Reconnaissance for uranium and thorium in Alaska ~~during~~ 1954

By John J. Matzko and Robert G. Bates

Trace Elements Investigations Report 611

UNITED STATES DEPARTMENT OF THE INTERIOR
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ABSTRACT

During 1954 reconnaissance investigations to locate minable deposits of uranium and thorium in Alaska were unsuccessful. Areas examined, from which prospectors had submitted radioactive samples, include Cape Yakataga, Kodiak Island, and Shirley Lake. Unconcentrated gravels from the beach at Cape Yakataga average about 0.001 percent equivalent uranium. Uranothorianite has been identified by X-ray diffraction data and is the principal source of radioactivity in the Cape Yakataga beach sands studied; but the zircon, monazite, and uranothorite are also radioactive. The black, opaque uranothorianite generally occurs as minute euhedral cubes, the majority of which will pass through a 100-mesh screen.

The bedrock source of the radioactive samples from Kodiak Island was not found; the maximum radioactivity of samples from the Shirley Lake area was equivalent to about 0.02 percent uranium. Radiometric traverses of the 460-foot level of the Garnet shaft of the Nixon Fork mine in the Nixon Fork mining district indicated a maximum of 0.15 mr/hr. In the Hot Springs district, drill hole concentrates of gravels examined contained a maximum of 0.03 percent equivalent uranium. A radioactivity anomaly noted during the Survey's airborne reconnaissance of portions of the Territory during 1954 is located in the Fairhaven district. A ground check disclosed that the radioactivity was due to accessory minerals in the granitic rock.

INTRODUCTION

Reconnaissance for uranium and thorium in Alaska during the 1954 field season consisted principally of a study of the radioactive beach placers east and west of Cape Yakataga, and ground and airborne radiometric traverses of portions of Kodiak Island and adjacent islands.

A short reconnaissance trip was made to the McGrath district, Nixon Fork area, to study the radioactive accessory minerals in the quartz monzonite - limestone contact zone exposed in the mines of the area. An investigation was made in the Hot Springs district, Tofty area, to test gravels obtained by the U. S. Bureau of Mines placer-drilling program in that area, where previous work by the U. S. Geological Survey had disclosed the presence of radioactive minerals in the gold - tin placers. A ground check was made of a radioactivity anomaly which was discovered in the Fairhaven district, Candle area, by the Geological Survey during the course of an airborne radioactivity reconnaissance of portions of the Territory early in the 1954 field season.

The reconnaissance party in the Yakataga and Kodiak areas was composed of Robert G. Bates and Donald L. Adair, geologists, and William K. Benda, geologic field assistant. The reconnaissance of the Tofty tin belt, Nixon Fork mines, and the Candle Creek area was conducted by John J. Matzko, geologist. G. Donald Eberlein, geologist, was a member of the party for the Nixon Fork reconnaissance. These investigations were made by the Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Acknowledgments

Acknowledgment is gratefully made to the following: Commander, Alaskan

Sea Frontier; Commanding Officer, Kodiak Naval Air Station; and the District Public Works Officer, 17th Naval District, for the logistic support given during the Kodiak reconnaissance; Mr. W. S. McIntosh of the Civil Aeronautics Administration, and Mr. and Mrs. Ben Watson, for their helpful advice during the work at Yakataga; and Mr. Jack Carson for the use of his cabins in the area. Grateful acknowledgment is made to Mr. and Mrs. C. S. Winan and Mr. and Mrs. Ted Strandberg for the hospitality they extended the reconnaissance party in the Nixon Fork area.

AREAS INVESTIGATED

Radiometric traverses were made with: (1) Scintillation counters with a $1\frac{1}{2}$ inch sodium iodide, thallium-activated crystal for the ground studies; (2) a 3-inch scintillation head attached (a) to an ammeter for the road-traverse studies, and (b) to a graphical recording device for the airborne traverses.

The areas investigated for radioactivity in 1954 are reported in the pages that follow; their locations are shown on figure 1. On figure 1 and in the text the mining districts in which the areas are located have been used as a matter of convenience to describe the general geologic setting.

Yakataga district

Geology

The oldest rocks exposed in the Yakataga district consist of approximately 9,500 feet of alternating sandstone and siltstone with minor amounts of coal (Miller, 1953). They range in age from late Paleocene or Eocene to early or middle Oligocene. Conformably overlying these rocks are approximately 4,000 feet of siltstone, sandstone, and mudstone which comprise the

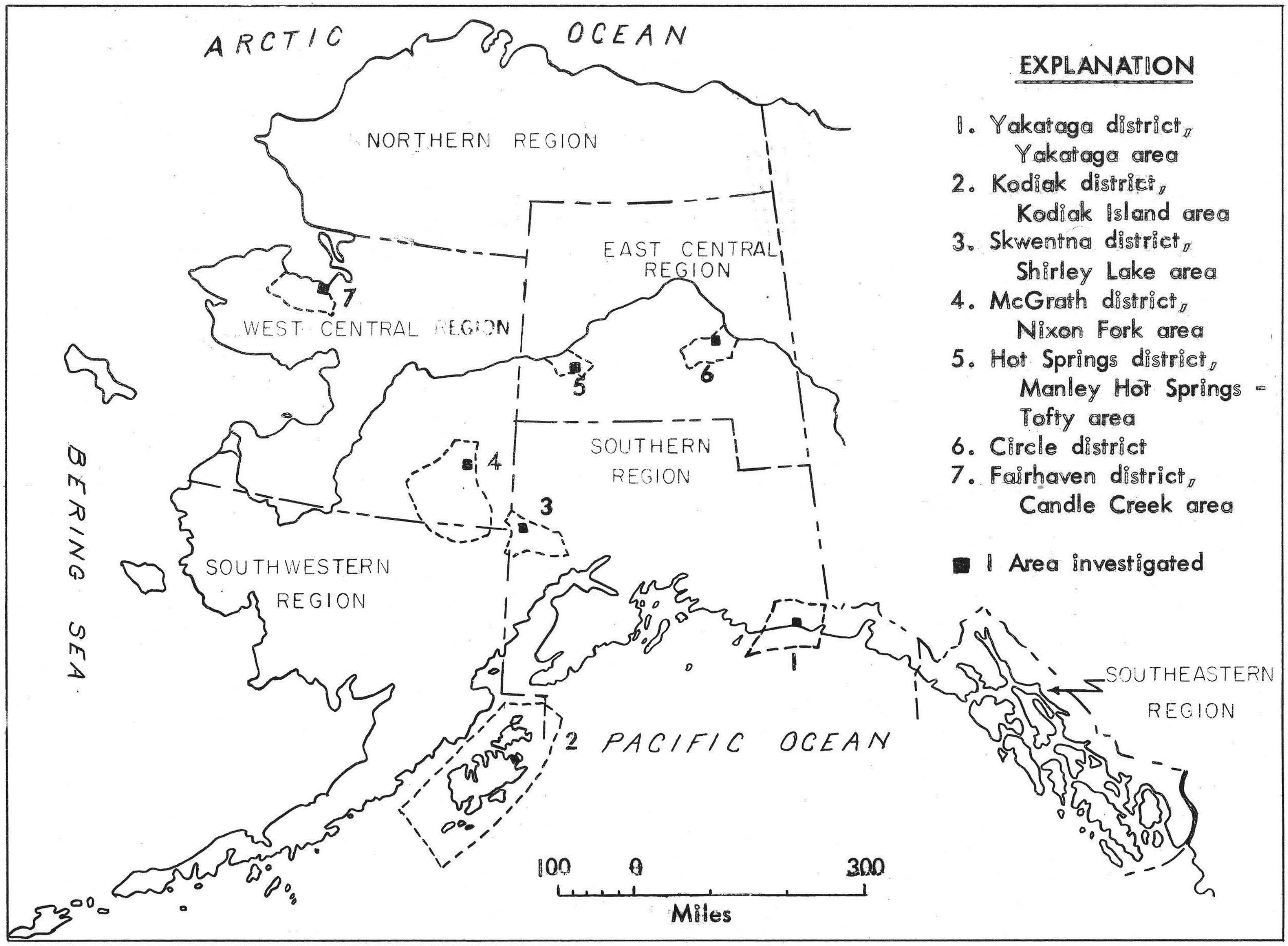

Figure 1.-- Index map of Alaska showing districts with areas investigated for uranium in Alaska, 1954

Poul Creek formation of middle and late Oligocene age. The Yakataga formation of early Miocene age conformably overlies the Poul Creek formation and consists of at least 8,000 feet of siltstone, sandstone, mudstone, and pebble or cobble conglomerate. Overlying the Tertiary rocks with marked unconformity are unconsolidated deposits of Quaternary age.

Cape Yakataga area

Introduction.--The radioactivity of the beach sands of the Yakataga area was first noted in 1945 when samples in the placer sample file of the U. S. Geological Survey were scanned for radioactivity (Harder and Reed, 1945).

Further laboratory studies on 9 concentrated samples of unknown concentration ratio that prospectors submitted in 1946 indicated an average of 0.044 percent equivalent uranium (Moxham and Nelson, 1952). As this was too low in radioactivity to be of commercial value for uranium, no further work was planned.

Concentrates of beach sands from the Yakataga area submitted to the Geological Survey in the fall of 1952 and the late summer of 1953 contained up to 38 percent equivalent uranium. On the basis of these samples and the increased interest of prospectors in the area, a Survey reconnaissance party examined the area during the 1954 field season. Its purpose was to evaluate the area as a possible source of radioactive minerals.

The Cape Yakataga area (fig. 1) lies along the north coast of the Gulf of Alaska about 120 miles southeast of Cordova. No roads lead into the area and the lack of harbor facilities makes air travel the only feasible means of access. The Civil Aeronautics Administration maintains an airfield that regularly accommodates DC-3 type planes. Travel by foot or by tracked vehicle is possible along the beaches but the softness of the beach sand prohibits the use of wheeled vehicles. The numerous streams and rivers, some of them glacial in origin, make even beach travel extremely difficult and hazardous.

Between Cape Yakataga and Umbrella Reef, a narrow coastal plain about half a mile to a mile wide extends inland to the base of a steep ridge. The beach bordering this plain is steep and not more than 300 feet wide. East of Umbrella Reef the beach widens to as much as a quarter of a mile. At one time the entire length of the present beach sands was mined for its gold content, but the only mining activity on the beach today is at and near Cape Yakataga. There Mr. Ben Watson has maintained a small placer operation for a number of years on the beach sands immediately west of the cape.

Previous work.--Prospecting in the Yakataga district, former gold-beach placer area, has increased greatly in the last few years partly because of the radioactivity of the black sand concentrates. To date there have been three organizations that carried out explorations to determine the mineral value of the sands in the Yakataga area.

In 1946 the Seymour Standish and Associates Company, a Chicago mining organization, prospected the beach sands on two eastward-trending lines, one at high tide, the other on the second beach, with holes on 2,000-foot centers (Moxham, 1952). The results of their work were probably discouraging because they did no further exploration in this area.

During the fall of 1952, Mr. Pat Bliss, a pilot for Cordova Airlines, submitted a sample to the Geological Survey. An analysis of the sample indicated an equivalent uranium content of approximately 38 percent. At the time, Mr. Bliss did not disclose the source of the sample.

In August, 1953 samples from the beach at Yakataga were submitted to the laboratory of the Geological Survey at College, Alaska by Mr. George Fennimore. Mr. Fennimore stated that the sample sent to the Geological Survey the previous fall by Mr. Bliss was also from the beach at Yakataga.

It was later learned that the sample submitted by Mr. Bliss and the most radioactive sample submitted by Mr. Fennimore were sluice-box concentrates from Mr. Watson's placer operations at Cape Yakataga.

One of the samples submitted by Mr. Fennimore contains 1.5 percent equivalent uranium in the total raw concentrate, 0.88 percent equivalent uranium in the -20+200-mesh iodide heavy fraction (sp. gr. >3.3), and 9.8 percent equivalent uranium in the -200-mesh fraction of the raw concentrate (table 1).

