GEOLOGICAL SURVEY CIRCULAR 348

RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN EASTERN ALASKA

1952

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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By Arthur E. Nelson, Walter S. West, and John J. Matzko

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Washington, D. C., 1954

Free on application to the Geological Survey, Washington 25, D. C.

Figure 1. —Index map of eastern Alaska showing areas investigated in 1952.

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ABSTRACT

Reconnaissance for radioactive deposits was conducted in selected areas of eastern Alaska during 1952. Examination of copper, silver, and molybdenum occurrences and of a reported nickel prospect in the Slana-Nabesna and Chisana districts in the eastern Alaska Range revealed a maximum radioactivity of about 0.003 percent equivalent uranium. No appreciable radioactivity anomalies were indicated by aerial and foot traverses in the area.

Reconnaissance for possible lode concentrations of uranium minerals in the vicinity of reported fluorite occurrences in the Hope Creek and Miller House-Circle Hot Springs areas of the Circle quadrangle and in the

Fortymile district revealed a maximum of 0.055 percent equivalent uranium in a float fragment of ferruginous breccia in the Hope Creek area; analysis of samples obtained in the vicinity of the other fluorite occurrences showed a maximum of only 0.005 percent equivalent uranium.

No uraniferous lodes were discovered in the Koyukuk-Chandalar region, nor was the source of the monazite, previously reported in the placer concentrates from the Chandalar mining district, located. The source of the uranothorianite in the placers at Gold Bench on the South Fork of the Koyukuk River was not found during a brief reconnaissance, but a placer concentrate containing 0.18 percent equivalent uranium was obtained. This concentrate is about 10 times more radioactive than concentrates previously available from the area.

EASTERN ALASKA RANGE
By Arthur E. Nelson

An appraisal of uranium possibilities in Alaska made in 1950-51 (Wedow and others, 1951) indicated that certain mineral deposits in several localities in the eastern Alaska Range were favorable for the occurrence of uranium ores. In the summer of 1952, seven localities (nos. 1-7, fig. 1) in the Slana-Nabesna and Chisana districts in the eastern Alaska Range were investigated for possible radioactive deposits on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. The work was done by the writer and Richard S. Smith, geologic field assistant. The investigation consisted of radioactivity traverses of mines and prospects in and around mineralized zones, contacts, and aureoles. Specific outcrop tests were made at various points along the traverses. Supplemental check samples were collected for radioactivity analysis and mineralogic study. These included channel and wall-rock samples of veins and mineralized zones, and samples of ore dumps and various rock types. Concentrates were taken of certain stream gravels to determine if radioactive minerals were being released from the bedrock within the specific drainage basins. In addition, an airborne radioactivity traverse was made over the Orange Hill area and other larger mineralized zones that were otherwise inaccessible with the equipment available.

Standard commercial portable survey meters adapted for a variety of probes were used to detect radioactivity. Individual outcrop tests were made with a 6-inch beta-gamma probe; ground traverses were made with the survey meter and a 2- x 20-inch gamma probe lashed to a packboard; and airborne traverses were made with a probe consisting of six 2- x 40-inch gamma tubes, connected in parallel, coupled to the survey meter, and carried in light, fixed-wing aircraft. (See Wedow, 1951.)

Geology

The Slana-Nabesna and Chisana districts lie in that part of the eastern Alaska Range known as the Mentasta and Nutzotin Mountains (fig. 1). These mountains merge near the Nabesna River, a northeastward flowing glacial stream originating in the Wrangell Mountains to the southwest. At Mentasta Pass in the Mentasta Mountains the Alaska Range trends southeastward toward the international boundary. On the northeast the range is bordered by the broad lowlands of the Tanana River and to the southwest by the Copper River and the Wrangell Mountains. The relief in this part of the Alaska Range is rugged, the mountains having been intensely glaciated in Recent geologic time. At higher altitudes there are numerous small glaciers.

The geology of the Nutzotin Mountains has been discussed in detail by Moffit (1943). In summary, a series of sedimentary beds, locally metamorphosed and ranging in age from Devonian to Quaternary, form a major part of the eastern Alaska Range. Shale, argillite, sandstone, arkose, graywacke, and conglomerate are the major bedrock types; minor amounts of limestone also occur. These beds have been folded and locally faulted.

Igneous rock types are widely distributed throughout the region and occur as both flows and intrusives. The flow types are present throughout most of the section and in the main are represented by basalts and andesites. Intrusive rocks of Paleozoic and Mesozoic age ranging from gabbro to granite intrude all the rock types, the intrusive rocks of Mesozoic age being more extensively developed. Superimposed upon the consolidated sedimentary and igneous rocks are a series of unconsolidated stream and glacial deposits which occur in most of the valleys.

Slana-Nabesna district

Mineral Point area

Thorne (1946, p. 8, 9) reported a nickel occurrence in a shear zone in argillite in the Mineral Point area (locality 1, fig. 1), which is about 32 miles northeast of Slana on the eastern section of the Glenn Highway. The prospect is on the north side of the road on a mountain that has two prominent limestone peaks which are separated by a saddle of reddish argillitic rock. Some of the rock in the shear zone has been altered to a red-yellow material.

Investigations conducted in the area revealed little mineralization. Radioactivity traverses were made over the entire area, which included the shear zone as well as contacts and all rock types outcropping on the mountain. No anomalous radiation was detected during the course of the traverses. The radioactivity data on the rock specimens collected are shown in table 1.

Slana area

Slana, located near the confluence of the Slana and Copper Rivers, is on the south flank of the Alaska Range. Deposits of silver-bearing galena and copper minerals in quartz veins occur at several prospects located at different sites northwest of Slana. Two of these properties—the Indian Group and Silver Creek prospects—were examined for radioactive minerals. (See fig. 1.)

Indian Group prospect.—The Indian Group prospect (locality 2, fig. 1) is near the top of a ridge separating the Indian Creek and Ahtell Creek valleys and is 13 airline miles from the Indian Creek bridge on the eastern section of the Glenn Highway. The site of most of the open cuts is on the Indian Creek side of the ridge dividing the Indian Creek drainage from that of Ahtell Creek. A trail from Indian Creek leads to the property, and the first of the open cuts is about 400-500 feet below the crest of the divide. Little or no development work has been done on the Indian Group claims in recent years. At the present time there are at least six recognizable open cuts, all of which have either caved or have been partially filled with slide rock so that none of the mineralized portions of the veins are exposed. Sampling, therefore, was confined to the numerous ore dumps and float in and around the cuts.

Moffit (1938) gives a detailed account of the geology of the Slana district. Briefly, the country rock at the Indian Group claims consists of quartz diorite which shows wide variations in texture. Most of the rock has a porphyritic texture with large phenocrysts of feldspar set in a coarse-granular groundmass. Locally, a series of nearly vertical fracture planes that strike nearly east seem to have had some control in the placement of the mineralized quartz veins. The ore minerals are galena, tetrahedrite, and chalcopyrite, all of which are silver bearing.

Radioactivity traverses were conducted over the area. These included checks in each of the open cuts as well as traverses along the veins and in the areas immediately adjacent to the prospect itself. No radioactivity anomalies were discovered. Supplemental check samples were collected from the country rock and ore dumps, and one concentrate (sample 4531, table 2) was collected from the sand and gravel in a stream draining the mineralized area. Results of the laboratory studies made on the samples collected during these investigations are shown in tables 1 and 2.

Silver Creek prospect. —The prospect on Silver Creek (locality 3, fig. 1) is located on the north side of the creek a little more than 1 mile upstream from its junction with Ahtell Creek. No work has been done recently on the prospect, but the trail to the property is in good condition and the site is easily accessible from the highway. The workings consist of two adits, several open cuts and prospect pits, all of which have caved, and an inclined shaft slightly more than 15 feet long. The site of the caved adit at creek level had been examined briefly by Wedow and Matzko in 1946 (Wedow, Killeen, and others, 1954, p. 16-18).

The prospect is located in a northwest-trending fault zone about 100 feet wide in the quartz diorite country rock. Bedrock in the fault zone has been altered to a relatively soft material, in places highly stained with iron oxide and with some copper carbonate. Prospecting has been carried out on several steeply dipping mineralized quartz veins which occur in the shear zone and have the same northwest trend. Although most of the workings were inaccessible, ore containing pyrite, galena, chalcopyrite, and a blue copper stain in quartz gangue was found on the lower dump.

No anomalous radiation was indicated in traverses made across the fault zone and adjacent areas, ore dumps, and along exposed parts of the veins. Check sampling was confined to ore dumps for the most part, but it was possible to take a channel sample across the face of the vein in the inclined shaft. This channel sample contained galena and chalcopyrite in a gangue of quartz. The results of laboratory studies on these samples are given in table 1.

Rock Creek prospect

The Rock Creek molybdenite prospect is located on the south flank of the Alaska Range (locality 4, fig. 1) about 3.5 miles north of mile 84.5 (measured from junction of the Richardson and Glenn Highways near Gakona—see fig. 1) on the Nabesna road. The prospect is near the head of the west fork of the east branch of Rock Creek at a height of 2,200 feet above the road. No work has been done on the prospect in recent years, but former development work consists of an adit 170 feet long and one open cut which has caved and is now 30 feet long.

A report by Van Alstine (1945) discusses the molybdenite deposits at Rock Creek. The bedrock at the head of Rock Creek is part of a mass of rock mapped by Moffit (1938) as undifferentiated granitic rocks of late Paleozoic and Mesozoic age. Permian lava flows are exposed in the middle part of the creek. The prospect site is in a pink gneissic syenite which has interlaminations of biotite schist. A pegmatite dike as much as 2 feet wide intrudes the syenite and schist. The dike crops out 150 feet north of the adit and is about 100 feet higher. Molybdenite, the only metallic mineral noted, occurs in the pegmatite dike as tiny plates and blebs erratically distributed. The pegmatite dike was not found in the adit which was driven in the syenite to intersect it.

Radioactivity traverses in the area failed to indicate any significant anomalies. Laboratory studies on check samples collected from the prospect are listed in table 1.

Nabesna mine

The Nabesna Mining Corporation property (locality 5, fig. 1) is located in the northern part of the Wrangell Mountains of the eastern Alaska Range where the Wrangell and Nutzotin Mountains merge. The property is accessible from Slana by a road which is about 54 miles long.

The Nabesna area has been prospected periodically since 1899. However, it was not until the fall of 1929 that a company was formed to mine gold at Nabesna. In 1931 a mill was in operation, and mining continued until about 1947 when most of the ore bodies had been exhausted. At present the several adits and shafts at the main property are in such poor condition that access into the mine is impossible. At a newer development, about half a mile north of the main mine, two adits have been driven into an ore body; one of these is caved, but the other is open for several hundred feet.

Wayland (Moffit, 1943) gives a detailed account of the geology of the Nabesna mine. Briefly, limestone of Triassic age, intruded by stocks and dikes of quartz diorite, overlies shale and basaltic lavas and is capped by Tertiary lavas. The limestone has been recrystallized in part with the development of tactite. Three types of ore bodies occur at the Nabesna mine, the most important being a series of discontinuous veins of auriferous pyrite and calcite with lesser amounts of chalcopyrite, sphalerite, and galena. These veins occur as replacements along fractures and contacts in the limestone. The other two types of ore deposits occur as bodies of magnetite and of pyrrhotite.

Minerals occurring at the Nabesna mine are pyrite, chalcopyrite, sphalerite, galena, pyrrhotite, arsenopyrite, stibnite, gold, and calcite with a suite of contact minerals including andradite, vesuvianite, epidote, magnetite, specularite, wollastonite, spinel, brookite, and others.

Because entrance into the mine was impossible, investigations consisted of traverses along contacts and ore dumps. At the newer development, half a mile north of the main mine, several hundred feet of the adit was traversed as well as the ground in the immediate area. At no time during the traverses was any radioactivity anomaly detected. Check sampling, of necessity, was confined to the ore dumps. The results of the laboratory studies of these samples are given in table 1.

Orange Hill

Orange Hill (locality 6, fig. 1) is located on the east side of the Nabesna River, 12 miles south of the Nabesna airfield and half a mile below the foot of Nabesna Glacier. It is elliptical in shape with its top about 600 feet above the level of the river. Access to Orange Hill is from Nabesna where the Nabesna River can be crossed in a boat or on horseback; routes across the rapidly shifting channels of this glacial stream should be selected carefully, and the crossings made at low water.

Development work done on the property includes adits, shafts, and opencuts as well as some diamond-drill work. Many of the shafts and adits are reported to be caved. (See Van Alstine and Black, 1945.) High melt waters in the Nabesna River at the time of the writer's visit made access to Orange Hill impossible. However, an airborne radioactivity traverse was flown over the mineralized area as well as over larger gossans in the region. No significant radioactivity anomalies were detected.

The oldest rocks of the region are thick lava flows and greenstones of Permian age. There is also a metamorphosed limestone of Permian age which is overlain and underlain by hornfels. The core of Orange Hill is a quartz diorite of probable Jurassic age. Dikes of alaskite intrude the quartz diorite as well as the sedimentary rocks, and all of these rocks are intruded by dacite and andesite dikes. Veinlets of quartz in the quartz diorite and silicic dikes contain pyrite, chalcopyrite, molybdenite, tetrahedrite, sphalerite, magnetite, and gypsum. The limestone has metamorphic deposits composed of magnetite, pyrrhotite, pyrite, chalcopyrite, sphalerite, and molybdenite. This summary of the geology and mineralogy at Orange Hill is taken from a detailed account by Van Alstine and Black (1945).

