	C.....	5.4	250-550	1480	80	24	.8	L	L	L	.01	.3	.02	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	.042

DESCRIPTION

1.....	0.5- to 0.8-ft-wide veins of coarse dolomite and ankerite, some hematite staining and local green mica, specular hematite, and pyrite.
2.....	On strike of sample 1, several dolomite-ankerite-hematite-pyrite .2- to .3-ft-wide veins over 8-ft-wide zone.
3.....	Radioactive carbonate-hematite veins, pinches out to south.
4.....	10-ft-wide zone of thin dolomite-specularite veins. Several lamprophyre dikes also exposed in area.
5.....	Several .1- to 8-ft-wide siderite (?)-rich veins comprise 1/3 to 1/2 of this zone.
6.....	Several carbonate-silica-pyrite veins within a zone of breccia (?) and silicified argillite. Up to 30 pct pyrite locally.
7.....	Lamprophyre dike, carbonate-altered in part with green (Cr?) micas. Cut by numerous quartz veinlets and carbonate-hematite veins. Forms hanging wall to carbonate veins in this area.
8.....	Irregular lamprophyre dike with numerous carbonate veinlets.
9.....	Radioactive argillite, local hematite and limonite staining.
10....	Zone of hematite-carbonate veins, veins comprise 20-30 pct of width.
11....	Zone of parallel carbonate-hematite veins. Locally silica rich and hematite may be after pyrite. High radioactivity occurs on strike in both directions.
12....	Zone of small veinlets. Recessive weathering of veinlets makes sampling difficult.
13....	Carbonate-hematite vein float. Cobbles in .3- to 5-ft-wide range.
14....	Zone of veins. Veins comprise approximately 50 pct of interval.
15....	Carbonate breccia zone with biotite, quartz veins, disseminated and locally massive pyrite, and local magnetite.
16....	Siliceous veins with trace pyrite.
17....	Lamprophyre dike, trace carbonate and pyrite and finely disseminated biotite.
18....	Quartz-carbonate vein, exposed for 100 ft above high tide.
19....	Siliceous veins cut and bordered by limonitic carbonate veins. Up to 0.5 pct pyrite occurs as disseminations.
20....	Siliceous veins with disseminated pyrite. More calcareous and radioactive towards footwall.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES1/--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Ppm Th	Ppm U	Pct Ba	Pct Mo	Pct P	Pct Pb	Pct Sr	Pct Ti	Pct Zn	Pct Zr	Rare-Earth Elements, Pct: Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE2/
21....	Ch....	3.2	350	550	60	14	.04	.032	L	L	.02	L	.002	L	L	L	L	L	L	L	L	L	L	L	L	D	D	L	L
22....	CR....	8.0	100-120	100	< 30	1.2	.08	L	L	L	.01	.2	.01	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
23....	CR....	4.0	1500-200	510	< 30	4.8	.1	.056	L	L	.04	.4	.004	L	L	L	L	L	L	L	D	L	L	L	L	.002	D	L	.002
24....	CR....	N	200-250	570	50	8.7	.5	L	L	.01	.02	.2	.06	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
25....	CR....	N	200-450	< 50	< 30	3.7	1.0	L	L	L	.002	.4	.05	.01	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
26....	CR....	N	B	280	< 30	2.8	.3	.015	2.0	L	.03	.7	.06	L	L	L	L	L	L	L	.02	L	L	L	L	L	D	L	.02
27....	CR....	18.0	B	< 50	< 30	.59	.1	L	3.0	L	.02	1.0	.02	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
28....	CR....	14.0	B	1360	35	17.0	.3	.043	L	L	.003	L	.006	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
29....	Gravel	N	N	430	250	14	.2	L	L	L	.02	3.0	.02	L	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
30....	CR....	N	250	< 50	35	.95	.1	L	L	L	.02	.5	.01	L	L	L	L	L	L	L	D	L	L	L	L	.002	D	L	.002
31....	CR....	N	B	50	< 30	1.9	.1	L	L	L	.02	.4	.01	L	L	L	L	L	L	L	D	L	L	L	L	.002	D	L	.002
32....	CR....	N	B	< 50	< 30	.71	.04	L	L	L	.008	.3	L	L	L	L	L	L	L	L	.009	L	L	L	L	.002	D	L	.011
33....	CR....	N	850	< 50	85	.83	.04	L	L	L	.02	.2	.01	L	L	L	L	L	L	L	.04	L	L	L	L	.002	D	L	.042
34....	CR....	N	B	< 50	< 30	1.2	.01	L	L	L	.007	.1	.008	L	L	L	L	L	L	L	.02	L	L	L	L	.002	D	L	.022
35....	CR....	N	180-230	< 50	< 30	.85	.004	L	L	L	.002	L	L	L	L	L	L	L	L	L	.02	L	L	L	L	.002	D	L	.022
36....	CR....	N	200	< 50	35	1.5	.2	L	L	L	.01	.5	.02	L	L	L	L	L	L	L	.009	L	L	L	L	.004	D	L	.013
37....	C.....	3.0	180-250	750	30	8.1	.5	L	L	L	.009	.3	.003	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
38....	CR....	2.0	ND	630	< 30	4.6	.7	L	L	L	.006	.1	.009	L	L	L	L	L	L	L	.009	L	L	L	L	L	D	L	.009
39....	CR....	N	190-230	50	< 30	1.4	.04	L	L	L	.05	.1	.02	L	L	L	L	L	L	L	D	L	L	L	L	.002	D	L	.002
40....	C.....	2.7	600	960	45	8.8	.5	L	L	L	.01	.2	.04	L	L	L	L	L	L	L	.009	L	L	L	L	L	D	L	.009