Another of the samples submitted by Fennimore contained 35 percent equivalent uranium in the total raw concentrate, 16 percent equivalent uranium in the -20+200-mesh iodide heavy fraction (sp. gr. >3.3), and 39 percent equivalent uranium in the -200-mesh fraction of the raw concentrate. A similar sample given by Mr. Fennimore to Harry Townsend, mining engineer representing the Anaconda Copper Company in Alaska, contained 24 percent uranium. The Anaconda Copper Company also made an analysis of the sample for precious metals, with the results prorated per ton of concentrates shown below:

Gold	73 oz.
Silver	None
Iridium	40 oz.
Platinum	446 oz.
Palladium	31 oz.

In 1954, on the basis of the above data, the Anaconda Copper Company obtained options on the placer claims east of Cape Yakataga to about Oil

Table 1.--Mineralogy of three beach and stream concentrates, Cape Yakataga area, Alaska.

	Estimated volume (percent)		
	I	II	III
Apatite	1	--	--
Cinnabar	1	--	--
Epidote	3	3	1
Garnet (mainly almandite-spessartite)	3	31	48
Hornblende	2	1	4
Ilmenite	4	10	-- 1/
Magnetite	20	36	1
Monazite	--	--	tr 2/
Quartz	--	1	--
Scheelite	1	tr	tr
Zircon	12	15	4
Uranothorianite	50	tr	tr
Uranothorite	1	tr	tr
Opaques 3/	1	tr	35
Others	1	3	6

I. The radioactive sample containing 35 percent eU 4/ contributed by Mr. George Fennimore is a concentration of sluice concentrates from the Ben Watson beach placer operation on the west side of Cape Yakataga. Other minerals include: cassiterite, gold, hematite, platinum, pyrite, pyrrhotite, rutile and tourmaline.

II. Sample from highly concentrated beach sand at Cape Yakataga, submitted by Mr. George Fennimore, contains 1.5 percent eU. Other minerals include: cassiterite, hematite, pyroxene, rutile, spinel, staurolite, thorite(?), tourmaline, and xenotime.

III. Pan concentrate from Felton Creek (sample 55ABa-57, fig. 2). Maximum radioactivity of about 0.04 percent eU is concentrated in the 1.5 amp. magnetic fraction. Other minerals include: gold, spinel, and thorite(?).

1/ Ilmenite probably constitutes most of the unidentified opaque minerals
2/ tr - trace, indicates amounts less than 1 percent
3/ Includes remaining opaque minerals not listed by name in table
4/ eU - equivalent uranium

Creek and west of the cape to South Channel Yakataga River. Drilling was done on a more or less random basis and included prospect holes from the west side of Cape Yakataga to Acme Creek, a distance of about 4 miles (fig. 2). Harry Townsend, Anaconda's engineer in charge, asserted (oral communication) that his most radioactive samples came from west of the Cape. The company, however, did not believe that the tenor of the sands was sufficient to justify continuing work in the area, and their option on the claims was allowed to expire.

In 1955 the Yukon Placer Mining Company, Inc., obtained the options on the group of claims between Cape Yakataga and the Yakataga River to the west and Oil Creek to the east. They sent a 3-man drilling party under the supervision of Charles F. Herbert to investigate their claims, with A. T. Tunley, field engineer-in-charge.

Holes were drilled on 200-foot centers along 3 lines spaced 2,000 feet apart (fig. 2) on the east side of Cape Yakataga. Profiles of the beach along the 3 lines are shown in figure 3. Bedrock was not reached in any of the holes; maximum depth of the holes was about 24 feet. The Yukon Placer Mining Company was interested in recovering any of the minerals in the sands that might be of economic value, but preliminary data available indicate that the sands are too low in tenor to be profitably mined. The company is reported to have relinquished its options on the claims in the Yakataga area.

Present study.--At the beginning of this investigation heavy liquid concentrations, using bromoform (sp. gr. 2.89), were made of rock samples from the Yakataga area to determine if the mineralogy of the bedrock could be correlated with that of the beach sands. The samples studied were supplied by Don J. Miller of the Geological Survey and represented the

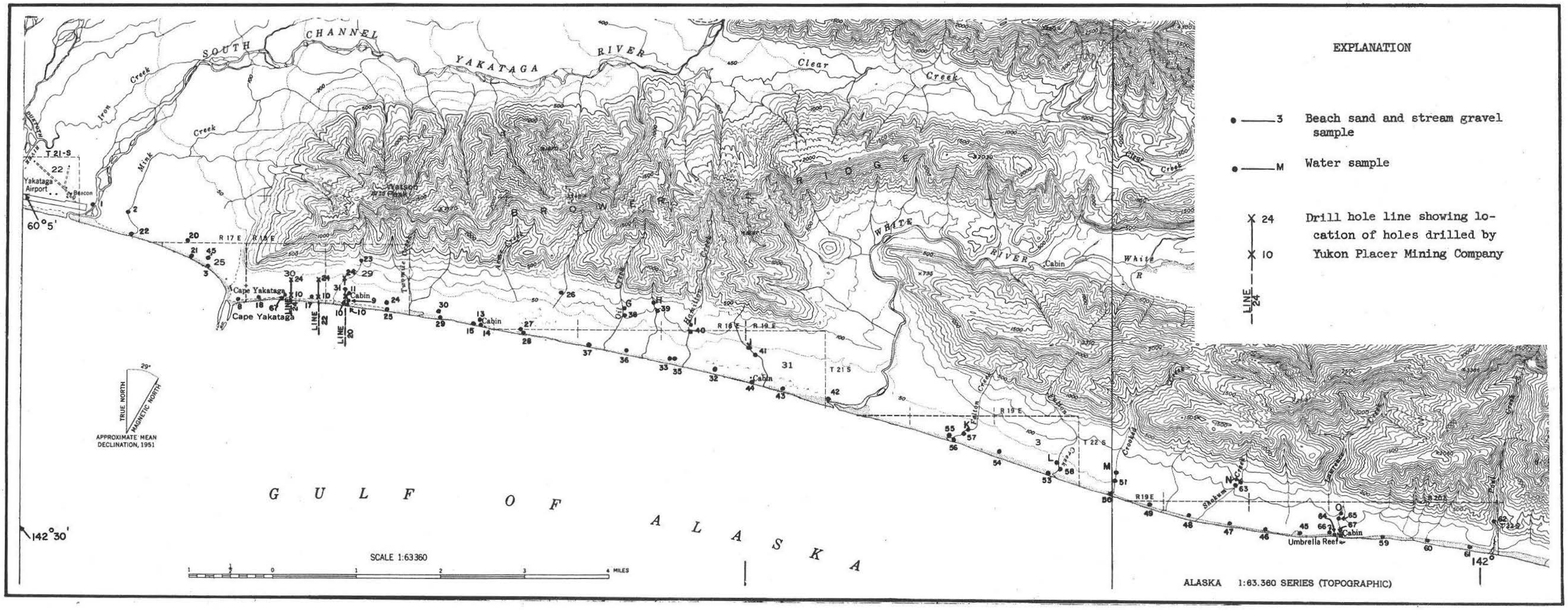

FIGURE 2.--LOCATIONS OF DRILL HOLE LINES OF THE YUKON PLACER MINING COMPANY AND OF U.S.G.S. SAMPLES, CAPE YAKATAGA AREA, ALASKA

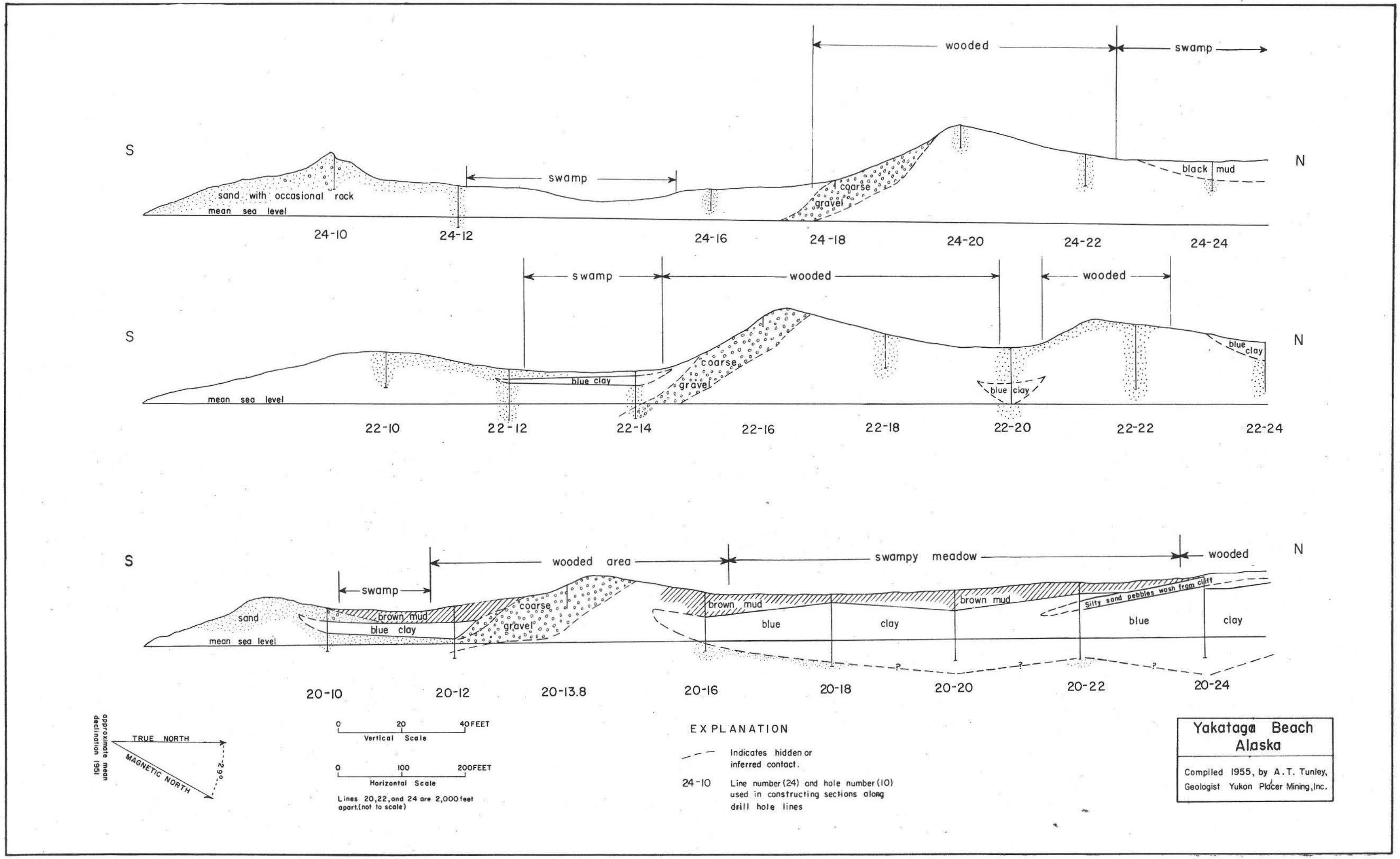

FIGURE 3. PROFILES ALONG 3 LINES OF DRILL HOLES (SHOWN ON FIG.2), CAPE YAKATAGA AREA, ALASKA.

"conglomeratic" sandy mudstone, sandstone, and siltstone of the Yakataga formation of early Miocene age, and sandstone from the Poul Creek formation of middle and late Oligocene age. Sandstone of the Poul Creek formation contains coal, but an unidentified asphaltic type of material that melted from the heat of a match was also found in one sample. No definite correlation could be made between the mineralogy of the beaches in the Yakataga area and the Poul Creek and Yakataga formations. Radioactivity tests on all the bromoform heavy concentrates of the rock samples showed 0.001 percent equivalent uranium, or less.