Chisana district

Bonanza Creek

Bonanza Creek in the Chisana district (locality 7, fig. 1) is a south-flowing creek in the Nutzotin Mountains emptying into Johnson Creek 7 miles east of the settlement of Chisana. (See fig. 2.) In this region most of the mining has been confined to placer-gold operations. At the time of the writer's visit there were three small placer mines in operation. However, some lode prospecting has been done recently in several mineralized zones in the district, but at none of these prospects has there been any extensive development work

Table 1.—Radioactivity and mineralogy of rock and ore samples collected in the Slana-Nabesna district, 1952

[Equivalent-uranium analyses by J. J. Matzko and others, U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of sample	Equivalent uranium (percent)	Radioactive minerals
4510	Mineral Point (nickel prospect)-	Rock occurring in shear zones.	< 0.001	
4529	Indian Group, Indian Creek------	Ore dump---------------	.002	
4530	-----------do------------------	Quartz diorite country rock.	.004	Accessory minerals, mostly zircon.
4532	Silver Creek (silver-lead prospect).	Ore dump---------------	< .001	
4533	-----------do------------------	Vein material----------	.001	
4534	-----------do------------------	Wall rock next to vein.	< .001	
4535	Rock Creek (molybdenite prospect).	Mafic phase of igneous country rock.	.002	
4536	-----------do------------------	Syenite country rock---	.003	Accessory minerals, mostly sphene and zircon.
4537	-----------do------------------	Pegmatite vein---------	.003	Accessory minerals, mostly zircon and a trace of sphene.
4538	Nabesna mine-------------------	Ore dump---------------	< .001	
4539	-----------do------------------	--------do-------------	< .001	
4540	-----------do------------------	--------do-------------	< .001	

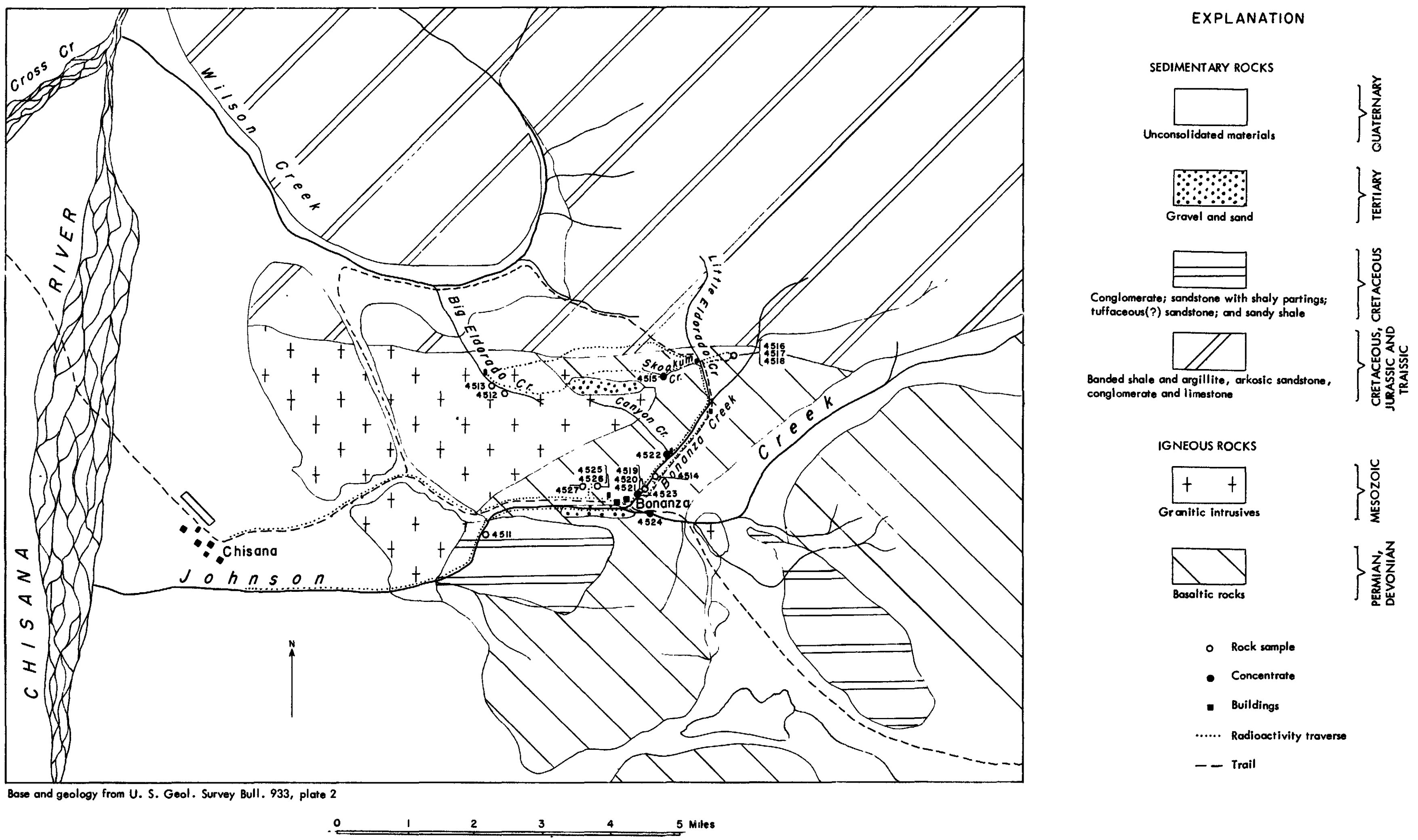


Figure 2. —Geologic sketch map of the Chisana district showing sample locations.

Table 2.—Radioactivity (percent equivalent uranium) of stream-gravel and placer concentrates collected in the eastern Alaska Range, 1952

[Equivalent-uranium content of original concentrates determined by J. J. Matzko and others, U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of sample	For original concentrate	For heavy mineral fraction		For magnetic fraction	
				Bromo-form[1]	Methylene iodide[2]	1.6 magnetic	1.6 non-magnetic
4515	Skookum Creek, Chisana district.	Placer----	< 0.001	---------	< 0.001	---------	----------
4522	Canyon Creek, Chisana district.	Stream-gravel.	< .001	---------	< .001	---------	----------
4523	Bonanza Creek, Chisana district.	---do------	.001	---------	< .001	---------	----------
4524	Johnson Creek, Chisana district.	---do------	.002	< 0.001	---------	---------	----------
4531	Unnamed creek near "Slana Lake," Slana-Nabesna district.	---do------	< .001	---------	.003	[3]0.01	[4]0.09

[1] Specific gravity greater than 2.8.
[2] Specific gravity greater than 3.3.
[3] Radioactive mineral: sphene.
[4] Radioactive mineral: zircon.

Table 3.—Radioactivity data on rock and ore samples collected in the Chisana district

[Equivalent-uranium analyses by J. J. Matzko and others, U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of sample	Equivalent uranium (percent)
4511	Canyon in Johnson Creek---------------------	Stained material in fracture zone.	< 0.001
4512	Big Eldorado Creek--------------------------	Granite country rock-----------	.001
4513	---------------do---------------------------	Sulfide float------------------	< .001
4514	Canyon in Bonanza Creek---------------------	Mafic dike---------------------	< .001
4516	On ridge 1 mile north of Little Eldorado Creek.	Sulfide vein-------------------	< .001
4517	---------------do---------------------------	Float material-----------------	< .001
4518	---------------do---------------------------	Wall rock----------------------	< .001
4519	Canyon of lower Bonanza Creek---------------	Sulfide vein-------------------	.001
4520	---------------do---------------------------	----------do-------------------	.003
4521	---------------do---------------------------	----------do-------------------	< .001
4525	Right limit of Johnson Creek, 1 mile west of Bonanza on hillside.	Vein material------------------	< .001
4526	---------------do---------------------------	----------do-------------------	.001
4527	---------------do---------------------------	----------do-------------------	< .001
4528	---------------do---------------------------	Wall rock----------------------	.003

done other than a few opencuts. At one prospect two adits had been driven into a mineralized zone many years ago, but these have caved.

Moffit (1943) gives an account of the geology of this region. Briefly, volcanic and sedimentary rocks of Devonian and Permian age have been intruded by andesitic dikes and sills and by a large mass of granodiorite of Mesozoic age.

Minerals occurring in the area include galena, molybdenite, cinnabar, pyrite, copper, silver, and gold. There appears to be a definite structural control in the formation of the mineralized zones in the district. The mineralized fissure veins all have the same general trend with a strike of west to northwest and a northerly dip. The fissures are probably the result of the stresses and strains developed during the intrusion of the granodiorite into the Devonian and Permian rocks.

Investigations consisted of radioactivity traverses of the mineralized zones and rock types occurring in the district as well as collecting supplementary check samples from mineralized zones, outcrops, and stream gravels. Figure 2 shows the routes of the radioactivity traverses and the location of the samples collected. The traverses conducted in the district did not indicate any anomalous radioactivity. The results of laboratory studies made on samples collected in this district are listed in tables 2 and 3.

Summary and conclusions

Results of radioactivity investigations conducted in the eastern Alaska Range during the 1952 field season showed that no high-grade uranium deposits occur in association with the metalliferous lodes previously deemed favorable (Wedow and others, 1951) for the occurrence of uranium ores. Only three of the samples collected contain 0.003 or more percent equivalent uranium, and the radioactivity of these samples is due primarily to the accessory igneous rock minerals, sphene and zircon.

Laboratory studies of the stream-gravel and placer concentrates indicated the presence of some radioactive material in one sample. The radioactivity of this sample, also, is due to trace amounts of sphene and zircon.

Therefore, the results of the studies made in the field and upon the samples collected indicate that there is little likelihood of finding high-grade uranium ores at the sites and prospects investigated. However, there are many other areas in the eastern Alaska Range which have not been studied and in which private prospecting should be encouraged.

HOPE CREEK AND MILLER HOUSE-CIRCLE HOT SPRING AREAS

By Walter S. West and John J. Matzko

The Hope Creek and Miller House-Circle Hot Springs areas, Circle quadrangle, Alaska, were investigated for the occurrence of uranium deposits by the U. S. Geological Survey in 1952.

The Hope Creek area is located approximately 55 miles northeast of Fairbanks and about 10 miles north of the Steese Highway (fig. 1). The area constitutes the headwaters sources of Hope, American Champion, Little Champion, Nome, and Sourdough Creeks. The nearest accessible point to Hope Creek is 5 miles north of milepost 67 on the Steese Highway. This point is at the end of a tractor trail along Sourdough Creek which will accommodate jeeps and trucks. (See fig. 3.)

The Miller House-Circle Hot Springs area is about 100 miles east-northeast of Fairbanks (fig. 1) and is drained by Mammoth, Independence, Bedrock, Boulder, Deadwood, Holdem, Ketchem, Hot Springs, Portage, and Half Dollar Creeks. Part of the area is accessible from the Steese Highway by roads and trails up Mammoth, Independence, Boulder, Deadwood, Ketchem, Portage, and Half Dollar Creeks. An airfield at Circle Hot Springs will accommodate small planes. (See fig. 4.)

Fluorite, suggestive of the possibility of the presence of associated uranium minerals, has been reported in the Hope Creek area (Prindle, 1910). Uraniferous fluorite and several other uranium-bearing minerals were found in the Miller House-Circle Hot Springs area in 1949 by White and Tolbert (Wedow, White, and others, 1954).

These areas were examined for the possibilities of lode concentrations of uranium during the summer of 1952 by Walter S. West, geologist, and George M. Haselton, geologic field assistant. Part of the work in the Miller House-Circle Hot Springs area was done by John J. Matzko, geologist, and Fred Freitag, field assistant.

Field work in the Hope Creek area consisted of radioactivity traverses on foot with standard portable survey meters equipped with interchangeable beta-gamma and gamma probes, and of the collection of rock and mineral samples. Helicopter support for part of the work was furnished by the Topographic Division of the U. S. Geological Survey.

The examination of the Miller House-Circle Hot Springs area consisted of radioactivity traverses by foot and car, and by the collection of rock, mineral, placer, and water samples. The equipment used for measuring radioactivity is the same as that described in the section on the eastern Alaska Range.

