Contributions to Economic Geology of Alaska

GEOLOGICAL SURVEY BULLETIN 1155

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ABSTRACT

Ten short reports by various authors, each dealing with a mineral investigation in Alaska, are combined under one cover. The reports include accounts of work done, largely under the auspices of the Defense Minerals Exploration Administration, at the Funter Bay nickel-copper deposit and the Stampede antimony mine; several uranium investigations made on behalf of the Division of Raw Materials, U.S. Atomic Energy Commission; an examination of coal at seven localities along the Yukon River between Ruby and Anvik; reconnaissance mapping and sampling of four perlite deposits in the Alaska Range; a brief study of a copper prospect site in Chitina Valley; and examination of a tungsten prospect on Kodiak Island.

INTRODUCTION

Ten short reports, each dealing with a mineral deposit or commodity of Alaska, are here combined under one cover. These reports, by a number of different authors, deal variously with nickel, copper, antimony, coal, uranium, perlite, and tungsten. Most of the reports give the results of either exploratory work done under the auspices of the Defense Minerals Exploration Administration or brief reconnaissance field investigations. None of the reports includes an exhaustive study of a deposit or commodity.

THE FUNTER BAY NICKEL-COPPER DEPOSIT, ADMIRALTY ISLAND, ALASKA

By Fred Barker

The nickel-copper deposit at Funter Bay, Admiralty Island, Alaska (fig. 1, locality 1), consists of a gabbro pipe that contains the sulfides pyrrhotite, pentlandite, and chalcopyrite. The pipe is in highly folded quartz-muscovite schist, black slate, and green schist. It plunges approximately 30° at S. 80° E., and its major axis ranges from about 60 feet to 200 feet in length.

The gabbro pipe, known as the Mertie lode, was discovered in 1919, but little exploration was done until 1928. At that time, the property was examined by H. M. Eakin, the 126-foot Mertie adit was driven, and nine holes were diamond drilled. John Worchester[1] made a

[1] Worchester, John, 1930, Examination and flotation experiments on a nickel-ore from Alaska: Massachusetts Inst. Technology B. S. thesis.

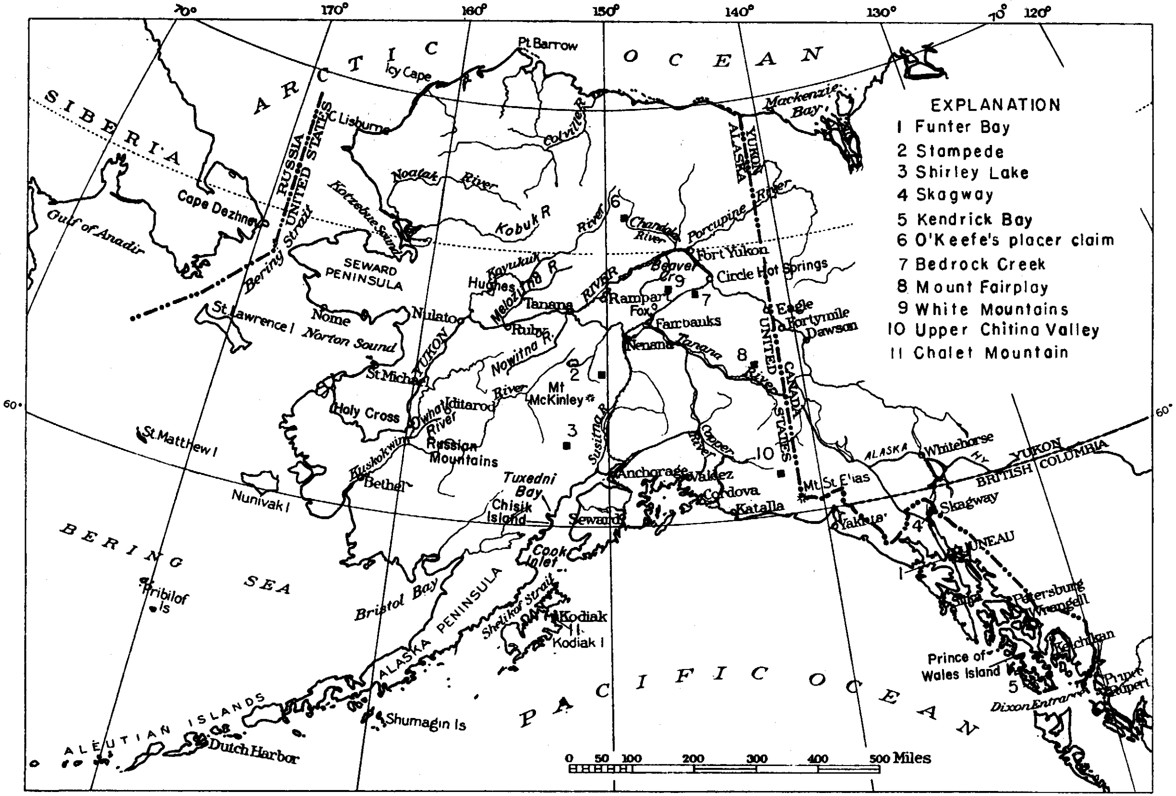


FIGURE 1.—Index map of Alaska showing localities described in this report.

microscopic study of the ore and performed flotation experiments on it. J. C. Reed of the Geological Survey mapped the geology of the Funter area in 1937 and made brief visits to the area in 1936 and 1938. Reed (1942) discussed both the regional geology and the nature and tenor of the gabbro body, then thought to be a sill.

U.S. Bureau of Mines engineers S. P. Holt and J. M. Moss (1946) sampled the walls of the Mertie adit, made beneficiation tests, and summarized unpublished sampling data of the Admiralty-Alaska Gold Mining Co. and private engineers.