Maddren (1914, p. 142) believed that the beach gold placers at Yakataga were concentrated from the coastal plain deposits which he believed to be glaciofluviatile from White River. He also suggested the possibility that glacial ice transported the gold, but did not believe the Tertiary sequence in the adjacent Robinson Mountains to be the source. Miller (personal communication), however, believes the source of the beach placers (and the coastal plain sediments) to be the Tertiary sediments to the north, and principally the Yakataga formation. In this area the Poul Creek formation apparently contributes very little or no gold to the gravels or beach sands, and creeks cutting this formation contain very little placer gold. On the other hand, prospectors have reported coarse gold from Carson Creek which cuts the Yakataga formation near Icy Bay (outside of fig. 2), about 35 miles southeast of Cape Yakataga. Carson Creek drainage is all in the Yakataga formation; however, the possibility exists that some, if not all, of the gold may be derived from the raised beach terraces cut by the creek (Miller, personal communication). The gold is coarse and shows rounded and overturned edges. Uranothorianite has been identified in the heavy mineral fraction from Carson Creek. Other minerals identified include epidote, garnet, hematite, magnetite, pyrite, and zircon.

The present study of the mineral suites from the Yakataga beach sands indicates that the original source was very probably diverse rock types. Zircon is commonly derived from silicic igneous rocks. The zircon in the beach sands at Yakataga is concentrated in the fractions from about 65 mesh to finer. It is colorless, generally euhedral, with minor amounts of unidentified inclusions and has a beta index of about 1.922. Uranothorianite occurs principally in granitic or silicic rocks similar to those containing zircon. The uranothorianite is considered to be very friable and at the beginning of this investigation it was believed that its source would have to be local. There is a possibility, however, that the uranothorianite may have been transported from a relatively great distance and been reworked. Hutton (1950) has shown that most minerals of any economic value in beach sands are restricted to the finer sized grains, and that mineral grains of about -120+230-mesh size are frequently euhedral and grains larger than this are often subrounded to well rounded. He also found that grains less than 325 mesh are commonly absent, having been removed from the beach sands by surf action. The not uncommon platinum in the placers at Yakataga probably came from a mafic environment. Garnet and epidote commonly form by metamorphism and grains of these minerals were probably derived from crystalline rocks. Mona Franck (U.S.G.S., Washington, D. C.) made spectrographic analyses of two garnet samples collected from the beach about half a mile east of Cape Yakataga and from the White River, upstream from the present coastal plain; the analyses are similar and show that the garnets are principally almandite (index 1.79) with minor amounts of the pyrope molecule. Wright (1938) in his comprehensive study of the garnets has shown that the almandite-pyrope molecule is common in rocks such as eclogite and that the pyrope occurs also in kimberlite and peridotites, whereas the almandite is found frequently in schists, contact zones, and pegmatites and granites. Omphacite (diopside-jadeite series), a primary constituent of eclogite, and the frequently associated kyanite have not been identified in the beach sands. Jaffe (1951) has shown that the manganese-rich garnets are commonly associated with the granite-pegmatite environment. The spectrographic analyses of the Yakataga garnets show only between 0.1 to 0.5 percent manganese. Therefore, it is believed that the garnets in the Yakataga beaches probably came from schist and contact zones.

The nearest known granitic rocks are in the Chitina district about 65 miles to the north of Cape Yakataga, and in the Yakutat district about 110 miles east of Cape Yakataga. The nearest known schistose rocks are in the Yakutat district.

Originally it was planned to evaluate the tenor of the beach sands in a reconnaissance investigation. A hand auger was to be used for this and it was hoped that bedrock could be reached in some of the holes. Samples from the various beds encountered and a composite sample of the entire hole would be taken. It was found, however, that the sides of the hole tended to pinch in after a depth of 7 to 8 feet had been reached, which effectively prohibited deeper drilling. As an alternate method, it was decided to dig test pits in the beach by hand to as great a depth as possible and take vertical channel samples from the sides of the hole. The sides of the pit tended to slough after a depth of 3 to 4 feet had been reached, and, therefore, the sampling was limited to this zone. In all, 32 pits were dug along the beach from the mouth of the South Channel of the Yakataga River east to Poul Creek, a distance of approximately 18 miles (fig. 2). Also, 3 auger holes as well as 8 pits were dug in the first beach inland from the present beach, hereafter called the second beach. The second beach was not everywhere present but was sampled wherever it could be identified. The equivalent-uranium content of the samples from both beaches is given in table 2.

Eight concentrates were collected from streams at altitudes above the recognizable beach sands, to determine if any of the drainage areas were concentrating radioactive minerals. No significant concentrations were found. The stream concentrates were further concentrated in the laboratory by heavy liquid media and analyzed for radioactivity.

Two samples of sluice concentrate were collected west of Cape Yakataga from the beach workings of Mr. Ben Watson. One of these samples contained 11.4 percent equivalent uranium, owing in large part to the high percentage of uranothorianite. The other sample contained 0.39 percent equivalent uranium, also owing to the uranothorianite content.

The maximum radioactivity of a concentrate from the beach sands obtained by the Survey party was 0.01 percent equivalent uranium. This sample (54ABa-3, table 2) was obtained from the beach where water from the ditches maintained by Mr. Watson flowed across the beach and partially concentrated the sands. Therefore, the mineralogy of the sample is representative of the beach sands only in a qualitative manner. The maximum radioactivity noted on unconcentrated samples of the beach sands was 0.001 percent equivalent uranium. Gold, silver, and uranium were all low in the assays of the unconcentrated samples; the platinum content was too low to be detected by fire-assay methods.

Uranothorianite and uranothorite are the source of most of the radioactivity in the beach sands in the Cape Yakataga area. Both are refractory minerals and the extraction of their uranium content presents a

Table 2.--Equivalent-uranium content of samples from the Cape Yakataga district, Alaska

(Under the heading "Equivalent uranium (percent)", the method of concentration is shown by: P for concentration with a gold pan; B by bromoform heavy liquid, sp.gr. 2.89; I by methylene iodide heavy liquid, sp.gr. 3.3. All samples are channel samples from pits trenched in the beach sands, unless otherwise noted; some samples are from stream gravels, as indicated. An average weight of 3,700 lbs. per cu.yd. was used to calculate the concentration of heavy minerals.)

Sample no.	Equivalent uranium (percent) Unconcentrated	Equivalent uranium (percent) Concentrated	Concentration ratio	Pounds heavy minerals per cu.yd. sand	Remarks
54ABa-1		0.001 P .003 B	1,608:1	2	4-pan concentrate from South Channel Yakataga River, bar 0.25 mile upstream from beach.
2		.001 P .002 B	747:1	5	4-pan concentrate from bar 20 yards upstream from bridge over Mink Creek.
3		.006 P .01 I	24:1	154	2-pan concentrate 0.25 mile west of Cape Yakataga, at present beach, 25 feet above high tide.
4	.001	.004 I	29:1	128	150 feet inland from sample 3.
5		< .001 P < .001 B	105:1	35	2-pan concentrate of sample from same pit as 4.
6	< .001	< .001 I	48:1	77	Base of sand dune, about 0.6 mile east of Cape Yakataga.
7	< .001	.002 I	24:1	154	100 feet west of sample 6 and 25 feet into south side of dune.
8	< .001	< .001 B	27:1	137	100 feet from west end of sand dune at Cape Yakataga. Au-Ag assay value $0.92 per cu.yd[1/] 0.001 percent uranium on the unconcentrated sample[2/].
9a	< .001	< .001 B	2:1	1,850	0-2 foot depth in augered hole. Fifty feet north of beach ridge in front of first cabin east of Cape Yakataga. Less than 0.001 percent uranium on the unconcentrated sample[2/].
9b	< .001	< .001 B	2.5:1	1,480	2-4 foot depth in augered hole. Less than 0.001 percent uranium on the unconcentrated sample[2/].
9c	< .001	< .001 B	1.9:1	1,947	4-6 foot depth in augered hole. Less than 0.001 percent uranium on the unconcentrated sample[2/].
9d	< .001	< .001 B	3.2:1	1,156	6-7 foot depth in augered hole. Blue gumbo-type clay at 7 feet. The unconcentrated sample contains 0.001 percent uranium[2/].
10a	< .001	< .001 B	3.1:1	1,194	0-2 foot depth in augered hole in present beach in front of first cabin east of Cape Yakataga.
10b	< .001	< .001 B	6.7:1	552	2-4 foot depth. Pebbly horizon encountered at 4 feet.
11a	< .001	< .001 B	7.8:1	474	0-2 foot depth in augered hole. 100 feet east of first cabin east of Cape Yakataga. Less than 0.001 percent uranium on unconcentrated sample[2/].
11b	< .001	< .001 B	10:1	370	2-4 foot depth in augered hole. Less than 0.001 percent uranium on the unconcentrated sample[2/].
11c	< .001	< .001 B	3.1:1	1,194	4-6 foot depth in augered hole. Less than 0.001 percent uranium on the unconcentrated sample[2/].
13	< .001	< .001 B	38:1	97	Trench--3 feet deep in second(?) beach, 25 feet east of second cabin, east of Cape Yakataga.
14a	< .001	< .001 B	52:1	71	0-1½ foot depth. From present beach in front of second cabin east of Cape Yakataga.
14b	< .001	.001 B	45:1	82	1½-3 foot depth.
15	.001	.003 B	961:1	4	Pan concentrate from iron stained zone about 25 feet northwest of sample 14.
17a	< .001	.002 I	50:1	74	0-2½ foot depth. South side base of sand dune 0.5 mile east of Cape Yakataga.
17b	< .001	.002 I	32:1	116	2½-5 foot depth.

1/ Assayer: W. A. Attwood, Territorial Department of Mines, College, Alaska.

2/ Chemical analysis: R. Moore, U. S. Geological Survey, Washington, D. C.

Table 2.--Equivalent-uranium content of samples from the Cape Yakataga district, Alaska--Continued

Sample no.	Equivalent uranium (percent) Unconcentrated	Concentrated	Concentration ratio	Pounds heavy minerals per cu.yd. sand	Remarks
54ABa-18a	<0.001	0.002 I	53:1	70	0-2½ foot depth. Vertical channel samples from south side base of sand dune 300 yards east of Cape Yakataga.
18b	< .001	.002 I	131:1	28	2½-5 foot depth.
20a	< .001	.002 I	92:1	40	0-1½ foot depth. Vertical channel sample 30 feet south of CAA road and about 0.15 mile north of sample 21.
20b	< .001	.001 I	352:1	11	1½-3 foot depth.
21a	< .001	.01 I	21:1	176	0-3 foot depth. Vertical channel sample on present beach 0.5 mile west of Ben Watson's cabin at Cape Yakataga.
21b	< .001	.009 I	34:1	109	3-6 foot depth.
22		.001 P .001 B	66:1	56	2-pan concentrate from Mink Creek at present beach.
23		< .001 P .004 I	1,595:1	2	2-pan concentrate from first unnamed creek east of Cape Yakataga.
24a	.001	.001 B	35:1	106	0-1½ foot depth. From second beach 0.5 mile east of first cabin east of Cape Yakataga.
24b	< .001	.001 B	19:1	195	1½-3 foot depth.
25a	< .001	< .001 B	14:1	264	0-1½ foot depth. From present beach due south of 24.
25b	< .001	< .001 B	15:1	247	1½-3 foot depth.
26		.002 P < .001 B	1,038:1	4	4-pan concentrate from unnamed creek between Acme and Oil Creeks.
27a	< .001	< .001 B	56:1	66	0-1½ foot depth. Second beach 0.5 mile east of second cabin east of Cape Yakataga.
27b	< .001	< .001 B	71:1	52	1½-3 foot depth.
28a	< .001	< .001 B	40:1	93	0-1½ foot depth. From present beach due south of 27.
28b	< .001	< .001 P	21:1	176	1½-3 foot depth.
29a	< .001	.002 B	27:1	137	0-1½ foot depth. Present beach 0.5 mile west of second cabin east of Cape Yakataga. Au-Ag assay value $0.04 per cu. yd.1/. Less than 0.001 percent uranium on unconcentrated sample2/.
29b	< .001	< .001 B	66:1	56	1½-3 foot depth. Au-Ag assay value $0.02 per cu. yd.1/. Less than 0.001 percent uranium on unconcentrated sample2/.
30a	< .001	.002 B	24:1	154	0-1½ foot depth. From second beach due north of sample 29.
30b	< .001	< .001 B	33:1	112	1½-3 foot depth.
31		< .001 P .001 B	36:1	103	1-pan concentrate from a small stream west of first cabin east of Cape Yakataga.
32a	< .001	< .001 P	54:1	69	0-1½ foot depth. From present beach 0.5 mile west of first cabin west of White River.
32b	< .001	< .001 P	22:1	168	1½-3 foot depth.
33a	< .001	< .001 P	53:1	70	0-1½ foot depth. From present beach 2 miles west of White River. Less than 0.001 percent uranium on unconcentrated sample2/.
33b	< .001	.002 B	45:1	82	1½-3 foot depth. Less than 0.001 percent uranium on unconcentrated sample2/.
35a	< .001	< .001 B	18:1	206	0-2 foot depth. From second beach and 100 feet east of 33.
35b	< .001	< .001 P	14:1	264	2-4 foot depth.
36a	< .001	< .001 P	12:1	308	0-2 foot depth. Present beach 1½ miles west of first cabin west of White River.
36b	< .001	< .001 P	22:1	168	2-4 foot depth.
37a	< .001	< .001 B	62:1	60	0-1½ foot depth. Present beach 0.25 mile west of Oil Creek.