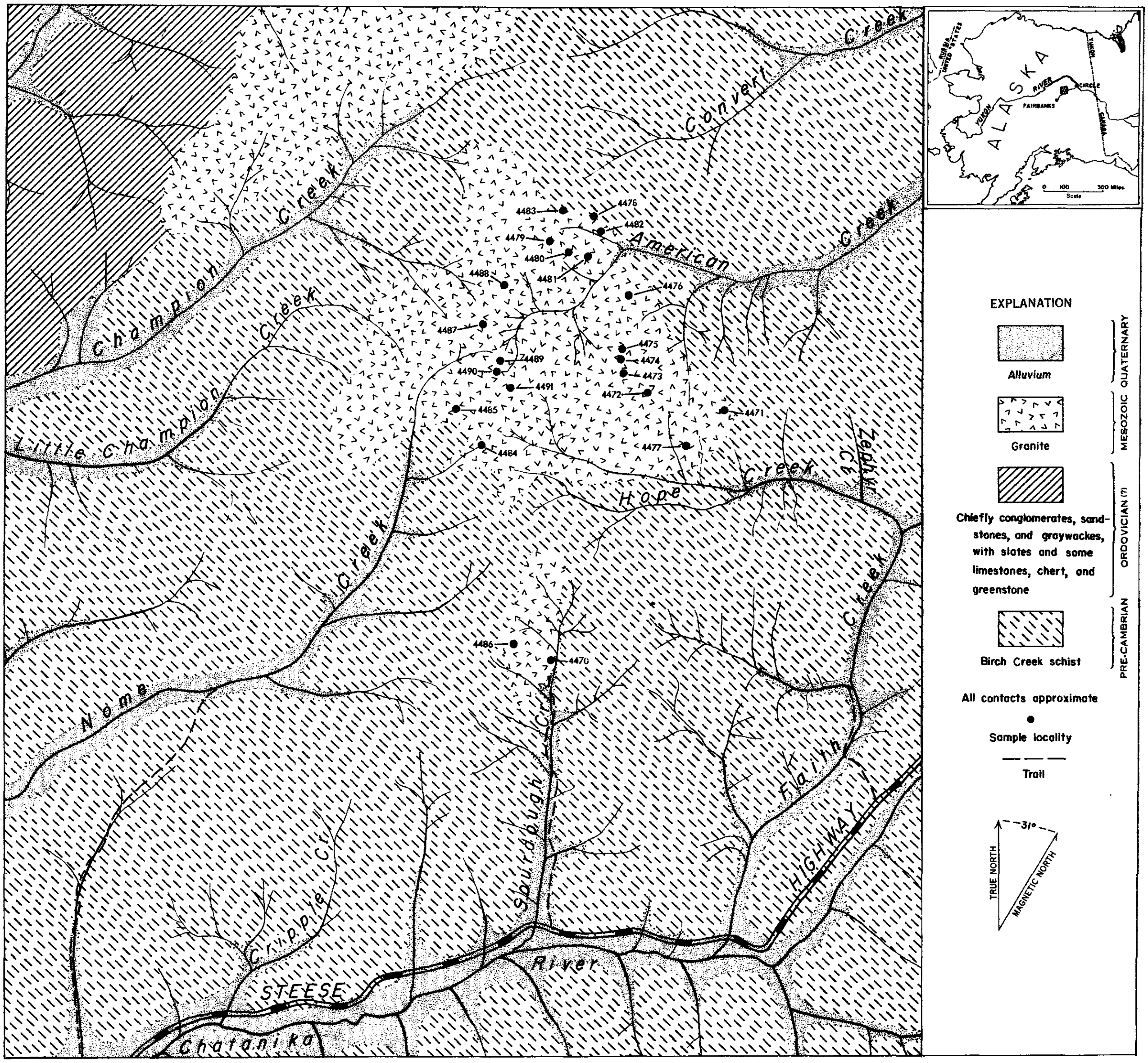
The equivalent-uranium analyses and mineralogic determinations were made at the Geological Survey's laboratories at College, Alaska, and Washington, D. C.

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

Hope Creek area

The geology of the Hope Creek area has been described by Prindle (1910, 1913a) and Mertie (1937).

The bedrock in the area consists of the Birch Creek schist of pre-Cambrian age, intruded by granitic rocks and dikes of Mesozoic(?) age (fig. 3).



Base modified from Circle quadrangle, Alaska Reconnaissance Topographic Series

Geology modified from U. S. Geol. Survey Bull. 525, plate 8

1 0 5 Miles

Figure 3. —Geologic sketch map of the Hope Creek area showing sample locations.

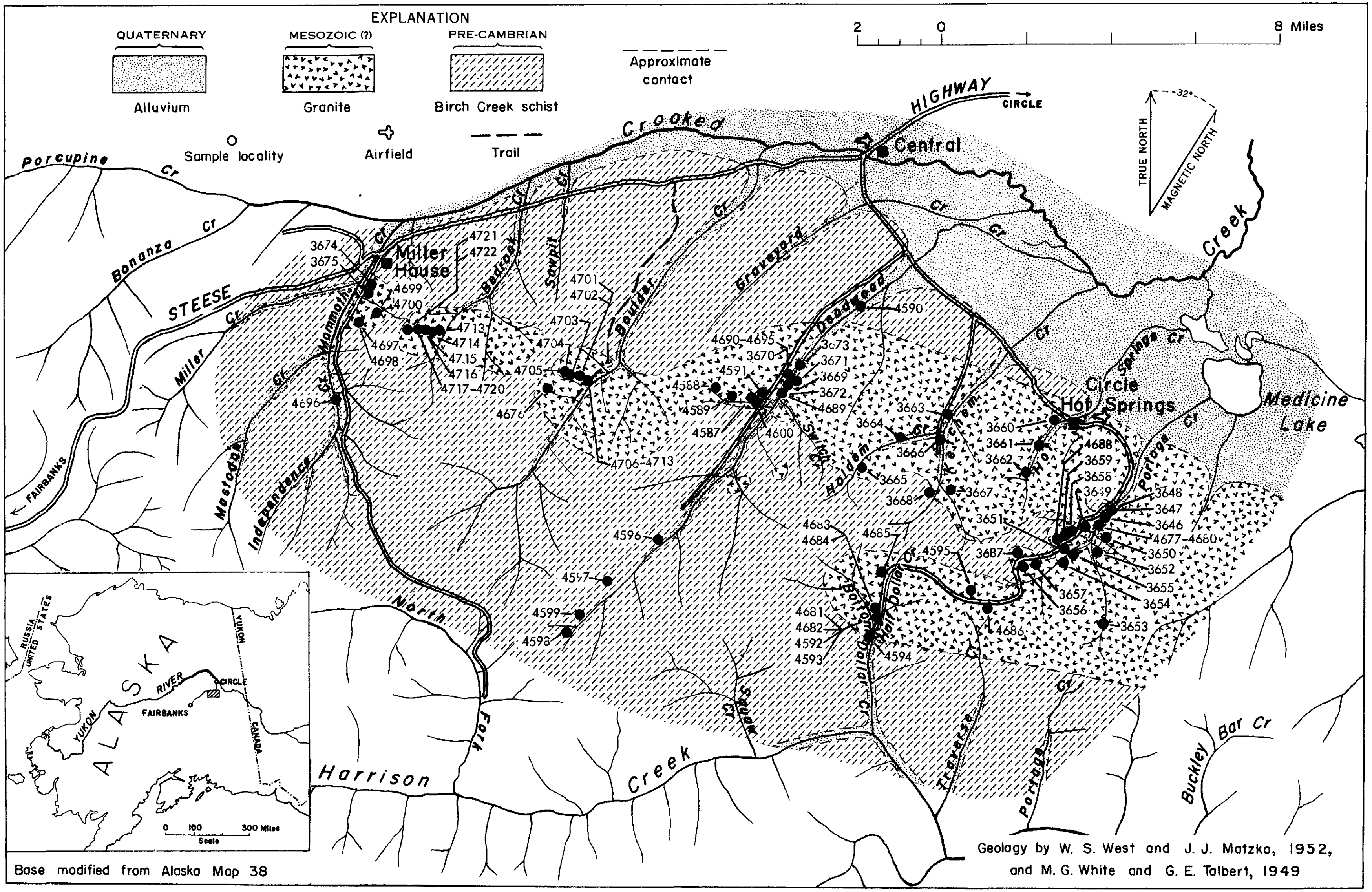


Figure 4. —Geologic sketch map of the Miller House-Circle Hot Springs area showing sample locations.

Erosion has exposed granite at two localities within the area: a small exposure consisting entirely of granite talus near the headwaters of Sourdough Creek, and a larger mass of granite that forms pinnacles and talus on the tops and sides of the high ridges at the headwaters of Hope, American, Champion, Little Champion, and Nome Creeks. The granite at both localities is a biotite-tourmaline variety, and its texture ranges from medium-grained equigranular to coarse-grained porphyritic. The accessory minerals include zircon, sphene, garnet, and pyrrhotite. Quartz and quartz-tourmaline veins occur in the granite. Granitic and aplitic dikes ranging from slightly less than 1 inch to 6 feet in width are of rather common occurrence in the granite.

In the Hope Creek area the Birch Creek schist consists mostly of quartz-mica schist. The occurrence of quartz-pyrite-fluorite veins in the schist adjoining the granite has been reported (Prindle, 1910; Mertie, 1937) but was not confirmed during the 1952 investigation. Pyrite was observed at several places along the granite-schist contact.

Radioactivity traverses in the Hope Creek area indicated that the granite bedrock and granite talus were more radioactive than the adjacent schist bedrock and schist talus. For this reason sampling was confined to the granitic rock localities. Sample locations are shown on figure 3. Equivalent-uranium analyses of unconcentrated crushed rock samples from the Hope Creek area are given in table 4. Laboratory studies revealed that most of the radioactivity was confined to the minerals present in the heavy-mineral fractions (sp gr greater than 3.3) of the samples. The mineralogy of the heavy-mineral fractions of selected samples is given in table 5.

Sample 4474, containing 0.055 percent equivalent uranium, was the most radioactive sample collected in the Hope Creek area. The rock occurs as float in a small saddle between two large granite pinnacles on the high divide between the middle and south headwater forks of American Creek (fig. 3). The granite float rock in this sample contains such an intricate network of hematite-goethite veinlets that it appears to be brecciated. No uranium-bearing minerals could be identified. An alpha plate made of the sample indicates that the radioactivity is probably due to a radioactive element or elements occurring as impurities in the goethite or in very minute discrete minerals, not discernible under the petrographic microscope, mixed with the goethite. Zircon probably contributes a small amount of radioactivity to the sample.

Table 4.—Equivalent-uranium analyses of samples, Hope Creek area, Alaska

[By U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of material	Equivalent uranium (percent)
4470	Headwaters of Sourdough Creek	Granite talus	0.003
4471	Divide between north headwater fork of Hope Creek and south headwater fork of American Creek.	Granite bedrock	.004
4472	do	Granite bedrock	.003
4473	do	do	.004
4474	Ridge between south and middle headwater forks of American Creek.	Granite talus	.055
4475	do	Granitic dike	.003
4476	do	Quartz veins	.002
4477	Left limit, north fork of Hope Creek	Granite bedrock	.004
4478	Granite-schist contact between the middle and north headwater forks of American Creek.	Granite and schist talus	.002
4479	Divide between American and Champion Creeks.	Granite bedrock	.003
4480	Divide between middle and north headwater forks of American Creek.	Aplitic dike	.002
4481	do	Granitic dike	.003
4482	Left limit, north fork of American Creek.	do	.004
4483	Granite-schist contact at head of north fork of American Creek.	Granitic talus	.001
4484	Saddle on divide between north headwater fork of Hope Creek and Nome Creek.	Granite bedrock	.003
4485	Divide between south headwater fork of Hope Creek and Nome Creek.	Granitic dike talus	.004
4486	Headwaters of Sourdough Creek	Granite talus	.003
4487	Headwaters of American Creek	Quartz-tourmaline vein	.002
4488	do	Granite bedrock	.003
4489	do	Granite talus	.001
4490	do	Granite bedrock	.003
4491	Headwaters of north fork of Hope Creek	do	.003

Table 5.—Mineralogy of heavy-mineral fractions (sp gr greater than 3.3) of selected samples, Hope Creek area, Alaska

[X indicates mineral is present but amount not determined]

Minerals	Estimated volume percent of minerals present in samples									
	4470	4471	4473	4474	4477	4478	4482	4483	4486	4487
Allanite(?)	----	----	----	----	9	----	----	----	----	----
Anatase	----	----	----	----	----	1	----	----	----	----
Apatite	----	----	Tr.	----	----	----	----	Tr.	----	----
Biotite	----	2	----	----	10	2	23	3	----	8
Diopside	----	Tr.	----	----	Tr.	----	----	----	----	----
Epidote	2	----	----	----	----	----	----	----	7	Tr.
Fluorite	----	----	1	----	----	----	----	----	Tr.	Tr.
Galena	----	Tr.	----	----	----	----	----	----	----	----
Garnet	1	----	----	----	----	----	Tr.	----	1	----
Goethite	----	----	10	X	----	----	----	25	----	----
Hematite	10	----	----	X	----	----	----	16	15	Tr.
Hornblende	9	----	----	X	----	----	----	----	12	----
Ilmenite	----	3	----	----	----	----	----	4	----	----
Limonite	1	----	----	----	----	21	----	11	Tr.	----
Malachite	----	----	----	----	----	----	Tr.	----	----	----
Molybdenite	----	Tr.	----	----	----	----	----	----	----	----
Muscovite	----	----	Tr.	----	----	----	----	----	----	Tr.
Pyrite	Tr.	Tr.	----	----	----	----	----	Tr.	Tr.	----
Pyrrhotite	50	40	1	----	20	20	50	16	45	50
Rutile	----	----	80	----	----	----	----	----	----	----
Scheelite	Tr.	----	----	----	----	----	----	----	Tr.	----
Sphene	15	1	----	----	----	----	2	----	20	----
Stibnite	1	----	----	----	----	1	----	----	----	----
Topaz	----	50	----	----	60	25	12	Tr.	----	----
Tourmaline	1	----	Tr.	X	----	30	11	25	----	40
Zircon	10	4	7	X	1	Tr.	2	----	Tr.	2

The radioactivity of the remaining samples from the Hope Creek area is attributed to the presence of zircon, sphene, hematite, and allanite(?). In addition to these minerals, fluorite, topaz, limonite, apatite, garnet, scheelite, and malachite may contain trace amounts of uranium as an impurity, as in the Miller House-Circle Hot Springs area. However, none of the minerals in samples from the Hope Creek area has been subjected to fluorimetric tests for uranium.