DESCRIPTION

Sample	Description
21....	Quartz-carbonate-pyrite veins.
22....	Irregular swarms of carbonate-biotite dike lenses along contact of siliceous vein zone sampled in sample 23.
23....	Quartz-carbonate vein zone, veins from 4- to 8-ft-wide.
24....	Chips collected from 18-ft-long by 5-ft-wide area of rose-colored calcareous cherty material forming an irregular vein zone. Trace pyrite. Zone interfingers with lamprophyre on all sides and is representative of most of the rock in this area.
25....	Chips collected from a 10-ft-long by 6-ft-wide area probably representing a 2- to 3-ft-wide, shallow-dipping vein breccia zone. Complexly faulted and intermixed lamprophyre, argillite and conglomerate. Pyritic breccia as well as local calcareous vein zones and breccias also are present.
26....	Chips over 10-ft-wide by 20-ft-long area. Intermixed lamprophyre and calcareous conglomerate (?). Rock consists of coarse biotite cut by calcite veinlets with biotite selvages. Nonradioactive.
27....	Foliated, dark-green weathering dike. Consists of fine biotite in a green, calcareous matrix. This is the hanging wall portion of the dike.
28....	Buff-weathering dike, non-calcareous and non-foliated. Contains garnet on fractures. Footwall to sample 27.
29....	.04 yd^3 of gravelly silt overlying green sandy silt. Reduced to 20.66 g of minus 16 mesh concentrate.
30....	Fine-grained carbonate-rich dike.
31....	Breccia (?) or conglomerate (?) with fragments of lamprophyre, quartz, and hornfels in a quartz-carbonate matrix.
32....	Massive, red-weathering carbonate with few angular clasts.
33....	Coarse calcite matrix with argillite clasts and trace disseminated pyrite. Only radioactive spot noted in carbonate.
34....	Sample collected along approximately 300 ft length of carbonate with argillite clasts. .1- to 2 pct disseminated and veinlet pyrite.
35....	Nonradioactive carbonate with argillite clasts.
36....	Quartz-carbonate-pyrite-altered lamprophyre dike and argillite.
37....	Quartz-carbonate veins with trace pyrite.
38....	Chip from several outcrops along 150 ft of strike length. Quartz-carbonate with disseminated pyrite. Vein parallels lamprophyre dike(s) in places.
39....	Breccia (?) with fragments of lamprophyre, quartz, and hornfels in a quartz-carbonate matrix. Disseminated hematite and black metallic mineral (rutile?), minor disseminated biotite.