1/ Assayer: W. A. Attwood, Territorial Department of Mines, College, Alaska.

2/ Chemical analysis: R. Moore, U. S. Geological Survey, Washington, D. C.

Table 2.--Equivalent-uranium content of samples from the Cape Yakataga district, Alaska--Continued

Sample no.	Equivalent uranium (percent) Unconcentrated	Concentrated	Concentration ratio	Pounds heavy minerals per cu.yd. sand	Remarks
54ABa-37b	<0.001	<0.001 B	38:1	97	1½-3 foot depth.
38		.001 P	631:1	6	4-pan concentrate from Oil Creek at 100 foot barometric elevation.
39		< .001 P .001 B	332:1	11	2-pan concentrate from unnamed creek between Oil and Hamilton Creeks.
40		.001 P .001 B	264:1	14	2-pan concentrate from Hamilton Creek.
41		< .001 P < .001 B	223:1	17	2-pan concentrate from small creek behind cabin at White River.
42a	< .001	< .001 B	36:1	103	0-1½ foot depth. From present beach, west side of White River, 0.1 mile upstream from mouth.
42b	< .001	< .001 B	74:1	50	1½-3 foot depth.
43	< .001	< .001 B	43:1	86	0-2 foot depth. From 0.5 mile west of mouth of White River.
44a	.001	< .001 B	58:1	64	0-1½ foot depth. From beach in front of first cabin west of White River. Au-Ag assay value of unconcentrated sample $0.04 per cu.yd.1/.
44b	< .001	< .001 P	26:1	142	1½-3 foot depth.
45	< .001	< .001 P	23:1	161	0-2 foot depth. From present beach 0.5 mile west of cabin on Lawrence Creek.
46	< .001	< .001 P	12:1	308	0-2½ foot depth. From present beach 1 mile west of cabin on Lawrence Creek. Boulders encountered in pit at 2½ feet.
47a	< .001	< .001 P	32:1	116	0-1½ foot depth. From present beach about 0.3 mile east of mouth of Shokum Creek.
47b	< .001	< .001 P	34:1	109	1½-3 foot depth.
48a	< .001	< .001 P	24:1	154	0-1½ foot depth. From present beach about 0.1 mile west of mouth of Shokum Creek.
48b	< .001	< .001 B	164:1	23	1½-3 foot depth.
49a	< .001	< .001 B	56:1	66	0-2 foot depth. From present beach 2.5 miles west of cabin at Lawrence Creek.
49b	< .001	< .001 P	22:1	168	2-4 foot depth.
50a	< .001	< .001 P	20:1	185	0-1½ foot depth. Present beach near mouth of Crooked Creek.
50b	< .001	< .001 P	25:1	148	1½-3 foot depth.
51		.002 P .001 B	2,314:1	1.6	4-pan concentrate from Crooked Creek, 0.2 mile upstream from mouth.
52a	< .001	< .001 P	13:1	285	0-1½ foot depth. From present beach 3.5 miles west of cabin on Lawrence Creek.
52b	< .001	< .001 B	28:1	132	1½-3 foot depth.
53a	< .001	< .001 P	25:1	148	0-2 foot depth. 100 yards west of mouth of Fulton Creek.
53b	< .001	< .001 B	26:1	142	2-4 foot depth.
54a	< .001	< .001 P	15:1	247	0-2 foot depth. From present beach about 0.7 mile west of mouth of Fulton Creek.
54b	< .001	< .001 P	32:1	116	2-4 foot depth.
55a	< .001	< .001 I	36:1	103	0-4 foot depth. Vertical channel sample from bank representing second (?) beach at mouth of Felton Creek.
55b	< .001	< .001 I	42:1	88	4-8 foot depth.
56a	< .001	.001 I	158:1	23	0-2 foot depth. From present beach east of mouth of Felton Creek.
56b	< .001	< .001 I	340:1	11	2-4 foot depth.
57		.006 P .006 I	85:1	44	2-pan concentrate from Felton Creek about 100 yards upstream from second beach.
58		.003 P .002 B	143:1	26	2-pan concentrate from Fulton Creek, 300 yards upstream from present beach.

1/ Assayer: W. A. Attwood, Territorial Department of Mines, College, Alaska

Table 2.--Equivalent-uranium content of samples from the Cape Yakataga district, Alaska--Continued

Sample no.	Equivalent uranium (percent) Unconcentrated	concentrated	Concentration ratio	Pounds heavy minerals per cu.yd. sand	Remarks
54ABa-59a	<0.001	<0.001 P	8.5:1	435	0-2 foot depth. From present beach 0.5 mile east of Lawrence Creek.
59b	< .001	< .001 B	41:1	90	2-4 foot depth.
60a	< .001	< .001 B	34:1	109	0-1½ foot depth. From present beach 1 mile east of Lawrence Creek.
60b	< .001	< .001 B	25:1	148	1½-3 foot depth.
61	< .001	< .001 B	18:1	206	0-2 foot depth. From present beach about 0.25 mile west of Poul Creek.
62		.002 P .001 B	1,467:1	2.5	2-pan concentrate about 0.4 mile upstream from mouth of Poul Creek.
63		.002 P < .001 B	1,438:1	2.6	3-pan concentrate about 0.6 mile upstream from mouth of Shokum Creek.
64a	< .001	.001 P	31:1	119	0-2½ foot depth. Vertical channel sample from old stream channel fill in bluff at upper end of present beach, 100 yards west of Lawrence Creek. Channel fill cemented with iron oxide and fill overlain by clay.
64b	< .001	< .001 P	35:1	106	2½-5 foot depth.
64c	.001	< .001 B	75:1	49	5-7½ foot depth.
65		< .001 P .004 B	1,190:1	3.1	3-pan concentrate from Lawrence Creek, 0.25 mile upstream from cabin.
66		< .001 B	28:1	132	Sample taken from bottom 6 feet of 30-foot bluff, 500 yards west of cabin on Lawrence Creek. Less than 0.001 percent uranium on unconcentrated sample2/.
67	< .001	< .001 P	11:1	336	Sample from present beach south of cabin at Lawrence Creek.

2/ Chemical analysis: R. Moore, U. S. Geological Survey, Washington, D. C.

difficult metallurgical problem.

Available data indicate that there is little possibility of profitable placer operations for the recovery of radioactive minerals from the beach sands.

An oil sample, donated by Mr. Miller, from a large seep in the Poul Creek formation on Johnson Creek (outside of area of fig. 2, about 3 miles east of Poul Creek), was analyzed for uranium and other elements (table 3). The ash of this sample contains 0.014 percent uranium. Erickson, Myers, and Horr (1954) have shown that the ash of 78 samples which they analyzed, representing crude oils, asphalts, and petroliferous rocks, ranged from less than 0.001 percent to more than 10 percent uranium.

Table 3.--Analyses of the ash of oil from seepage on Johnston Creek, Yakataga district, Alaska.

Spectrographic 1/ (percent)					Chemical 2/ (percent)
X	.X	.0X	.00X	.000X	.0X
Al, Fe, Ti Pb, Sn	Ca, B, Co, Cr, Cu, Ni, V, Zn	Mn Mg, Na, Ce, La, Mo, Nd, Sc, Y, Zr	Ba, Sr, Yb	Be, Ga	U 3/

Sample on ignition gave 0.0074 percent ash by weight. All analyses were run on ash of sample.

1/ Analyses by P. J. Dunton, U. S. Geological Survey, Denver, Colorado
2/ Analysis by M. Curtis, U. S. Geological Survey, Denver, Colorado
3/ Ash contained 0.014 percent uranium.

Water samples for hydrogeochemical study were collected from streams draining the ridges north of the beach but no anomalous amounts of uranium were noted. Six of the samples were analyzed for uranium by the Geological Survey at the Washington laboratory, and ten of the samples collected at a later date were analyzed at the Denver laboratory. The samples contain an insignificant amount of uranium, from less than 0.1 to 0.2 parts per billion uranium. Residues of ten of the water samples were analyzed spectrographically at the Denver laboratory with the results shown in table 4.

Kodiak district

Geology

The Kodiak group of islands lies 20 miles east of the Alaskan Peninsula and 40 miles southwest of the Kenai Peninsula. The group consists of two main islands, Kodiak and Afognak, as well as numerous smaller islands, and extends for 177 miles in a northeastward direction (fig. 1).

The oldest rocks of the Kodiak group of islands consist of minor amounts of mica schist of probable Paleozoic age or older, and undifferentiated rocks of probable Triassic or Jurassic age that include slates, cherts, tuffs, and greenstone flows and their metamorphic equivalents (Capps, 1937). These rocks are overlain unconformably by a thick series of slate, graywacke, and conglomerate, probably mostly Cretaceous in age. Unconformably overlying this series is a thick series of estuarine sandstones and shales of Eocene(?) age. These in turn are unconformably overlain by sandstones of Miocene and Pliocene age.

The intrusive rocks consist of a large mass of diorite that lies axially along the center of Kodiak Island, and numerous smaller dikes, stocks, and sills. The igneous rocks are younger than the marine sediments of Cretaceous age and older than the fresh water beds of Eocene(?) age.