Niobium and tantalum have been detected spectroscopically in trace amounts in the heavy-mineral fraction of sample 4473 (fig. 3) and may be present in the rutile which constitutes an estimated 80 percent of this fraction of the sample (table 5).

Miller House-Circle Hot Springs area

The geology of the Miller House-Circle Hot Springs area has been described by Johnson (1910), Prindle (1913b), and Mertie (1937, 1938).

Bedrock in the area includes metamorphic and igneous rocks consisting of Birch Creek schist of pre-Cambrian age intruded by a granite stock and dikes of Mesozoic(?) age (fig. 4). The exposed part of the igneous stock is composed principally of coarse-grained granular-to-porphyritic biotite granite. The common accessory minerals are zircon, sphene, allanite, garnet, scheelite, and pyrrhotite. The granite stock has a greater areal extent than has been shown on any previous geologic map of the region (Prindle, 1913b, pl. 2; Mertie, 1938, pl. 1). The Birch Creek schist is mainly of the mica and quartz-mica varieties. Feldspathic, carbonaceous, and chloritic schists are also present in the area. Granitic and aplitic dikes, genetically related to the granite stock, occur in the granite and adjoining schist. The dikes range in width from a few inches to 2 feet. Numerous quartz veins, ranging from a fraction of an inch to several feet in width, occur in the schist and to a lesser extent in the granite. Most of the veins show no signs of mineralization. However, pyrite, arsenopyrite, galena, wolframite, and gold have been found in a few of these veins.

Stream and bench gravels in the valleys of Porcupine, Bonanza, Miller, Mastodon, Independence, Mammoth, Crooked, Boulder, Deadwood, Switch, Ketchem, Portage, and Half Dollar Creeks and the North Fork of Harrison Creek have been mined for placer gold. During 1952 the only active mining in the area was on Independence, Mastodon, Crooked, Deadwood, and Portage Creeks.

Radioactivity traverses by foot and car in the Miller House-Circle Hot Springs area disclosed that the granite localities are more radioactive than those composed of schist. This conclusion was borne out by the results of radioactivity studies of the samples collected in the area. The sample locations are shown on figure 4. Equivalent-uranium analyses of representative samples are given in table 6; with the exception of placer samples, the analyses were made on unconcentrated crushed rock material.

As shown in table 6, the equivalent-uranium content ranges from 0.001 to 0.005 percent for the granite samples, 0.002 to 0.004 percent for the dike samples, 0.001 to 0.002 for the schist samples, and 0.001 to 0.01 percent for

Table 6.—Equivalent-uranium analyses of samples, Miller House-Circle Hot Springs area, Alaska

[By U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of material	Equivalent uranium (percent)
4696	Independence Creek	Placer	0.001
4699	Mammoth Creek, right limit	Granite talus	.004
4698	do	Dike talus	.003
4697	do	Granite talus	.005
4722	Divide between Mammoth and Bedrock Creeks	do	.005
4721	do	do	.004
4720	Bedrock Creek, left limit	Granite bedrock	.005
4719	do	do	.005
4718	do	do	.005
4717	do	Vein in granite	.003
4716	do	Granite bedrock	.004
4715	do	Dike talus	.001
4714	do	Granite bedrock	.004
4676	Boulder Creek, left limit	do	.004
4705	do	do	.004
4704	do	Granite talus	.003
4702	do	Granite bedrock	.003
4701	do	do	.004
4706	Boulder Creek, stream bed	Granitic dike	.004
4709	do	Granite boulder	.005
4590	Deadwood Creek, 1.5 miles below Switch Creek	Schist bedrock	< .001
4690	Deadwood Creek, 0.5 mile below Switch Creek	Weathered dike	.003
4691	do	Granite bedrock	.005
4692	do	do	.003
4693	do	do	.004
4689	Deadwood Creek, 0.25 mile below Switch Creek	Vein in granite	.005
4591	Deadwood Creek, 0.4 mile below Discovery Creek	Schist bedrock	< .001
4587	Discovery Creek, tributary to Deadwood Creek	Granite talus	.004
4588	do	do	.001
4589	do	do	.005
4600	do	Placer	.005
4596	Deadwood Creek, 0.5 mile upstream from road end	Schist bedrock	.002
4597	Deadwood Creek, 1 mile upstream from road end	do	.001
4599	Deadwood Creek, west tributary below 25 Pup	do	.001
4598	Deadwood Creek, 2 miles upstream from road end	do	< .001
4677	Portage Creek, Carstens' mining operation	Granite bedrock	.005
4678	do	Mafic dike	.002
4679	do	Placer	.01
4680	do	Tin-iron nuggets	< .001
4688	Portage Creek, left limit	Granite bedrock	.003
4687	do	Granite talus	.003
4595	Divide between Portage and Half Dollar Creeks	do	.002
4685	Half Dollar Creek, right limit	Granite bedrock	.003
4683	do	Granitic dike	.003
4681	do	Granite bedrock	.002
4592	do	Aplite dike	.003

the placer samples. The equivalent-uranium content averages 0.004 percent for the granite samples and 0.003 percent for the dike samples.

A limited number of water samples were taken for experimentation in the use of a water-sampling technique to locate lode concentrations of uranium in an area where radioactivity traversing and rock sampling were of no avail because of the widespread cover of disintegrated bedrock, alluvium, and vegetation. The analyses are shown in table 7.

Table 7 shows that sample 52AMz 15 from Portage Creek contains a relatively high uranium content compared with the average uranium content of fresh waters, which is $1x10^{-8}$ percent (Irving May, personal communication), and the average uranium content of sea waters, which is $3x10^{-7}$ percent (Nakanishi, 1951; and Pietsch and Grimaldi, 1954). This may indicate the desirability of using a more detailed water sampling technique in this and other areas where large expanses of ground cover effectively shield radiation that might come from the underlying rocks.

Radioactivity and mineralogic examinations of the rock, mineral, and placer samples indicate that most of the radioactive minerals are present in the heavy-mineral fractions (sp gr greater than 3.3) of these samples The minerals found in the heavy-mineral fractions of selected samples are listed in table 8.

Table 7.—Analyses of water samples, Miller House-Circle Hot Springs area, Alaska

[By Ivan Barlow, U. S. Geological Survey laboratory, Washington, D. C., September, 1952]

Sample number	Location	Uranium (percent)	Uranium (ppb)
52AMz 5	Discovery Creek--	0.33×10^{-7}	0.33
52AMz 6	Switch Creek, tributary to Deadwood Creek--------------------------	$.42\times10^{-7}$	.42
52AMz 10	Deadwood Creek---	1.56×10^{-7}	1.56
52AMz 11	------------do---	2.01×10^{-7}	2.01
52AMz 12	Ketchem Creek--	1.11×10^{-7}	1.11
52AMz 13	Holdem Creek, tributary to Ketchem Creek---------------------------	1.74×10^{-7}	1.74
52AMz 14	Hot Springs Creek--	1.44×10^{-7}	1.44
52AMz 15	Portage Creek[1]---	40.2×10^{-7}	40.2

[1] Original sample contained much clay-size material in suspension because of sluicing operation upstream from sample site; therefore, uranium content may be high because all solids may not have been removed in subsequent decanting to obtain clear sample, or because more uranium was taken into solution during the period of sluicing when more solid material than normal was in suspension and subject to corrosion. Another factor may be that some additional uranium was taken into solution from the suspended solids when the sample was acidified prior to decanting.

Table 8.—Mineralogy of the heavy-mineral fractions of selected samples from the Miller House-Circle Hot Springs area, Alaska

Minerals	Estimated volume percent of minerals present in samples												
	4696	4697	4718	4701	4709	4691	4689	4600	4596	4677	4679	4685	4683
Allanite------------------------	Tr.	3	----	45	50	----	----	----	----	----	Tr.	25	20
Amphibole-----------------------	----	11	----	----	----	----	----	----	----	----	----	----	----
Anatase-------------------------	----	----	----	----	----	10	----	----	----	----	----	----	----
Apatite-------------------------	----	----	----	----	----	----	----	1	----	Tr.	----	----	----
Arsenopyrite--------------------	Tr.	----	----	----	----	----	----	----	----	Tr.	1	----	----
Azurite-------------------------	----	Tr.	----	----	----	----	----	----	----	----	----	----	----
Biotite-------------------------	----	2	24	25	15	1	----	----	----	10	Tr.	Tr.	----
Bismuthinite--------------------	----	----	----	----	----	----	----	----	----	----	Tr.	----	----
Cassiterite---------------------	3	----	----	----	----	----	1	----	----	----	3	----	----
Cerussite-----------------------	----	----	----	----	----	----	----	----	----	----	----	Tr.	----
Chalcopyrite--------------------	----	----	----	----	----	----	----	----	----	Tr.	----	----	----
Chlorite------------------------	----	Tr.	----	15	Tr.	2	----	----	----	7	Tr.	----	Tr.
Diopside------------------------	Tr.	----	----	----	----	----	----	----	----	----	3	----	----
Epidote-------------------------	----	----	----	1	----	----	----	4	----	----	----	1	3
Fluorite------------------------	----	----	----	Tr.	----	----	----	----	----	1	----	----	----
Galena--------------------------	Tr.	Tr.	----	----	----	10	----	----	----	----	----	----	----
Garnet--------------------------	40	4	1	1	----	----	----	6	----	1	10	2	6
Goethite------------------------	----	----	----	----	----	50	35	----	----	----	----	----	----
Gold----------------------------	Tr.	----	----	----	----	----	----	----	----	----	Tr.	----	----
Hematite------------------------	----	9	----	Tr.	----	----	40	1	5	2	5	15	----
Ilmenite------------------------	12	----	10	----	----	5	22	5	75	60	50	----	----
Jamesonite----------------------	----	----	----	----	----	----	----	----	----	Tr.	----	----	----
Leucoxene-----------------------	----	----	----	----	----	10	----	----	----	----	----	----	----
Limonite------------------------	4	----	----	Tr.	----	----	----	3	----	Tr.	----	----	10
Magnetite-----------------------	30	----	----	----	----	----	----	Tr.	----	----	15	----	----
Malachite-----------------------	----	Tr.	Tr.	----	----	----	----	----	----	----	----	----	----
Molybdenite---------------------	----	Tr.	----	----	----	----	----	----	----	----	----	----	----
Monazite------------------------	----	----	10	----	----	----	----	----	----	4	Tr.	----	----
Muscovite-----------------------	2	----	----	----	----	----	----	----	10	----	Tr.	----	Tr.
Pyrite--------------------------	2	1	----	Tr.	----	1	1	----	4	1	1	2	1
Pyrochlore-microlite------------	----	----	----	----	----	----	----	----	----	----	Tr.	----	----
Pyrrhotite----------------------	----	50	35	7	30	Tr.	----	----		----	----	40	55
Rock forming minerals[1]--------	----	----	----	----	----	----	----	----	----	----	----	15	----
Rutile--------------------------	1	----	----	----	----	5	----	----	4	----	----	----	----
Scheelite-----------------------	2	Tr.	Tr.	----	----	----	----	Tr.	----	Tr.	1	Tr.	Tr.
Schist fragments----------------	3	----	----	----	----	----	----	70	----	----	----	----	----
Sphalerite----------------------	----	----	----	----	----	----	----	----	----	1	----	----	----
Sphene--------------------------	----	----	----	----	Tr.	2	----	----	----	----	1	----	Tr.
Spinel--------------------------	----	----	----	----	----	----	----	2	----	----	1	----	----
Topaz---------------------------	----	20	5	----	----	----	----	----	----	----	Tr.	----	----
Tourmaline----------------------	Tr.	----	----	----	----	----	----	2	----	----	1	----	----
Uranothorianite-----------------	----	----	----	----	----	----	----	----	----	----	Tr.	----	----
Wolframite----------------------	1	----	----	----	----	----	----	Tr.	----	----	5	----	----
Xenotime------------------------	Tr.	----	----	----	----	----	----	----	----	----	----	----	----
Zircon--------------------------	Tr.	----	15	6	5	2	1	1	2	10	1	Tr.	5

[1] Mostly quartz and feldspar.

Mineralogic studies of the samples revealed that fluorite, which was previously reported in the granite bedrock only on Deadwood Creek, also occurs in vugs of granitic rock on Portage and Boulder Creeks.

Fluorimetric tests proved that fluorite, limonite, malachite, zircon, sphene, topaz, allanite, garnet, uranothorianite, and scheelite contained in some of the Miller House-Circle Hot Springs samples were uraniferous. Other minerals listed in table 8, such as hematite, goethite, monazite, xenotime, pyrochlore-microlite, and some of the sulfides, may contain impurities or intergrowths of uranium, but none has yet been subjected to fluorimetric examinations. The biotite in many of the samples contains pleochroic halos. The distribution of the uranium-bearing minerals in samples from the area is summarized in table 9.

In addition to the minerals listed in tables 8 and 9, a nonfluorescent yellow-green uranium mineral was found in granite bedrock, sample 4677 (fig. 4), from H. C. Carstens' gold-mining operation on Portage Creek. The mineral could not be identified because an insufficient quantity was available for X-ray determination. Practically all of the biotite in this sample contains pleochroic halos. The ilmenite contains trace amounts of niobium.