40....	Siliceous carbonate veins with disseminated pyrite.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]/--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Ppm Th	Ppm U	Pct Ba	Pct Mo	Pct P	Pct Pb	Pct Sr	Pct Ti	Pct Zn	Pct Zr	Rare-Earth Elements, Pct Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE2/
41....	C.....	0.3	220	190	215	2.2	.5	L	L	L	.07	.2	.02	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
42....	Ch....	2.5	ND	1170	35	14.0	.07	L	L	L	.02	L	.03	L	L	L	L	D	L	L	L	L	L	L	L	L	D	L	L
43....	C.....	2.0	250-350	940	35	6.8	.09	L	L	L	.02	L	.009	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
44....	Ch....	2.5	B	800	< 30	8.2	.2	L	L	.04	.02	.09	.04	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
45....	C.....	1.3	125-210	580	45	9.2	.1	L	L	L	.01	L	.02	L	.1	L	L	.05	L	L	.02	L	L	L	L	D	L	L	.17
46....	C.....	4.0	125-210	< 50	< 30	.88	.02	L	L	L	.03	L	.003	L	.2	L	L	L	L	L	.09	L	L	L	L	.002	D	L	.292
47....	C.....	9.0	125-450	< 50	35	< .5	.006	L	L	L	.07	L	.02	L	.2	L	L	D	L	L	.09	L	D	D	L	.004	D	L	.294
48....	H.....	N	450	89	170	.72	.01	L	L	L	.04	L	.07	L	.1	L	L	D	L	L	.2	L	D	.1	L	.01	D	L	.41
49....	C.....	8.0	200-750	140	35	1.5	.007	L	L	L	.08	L	.02	L	L	L	L	L	L	L	.04	L	L	L	L	.002	L	L	.042
50....	CR....	N	ND	150	< 30	1.9	.06	L	L	L	.04	.2	.03	L	L	L	L	L	L	L	.009	L	L	L	L	L		L	.009
51....	C.....	9.0	B	260	< 30	3.8	.2	L	L	L	.02	.1	.02	L	L	L	L	L	L	L	.02	L	L	L	L	.002	L	L	.022
52....	C.....	11.0	200-750	93	30	.61	.01	L	L	L	.1	L	.02	L	.1	L	L	D	L	L	.09	L	D	D	L	.004	D	L	.194
53....	C.....	4.0	450	66	45	7.3	.2	L	L	L	.01	.1	.02	L	.1	L	L	L	L	L	.04	L	L	L	L	D	L	L	.14
54....	C.....	2.0	450	140	50	.77	.01	L	L	L	.1	.1	.02	L	.9	L	L	D	L	L	.2	L	.1	L	L	.01	.002	L	1.212
55....	C.....	.3	250	53	65	< .5	.02	L	L	L	.1	.1	.02	L	L	L	L	L	L	L	.02	L	L	L	L	.002	L	L	.022
56....	C.....	.1	600	550	195	1.8	1.0	L	L	L	.02	.4	.05	L	L	L	L	L	L	L	.02	L	L	L	L	.01	D	L	.03
57....	Ch....	3.5	550-1100	< 50	185	4.8	.009	L	L	L	.03	L	.05	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
58....	Ch....	3.5	550-800	< 50	150	8.8	.009	L	L	L	.02	L	.09	L	L	L	L	L	L	L	.04	L	L	L	L	.002	D	L	.042
59....	C.....	N	ND	63	400	.64	.02	L	L	L	.1	.1	.2	L	.2	L	L	L	L	L	.04	L	L	L	L	.002	D	L	.242
60....	Ch....	1.5	350-600	< 50	50	1.5	.07	L	L	L	.03	.3	.01	L	L	L	L	D	L	L	.02	L	L	L	L	D	D	L	.02