Table 4.--Spectrographic analyses of residues of water samples from the Yakataga district, Alaska
Analyses by N. M. Conklin, U. S. Geol. Survey, Denver

Field No. 1/ Laboratory No.	G 214266	H 214267	I 214268	J 214269	K 214271	L 214272	M 214270	N 214274	O 214275	P 214273
Elements (percent): XX	Ca, Na	--	Ca	Ca	Ca	Ca, Na	Ca, Na	Ca	--	--
X	Mg	Ca, Na	Mg, Na	Mg, Na	Fl, Mg Na	Mg	Mg	Mg, Na	Al, Fe Ca, Mg Na	Al, Fe Ca, Mg Na
.X	B	Fe, Mg	Al,Fe,B	Fe	Al, B	Fe, B	Fe, B	Fe, B	--	Ti
.0X	Fe, Al Sr	Mn, Al B, Pb Sr	Ti, Mn Ba, Cu Sr	Al, Mn B, Sr	Ti, Mn Ba, Cu Sr	Al, Mn Sr, V	Al, Cu Sr	Al, Mn Ba, Cu Pb, Sr	Ti, Mn B, Ba Cu, Sr	Mn, B Ba, Cu Sr, V
.00X	Mn, Ti Ba, Cu Pb, Sn V, Zr	Ti, Ba Cr, Cu Ni, V Zr	Cr, Ni Pb, V Zr	Ti, Ba Cu, Ni Pb, V Zr	Cr, Ni Pb, V Zr	Ti, Ba Cu, Ni Pb, Zr	Ti, Mn Ba, Ni Pb, V Zr	Ti, Ni V, Zr	Co, Cr Ni, Pb V, Zr	Co, Cr Ni, Pb Sc, Zr
.000X	Ag,Cr,Ni	Ag	Ag	Ag, Cr	Ag	Ag, Cr	Ag, Cr	Ag, Cr	Ag	Ag
trace (near threshold amount of element)	--	--	--	--	--	--	--	--	Ga	Ga
0 2/	Co, Ga Sc	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Co, Ga Sc, Sn	Sc, Sn	Sn
Total solids (parts per million)	225	75	200	150	125	325	150	150	225	300

1/ Letters refer to sample locations shown on figure 2.
2/ Looked for but not detected. Also, not detected were: P, K, As, Au, Be, Bi, Cd, Ce, Dy, Er, Gd, Ge, Hf, Hg, In, Ir, La, Li, Mo, Nb, Nd, Os, Pd, Pt, Re, Rh, Ru, Sb, Sm, Ta, Th, Tl, Te, U, W, Y, Yb, and Zn

During Pleistocene time the island group was intensely glaciated, which resulted in the present U-shaped valleys and deeply embayed coastline. Relatively minor amounts of glacial deposits are present because most of the debris was carried out to sea by the glaciers. Unconsolidated deposits of Recent age cover the floors of most of the valleys and form deltas at the mouths of the larger streams.

The mineralization, particularly sulfide mineralization, is rather widespread though very sparsely distributed on Kodiak, Afognak, Sitkalidak, and several of the other islands. No lode or placer mines are in operation, though placer mining has been carried on intermittently for a number of years on the beaches on the western side of Kodiak Island and also on Raspberry Island. Gold and a small amount of platinum have been recovered from these areas.

More detailed descriptions of the geology and mineralogy of the Kodiak Island group can be obtained from the reports by Becker (1898), Martin (1913), Maddren (1919), and Capps (1937).

Kodiak Island

Introduction.--Samples of rocks containing secondary uranium minerals, and with up to 1 percent equivalent uranium, were submitted to the Geological Survey early in 1954 by two prospectors from Kodiak. Subsequently, they submitted a sample of a pebbly conglomerate containing fluorescent meta-autunite; this sample was reported to be from another area on the island.

Objects of the 1954 reconnaissance of Kodiak Island were: (1) to study the sample locales and determine the grade and extent of mineralization; (2) to run radioactivity traverses of all the roads; and (3) to fly airborne radioactivity traverses of the coastline and portions of the interior of Kodiak Island and adjacent islands (fig. 4). The equivalent-uranium content of some of the samples collected in the Kodiak area is shown on table 5 and mineral analyses of beach sands are shown on table 6.

Pillar Mountain.--The two samples containing about 1 percent equivalent uranium submitted by Mr. Don Petacchi and his partner, George Cornelius of Kodiak, early in 1954, contained metatyuyamunite in a friable sandstone, and fluorescent meta-autunite in an iron-stained, sericitized orthoclase fragment. Mr. Petacchi stated that the samples were found as float at the base of the south side of Pillar Mountain, midway between the town of Kodiak and the Kodiak Naval Air Station (fig. 4).

Pillar Mountain is composed of metamorphosed, highly fractured shale of Late Cretaceous age cut by numerous quartz stringers. Personnel of the Geological Survey, accompanied by Mr. Petacchi, visited the reported sample area. The samples could not be duplicated and no sandstone or feldspar was found in the vicinity. Traverses of the area on three separate occasions disclosed no anomalous radiation.

Narrow Point.--A sample submitted by Mr. George Cornelius contained 0.005 percent equivalent uranium. The radioactivity was due to fluorescent meta-autunite disseminated in a pebble conglomerate. The location of the sample was given as Narrow Point (fig. 4), 25 miles south of the city of Kodiak, where marine sandstone of Tertiary age is exposed over an area of approximately 10 square miles. The site was visited in the company of Mr. Petacchi, but no anomalous radiation was detected. Representative samples were taken of the sandstone and conglomerate (Sample no. 73, table 5) around the prospect site, but no meta-autunite or other radioactive minerals were identified.

Beach sands.--The only gold placer activity of any extent has been on

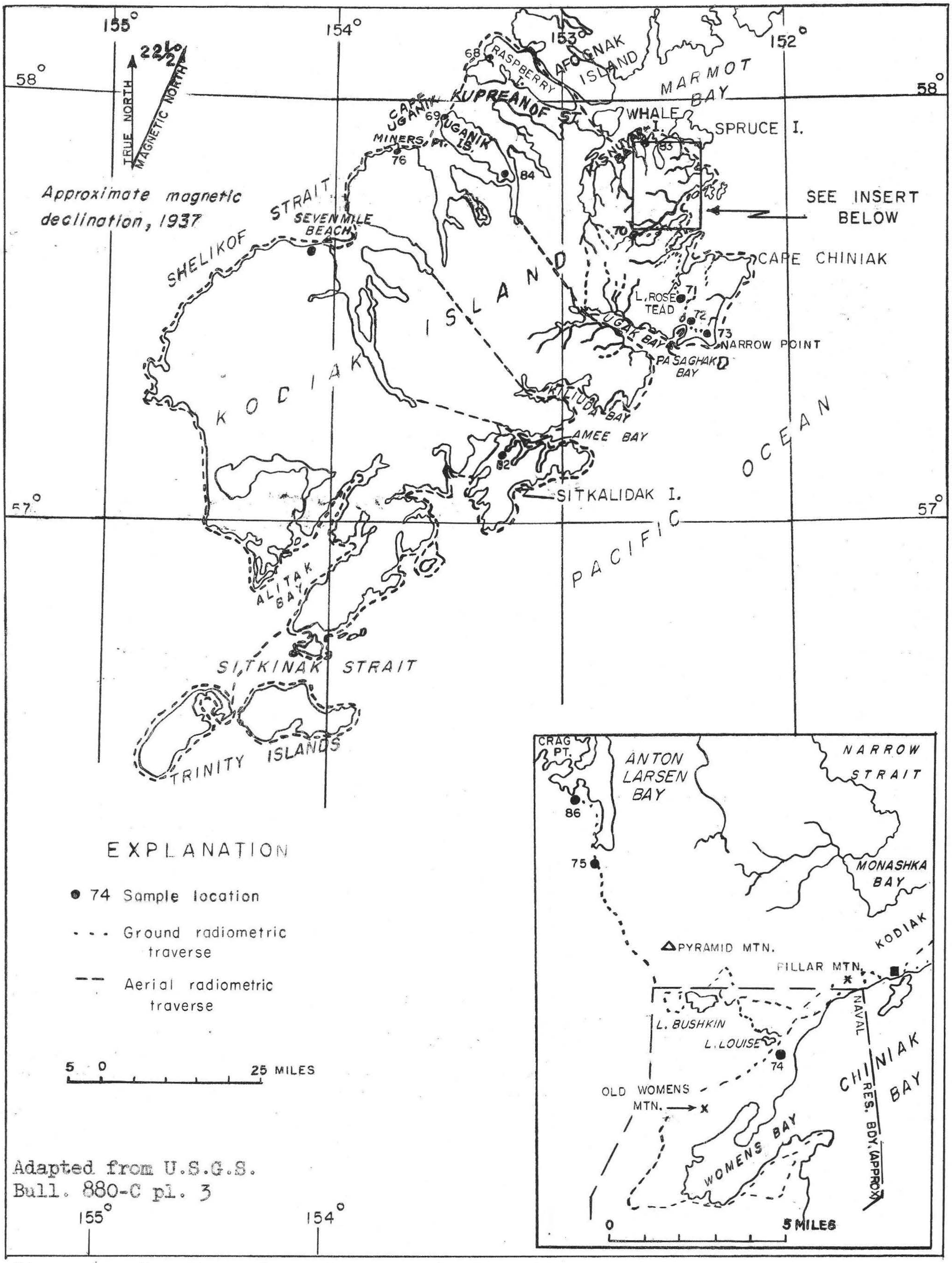

Figure 4.--Location of samples and radiometric traverses of Kodiak Island and adjacent islands.

Table 5.--Equivalent-uranium content of samples from Kodiak Island and adjacent islands, Alaska.

(The method of concentration used is shown by: P-sample concentrated by panning methods; B-sample concentrated by bromoform heavy liquid, sp. gr. 2.89; I-sample concentrated by methylene iodide heavy liquid, sp. gr. 3.3.)

Sample No.	Equivalent uranium (percent) Unconcentrated	Concentrated	Location and remarks
54ABa-68a	<0.001	<0.001 B	Beach sand, Raspberry Island, 0-1½ ft. depth, 0.0006 percent uranium 1/ on unconcentrated sample.
68b	< .001	< .001 B	Beach sand, Raspberry Island, 1½-3 ft. depth, 0.0006 percent uranium 1/ on unconcentrated sample.
69	.002	< .001 B	Beach sand, Cape Uganik, 0-1½ ft. depth.
70	.002	< .001 B	A concentrate from 100 lbs. of material from gravels of stream flowing into Middle Bay.
71	.001	--- -	Diorite dike on road to Pasagshak
72	.002	< .001 B	A concentrate from 100 lbs. of material from gravels of stream draining from east into south end of Lake Rose Teal.
73	< .001	--- -	Conglomerate from 1.8 miles north of buildings on Narrow Point.
74	< .001	--- -	Bedrock sample of shale from south side of road on south side of Lake Louise on naval reservation.
75	< .001	--- -	Shale from cliff on west side of road along west side of Anton Larsen Bay.
76a	< .001	< .001 B	Beach sand, Miner's Point, 0-1½ ft. depth, 0.0005 percent uranium 1/ on unconcentrated sample.
76b	.001	.001 P	Beach sand, Miner's Point, 1½-3 ft. depth, 0.0006 percent uranium 1/ on unconcentrated sample.

1/ Chemical analyses by Carmen Johnson, U. S. Geological Survey, Washington, DC.

Table 5.--Equivalent-uranium content of samples from Kodiak Island and adjacent islands, Alaska--Continued

Sample No.	Equivalent uranium (percent) Unconcentrated	Concentrated	Location and remarks
54ABa-77a	0.001	0.001 P	Sevenmile Beach, 0-1½ ft. depth, 0.002 percent uranium 1/ on unconcentrated sample.
77b	< .001	< .001 P	Sevenmile beach 1½-3 ft. depth, 0.0006 percent uranium 1/ on unconcentrated sample.
82	.001	.001 P	Sitkalidak Island, Amee Bay, Jack Creek. A grab sample assayed $1.40 per ton for Au 2/.
83	.002	< .001 P	Women's Bay lode. A grab sample assayed $1.04 per ton, mostly Ag 2/.
84	.001	< .001 P	South side of Uganik shaft, Uganik Island. No Au, Ag found 2/.
86	.003	.032 I	Diorite dike near road at Anton Larsen Bay, northwest of triangulation point Lar.

2/ Assayer: W. A. Attwood, Territorial Department of Mines, College, Alaska

Table 6.--Mineral determinations of beach sand concentrates from Afognak and Kodiak Islands, Alaska 1/

Mineral	Weight (percent) 1/ 54ABa-68a	54ABa-68b	54ABa-76a	54ABa-76b
Epidote	17	24	16	21
Garnet	tr 2/	1	tr	--
Hypersthene	29	16	32	33
Limonite-hematite	tr	tr	tr	tr
Magnetite	43	50	25	25
Opaque	tr	tr	--	--
Pyroxene, monoclinic	11	9	27	19
Zircon	tr	--	--	tr

1/ Mineral determination by Jerome Stone, U. S. Geol. Survey, Washington, D. C., on the methylene iodide heavy mineral fractions of the samples.