The only occurrence of uranothorianite, the most important uranium-bearing mineral found in the area, was in sample 4679, a sluice-box concentrate also from Carstens' mining operation on Portage Creek. The uranothorianite occurs as very small black cubes, principally in that fraction of the placer concentrate which has a mesh size between minus 100 and plus 200. This fraction of the sample contains 0.091 percent equivalent uranium. The uranothorianite appears to be responsible for most of the radioactivity of the sample. An assay made on part of this sluice-box concentrate by the Territorial Department of Mines, Fairbanks, Alaska, gave 4.65 percent tungsten trioxide (WO_3). Most of the tungsten is in the form of wolframite with only minor amounts of scheelite.

Although no quantitative analyses for uranium and thorium were made on the samples from the Miller House-Circle Hot Springs area, mineralogic studies indicate that most of the radioactivity of these samples is apparently due to uranium rather than thorium.

Summary and conclusions

No lode or placer deposits in the Hope Creek and Miller House-Circle Hot Springs areas were found to contain sufficient quantities of uranium-bearing minerals to be of commercial value.

Table 9.—Uranium-bearing minerals in samples from the Miller House-Circle Hot Springs area, Alaska

Locality and type of sample	Uranium-bearing minerals										
	Allanite	Apatite	Fluorite	Garnet	Limonite	Malachite	Scheelite	Sphene	Topaz	Uranothorianite	Zircon
Independence Creek:											
Placer	X	----	----	X	X	----	X	----	----	----	X
Mammoth Creek:											
Granite	X	----	----	X	----	X	X	----	X	----	----
Bedrock Creek:											
Granite	----	----	----	X	----	X	X	----	X	----	X
Boulder Creek:											
Granite	X	----	X	X	X	----	----	X	----	----	X
Deadwood Creek:											
Granite	----	----	X[1]	----	----	----	----	X	----	----	X
Placer[2]	----	----	----	----	----	----	X	----	----	----	----
Discovery Creek:											
Placer	----	----	----	X	----	----	X	----	----	----	X
Ketchem Creek:											
Placer[2]	X	----	----	X	----	----	X	X	X	----	----
Hot Springs Creek:											
Placer[2]	X	----	----	----	----	----	----	X	----	----	----
Portage Creek:											
Granite	----	X	X	X	X	----	X	----	----	----	X
Placer	X	----	----	X	----	----	X	X	X	X	X
Half Dollar Creek:											
Granite	X	----	----	X	X	----	X	X	----	----	X

[1]Mineral present in sample collected by M. G. White and G. E. Tolbert in 1949.
[2]Samples collected by M. G. White and G. E. Tolbert in 1949.

A wide variety of radioactive minerals were found to occur in granite. Certain uranium-bearing minerals in the Miller House-Circle Hot Springs area, which are also believed to contain uranium in the Hope Creek area, appear to be primary accessory minerals in the granite. Other minerals, such as fluorite, topaz, and several metallic sulfides in both areas, and cassiterite and wolframite in the Miller House-Circle Hot Springs area, were probably formed as a result of pneumatolytic action after the crystallization of the magma or during the late stages of crystallization. Some of the minerals in the latter group are known to be uranium bearing; therefore, it seems likely that hydrothermal solutions were partly responsible for the introduction of uranium during the process of pneumatolysis.

On the basis of present information, the Hope Creek area does not appear to be favorable for the occurrence of high-grade uranium ores. It should be pointed out, however, that the work done in 1952 consisted only of a brief reconnaissance primarily intended to locate and test reported fluorite occurrences. Prospectors searching the area for other metals should keep in mind the possible association of uranium with mineralized zones containing hematite of hydrothermal origin, with minerals containing silver, cobalt, nickel, bismuth, and fluorine, and to a lesser extent with lode deposits containing copper, tin, lead, molybdenum, and gold.

The investigation conducted by the Geological Survey in 1949 (Wedow, White, and others, 1954) and in 1952 (this report) show that there is little hope of discovering commercial concentrations of uranium in the Miller House-Circle Hot Springs area by established methods of radioactivity traversing with portable survey meters, primarily because of the widespread cover of vegetation, soil, and disintegrated bedrock. On the other hand, this area, particularly the watershed of Portage Creek, cannot be ruled as unfavorable for the occurrence of uranium in lode deposits, because of the relatively high uranium content of water and the presence of uranothorianite in concentrates from Portage Creek. (See tables 7 and 8.) Prospectors interested in the uranium possibilities of the Miller House-Circle Hot Springs area will probably find that geochemical methods of prospecting, such as water, soil, and vegetation sampling, would be the best techniques to use in the search for uraniferous lodes in the area. Also, the testing of heavy-mineral concentrates from gravels, slope wash, and disintegrated bedrock for radioactivity, in a fashion similar to that used by West (1953) in the Darby Mountains of the Seward Peninsula, would aid considerably in localizing the occurrence of the uranothorianite on Portage Creek.

KOYUKUK-CHANDALAR REGION
By Arthur E. Nelson

The presence of radioactive materials is known in two localities in the Koyukuk-Chandalar region (Wedow and others, 1951; White, 1952). Accordingly, radioactivity reconnaissance investigations were undertaken in the Chandalar mining district and at the Gold Bench mining area (fig. 1). Airborne radioactivity traverses were conducted over a part of the region while flying the party into the region and returning it to Fairbanks.

Radioactivity traverses and outcrop tests were made in and around the mines and prospects, mineralized zones, and the country rock at the two localities, and samples were collected for equivalent-uranium determinations and mineralogic studies. Stream gravels were sampled to determine if radioactive minerals are being liberated from the bedrock of areas drained by the streams.

A standard portable survey meter was modified to accept interchangeable 6-inch beta-gamma and 2- by 20-inch gamma probes, which were used for individual outcrop tests and normal ground traverses, respectively. For airborne traverses a standard survey meter coupled with six 2- by 40-inch gamma probes, connected in parallel, was mounted in a light aircraft (Wedow, 1951).

The field work in this area was conducted in late August 1952, by Arthur E. Nelson, geologist, and Richard S. Smith, geologic field assistant. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Geology and radioactivity studies

The Koyukuk-Chandalar region (fig. 1) lies in the southern foothills of the Endicott Mountains which are a part of the Brooks Range. The region is drained by the south-flowing Koyukuk River on the west and the Chandalar River on the east, both of which empty into the Yukon River. To the south the area is bounded by the Koyukuk flats and the Hodzana highlands; to the north, by the crest of the Endicott Mountains.

Maddren (1913) gives an account of the geology of the Koyukuk-Chandalar region, and Mertie (1925) gives a detailed account of the Chandalar mining district; hence, only a summary of the main geologic features is presented herein.

The rocks of the region consist of a series of sedimentary strata which have been folded and faulted and range from pre-Cambrian or pre-Ordovician to Cretaceous in age, and of igneous rocks of Paleozoic and Mesozoic age. Generally, the oldest sedimentary rocks occur in the southernmost extremities of the district and are overlain by successively younger sedimentary beds to the north.

The southernmost belt of sedimentary rocks, consisting chiefly of quartzite and quartzitic schist of pre-Cambrian or pre-Ordovician age, is folded along a general east-west axis and has a northerly dip. Overlying the quartzite and quartzitic schist is a sedimentary sequence of Paleozoic age, now metamorphosed to schist and phyllite. These latter rocks have the greatest areal distribution in the region and have the same general attitude as the underlying quartzite and quartzitic schist. Limestone of Silurian age overlies the metamorphic rocks of Paleozoic age and is in turn overlain by Devonian and Mississippian slates, sandstones, and limestones. In the southern part of the district Cretaceous conglomerates, sandstones, and shales lie unconformably on the older rocks. The igneous rocks in the region consist of Upper Silurian or Lower Devonian granitic gneiss and a granodiorite of possible Mesozoic age. Greenstones of late Paleozoic age occur as dikes, sills, and flows and are associated with all rocks of Paleozoic and pre-Paleozoic(?) age.

No significant radioactivity anomalies were noted during any of the airborne traverses conducted in the

Koyukuk-Chandalar region. The airborne traverses were made over many mineralized zones located in and around granitic masses which were not easily accessible otherwise. Most of these areas are located in the region drained by the North Fork of the Koyukuk River. In general that area drained by the South Fork of the Koyukuk River has a heavy cover of overburden, and it was impossible to get effective radioactivity coverage; thus, little traversing was done there.

Chandalar mining district

The Chandalar mining district (fig. 5) is located about 6 miles east-northeast of the head of Lake Chandalar and comprises an area of about 100 square miles. Prospecting for placer- and lode-gold deposits has been carried on intermittently in this district since 1900. Placer mines have been located on four creeks in the district, including Little Squaw, Big Squaw, and Tobin Creeks. Development work on numerous quartz veins in the district consists of adits, shafts, and opencuts, most of which are now inaccessible. Hence, all that can be seen of the geological relationships is at the surface outcrops.

Mining activity in recent years has been somewhat limited; in 1952 only five men were engaged in either prospecting or mining operations. One man was prospecting on a very limited scale, and two men were developing a quartz vein on the divide between Big and Little Squaw Creeks. Sluicing at a small placer mine on Tobin Creek and at another on Big Creek, each a one-man operation, was considerably hampered because of a limited water supply.

Sedimentary and igneous rocks of Paleozoic age were the only formations seen in the district besides the unconsolidated stream and glacial deposits. The sedimentary rocks are primarily mica schist with minor amounts of chlorite schist. The schist is cut by greenstone dikes and locally by small bodies of granitic gneiss. Numerous gold-bearing quartz veins occur in the schist and are apparently confined to four main zones, all of which have a westerly trend, but some dip to the north and others to the south. Locally, minor veins are subsidiary to the more persistent ones. These subsidiary veins have different trends which are probably the result of local stresses superimposed upon regional structure.

Radioactivity traverses were made across and along mineralized zones, ore dumps, and adits; specific outcrop tests were made and a general traverse conducted in the main drainage systems of the district. At no point along any of the traverses was a significant anomaly noted. Samples were collected from these areas for further study in the laboratory. The results of laboratory studies of the samples are summarized in tables 10 and 11.

Laboratory studies found traces of monazite, zircon, and uranothorianite in certain stream samples collected during the summer field season of 1952, as indicated in table 10. A few grains of pyrite and galena and one grain of molybdenite were found in the sample containing the uranothorianite. This suggests the possibility of sulfide minerals occurring in veins in the drainage basin of Big Squaw Creek, which may be the source of the uranothorianite.

Gold Bench

Gold Bench, a high-level deposit of stream gravels, is situated on the northwest side of the South Fork of the Koyukuk River (fig. 1). Placer gold has been mined from these gravels since about 1899, but no mines were being operated in 1952. The gold-bearing gravels consist mostly of schist fragments with varying amounts of quartz, chert, and igneous rocks, and they overlie a thick sequence of wash deposits. The size of the unconsolidated sediments (gravel and wash) ranges from coarse to fine grained. The deposits are crudely stratified and are about 200-300 feet high on the south side of the river. Little is known of the geology in the vicinity of Gold Bench, and the actual source of the gravels is unknown at the present time. The following minerals have been observed by White (1952, p. 11) in concentrates from Gold Bench: magnetite, garnet, hematite, zircon, olivine, epidote, sphene, pyrite, scheelite, galena, chalcopyrite, rutile, cinnabar, cassiterite, bismuthinite(?), and thorianite(?).

A radioactivity traverse of the entire mining area of Gold Bench was made, the stream gravels sampled, and a placer concentrate obtained. The traverse indicated no radioactivity of any significance above the normal background count. However, a placer concentrate obtained contains 0.18 percent equivalent uranium. The results of the laboratory studies on the radioactivity of the samples are summarized in table 10.

Summary and Conclusions

The results of radioactivity investigations in the Koyukuk-Chandalar region during the summer of 1952 showed that no high-grade radioactive deposits are associated with certain metalliferous lode deposits in the Chandalar mining district that were previously deemed favorable for the occurrence of uranium ores.

Trace amounts of monazite have been found in samples from Little Squaw, Big Squaw, and Tobin Creeks in the Chandalar mining district, but traverses in the area did not locate the bedrock source of the monazite. However, Mertie (1925, p. 263) has suggested the source of the monazite to be some highly acid granitic rock, possibly of pegmatitic character. The results of investigations in the Chandalar mining district indicate that there is little possibility of finding commercial quantities of monazite in the stream gravels.

Traces of uranothorianite have been found in the stream gravels of the middle fork of Big Squaw Creek in the Chandalar mining district. The valley of Big Squaw Creek is about 5 miles long, and it divides into west, middle, and east forks approximately 1.5 miles from its mouth. Stream-gravel samples were taken from each fork, but only the sample from the middle fork contained uranothorianite.