DESCRIPTION

Sample	Description
41....	Carbonate vein.
42....	Quartz vein with minor disseminated pyrite. Clots of green mica locally present. Vein cuts lamprophyre.
43....	Siliceous carbonate vein, local hematite staining, cuts lamprophyre dike.
44....	Siliceous carbonate vein on strike 15 ft to west of sample 43.
45....	Quartz-calcite-hematite-pyrite vein.
46....	Carbonate vein with pyrite and trace specularite.
47....	Coarse calcite and feldspar (?) in a siliceous matrix, locally pyrite-rich vein. Trace fluorite.
48....	Most radioactive zone from sample 47. Approximately 30 pct pyrite in sample.
49....	Coarse calcite and feldspar phenocysts (?) in a fine chalcedonic matrix. Locally pyrite-rich.
50....	5-in-wide lamprophyre (?) dike from hanging wall of sample 49.
51....	Silicified, bleached, and locally hematite-stained argillite from hanging wall of sample 49 and 50.
52....	Similar to vein sampled in sample 47, 200 ft on strike to south.
53....	Calcite with magnetite and pyrite, vein.
54....	Do.
55....	Flat-lying carbonate-feldspar-specularite-pyrite vein.
56....	Thin chlorite-sericite-specularite-carbonate vein.
57....	Carbonate-hematite vein with trace pyrite and fluorite.
58....	Collected adjacent to sample 57 on some veins.
59....	Radioactive carbonate boulders with abundant fluorite, some quartz.
60....	Carbonate vein with a green mica, pyrite, and specularite selvage and a core of dense, black, siliceous, fine-grained material.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES1/--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Th	U	Pct Ba	Mo	P	Pb	Sr	Ti	Zn	Zr	Rare-Earth Elements, Pct Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE2/
61....	C.....	4.0	150-170	64	< 30	2.7	.1	L	L	L	.03	.1	.004	L	L	L	L	L	L	L	.009	L	L	L	L	.004	D	L	.013
62....	C.....	1.0	300	< 50	< 30	1.1	.003	L	L	.1	.02	L	.1	L	L	L	L	D	L	L	L	L	L	L	L	.002	L	L	.002
63....	C.....	2.5	175-300	86	< 30	1.3	.07	L	L	L	.03	.1	.04	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
64....	C.....	1.5	125-400	300	495	4.6	.1	L	L	L	.2	.1	.03	L	L	L	L	L	L	L	L	L	L	L	L	.01	D	L	.01
65....	C.....	N	ND						L						L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
66....	CR....	N	175-350	< 50	< 30	2.0	.2	L	L	L	.08	.2	.007	L	L	L	L	L	L	L	.009	L	L	L	L	.002	D	L	.011
67....	C.....	.3	220	< 50	< 30	< .5	.01	L	L	L	.006	L	.1	L	L	L	L	L	L	L	.009	L	L	L	L	.002		L	.011
68....	C.....	1.6	475-700	78	225	2.6	.02	L	L	L	.03	.08	.007	L	L	L	L	D	L	L	.004	L	L	L	L	.01	D	L	.014
69....	Ch....	1.7	600-850	67	300	44	.07	L	L	L	.01	.3	.02	L	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
70....	C.....	4.0	800-1100	960	300	16	.05	L	L	L	.01	.3	.004	L	L	L	L	L	.02	L	.004	L	D	L	L	.01	D	L	.035
71....	Ch....	1.9	900-1750	250	195	1.5	.02	L	L	L	.02	.1	.09	L	L	L	L	L	L	L	.009	L	L	L	L	D	L	L	.009
72....	Ch....	3.1	900-1400	290	165	1.3	.05	L	L	L	.01	.2	.2	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
73....	Ch....	.5	1500	92	1045	2.4	.04	L	L	L	.08	.1	.01	L	.1	L	L	D	L	L	.04	L	D	L	D	.01	D	L	.035
74....	Gravel	N	N	80	45	5.6	.4	L	L	.02	.02	1.0	.04	.04	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
75....	Gravel	N	N	440	275	11	1.0	L	L	.01	.01	4.0	.07	.4	L	L	L	L	L	L	L	L	L	L	L	.007	D	L	.007
76....	Gravel	N	N	80	70	11	1.0	L	L	.20	.02	2.0	.04	.1	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
77....	CR....	N	130	67	< 30	3.8	.2	L	L	L	.07	.3	.009	L	L	L	L	L	L	L	.004	L	D	L	L	.002	D	L	.006
78....	C.....	.7	160	200	35	2.3	.3	L	L	L	.1	.2	.01	L	L	L	L	L	L	L	.009	L	L	L	L	.01	D	L	.019
79....	C.....	.3	160	320	95	2.6	.4	L	L	L	.1	.3	.007	L	L	L	L	L	L	L	.004	L	L	L	L	D	D	L	.004
80....	CR....	N	250	110	260	3.0	.02	L	L	L	.03	.1	.02	L	L	L	L	L	L	L	L	L	L	L	L	.01	.002	L	.012