2/ tr - is less than 1 percent.

the western side of Kodiak Island and on Raspberry Island. Because very little information is available on these beach sands, samples of the sand were collected from Raspberry Island, Cape Uganik, Miner's Point, and Seven-mile beach (fig. 4) for a study of their radioactivity and heavy-mineral content (tables 5, 6). No appreciable radioactivity was noted in any of the samples.

Capps (1937, p. 172) has explained the auriferous beach placers as the result of wave erosion of the steep shoreline, which consists of extensive deposits of glacial till and outwash gravel that contain very minor amounts of gold.

Radiometric traverses.--Radioactivity traverses were made along all roads leading out of Kodiak. Traverses by foot were made along the crest of Old Women's Mountain and Pillar Mountain, as well as around the base of Pillar Mountain. Airborne scintillation traverses were made along the coast of Kodiak Island and parts of adjacent islands, and three single-line traverses were made across the intrusive diorite core of Kodiak Island (fig. 4). No anomalous radiation was detected on any of the traverses.

For the road traverse, scintillation equipment connected to an ammeter was used in a jeep. For the airborne traverses, the single 3-inch sodium iodide, thallium-activated crystal was connected to an Esterline-Angus recorder, and mounted in a U. S. Navy airplane. The traverse was made at an elevation of 200-300 feet above the surface. The deep canyons, precipitous shoreline, and generally alpine nature of Kodiak Island are not suitable for airborne radiometric traverses. It is believed, therefore, that the airborne data are inconclusive and do not necessarily prove the absence of uranium or thorium of possible commercial grade.

Hydrogeochemical investigation.--To supplement the road-traverse data and localize possible radioactive areas, water samples were collected from streams near the roads in the Kodiak area. The chemical analyses of the samples indicate about 1 part per billion uranium and do not reveal any significant anomalies.

Skwentna district

Geology

In the Skwentna district of the Shirley Lake - Long Lake area, granitic intrusive rock of probable Late Cretaceous age has been mapped by Capps (1935) as a wedge-shaped mass lying between the Happy River on the north and the Skwentna River on the south. Capps has described an undifferentiated complex of Jurassic or Cretaceous age that crops out in the canyons of the Happy and Skwentna Rivers; above the mouth of the Happy River he noted shale and graywacke with some limy beds. He also described rock types, in these areas, that locally contain admixtures of tuffaceous material. Granite crops out near the headwaters of the Skwentna River and north of Shirley Lake.

Shirley Lake area

Introduction.--In 1954, Bertram Rick of the Alaska Exploration and Development Company, Anchorage, Alaska, submitted samples to the College laboratory of the Geological Survey that he received from a prospector, Edgar Curtis. These samples contained up to 0.02 percent equivalent uranium. The samples were from the Shirley Lake area, Skwentna district, in the northwestern corner of the Tyonek quadrangle, and approximately 120 miles northwest of Anchorage, Alaska (fig. 1). Access to the area is by float plane.

The discoverers tried to keep the source of their radioactive material a secret until they had time to prospect the area thoroughly. Newspaper stories, however, soon aroused prospector interest in the area, and all the ground adjacent to Shirley Lake and some ground at nearby Long Lake (about 0.5 mile to the northwest) were staked for uranium. A brief investigation was made in the company of the original locators to determine the extent of radioactivity.

Present study.--The discoverers of the Shirley Lake radioactive area formed the United Six Mining Company to further explore their claims. Accompanied by one of the original locators, the authors spent one day late in the field season in examining and making a radiometric traverse of the claims. No anomalies were detected, and the several prospectors traversing the area indicated their disappointment at the low radioactivity readings they obtained.

The samples from the Shirley Lake - Long Lake area that show maximum radioactivity are from iron-stained altered rocks that contain up to 0.028 percent uranium and 0.70 percent P_2O_5. A spectrographic analysis of the most radioactive sample (54A93) is listed in table 7. A thin layer of volcanic ash collected from the north side of Shirley Lake contains less than 0.001 percent uranium.

An examination of a thin section of the more radioactive rock indicates that it is a tuffaceous graywacke with about 90 percent detrital volcanic material. The dominant feldspar is andesine. Sericite is abundant and the sample also contains apatite(?), calcite, chlorite, chalcedony(?), epidote, oligoclase, goethite, hornblende, and magnetite dust.

The feldspar is highly shattered, corroded, strongly zoned and occurs in a finer feldspar matrix. Chlorite appears to replace the feldspar. A "veinlet" with a sharp but irregular contact contains finer-sized feldspar also with a feldspar matrix, and a greenish to opaque unidentified material. Some flowage is noted around the larger feldspar crystals.

Table 7.--Spectrographic analysis of a radioactive sample from the Shirley Lake area, Skwentna district, Alaska.

Sample No.	54A93
Laboratory No.	138503
Over 10 percent	Al, Si
5-10	Na
1-5	Fe, K, Ca, Mg, Ti
0.5-1	Co
.1-.5	Mn, As, Cu, Sr, P
.05-.1	Ba
.01-.05	B, Mo, V
.005-.01	Zr, Ni, Pb, Ga
.001-.005	Sc, Cr, La, Y
.0005-.001	--
.0001-.0005	Yb
.00005-.0001	Be

Spectrographic analyses by Katherine E. Valentine, U. S. Geological Survey Washington, D. C.

Nuclear-emulsion and alpha-plate studies of samples exposed for 60 days did not reveal the source of the radioactivity. No concentration of radioactivity is effected by heavy-liquid separations.

McGrath district

Geology

The Nixon Fork mines in the McGrath district (fig. 1), are located on a low range of hills composed of limestone of Paleozoic age, and sandstone, shale, and slate of Late Cretaceous age (Brown, 1926). These rocks have been intruded by quartz monzonite of probable Eocene age. The lode deposits of the district are contact metamorphic deposits of copper and gold in the limestone along the limestone-monzonite contact. Allanite, parisite, and radioactive idocrase, as disclosed by the 1949 reconnaissance, (see Nixon Fork area) all lie in this contact metamorphic zone.

More detailed descriptions of the geology, mining, and minerals of the McGrath mining district are contained in the reports by Brown (1926), and Mertie (1936).

Nixon Fork area

Introduction.--Routine radioactivity scanning of the U. S. Geological Survey's Alaskan placer-concentrate file, prior to 1949, disclosed the presence of uraniferous thorianite associated with bismuth and copper in concentrates from the Nixon Fork area, Medfra quadrangle, west-central Alaska (fig. 1). This association suggested that the area might be favorable for the occurrence of high-grade uranium lode deposits. Therefore, in 1949 White and Stevens conducted a reconnaissance of the area to determine its uranium possibilities. This reconnaissance disclosed the presence of allanite, parisite, and radioactive idocrase in limestone along a limestone-monzonite contact. The bedrock source of the uraniferous thorianite was not found. Although no high-grade uranium lode deposits were discovered, it was felt that the work was inconclusive due to the thick moss cover over most of the area which greatly limited the effectiveness of the radiometric traversing. Work was accordingly recessed until such time as new techniques or reopening of the mines would make possible an effective reconnaissance of the area.

Present study.--The association of the radioactive minerals with copper suggested that geochemical methods might be of use in detecting lode sources of these metals through the thick moss cover (average of about 3 feet) in the Nixon Fork area. Personnel of the Geological Survey spent several days, late in the 1954 field season, taking soil samples along the limestone-monzonite contact. Samples were taken in the immediate vicinity of the Crystal mine where most of the vegetation had been bulldozed away to expose the bedrock rubble, and also in a prospect trench, downslope to the west of the Crystal shaft. The samples that were analyzed for copper, lead, and zinc showed anomalies for all three metals; the largest and most persistent anomalies were given by the zinc.

A water sample collected from the headwaters of Ruby Creek, tributary to Nixon Fork, upstream from the mining camp's water trough, contains a relatively high content of uranium (20 parts per billion). At the time of sampling, the water had a temperature of 5° C. and a pH of 6. The drainage area above the sample location is in the monzonite and heavily covered by vegetation; some drainage may possibly be coming from the Whalen mine dumps where radioactive minerals are exposed. Topographically, however, it appears that the drainage from the Whalen mine empties southward, toward Hidden Creek. Water sampling seems to have possibilities in the reconnaissance for uranium in the Nixon Fork district, but further sampling is necessary before the method can be properly evaluated.

Two grab samples from the Nixon Fork area submitted by prospectors near the end of the 1954 field season contained 0.026 and 0.06 percent equivalent uranium. The radioactivity of the samples is due principally to thorium in the mineral allanite. The allanite is strongly pleochroic and ranges from dark brown or black brown to violet, with r>v strong, medium - large 2V, positive, and beta index about 1.74. The results of a spectrographic analysis by Katherine E. Valentine, U. S. Geological Survey, of hand-picked grains of allanite from near the Whalen property is given in table 8.

Table 8.--Spectrographic analysis of allanite from Nixon Fork district, Alaska.

Laboratory No.	140,590
Over 10 percent	Al, Si
5-10	Ca, La, Ce
1-5	Fe, Nd, K
0.5-1	Mg, Pr, Th
.1-0.5	P
.05-.1	Mn
.01-.05	Ga, Ti, Sr, Y, Ni, B, Cu
.005-.01	Cr, Pb
.001-.005	Ba, Yb, V
.0005-.001	--
.0001-.0005	Ag

While in the area, the party also made a scintillation traverse of the 460-foot level of the Garnet shaft of the Nixon Fork mine that contains gold and copper along the limestone-monzonite contact. (The Garnet shaft is about 0.1 mile southwest of the Crystal shaft, also part of the Nixon Fork

Mine.) The contact zone, heavily coated with dust, was readily distinguished with the use of the scintillation counter. Readings ranged from 0.002 to 0.004 mr/hr on the limestone and from 0.006 to 0.008 mr/hr on the monzonite. Maximum readings of as much as 0.15 mr/hr were obtained on malachite-enriched zones.

At the time of the investigation in 1954 the only shaft open was the Garnet shaft in which the 460-foot level was traversed; the other levels were inaccessible. Prospectors have become interested in the area, but a heavy cover of vegetation shields most of the possible radiation. Therefore, the best chance of locating uranium deposits, if any are present in the Nixon Fork mining district, appears to be in the operation of the lode gold-copper producing mines of the area with the attendant radiometric examination of various levels and adits as mining progresses.

Hot Springs district

Geology

Mertie (1934) has described the geology of the Hot Springs-Rampart districts. The oldest rocks are the slates of pre-Middle Ordovician age that form the low hills in the southeastern part of the district. Successively younger formations crop out to the northwest; among these are the Tolovana limestone of Middle Silurian age and a series consisting of slate, graywacke and greenstone of Devonian age. Three units of Mississippian age are present in the area; a complex of slate, shale, schist, and quartzite crops out north of the Yukon-Tanana divide; limestone forms the divide in the east-central part of the district; and the Rampart group, composed of bedded volcanic rocks and associated meta-sedimentary strata, crops out between the divide and the Yukon River. Slate, quartzite, and schist of Cretaceous age crop out between the Tanana River and the divide that separates the Tanana and Yukon Rivers, and form the hills surrounding the Tofty tin belt. Shale, sandstone, conglomerate, and coal of Tertiary age occur in a few small isolated patches near the Yukon River.

In some of the valleys and lowlands of the Tofty, Eureka, and Rampart districts there are buried deposits of late Tertiary or early Quaternary gravels. These gravels are overlain by 5 to 90 feet of frozen gravels of Pleistocene age. Gravels of Pliocene age are found on the tops of ridges at altitudes up to 1,500 feet in the Rampart district.