A traverse of a part of the ridge at the head of the valley of Big Squaw Creek revealed no anomalous radioactivity. Likewise, no prominent zones of oxidation or alteration were found in the valley of Big Squaw Creek to denote the presence of sulfide-bearing mineral deposits that could be the source of the uranothorianite and the other metallic minerals occurring in the placer concentrates. It is highly probable that such mineral deposits exist, but they may not be very extensive because only

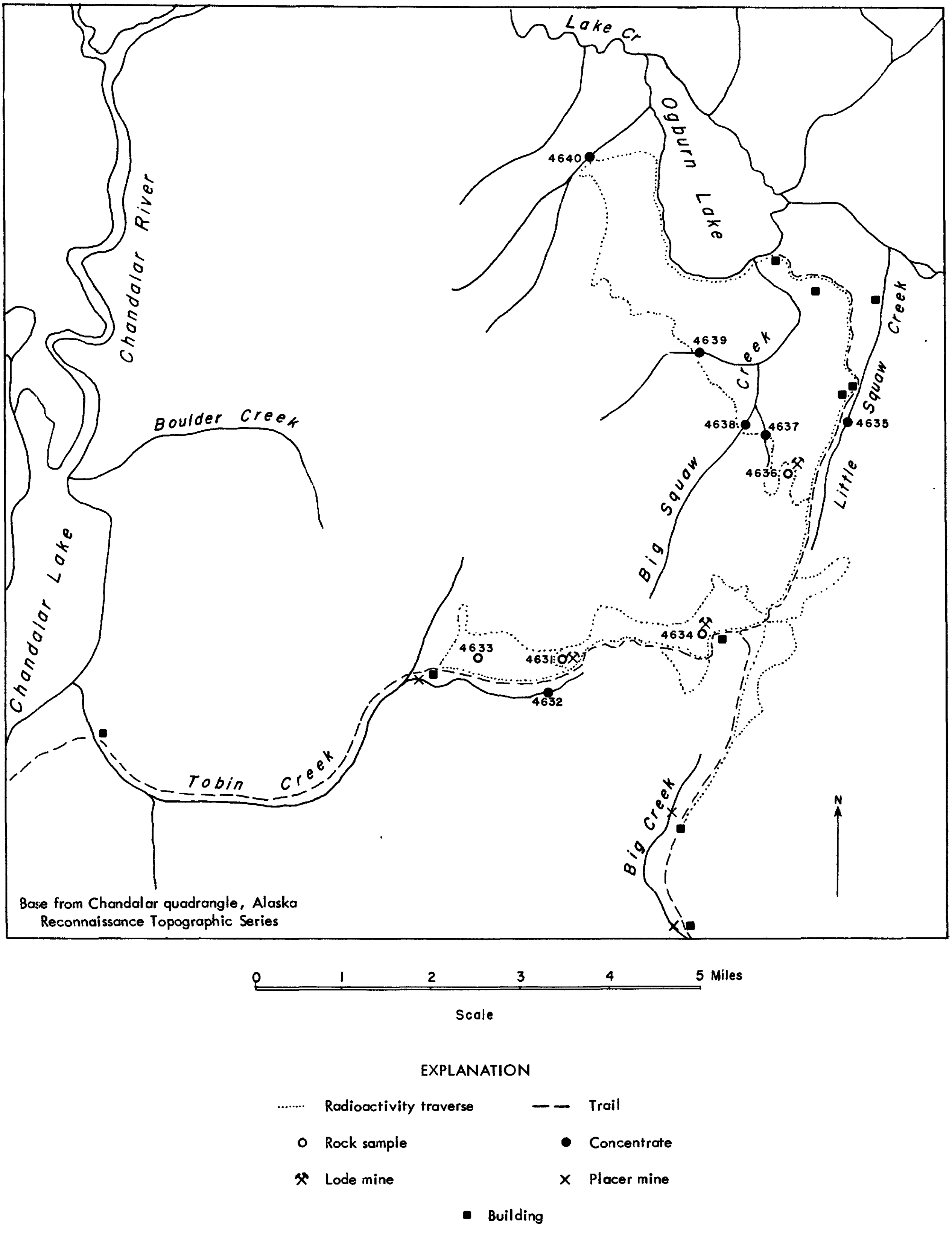


Figure 5.—Sketch map of the Chandalar mining district showing sample locations.

Table 10.—Equivalent-uranium analyses and radioactive minerals of stream and placer concentrate samples from the Koyukuk-Chandalar region, Alaska

[Equivalent-uranium analyses and mineral identifications by J. J. Matzko and A. E. Nelson. X indicates that magnetic fraction contains less than 0.003 eU]

Sample number	Location	Type of sample	For original concentrate	For heavy mineral fraction: methylene iodide[1]	For magnetic fraction: methylene iodide[1]							Radioactive minerals
					0.1 amp	0.4 amp	0.5 amp	0.7 amp	1.0 amp	1.6 amps magnetic	1.6 amps non-magnetic	
4632	Tobin Creek-----	Stream--	< 0.001	0.01	X	X	[2]0.10	--------	--------	--------	--------	Monazite in trace amounts.
4635	Little Squaw Creek.	--do-----	< .001	.002	X	--------	X	[2]0.005	--------	--------	--------	Monazite; only a few grains.
4637	East fork of Big Squaw Creek.	--do-----	< .001	< .001	X	--------	--------	--------	--------	--------	--------	
4638	Middle fork, Big Squaw Creek.	--do-----	.001	.018	X	--------	[2]X	--------	[3]3.2	--------	[4]X	Uranothorianite in trace amounts, with a few grains of monazite and zircon.
4639	West fork, Big Squaw Creek.	--do-----	< .001	.003	X	--------	--------	--------	--------	--------	--------	
4640	Unnamed stream west of Big Squaw Creek.	--do-----	< .001	.005	X	--------	X	--------	--------	--------	--------	
4641	Gold Bench, south fork of the Koyukuk River.	--do-----	< .001	.015	X	X	--------	X	[5].05	X	[4]0.08	Sphene, zircon, and thorite(?) in trace amounts.
4642	---do----------	Placer--	.18	----------	X	--------	--------	--------	--------	--------	--------	Uranothorianite with trace amounts of sphene, zircon, and monazite.

[1] Heavier than methylene iodide (sp gr 3.3).
[2] Monazite.
[3] Uranothorianite.
[4] Zircon.
[5] Sphene and thorite(?).

Table 11.—Radioactivity of rock and ore samples from the Koyukuk-Chandalar region, Alaska

[By U. S. Geological Survey laboratory, College, Alaska]

Sample number	Location	Type of sample	Equivalent uranium (percent)
4631	Mine at the head of Tobin Creek-------------------------	Ore dump-------------	< 0.001
4633	Valley of upper Tobin Creek-----------------------------	Igneous float--------	.001
4634	Mine on divide between Big Creek and Little Squaw Creek-	Vein-----------------	< .001
4636	Mine on divide between Little Squaw and Big Squaw Creeks.	Ore dump-------------	.001

trace amounts of the metallic minerals were found. It is thought that these minerals were not deposited by glacial action because the upper valley of Big Squaw Creek does not appear to have been glaciated, nor do the tops of the mountains at its head seem to have been overrun by glaciers, as has been pointed out by Mertie (1925).

Thus, the traces of uranothorianite and metallic sulfides in concentrates from the placers of the valley of Big Squaw Creek suggest that this locality may be favorable to prospect for a uraniferous lode deposit. It should be stressed, however, that the discovery of the bedrock source of the uranothorianite at this locality would not necessarily lead to commercial production of uraniferous ores. The size, extent, and grade of a deposit, insofar as they can be determined by surficial investigations, as well as the remoteness and, hence, accessibility of the district require much consideration and study prior to exploration and development.

Uraniferous thorianite has been noted in placer concentrates taken from Gold Bench previous to 1952 (White, 1952, p. 8-12). A placer concentrate obtained during the summer of 1952 contains 0.18 percent equivalent uranium that is due primarily to uranothorianite and, to a lesser extent, to monazite.

Maddren (1913, p. 106), in discussing the origin of the placer gold and, presumably, of the uranothorianite occurring at Gold Bench, suggests that the mountains on the south side of the South Fork of the Koyukuk River are the probable source area, because the rocks there are known to contain gold. These mountains are drained by tributaries of the South Fork and are formed in part of igneous rocks that may have genetically associated metalliferous lode deposits that could be the source of the radioactive and metallic minerals in the placers at Gold Bench. A reconnaissance consisting of the radioactivity testing of concentrates from the placer gravels of minor creeks and slope wash in the mountains south of the South Fork might locate the source of the uranothorianite. A similar technique was used in 1947 by West and Matzko (Gault, Killeen, West, and others, 1953, p. 21-27) and in 1948 by West (1953) on the eastern part of the Seward Peninsula, Alaska, where soil conditions and sampling problems are about the same as in the vicinity of the South Fork of the Koyukuk River.

FORTYMILE DISTRICT
By John J. Matzko

A sample of fresh fluorite ranging from colorless to blue, green, and purple was received by the Territorial Department of Mines in the summer of 1952 from Mr. George King, Boundary, Alaska. The writer learned from Mr. King that the sample came from Mr. George Robinson of Jack Wade on Wade Creek; also, that Mr. McDonald, who was prospecting in the Fortymile district, had uncovered some fluorite along the highway east of Chicken, Alaska (figs. 1 and 6).

A party consisting of John J. Matzko, geologist, and Fred Freitag, field assistant, investigated these occurrences during the latter part of August 1952. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Wade Creek

Wade Creek heads against Steel Dome and flows almost due southwest to join Walker Fork. The bedrock in Wade Creek includes several varieties of schist and some thin-bedded ferruginous limestones, all of which are a part of the Birch Creek schist of pre-Cambrian age (Prindle, 1909; Mertie, 1938). Several small bodies of granitic rocks intrude schist in the valley. A basaltic dike is reported to occur near the head of the creek (Prindle, 1909, p. 36).

Mr. Robinson, who had given the fluorite sample to Mr. King for identification, was working a small gold-placer deposit on Wade Creek. Robinson reported that he had found the fluorite in a prospect pit which he had dug on a fourth left tributary above the mouth of Wade Creek (fig. 6) and that the pit had since caved. The source of the fluorite was not determined.

A concentrate of stream-gravel (sample 4626, fig. 6) from Wade Creek taken below the mouth of the fluorite-bearing tributary has an equivalent-uranium content of 0.001 percent. No radioactive minerals were found in the sample.

Walker Fork

Mr. George King reported to the writer that Mr. McDonald, prospecting in the Fortymile district, Eagle quadrangle, had uncovered some fluorite along the highway east of Chicken. The fluorite monument, which McDonald had set up to mark the location, was found east of Chicken and about 2 miles west of the Walker Fork bridge on the south side of the road (fig. 6). Only a few extra pieces of weathered fluorite besides those of the marker were found. A traverse made with a Geiger counter did not locate any anomalous radioactivity.

A channel sample, 4627, taken across the zone of decomposed rock contains only trace amounts of radioactive minerals—0.003 percent equivalent uranium as

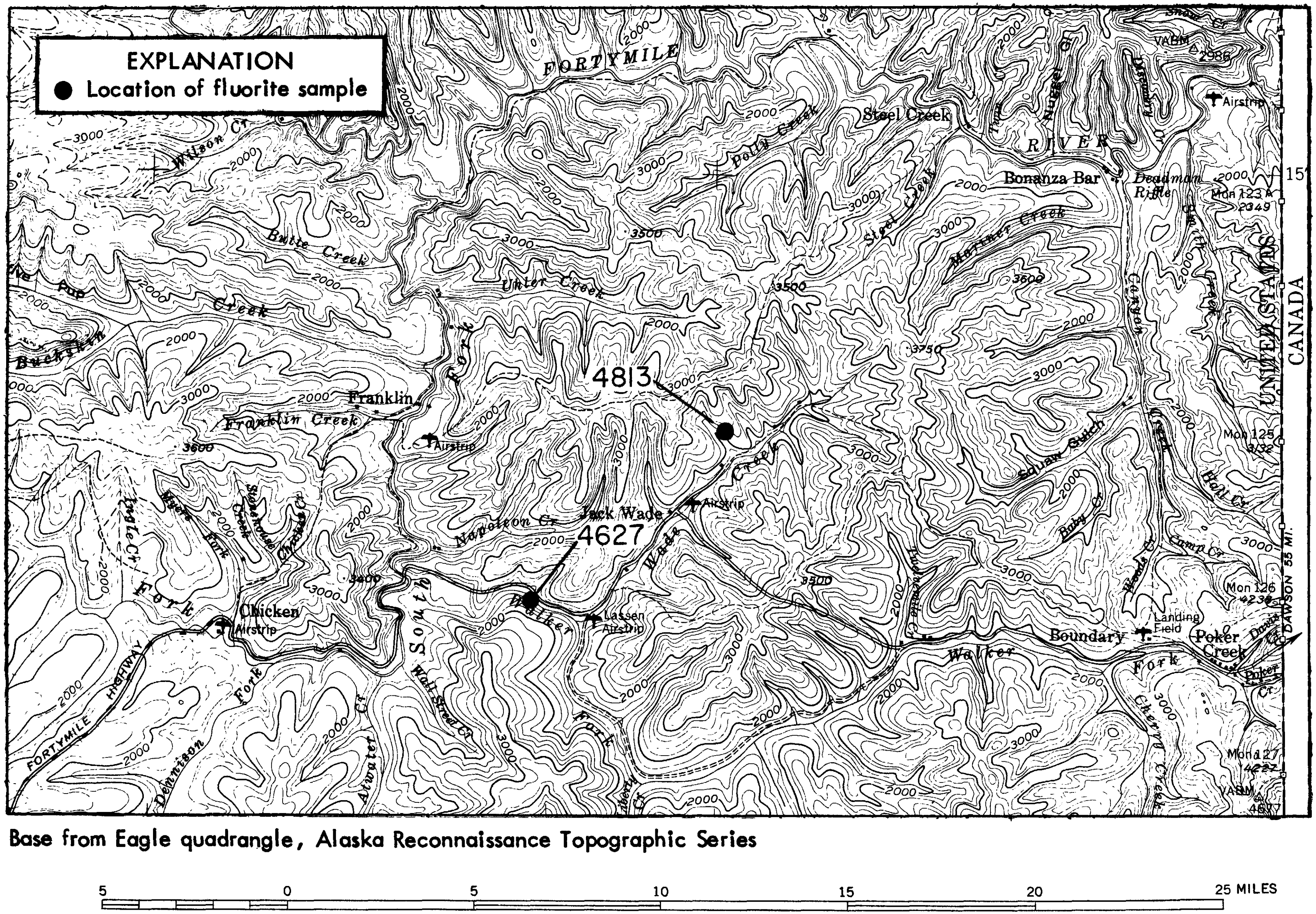


Figure 6. —Topographic map of part of the Fortymile district, east-central Alaska.

determined in the laboratory. Mineralogic examination of the sample indicates that goethite and hematite are the major constituents; colorless fluorite constitutes about 5 percent of the sample, and iron-stained mica, pyrite, and rutile occur in minor amounts.