DESCRIPTION

61....	Carbonate-quartz vein with trace pyrite.
62....	Stockwork vein zone, extends over 100- to 200-ft-wide zone.
63....	Pyritic carbonate zone.
64....	Vein of coarse calcite with up to 10 pct fluorite, 5 pct pyrite, and 2 pct hematite. Siliceous selvage extends for 1 in from vein.
65....	.5-ft-wide radioactive zone consisting of hematite-altered selvage and 2 carbonate veins with disseminated pyrite and specular hematite.
66....	Carbonate-veined argillite. Individual veins are thin and show no preferred orientations.
67....	Massive calcite vein with trace specularite.
68....	Carbonate vein with sparse pyrite and quartz.
69....	Carbonate vein, locally siliceous or pyritic.
70....	Siliceous and pyritic carbonate vein 160 ft along strike from samples 71 and 72.
71....	Gray cherty vein with carbonate and trace pyrite. Minor chalcopyrite also observed.
72....	Sample collected from vein adjacent to and similar to that sampled in sample 71.
73....	Selvage of 1.5-ft-wide carbonate vein.
74....	.045 yd^3 of silty gravel collected from sloping bottom of Salmon Bay. Reduced to 18.86 g of minus-10-mesh concentrate.
75....	.046 yd^3 of sand and gravel from left limit of mouth of Salmon Bay. Reduced to 19.23 g of minus-10-mesh concentrate.
76....	.046 yd^3 of sand and gravel from right limit of mouth of Salmon Bay. Reduced to 19.94 g of minus-10-mesh concentrate.
77....	Carbonate-altered lamprophyre dike.
78....	Quartz-carbonate vein with chlorite and specularite.
79....	Vein in same set as sample 78 vein.
80....	Carbonate vein with open-space filling specularite. Very irregular thickness.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Ppm Th	Ppm U	Pct Ba	Pct Mo	Pct P	Pct Pb	Pct Sr	Pct Ti	Pct Zn	Pct Zr	Rare-Earth Elements, Pct Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE[2]
81....	C.....	.3	1000	< 50	920	8.9	.08	L	L	L	.06	L	.009	L	.1	L	L	.2	.05	L	.04	L	.2	L	D	.02	.005	L	.435
82....	C.....	.3	750	150	740	6.8	2.0	L	L	L	.1	.09	<.0002	L	D	.02	L	D	.02	L	.04	L	.1	L	L	.03	.002	L	.212
83....	C.....	.1	B	460	240	.83	.02	L	L	L	.01	.2	.01	L	L	L	L	D	L	L	.009	L	L	L	L	.004	D	L	.013
84....	C.....	.5	ND	220	50	5.6	.02	L	L	L	.01	.2	.01	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
85....	C.....	.6	2100	65	715	2.9	.4	L	L	L	.2	L	.1	L	L	L	L	D	L	L	.02	L	D	L	L	.004	.002	L	.026
86....	CR....	N	1400	150	90	1.8	.02	L	L	L	.02	.1	.01	L	L	L	L	L	L	L	.004	L	L	L	L	.004	D	L	.008
87....	C.....	N	1200	< 50	1140	1.4	1.0	L	L	L	.3	L	.02	L	L	L	L	D	.02	L	.04	L	L	L	L	.04	.005	L	.105
88....	C.....	N	800	150	505	1.1	.1	L	L	L	.2	.1	.02	L	D	L	L	D	L	L	.04	L	L	L	L	.02	.002	L	.062
89....	CR....	N	B	63	40	4.9	.01	L	L	L	.004	.08	.002	L	L	L	L	L	L	L	L	L	L	L	L	2.0	D	L	2.0
90....	CR....	N	B	< 50	30	2.2	.2	L	L	L	.003	.1	.001	L	L	L	L	L	L	L	L	L	D	L	L	L	L	L	L
91....	C.....	N	300	< 50	< 30	< .5	1.0	L	L	L	.007	L	.002	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
92....	CR....	N	ND	< 50	< 30	2.7	.2	L	L	L	.04	.4	.007	L	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
93....	C.....	N	1200	190	875	4.2	.1	L	L	L	.3	L	.09	L	L	L	L	L	L	L	.02	L	L	L	L	.03	.002	L	.052
94....	C.....	N	B	< 50	50	1.6	.006	L	L	L	.004	L	.004	L	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
95....	C.....	N	3350	< 50	280	3.7	.05	L	L	L	.03	.1	.004	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
96....	H.....	N	ND	160	165	2.8	.01	L	5.0	L	.08	.3	.008	L	L	D	L	L	L	L	L	L	L	L	L	.04	.002	L	.122
97....	Ch....	N	ND	500	230	31	.3	L	L	L	.1	.1	.004	.02	L	L	L	L	L	L	L	L	D	L	L	.01	D	L	.01
98....	CR....	N	ND	500	80	4.6	.5	L	L	L	.01	.3	.004	.006	L	L	L	L	L	L	L	L	L	L	L	.004	D	L	.004
99....	CR....	N	ND	230	305	8.4	.4	L	L	L	.01	.3	.02	.5	L	L	L	L	L	L	L	L	L	L	L	.01	.005	L	.015
100...	H.....	N	ND	390	305	1.2	.4	L	L	L	.01	.5	.02	.004	L	L	L	L	L	L	L	L	L	L	L	D	D	L	L