The principal igneous rocks of the area are the granites and monzonites of Tertiary age that form Hot Springs Dome, Elephant Mountain (about 7 miles northeast of Eureka), Roughtop Mountain, and the "ramparts" along the Yukon River. Small bodies of mafic intrusive rock are found in the headwaters area of Patterson Creek.

Tofty tin belt

Introduction.--The Tofty tin belt is 10 miles northwest of Manley Hot Springs in the Manley Hot Springs - Rampart districts, Tanana and Kantishna River quadrangles, east-central Alaska (fig. 1). Commercial gold - tin placers are found in a narrow, northeastward-trending belt extending from Woodchopper Creek on the west to Killarney Creek on the east, a distance of about 12 miles (fig. 5).

The presence of certain radioactive minerals in the placers of the Tofty district has been known for some time. Waters (1934) mentioned eschynite, monazite, and xenotime in concentrates from the placers of the district. In 1947, further studies by Moxham (1954) of concentrates from the area indicated ellsworthite, columbite, and zircon in addition to the

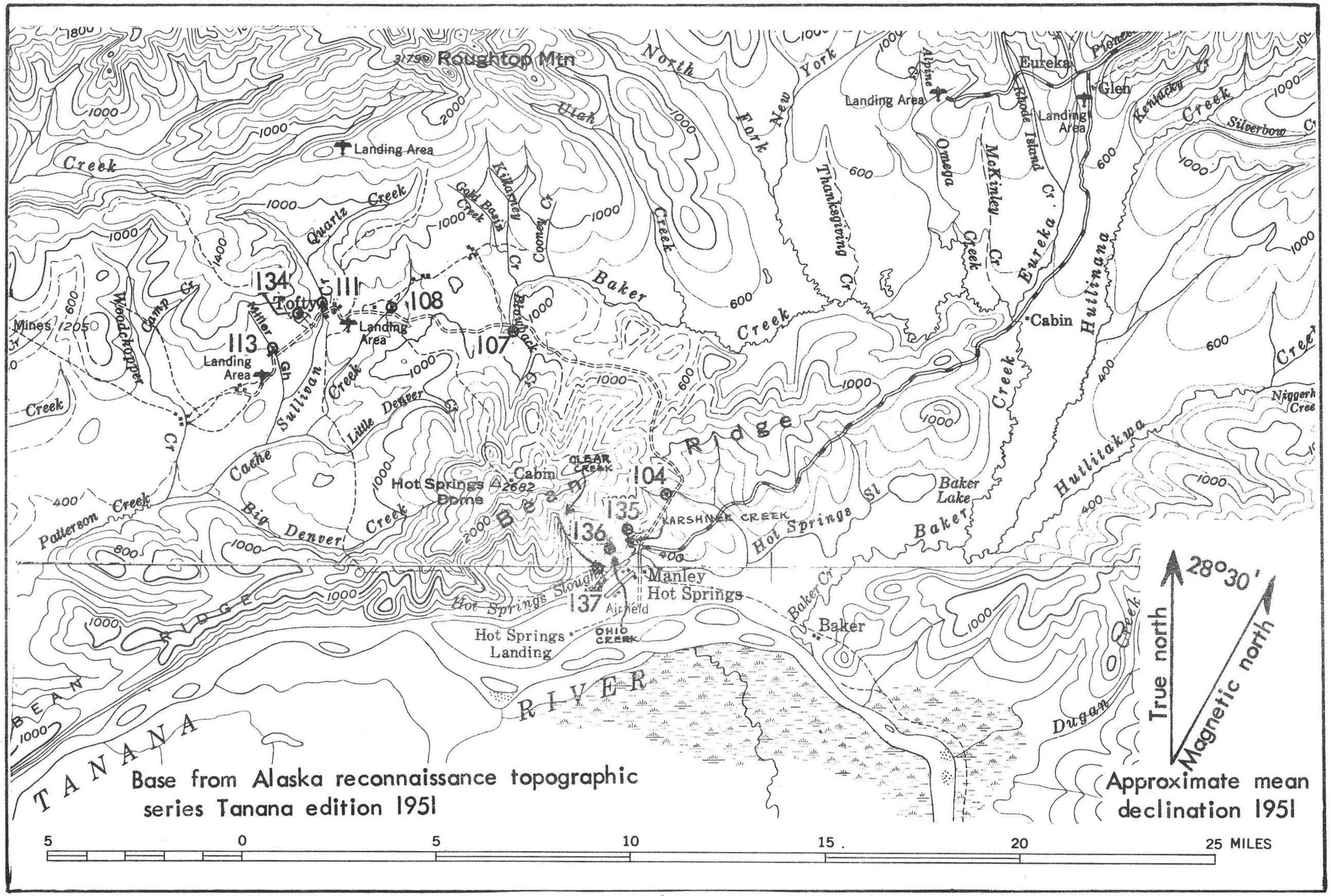

Figure 5.-- Locations of water samples, Tofty and Manley Hot Springs areas, Hot Springs District, Alaska

overburden of permanently frozen muck and gravels that restricts the circulation of ground waters than to absence of radioactive materials in the underlying rocks. Not enough work was done, however, to determine if this was the only factor involved in the low percentages of niobium and tin in the soil.

The present data available on the gold - tin placers of the Tofty area indicate that the radioactive mineral content is probably too low to make recovery of it economically possible, even as a byproduct of the tin and gold operations.

Manley Hot Springs

Introduction.--Uraniferous goethite float found near the town of Manley Hot Springs by a prospector, Leo Mark Anthony, contains up to 0.054 percent uranium. Many large pieces of the radioactive goethite, weighing several pounds, have been found subsequently by Mr. Anthony in several of the valleys north of the town (fig. 5).

Present study.--A radiometric reconnaissance of many of the valleys was made with Mr. Anthony to locate, if possible, this goethite or other radioactive minerals in place. Hand trenching methods were used along several of the streams but bedrock was not reached, and no other rocks similar to the original radioactive geothite float samples were found. Stream gravel concentrates contain as much as 0.04 percent equivalent uranium, but the source of the radioactivity was not determined. Decomposed granite and pieces of black tourmaline-bearing rock, up to about an inch in diameter, were noted at the orifices of several warm springs in the area.

Hydrogeochemical investigations

A luxuriant growth of ferns in most of the valleys examined indicates the widespread presence of warm waters. Many of the streams, however, are cool at the surface, probably owing to admixture of the ascending hot waters with the surface runoff.

Nine water samples were collected from creeks and hot springs in the Hot Springs district for analyses of their uranium content, and spectrographic analyses were also made on residues of the samples (table 9). A mineral analysis of water from a hot spring at Manley Hot Springs is compared in table 10 with an earlier analysis of a hot spring sample collected in the same area by G. A. Waring (1917). No appreciable anomalies were found. Two samples, one from Manley Hot Springs on Karshner Creek (135) the other from Ohio Creek (136), west of Karshner Creek (fig. 5), contain the maximum recorded uranium values, 4 parts per billion.

Circle district

Geology

Mertie (1937) has described the geology of the Circle district, which in the area of Circle Hot Springs includes Birch Creek schist of Precambrian age, intruded by granite of Mesozoic(?) age.

Introduction.--Radioactivity has been reported in the Circle district - Circle Hot Springs area (fig. 1) by West and Matzko (1953) and (1954), and White and Tolbert (1954). The radioactive minerals identified are allanite, monazite, uranothorianite, xenotime, and pyrochlore-microlite.

Present study.--Water samples were collected for chemical analysis from several of the streams in the district and also from the hot spring at

Table 9.--Analyses of residues and uranium content of water samples from the Hot Springs district, Alaska.

Sample No. 3/	Percent 1/						Total Solids	Uranium 2/ Content	Location
	XX	X	.X	.0X	.00X	.000X	(ppm)	(ppb)	(shown on fig. 5)
104 214281	--	Ca, Mg, Na	Fe	Al, Mn, B, Ba, Sr	Ti, Cr, Cu, In, Ni, Pb, V	Ag	100	1	First stream north on Tofty road, above junction with Eureka road.
107 214282	--	Ca, Mg, Na	Fe	Al, Mn, B, Ba, Sr	Ti, Cr, Cu, In, Ni, Pb, V, Zr	Ag	100	1	Blowback Creek, 20 feet upstream from Tofty road.
108 214283	--	Ca, Mg, Na	Fe	Al, Mn, Ba, Sr	Ti, B, Cu, Ni, V, Zr	Cr	250	1	Cache Creek, about 10 feet upstream from Tofty road.
111 214284	--	Ca	Al, Fe, Mg, Na	Ti, Mn B, Sr	Ba, Cr, Cu, Ni, V, Zr	--	200	<1	Sullivan Creek, upstream from Tofty road.
113 214285	--	Ca, Mg, Na	Fe, Zn	Al, Mn, Ba, Cd, In, Sr, V	Ti, B, Cu, Ni, Pb, Sn, Zr	Ag, Co, Cr	175	1	Miller Creek, upstream from road to landing area.
134 214286	--	Ca, Mg, Na	Fe, Mn	Al, B, Ba, Sr	Ti, Cr, Cu, Ni, V, Zr	Co	225	<1	Near Tofty, Idaho Gulch, upstream from placer mine tailings.

1/ Spectrographic analyses by N. M. Conklin, U. S. Geol. Survey, Denver, Colorado.
2/ Chemical analyses by J. W. Wilson, U. S. Geol. Survey, Denver, Colorado.
3/ Three digit numbers are field numbers as shown in fig. 5. Six digit numbers are Denver laboratory numbers.

Table 9.--Analyses of residues and uranium content of water samples from the Hot Springs district, Alaska (continued)

Sample No. 3/	Percent 1/						Total Solids	Uranium Content 2/	Location
	XX	X	.X	.0X	.00X	.000X	(ppm)	(ppb)	(shown on fig. 5)
135 214278	Na	Ca, K	Mg	Al, Fe, B, Ba, Li, Sr, Zn	Ti, Cr, Cu, In, Ni, Pb, V, Zr	Mn	450	4	Manley Hot Springs, center pool. Temperature 122° F.
136 214279	Na	Ca, K	Mg, Li	Al, Fe, B, Ba, Sr, Zn	Ti, Mn, Cu, In, Pb, V	Cr, Ni	400	4	Ohio Cr., west of Manley Hot Springs, about 50 yds. upstream from road (town's source of drinking water).
137 214280	Ca	Na, K	Fe, Mg Ba, Zn	Al, Ti, B, Cu, In, Pb, Zn	Mn, Ag, Cr, Ni, Sn, V, Zr	Co	50	2	Clear Cr., about 20 yds. upstream from Hot Spring slough.

1/ Spectrographic analyses by N. M. Conklin, U. S. Geol. Survey, Denver, Colorado.
2/ Chemical analyses by J. W. Wilson, U. S. Geol. Survey, Denver, Colorado.
3/ Three digit numbers are field numbers as shown in fig. 5. Six digit numbers are Denver laboratory numbers.

Table 10.--Chemical analyses (in ppm) of samples of hot spring waters from Manley Hot Springs, Alaska.

	A 1/	B 2/
Silica (SiO_2)	52	59
Iron (Fe)	0.00 3/	0.80 4/
Copper (Cu)	.00	--
Manganese (Mn)	.00	--
Calcium (Ca)	9.1	9.1
Magnesium (Mg)	.0	.9
Sodium (Na)	117	121
Potassium (K)	6.8	8.2
Bicarbonate (HCO_3)	83	86
Carbonate (CO_3)	0	.0
Sulfate (SO_4)	41	48
Chloride (Cl)	124	120
Nitrate (NO_3)	.2	--
Dissolved solids		
Sum	391	409
Residue on evaporation at 180° C.	--	417
Hardness as $CaCO_3$	23	27
Temperature (°C.)	50	52
pH	6.5	--

1/ Lowermost spring, bubbling, possibly very near same spring from which Waring collected his sample, described in column 2. The locations of the springs in 1915, as noted by Waring, cannot be reconciled with the present locations of the 1 active, and 2 only slightly active hot springs. Granite bedrock is exposed in the area of the springs. Sample collected September 1, 1954 by J. J. Matzko; analyzed by G. D. Whetstone.