Bedrock outcrops alongside the road west of the bridge across Walker Fork and on either side of the sample fluorite zone consist of fresh-appearing granodioritic rock. Details of the geology of the area have been discussed by Prindle (1909) and Mertie (1938).

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

GEOLOGICAL SURVEY CIRCULAR 332

THE KATHLEEN-MARGARET (K-M) COPPER PROSPECT ON THE UPPER MACLAREN RIVER, ALASKA

By Robert M. Chapman and Robert H. Saunders

Prepared in cooperation with the Department of Mines, Territory of Alaska.

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Free on application to the Geological Survey, Washington 25, D. C.

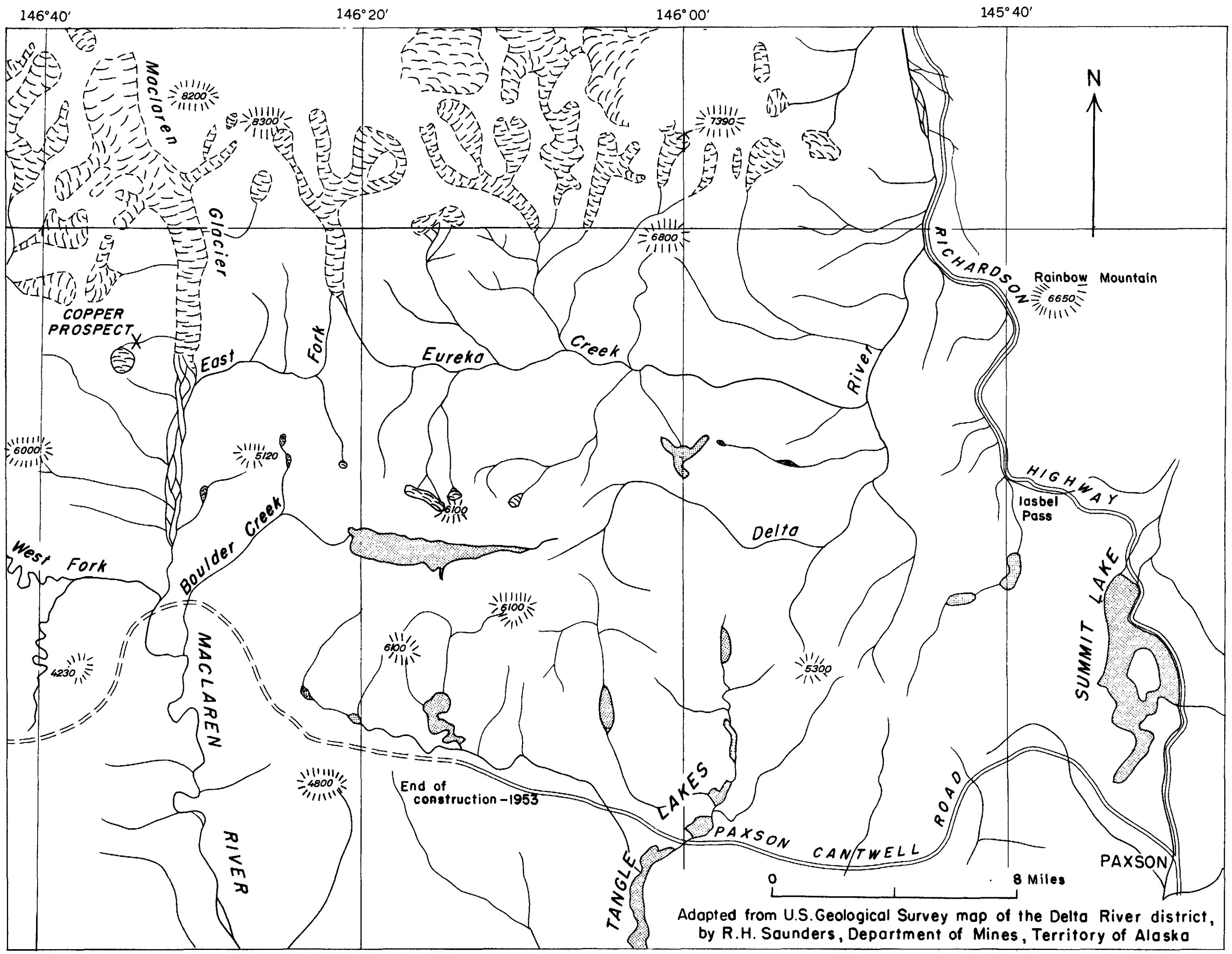

Figure 1.—Map of upper Maclaren River, Alaska.

THE KATHLEEN-MARGARET (K-M) COPPER PROSPECT ON THE UPPER MACLAREN RIVER, ALASKA

By Robert M. Chapman and Robert H. Saunders

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ABSTRACT

The Kathleen-Margaret (K-M) prospect is in the Mount Hayes quadrangle on the west side of the Maclaren Glacier about 25 miles south of the peak of Mount Hayes. The proposed route of the Denali Highway is about 9 miles south of the prospect.

Several veins have been discovered on the prospect, but only one appears to be minable. The vein is about 10.5 feet thick; it strikes N. 3°-4° E. and dips 70°-90° W. Along its east wall there is a zone of nearly barren quartz 1.5 to 2 feet thick. The richest ore, samples from which have assayed 30 to 45 percent copper, is confined to a zone about 1.5 to 2 feet thick adjacent to the nearly barren zone. Assays of samples from the remainder of the vein, about 7 feet thick, have ranged from 3.5 to 12.5 percent copper.

INTRODUCTION

In 1950 E. O. Albertson and F. S. Pettyjohn, Jr., of Big Delta, Alaska, formed a partnership and prospected the vicinity of Chistochina, a gold-placer district on the south slope of the Alaska Range about 20 miles east of the Richardson Highway. From Chistochina they gradually worked westward until they reached the Maclaren River drainage. In 1952 Pettyjohn discovered an outcrop of a copper-bearing vein on the west side of the Maclaren Glacier.

From August 11 to 14, 1953, the copper-bearing outcrops and adjacent area were examined by R. M. Chapman of the U. S. Geological Survey and R. H. Saunders of the Department of Mines, Territory of Alaska. This report is written from notes taken during that examination and from information furnished by Albertson and Pettyjohn.

LOCATION AND ACCESSIBILITY

The Kathleen-Margaret (K-M) copper prospect is in the Mount Hayes quadrangle at latitude 63°17' N. and longitude 146°35' W. By U. S. Geological Survey classification, it is in the upper Susitna valley district of the Cook Inlet region and by the U. S. Bureau of Mines classification, the prospect is in the Valdez Creek subdistrict of the Cook Inlet-Susitna region. The claims lie on the west side of the Maclaren Glacier about 25 miles south of the peak of Mount Hayes. A glacial stream flows along the lower part of the west side of the glacier; it is fed by eastward-flowing tributaries that head in icefields on the ridge west of the glacier. The main outcrop is in the north wall of the gulch that has been eroded by Discovery Creek, named by Albertson and Pettyjohn, the first tributary upstream from the terminus of the glacier. This outcrop is at an altitude of 4,100 feet.

The prospect is about 9 miles north of the proposed route of the Denali Highway between Paxson and Cantwell. The highway is now under construction. The extent of the road at the end of the 1953 working season is shown on figure 1. By the end of 1954 the road probably will be completed as far as the Maclaren River.

An access road from the prospect to the Denali Highway would be 9 to 10 miles long. The flood plain of the Maclaren River probably would provide the best route for the first 7 or 8 miles of the access road. The flood plain consists mostly of coarse well-drained gravel and it appears that the building of a road on the gravel would require little more than clearing boulders from the roadway. A mile or two south of the prospect the road would leave the flats and would be built on the lower slopes on the west side of the river. This part of the road would be more difficult to build, but there are no obstacles that would make the cost of construction prohibitive.

After the necessary roads are built, the prospect will be 50 miles from Paxson, 245 miles from Valdez, and 450 miles from Seward by road. Shipping over the Alaska Railroad would require a truck haul of 105 miles to Cantwell; the distance by rail from Cantwell to Seward is 320 miles.

There are only a few small lakes within 10 miles of the copper prospect, and the nearest lake that is suitable for use by small pontoon-equipped aircraft is situated near the west bank of the Maclaren River about 2.5 miles south of the terminus of the Maclaren Glacier and about 5 miles south of the prospect. Several large lakes, 12 to 20 miles southeast of the prospect area, would be suitable for larger pontoon aircraft.

A landing field large enough for multiengine aircraft could be constructed on the braided flood plain of the Maclaren River. Many stretches of the alluvial gravel between Cottonwood Creek and Maclaren Glacier are nearly smooth and clear enough in their natural state to serve as a landing strip. If a permanent strip is built on the flood plain, it will be necessary to raise the level of the runway surface and possibly to build protective dikes to prevent flooding during extreme high water stages, as channel shifting is frequent in the braided channel areas.

The prospect can be reached conveniently by small pontoon aircraft from one of the lakes along the Richardson Highway to the small lake on the west side of the Maclaren River. Pontoon planes are available for charter at Summit and Meier Lakes.

PHYSICAL FEATURES AND CLIMATE

The upper Maclaren River area is a part of the rugged glaciated south slope of the Alaska Range. The altitudes range from about 3,000 to 8,000 feet and the copper-bearing veins are exposed at altitudes of 3,800 to 4,100 feet. The mountain slopes are predominantly steep, and the average relief is about 2,000 feet. The main Maclaren River valley and the other large valleys are wide, flat floored, typical glacial valleys, and the smaller tributary valleys are either small glacial valleys with moderate gradients, or small, sharp postglacially eroded valleys with gradients steep enough to produce cascades and small waterfalls. Many of the small glacial hanging valleys are connected to the main valley by a postglacial notch in their lip. Discovery Creek is an example of this.

There are several glaciers in the vicinity of the copper prospect. The large Maclaren Glacier is about 10 miles long and occupies the head of the main Maclaren valley. A number of cirque glaciers and small icefields, remnants of larger tributary glaciers, are present at altitudes of 5,000 feet and higher in the peaks between the Maclaren River and the West Fork.

A flow of water adequate for the needs of a camp and mining operations is available during the summer months from any of the small streams that are fed by snowfields and glaciers. In addition to the melt water, precipitation is frequent in this area during the summer, according to Pettyjohn's report and the writers' experience during the field examination. The Maclaren River carries a large volume of water, but much of its upper course is braided, and fordings with tractors and other equipment can be made in the braided stretches if reasonable care is used.

The area within several miles of the copper prospect and the Maclaren Glacier is devoid of timber. The vegetation consists of scrub willows and alders in the main valley floor and in a few protected valleys, and low brush and small tundra plants, mosses, and lichens on the slopes and mountains. Timberline in this part of the Alaska Range is at an altitude of 2,500 to 3,000 feet. It is reported that some spruce timber of usable size can be obtained on the Maclaren River about 9 miles south of the terminus of the Maclaren Glacier, but most of the timber would have to be hauled from greater distances.

The climate in this area is moderately severe. Weather records for 7 years between 1914 and 1944 taken at Paxson, about 36 airline miles east-southeast of the copper prospect, show 18.36 inches mean annual precipitation, most of which falls during the period of June through September. The snowfall ranges from about 10 to 22 inches per month during the period from October through April. Written records, and personal observations indicate that cloudy skies and strong winds are common. The mean temperature at Paxson is 25.3° F. The mean maximum temperature during June, July, and August is about 65° F, and during December and January is about 8 degrees. The mean minimum temperature is about 37° F during June, July, and August, and about -12° F during December and January.

PROPERTY AND OWNERSHIP

The two owners have staked 10 claims to cover the veins that they have discovered. The claims are designated Kathleen-Margaret Nos. 1 to 10. The locations of the claims are shown on figure 2. Each claim is owned jointly by the two partners. The location certificates are recorded in the records of the U. S. Commissioner at Talkeetna, Alaska.

GEOLOGY AND MINERAL DEPOSITS

Geology

Little time was available for general study of the rock formation during the visit to the copper prospect, and only the rock exposed in the immediate area of the prospect was examined. The formations have been generally defined and mapped by Moffit (1912) and distant observations and examination of aerial photographs confirm his reconnaissance mapping.