DESCRIPTION

Sample	Description
81....	Vein of coarse calcite and pink-colored carbonate with trace fluorite and pyrite.
82....	Vein of coarse calcite and disseminated hematite, specularite, and green mica.
83....	Nonradioactive vein, trace pyrite.
84....	Zone of calcite-specularite veinlets.
85....	Calcite-hematite-fluorite vein.
86....	Chip of wall rock to sample 85 vein. Hematite-altered graywacke.
87....	Vein with coarse calcite and abundant disseminated hematite and unidentified opaque minerals.
88....	Calcite-quartz-hematite-fluorite vein zone.
89....	Grab of carbonate vein material from irregular zone. Minor pyrite along vein selvage and specularite in the veins.
90....	Shallow-dipping, nonradioactive carbonate vein.
91....	Carbonate veins with minor hematite.
92....	Lamprophyre dike hosting vein sampled in sample 91.
93....	Coarse calcite vein with bands of hematite and pyrite. Adjacent to olivine- and biotite-bearing lamprophyre dike.
94....	Irregular zone containing veins and clots of coarse calcite, pyrite, hematite, and specularite.
95....	Several thin hematite-altered fractures with carbonate and trace pyrite located near lamprophyre dike.
96....	High grade of > 1-inch-wide vein from 7-ft-wide zone of veining. Veins contain quartz, dolomite, siderite, pyrite, and possibly rutile. Veins comprise 10 pct of zone.
97....	Coarse calcite vein with siderite and disseminated pyrite.
98....	Random chip of two 6-ft-wide zones of calcite-veined hematitic graywacke separated by 5 ft of green graywacke.
99....	Random chip of 7-ft-wide zone of specularite-calcite-quartz-siderite-limonite veinlets.
100...	Coarse dolomite grains in matrix of calcite-siderite vein with blebs of pyrite and specularite.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]/--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses																									
				Ppm			Pct								Rare-Earth Elements, Pct														
				Cb	Th	U	Ba	Mo	P	Pb	Sr	Ti	Zn	Zr	Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE[2]/
101...	CR....	N	B	< 50	< 30	.54	.07	L	L	L	.007	.3	.005	L	L	L	L	L	L	L	L	L	L	L	L	D	D	L	D
102...	C.....	4.0	ND	< 50	155	7.5	.05	L	L	L	.03	.2	.002	.01	L	L	L	L	L	L	L	L	L	L	L	.01	D	L	.01
103...	C.....	.6	300-600	700	245	26	.1	L	2.0	L	.04	.2	.007	L	L	L	L	D	L	L	.04	L	L	L	L	.02	D	L	.06
104...	CR....	N	120	< 50	< 30	1.6	.6	L	L	L	.04	.6	.005	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
105...	CR....	N	200	90	< 30	1.5	.2	L	2.0	L	.07	.5	.01	L	L	L	L	L	L	L	L	L	L	L	L	.01	D	L	.01
106...	Ch....	.5	1100	120	580	11	.07	L	L	L	.01	.2	.005	.004	L	L	L	L	L	L	L	L	L	L	L	.02	D	L	.02
107...	Ch....	2.7	1100-2400	360	450	7.1	.1	L	3.0	L	.03	.3	.008	L	L	L	L	L	L	L	L	L	L	L	L	.02	D	L	.02
108...	Ch....	2.8	3000	150	1670	18	.02	L	4.0	L	.1	L	.01	L	L	L	L	L	L	L	L	L	L	L	L	.04	.005	L	.045
109...	Ch....	2.1	100	480	200	4.9	.07	L	L	L	.006	.2	.007	.008	L	L	L	L	L	L	L	L	L	L	L	.02	D	L	.02
110...	C.....	2.9	ND	< 50	530	4.5	.04	L	L	L	.06	.2	.006	L	L	L	L	L	L	L	.009	L	L	L	L	.04	.002	L	.051
111...	C.....	4.9	ND	230	1020	33	.01	L	3.0	L	.1	.1	.01	.003	L	L	L	L	L	L	.02	L	L	L	L	.04	.002	L	.062
112...	C.....	19.0	ND	80	40	3.5	L	L	L	L	.02	.2	.005	.1	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
113...	C.....	4.6	ND	60	50	2.2	1.0	L	L	L	.01	.5	.002	L	L	L	L	L	L	L	L	L	L	L	L	D	D	L	L
114...	C.....	1.0	ND	130	2060	19	.8	L	L	L	.06	.7	.01	L	L	L	L	L	L	L	.04	L	L	L	L	.09	.005	L	.135
115...	C.....	1.2	ND	< 50	110	14	.02	L	L	L	.008	.2	.006	L	L	L	L	L	L	L	L	L	L	L	L	.01	.005	L	.015
116...	C.....	1.4	ND	180	75	9.3	.02	L	L	L	.004	.3	.007	L	L	L	L	L	L	L	L	L	L	L	L	.01	.002	L	.012
117...	CR....	N	ND	70	55	5.3	.07	L	L	L	.004	.3	.006	.02	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
118...	C.....	2.4	ND	60	< 30	2.4	.04	L	L	L	.007	.09	.003	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
119...	CR....	N	800	310	665	4.4	.3	L	L	L	.02	.7	.002	.006	L	L	L	L	L	L	L	L	L	L	L	D	L	L	L
120...	C.....	.7	300	250	35	10	.2	L	L	L	.002	L	.002	L	L	L	L	L	L	L	L	L	L	L	L	.02	D	L	.02