2/ Sample collected August 5, 1915 by G. A. Waring; analyzed by R. B. Dole and Alfred A. Chambers (See Waring, 1917.)

3/ Fe^{++}

4/ $Fe_2O_3 + Al_2O_3$

Circle Hot Springs (table 11). The mineral analysis of the hot spring sample is compared with that of a sample collected earlier by Waring (1917). The chemical uranium content of the hot spring water is 0.2 parts per billion (Matzko and Bates, 1955).

Fairhaven district

Geology

The geology of the Fairhaven district, which includes Candle, has been described by Moffit (1905). The bedrock along Candle Creek is predominantly a locally graphitic mica schist cut by small quartz stringers. Small dikes and sills of rhyolite also cut the schist. The distribution of float material indicates that granite must form a large portion of the hill lying between Candle Creek and the Kiwalik River.

Both creek and bench gravels occur along Candle Creek and its tributaries (Moffit, 1905). The creek gravels are 12 to 18 feet thick and are covered by 10 to 20 feet of tundra; the bench gravels are 4 to 10 feet thick and covered by 5 to 10 feet of tundra. All the ground is permanently frozen a few feet below the surface.

Candle Creek area

Introduction.--Candle Creek is a northeastward-flowing stream that empties into the Kiwalik River at the town of Candle, Candle quadrangle west-central Alaska (fig. 1). The area is in the northeastern part of the Seward Peninsula in the Fairhaven district. As there are no roads into the area, access is by airplane from Nome, about 140 miles to the southwest, or from Kotzebue about 60 miles to the northeast.

Routine scanning of the Alaskan placer sample file of the U. S.

Table 11.--Chemical analyses (in ppm) of water samples from the Circle Hot Springs area, Circle quadrangle, Alaska.

	Laboratory number				
	2035 1/	2036 2/	2038 3/	2040 4/	----5/
Silica (SiO_2)	7.8	6.0	9.7	86	82
Iron (Fe)	.10	.22	.37	0.08	1.3
Aluminum (Al)	--	--	--	--	3.7
Calcium (Ca)	50	26	5.0	21	29
Magnesium (Mg)	10	7.2	.3	1.7	2.1
Sodium (Na)	2.5	4.5	1.3	263	248
Potassium (K)	1.6	1.6	1.0	14	8.6
Carbonate (CO_3)	0	0	0	0	.0
Bicarbonate (HCO_3)	79	57	12	168	173
Sulfate (SO_4)	105	54	3.3	100	98
Chloride (Cl)	0	0.8	0.5	257	252
Fluoride (F)	0.8	0.2	0.4	10	--
Nitrate (NO_3)	1.1	0.9	1.8	0.2	.0
Total dissolved solids					
Sum	218	129	30	836	807
Residue on evaporation at 180° C.	--	--	--	--	816
Hardness as $CaCO_3$					
Noncarbonate	101	47	4	0	--
Total	166	94	14	59	81
Temperature (°C.)	--	--	--	55	55
pH	7.0	6.8	6.0	7.4	--

1/ Deadwood Creek, 50 yards below the mouth of Switch Creek.

2/ Birch Creek, upstream from intersection of creek and the Circle road.

3/ Portage Creek, upstream from Hank Martin's placer claims.

4/ Circle Hot Springs, sample collected from small spring emerging from hillside, in decomposed granite, behind, and to the south of the resort building.

Note: Samples 1 to 4 were collected July 7, 8, 1953 by J. J. Matzko; analyzed by Russel L. McAvoy.

5/ Circle Hot Springs; northernmost spring. Sample collected July 12, 1915, by G. A. Waring; analyzed by S. C. Dinsmore: U. S. Geol. Survey Water-Supply Paper 418.

Geological Survey in early 1945 disclosed a sample from Candle Creek that contained 5 percent equivalent uranium (Harder and Reed, 1945). The radioactive mineral was identified by X-ray diffraction data as uranothorianite. An investigation by the Geological Survey during July 1945 did not locate the bedrock source of this mineral (Gault, Killeen, West, and others, 1953). These authors also report that in other studies of the radioactivity of the area to the south around Sweepstakes Creek, Granite Mountain, the headwaters of the Peace River, and the Buckland-Kiwalik divide, radioactive minerals have a rather wide distribution in the stream gravels. Subsequently, scintillation traverses of the area were made by the Geological Survey in the course of airborne radioactivity and magnetic surveys of portions of Alaska during the 1954 field season. Several radioactivity anomalies were found in the Candle area and the area of the Buckland-Kiwalik divide. A ground party in 1954 checked the anomalies in the more readily accessible Candle area; further work in the Buckland-Kiwalik divide area was postponed until a later date.

Present study.--The airborne scintillation-counter traverse of the Candle area disclosed two sharp radioactivity anomalies on the ridge between the Kiwalik River and Candle Creek, just south of their junction, and one on the ridge north of Jump Creek, a west tributary of Candle Creek (fig. 6). It was thought that since part of these anomalies are in the drainage basin of Candle Creek where radioactive minerals are known to occur in the gravels, the anomalies might give a clue to the location of the bedrock source of the radioactive minerals.

The anomalies near the Kiwalik River and the group of anomalies near the head of Blank Creek, an east tributary of Candle Creek, were investigated. It was found that the anomalies near the Kiwalik River were caused

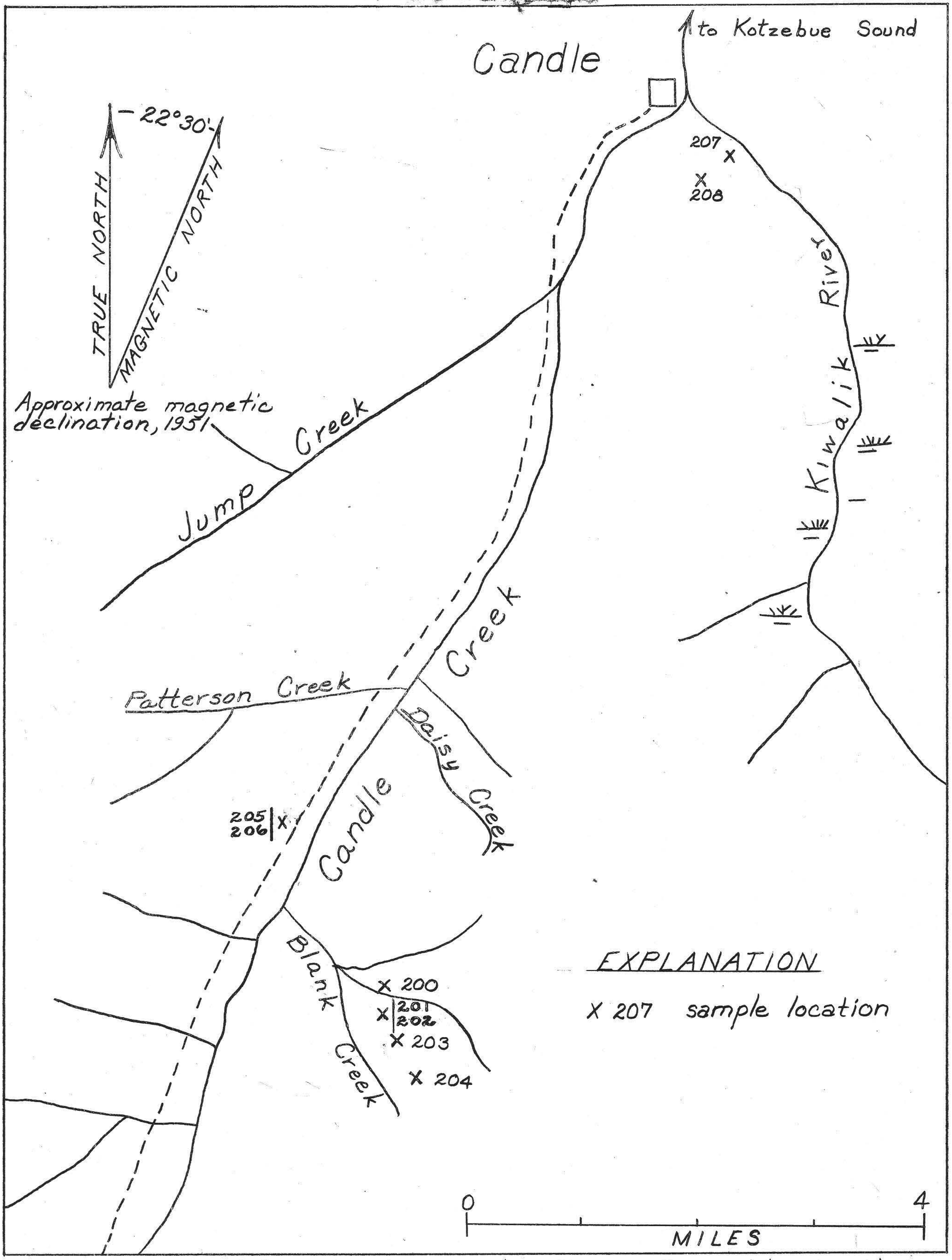

Figure 6.-- Sketch map showing locations of samples in the Candle Creek area, Fairhaven district, Alaska

by monzonite boulders exposed as float, surrounded by a tundra-covered area, and those near the head of Blank Creek were caused by patches of soil from which the shielding vegetation cover had been removed, probably by frost action. Some of these uncovered zones were pebbly at the surface, others had only a fine soil at the top, but probing beneath the surface in both types exposed pieces of granitic rock that is believed to be the source of the radioactivity anomalies.

The equivalent-uranium content of all samples collected in the Candle Creek area is listed in table 12. Sample 208 with 0.005 percent equivalent uranium for the unconcentrated monzonite and 0.006 percent equivalent uranium for the iodide heavy concentrate (sp. gr.>3.3) of the sample contains the maximum radioactivity noted. The heavy-mineral fraction is composed essentially of clinozoisite, hematite, ilmenite, magnetite, pyrite, rutile, and zircon, and the principal minerals of specific gravity less than 3.3 are apatite, microcline, oligoclase, orthoclase, and phlogopite. No pleochroic halos were noted in any of the phlogopite examined and alpha plates exposed for 4 weeks indicate that the zircon and an unidentified opaque material are only slightly radioactive.

From the results of this and previous studies it is believed unlikely that there will be any economically profitable production of radioactive material from the drainage area of Candle Creek. The sample from Candle Creek that contained 5 percent equivalent uranium was probably a dredge concentrate and therefore represented an extremely high concentration ratio. Work to date indicates that the uranothorianite probably occurs as an accessory mineral in the granitic rocks of the area and represents such a small fraction of the granitic material as to make its recovery unprofitable.

Table 12.--Equivalent-uranium content of samples from the Candle Creek area, Fairhaven district, Alaska.

Sample no.	Equivalent uranium (percent) Unconcentrated	Concentrated		Remarks
54AMz-200	--	0.002	P	Soil sample, Blank Creek
-201	< 0.001	--		Soil sample, Blank Creek
-202	.003	.004	P	Soil sample, Blank Creek
-203	.004	.005	P	Weathered biotite-hornblende granite found as float on Blank Creek
-204	.001	.001	I	Green schistose rock found as float on Blank Creek
-205	.001	.001	I	Soda rhyolite bedrock from west side of Candle Creek, in contact with fissile black shale
-206	.005	--		Weathered soda rhyolite with phenocrysts of soda sanidine. Bedrock west side of Candle Creek
-207	.005	.004	I	Monzonite float, Kiwalik River
-208	.005	.006	I	Monzonite float, Kiwalik River

P - sample concentrated by panning.
I - sample concentrated by methylene iodide, sp. gr. 3.3.

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