The country rock in which the copper-bearing quartz veins occur is chiefly a green diabasic lava.

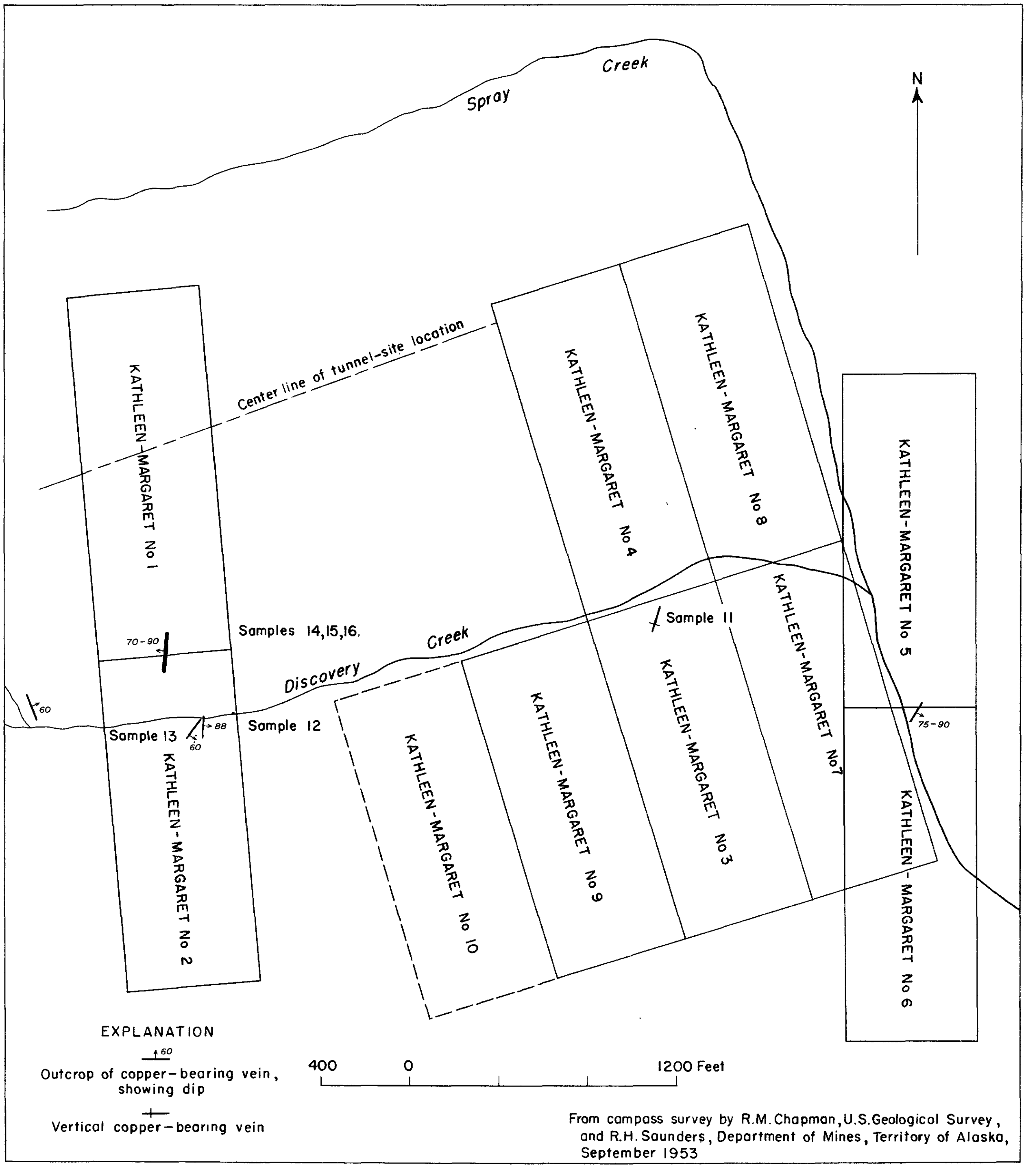

Figure 2.—Sketch map of claims showing Albertson-Pettyjohn copper prospect, Maclaren River, Alaska.

Moffit assigned a late Carboniferous or early or middle Triassic age to this unit, which is exposed in a west-trending range of low mountains that lies between Summit Lake and the Susitna River. Capps (1940, pl. 2) shows the same unit as pre-Cretaceous (Mesozoic). As described by Moffit (1912, p. 29-30):

"The rocks consist largely of diabase and locally are amygdaloidal. They are associated with argillites, tuffs, and tuffaceous conglomerates in a number of places and are intruded by diabases and by dikes of less basic, light-colored porphyritic rock. Intrusions of peridotite have taken place in the Tangle Lakes vicinity, and probably also in other places, for boulders of this character were found in some of the younger conglomerates near the glacier at the head of the east fork of Maclaren River. The lava flows have been deformed in the general folding of the region so that steep dips are common, and schistosity is occasionally developed."

Apparently the oldest rocks in the area lie east of the Maclaren Glacier and northeast of the copper prospect. These rocks, correlated by Moffit with the Chisna formation of Mendenhall (1905), lie in a west-trending belt on the south side of the Alaska Range. This formation extends eastward from the Maclaren Glacier to the Summit Lake area, but has not been recognized west of the Maclaren valley. The Chisna formation was not examined in the field, but Pettyjohn reports that he found no mineralization in the parts of it that he prospected. As described by Moffit (1912, p. 27-28), the formation consists of quartzite, tuffaceous beds, and metamorphosed limestone containing associated granular intrusives. Many of the weathered surfaces of this formation have a rusty red color that is particularly conspicuous.

Rocks of probable Triassic age include limestone, conglomerate, and thick units of slate having intercalated basic igneous flows or intrusives, all of which are cut by granular intrusives of dioritic or related compositions. These rocks are exposed on the west side of Maclaren valley about 2.5 miles north of Discovery Creek, and they form an outcrop belt that extends west-southwestward from this point. Triassic rocks apparently are not exposed in the area between the Maclaren River and the Richardson Highway.

The Jurassic rocks, as described by Moffit, consist of gray quartz diorite and hornblende diorite that in part show well developed cleavage and schistosity. They occur as dikes, sills, and large, irregular, intrusive masses. Several small masses of Jurassic rocks were mapped by Moffit (1912, pl. 11) on both sides of the Maclaren valley in the area just north of the copper prospect. An igneous mass of batholithic size lies in the Susitna River drainage about 5 to 12 miles west of the Maclaren Glacier.

The geologic mapping of this region is of the general reconnaissance type. Additional reconnaissance and semidetailed geologic mapping of the south slope of the Alaska Range between the Richardson Highway and the Alaska Railroad should be done to provide basic geologic and economic data.

Mineral deposits

Several quartz veins bearing bornite and chalcopyrite with malachite surface alteration occur in the vicinity of Discovery Creek, a western tributary of the Maclaren River near the terminus of the Maclaren Glacier (fig. 2). The largest and richest vein is located on the steep north slope of Discovery Creek about 3,200 feet upstream from the mouth. This vein is about 10.5 feet thick, strikes N. 3°-4° E., and dips 70°-90° W. Mineralized talus from this vein can be traced down the slope to Discovery Creek and downstream in the creek gravel. The best exposure of the vein is near the top of the slope about 180 feet above the bottom of the valley. It is from this outcrop, which had been dug out for sampling and examination, that the authors obtained samples. The vein crops out at several places down the slope within a vertical distance of about 80 feet, and the width and mineralization appear to be fairly uniform throughout this distance. The richest ore, samples from which have assayed 30 to 45 percent copper, is confined to a zone about 1.5 to 2 feet thick within the vein. Assays of samples from an adjacent zone about 7 feet thick have ranged from 3.5 to 12.5 percent copper. Appreciable amounts of silver and traces of gold also are present in the samples from both zones. The gold content seems to be higher in the lower grade copper bearing material than in the rich zone.

Two small quartz veins about 30 feet apart containing bornite and chalcopyrite with malachite surface alteration crop out on the south side of Discovery Creek about 200 feet downstream from the 10.5-foot thick vein. These veins are 0.75 to 1.0 foot thick. Several barren quartz veinlets associated with them are 1 to 2 inches thick. One vein strikes N. 35°E. and dips 60° south. Samples taken from widths of 0.75 foot in these veins assayed 1.58 percent copper (sample 12) and 2.95 percent copper (sample 13) with only traces of gold and silver. The bedrock in this zone is a highly fractured, dark grayish-green flow(?) rock and includes light apple-green pods and small dikes that are composed largely of epidote(?). Thin, sheared zones of blackish-green serpentine and/or chlorite are associated with the quartz veins. Some brick-red iron staining is present in this fractured zone.

A small quartz vein, banded with bornite and calcite, crops out on the south side of Discovery Creek about 1,000 feet above the mouth. Chalcocite, chalcopyrite, and epidote have been identified in other specimens from this vein. This vein, which is 0.4 foot thick, strikes N. 15°-20° E., and is vertical, apparently continues northeastward for at least 100 feet to another small vein outcrop. Sample 11, taken across the width of the vein, assayed 1.33 percent copper, a trace of gold, and no silver or nickel. Albertson and Pettyjohn reported that their sample from this vein showed 2 percent copper and a trace of nickel.

Another small quartz vein is exposed on a rock knob on the east side of Spray Creek about 600 feet downstream from Discovery Creek. This vein strikes N. 30° E. and dips 75°-90° southeast. It contains traces of copper minerals and has some greenish-black serpentine streaks and pockets and some epidote within the quartz.

A quartz vein bearing some chalcopyrite and bornite with malachite surface staining is exposed in a small gully tributary to Discovery Creek about 600 feet upstream from the 10.5-foot vein. The quartz vein is 3 to 5 inches thick and can be traced laterally for at least 20 feet. The rock exposed in the gully has slumped, but the vein appears to strike N. 20° W. and to dip 60° north.

Minor amounts of malachite are found on weathered exposures of the copper-bearing veins, but azurite occurs only rarely. Chrysocolla has been identified in at least one sample that was collected by the owners.

In addition to the above-mentioned veins that were examined by the writers, Pettyjohn reports that there are several copper-bearing veins about 2.5 miles southwest of Discovery Creek on the slopes of Cottonwood Creek valley. Several specimens from veins are reported to assay 0.5 to 1.5 percent copper, and one piece of float assayed 40.85 percent copper. Samples from a 51-inch thick quartz vein near the high-grade float had copper assays ranging from nil to 1.43 percent. The 51-inch vein reportedly is cut off at one end by a fault. Pettyjohn plans further prospecting in the Cottonwood Creek and West Fork area. Pettyjohn also reports that he found no metallization on the east side of the Maclaren valley or on the west side north of Spray Creek.

SAMPLING AND ASSAYS

Six samples taken during the field examination were assayed by the Department of Mines Assay Office at College, Alaska, and the results of the assays are shown in table 1. The sampling points are shown on figure 2.

Table 1.—Analyses of six samples assayed by the Department of Mines Assay Office at College, Alaska

Sample no.	Width sampled (feet)	Ounces per ton		Copper (percent)
		gold	silver	
11	0.40	(1)	(2)	1.33
12	.75	(1)	(1)	1.58
13	.75	(1)	(1)	2.95
14	2.00	(1)	(2)	.27
15	1.75	(2)	2.55	30.45
16	7.00	0.18	1.20	8.99

[1]Trace.
[2]Nil.

Samples 14, 15, and 16 are rough channel samples that were taken across the uppermost outcrop of the main 10.5-foot vein. Sample 14 represents a band of barren quartz 2 feet wide on the east side of the vein. Sample 15 represents a band of "high grade" adjacent to the barren quartz; it ranges in width from 1.5 to 2 feet. The high-grade band consists mostly of bornite and contains minor amounts of chalcopyrite and quartz probably with a few other minerals. The remainder of the vein, represented by sample 16, ranges from 6.5 to 7.5 feet in width. It consists of quartz impregnated with bornite and chalcopyrite. The three bands in the vein appear to be consistent in width. The vein is exposed at several points over a distance of about 150 feet on the slope.

Samples 11, 12, and 13 were tested for nickel; none was present. The owners reported that there was a trace of nickel in a sample that they took from the vein from which sample 11 was taken. The owners have taken several samples across the high-grade band in the main vein. All have assayed more than 40 percent copper. Samples taken by the owners from the 7-foot band of quartz, bornite, and chalcopyrite on the west side of the vein have assayed from 3.5 to 12.5 percent copper.

CONCLUSION AND RECOMMENDATIONS

The 10.5-foot bornite-chalcopyrite-quartz vein on Discovery Creek is worthy of further exploration. The tenor and the apparent downdip continuity of the vein indicate a minable deposit if the vein has sufficient continuity along its strike. Unfortunately the ridge top to the north of Discovery Creek is completely covered by vegetation, and no surface indications of the vein or bedrock can be found without trenching or underground exploration.

In addition to exploration of the 10.5-foot vein, further prospecting is recommended in the Discovery Creek area and the westward extension of the outcrop belt of basaltic lavas. The headwaters of Cottonwood Creek and the West Fork are a virtually unknown area, and the basaltic lava formation continues westward to the Susitna River. Moffit (1915, p. 76) points out that a vein of chalcopyrite was found on Butte Creek, just west of the Susitna River, and that copper-bearing minerals have been found in the lava flows between Butte and Wachana Creeks and the Susitna River.

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