DESCRIPTION

Sample	Description
101...	Silica-carbonate-fuchsite-altered dike boulders. Probably originally lamprophyre.
102...	Zone of recessively weathered carbonate veins.
103...	Silica-carbonate vein with hematite stain and trace pyrite.
104...	Siliceous carbonate vein. Local coarse carbonate and minor green fluorite (?).
105...	Lamprophyre dike adjacent to vein of sample 104.
106...	Dolomitic carbonate vein cutting lamprophyre dike of sample 105.
107...	.5-ft-wide dolomitic carbonate vein in zone of hematite-altered and silicified graywacke.
108...	Channel sample of 2 carbonate veins each 4-ft-wide, separated by a zone of hematite and silicic graywacke (sample 109).
109...	Hematite and silicic graywacke between carbonate veins of sample 108.
110...	Sample collected about 12 ft west of split in vein.
111...	Widest portion of curved vein.
112...	Wide hematite-altered zone in graywacke.
113...	Hanging wall (southeast) side of zone in sample 112.
114...	West side of radioactive vein of sample 115.
115...	Radioactive vein.
116...	East side of vein of sample 114.
117...	Carbonate-veined, bleached, and carbonate-altered lamprophyre (?) dike.
118...	Carbonate vein.
119...	Zone of brecciated graywacke and cross-cutting carbonate veins. Sample includes three veins, 4-in, 1-in, and 2-in-wide.
120...	Salmon-colored chert with specularite and quartz on fractures.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]/--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses: Ppm Cb	Ppm Th	Ppm U	Pct Ba	Pct Mo	Pct P	Pct Pb	Pct Sr	Pct Ti	Pct Zn	Pct Zr	Rare-Earth Elements, Pct: Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE2/
121...	CR....	N	ND	50	< 30	.57	.07	L	L	L	.005	L	.001	L	L	L	L	L	L	L	.009	L	L	L	L	D	D	L	.009
122...	C.....	2.3	B	< 50	< 30	1.4	.01	L	L	L	.02	.2	.008	.01	L	L	L	L	L	L	L	L	L	L	L	L	D	L	L
123...	C.....	4.0	100	60	< 35	1.2	.08	L	L	L	.004	1.0	.01	L	L	L	L	D	L	L	L	L	L	L	L	D	D	L	L
124...	C.....	1.5	430	760	85	11	.07	L	L	L	.01	.09	.002	.02	L	L	L	L	L	L	L	L	L	L	L	.002	D	L	.002
125...	C.....	7.3	B	< 50	< 30	1.7	L	L	L	L	.02	.2	.005	.2	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
126...	C.....	8.2	B	< 50	< 30	1.4	.03	L	L	L	.01	.2	.008	.004	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
127...	C.....	2.9	B	< 50	< 30	2.4	.02	L	L	L	.007	.3	.01	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
128...	C.....	1.8	B	120	< 30	6.1	.4	L	L	L	.05	.4	.006	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
129...	C.....	1.8	B	80	< 30	3.8	1.0	L	L	L	.01	.5	.002	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
130...	C.....	7.0	B	< 50	< 30	1.4	.03	L	L	L	.03	.4	.004	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
131...	CR....	4.5	B	< 50	< 30	1.3	.6	L	2.0	L	.04	.5	.01	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
132...	C.....	6.8	B	< 50	< 30	4.1	.02	L	L	L	.09	.07	.003	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
133...	C.....	4.7	B	< 50	< 30	2.1	.004	L	L	L	.004	.1	.003	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
134...	C.....	3.9	B	< 50	< 30	1.8	.01	L	L	L	.003	.1	.001	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
135...	C.....	3.4	B	< 50	< 30	2.0	.02	L	L	L	.004	.2	.003	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
136...	C.....	13.1	B	< 50	< 30	1.7	L	L	L	L	.004	L	.005	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
137...	C.....	14.1	B	< 50	< 30	1.2	.009	L	L	L	.01	.2	.006	L	L	L													
138...	CR....	.2	1200-4200	< 60	1870	11	.7	L	L	L	.04	.5	.003	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
139...	C.....	1.7	3600-4000	< 50	2105	9.6	.1	L	5.0	L	.2	.08	.006	L	L	L	L	D	.05	L	.09	L	L	L	D	.2	.01	L	.35
140...	C.....	1.5	5000	< 50	2165	7.2	.09	L	4.0	L	.2	.2	.005	L	L	L	L	D	L	L	.02	L	L	L	L	.09	.005	L	.115

DESCRIPTION

121...	Carbonate veinlets and hematite staining in north-trending zone.
122...	Carbonate vein consisting of fine-grained cherty carbonate with trace pyrite and local green micas, cut by calcareous veinlets.
123...	Bleached, light-green mafic (lamprophyre) dike with green patches of chlorite (?) replacing mafic minerals.
124...	Fine-grained mottled dark red and black siliceous carbonate vein with trace pyrite.
125...	Carbonate vein.
126...	Do.
127...	Altered (?) wall rock on south side of sample 126 vein.
128...	Carbonate vein.
129...	Do.
130...	Do.
131...	Vein of altered plagioclase and fuchsite with cross-cutting calcareous veinlets.
132...	Carbonate vein.
133...	Do.
134...	Do.
135...	Altered wallrock on east side of sample 134 vein.
136...	Carbonate vein.
137...	Do.
138...	Tan- to pink- to red-colored chert vein cut by coarse calcite-specularite veins.
139...	Calcite-siderite vein with local siliceous or pyritic zones.
140...	Center of 1.8-ft-wide vein. Calcite mottled with siderite.

See explanatory notes at front of appendix.

APPENDIX A RESULTS OF SAMPLE ANALYSES[1]--Continued

Sample	Type	Length ft	Radioactivity cps	Analyses																									
				Ppm			Pct								Rare-Earth Elements, Pct														
				Cb	Th	U	Ba	Mo	P	Pb	Sr	Ti	Zn	Zr	Ce	Dy	Er	Eu	Gd	Ho	La	Lu	Nd	Pr	Tm	Y	Yb	Tb	REE[2]
141...	Ch....	.3	6000	180	1910	8.5	.3	L	4.0	L	.2	.2	.005	L	L	L	L	D	L	L	.04	L	L	L	L	.09	.005	L	.135
142...	Ch....	1.8	4500-7200	150	2065	11	.03	L	5.0	L	.2	.1	.005	L	L	L	L	D	.02	L	.04	L	L	L	L	.09	.005	L	.155
143...	H.....	.1	7200	50	1650	6.2	.05	L	L	L	.1	.2	.004	L	L	L	L	L	L	L	L	L	L	L	L	.02	D	L	.02
144...	C.....	3.0	2600-5500	210	1255	8.0	.1	L	3.0	L	.1	.1	.004	L	L	L	L	D	.02	L	.04	L	L	L	L	.04	.002	L	.102
145...	C.....	2.0	1000-400	120	125	1.6	.05	L	L	L	.03	.5	.002	L	L	L	L	D	L	L	L	L	L	L	L	.004	D	L	.004
146...	C.....	3.0	2500-3500	110	1107	6.4	.02	L	L	L	.06	.2	.003	L	L	L	L	D	L	L	.04	L	L	L	L	.02	.002	L	.062
147...	CR....	N	3500	110	1465	5.6	.01	L	3.0	L	.02	L	.005	L	L	L	L	D	.05	L	.04	L	L	L	L	.09	.005	L	.185
148...	CR....	N	2500	190	295	3.8	.2	L	L	L	.008	.2	.001	L	L	L	L	D	L	L	.02	L	L	L	L	.01	D	L	.03
149...	Ch....	3.0	ND	120	1760	8.8	L	L	L	L	.01	.2	.003	L	L	.08	L	L	.01	L	.02	L	L	L	L	.09	.005	L	.205
150...	Ch....	4.2	ND	< 50	1790	8.2	.003	L	L	L	.006	L	.007	L	L	L	L	L	L	L	.04	L	L	L	L	L	L	L	.04

DESCRIPTION

141...	2-in-wide selvage on both walls of sample 140 vein. Consists of siliceous carbonate with disseminated pyrite.
142...	Vein, variable in character, carbonate-rich to siliceous with cross-cutting calcareous veins, locally pyritic.
143...	High grade of siliceous, most-radioactive portion of vein in sample 142.
144...	Vein includes 1.0 ft of coarse carbonate, 2.0 ft of hematitic chert with calcite and pyrite veinlets, and 1.0 ft of siliceous carbonate with veinlet pyrite.
145...	1.0 ft from both hanging wall and footwall of vein in sample 144.
146...	Carbonate vein with irregular zone of hematitic chert.
147...	Dolomitic calcite and siderite with disseminated pyrite from carbonate-rich portion of vein of sample 146.
148...	Cherty portion of vein of sample 146, trace pyrite.
149...	Carbonate-chert vein.
150...	Do.

[1] Ag, As, Au, B, Be, Bi, Cd, Co, Cr, Cu, Ga, Pd, Pt, Sc, Sm, Te, and V also analyzed by emmision spectrographic methods, but not detected; Sn and Ta also analyzed by x-ray fluoresence, but not detected; W also analyzed in some samples by colorimetry, but not detected.
[2] Total REE.

APPENDIX B

Random check analyses by XRF procedure

Sample	La (ppm)	Ce (ppm)	Y (ppm)
SE 21493	6379	4267	>90
SE 21615	729	1497	560
SE 21635	2498	3228	25
SE 21809	16,000	10,000	>1200
SE 21817	4884	3519	46

DESCRIPTION AND LOCATION	
SE 21493:	1.5-in-wide vein near map number 77 ,exposed for 30 ft on strike.
SE 21615:	Duplicate split to sample map no. 85, Appendix A.
SE 21635:	Duplicate split to sample map no. 52, Appendix A.
SE 21809:	1.0-in-wide vein selvage with sulfide minerals, up to 2500 cps possible extension to vein sampled at map no. 73, Appendix A.
SE 21817:	Duplicate split to sample map no. 46, Appendix A.