An exploration program was carried out on the gabbro pipe under auspices of the Defense Minerals Exploration Administration from 1951 through 1956. This work included 1,093 feet of crosscutting and drifting, 308 feet of long-hole drilling, 5,742 feet of diamond drilling, and 5,325 cubic feet of excavation for diamond-drill stations and turn-outs. During that period, sampling and surveying were done by Bureau of Mines personnel, and geologic mapping was carried out by geologists of the U.S. Geological Survey.

GEOLOGIC SETTING

The mountainside near the gabbro pipe is underlain by black graphitic phyllite with interlayered quartz-sericite-biotite schist and greenschist. These rocks strike mostly N. 10° W. to N. 30° W. and dip gently to steeply east. The rocks in this area have been intensely folded and have axial planes that strike north-northwest and dip steeply to the east. At the surface the quartz-sericite-biotite schist adjacent to the gabbro pipe dips 31° to 50° E. and strikes parallel to the upper and lower contacts. Black phyllite lies about 30 feet uphill and to the east of the pipe. Underground the pipe is enclosed by quartz-sericite-biotite schist with only minor black phyllite, except at the upper contact near the face of the DMEA crosscut where black graphitic phyllite lies parallel to the contact and dips 30° E.

Faults A, B, C, and D (pl. 1), and a number of lesser faults, were found in the DMEA crosscut. Only faults B, C, and D offset the gabbro body. Reverse fault B has a dip-slip component of about 10 feet. Fault C has a dip-slip component of several feet and a strike-slip component of probably 12 feet. The direction and amount of movement along fault D is not known, because the pipe shows an irregular pinching and swelling in this vicinity. However, sulfide-rich coarse-grained gabbro in the west wall of this fault lies against sulfide-poor medium- to fine-grained gabbro in the east wall. The sulfide-rich coarse-grained type is believed to have formed in the central core of the pipe; the sulfide-poor medium- to fine-grained type is close to a contact zone that has formed along the roof of the pipe. These relations suggest that the east block has dropped relative to the west block.

Faults C and D are believed to merge about 180 feet above the DMEA crosscut to form a single fault that probably continues up to the surface.

DESCRIPTION OF THE GABBRO PIPE

The extent of the pipe at the surface and at the DMEA level is shown on the maps and sections of plate 1 and figure 2. The DMEA

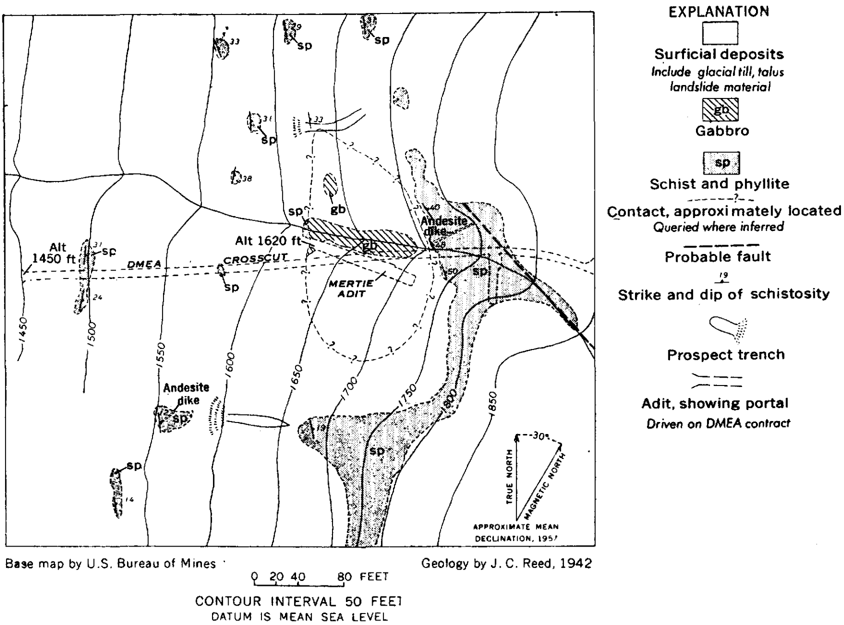


FIGURE 2.—Surface geologic map, Funter Bay nickel-copper prospect, Admiralty Island.

adit and drilling program have shown that the axis of the pipe extends more than 900 feet, and plunges about 30° at S. 80° E. The area of the pipe at the surface is about 23,000 square feet; the calculated area normal to the axis of the pipe at the surface is roughly 22,000 square feet. The pipe decreases in cross-sectional area from the surface downward; and at the level of the DMEA crosscut, 360 feet along the axis from the surface, the inferred area of a horizontal section is about 16,000 square feet. This area projected normal to the axis of the pipe is approximately 8,000 square feet. Eastward and down its axis, the pipe enlarges to an elliptical cross section with major and minor axes of about 190 feet and 125 feet, respectively.

The inferred volume of the known extent of the gabbro body is 9 million cubic feet, and the total tonnage of rock is 900,000 short tons (assuming an average density of 3.1).

The relative proportions of different minerals in the pipe vary widely from place to place, but the rock can be divided roughly into two types: sulfide-rich olivine-hornblende-labradorite gabbro and sulfide-poor labradorite-augite gabbro. Norite is common in the pipe and is similar to the augite gabbro except that hypersthene is present instead of augite. The olivine-hornblende gabbro is potential ore material, but the augite gabbro and norite contain only a small percentage of sulfide, except in very local concentrations.

The types and distribution of gabbro suggest that (1) the original magma was of gabbroic composition; (2) olivine crystallized early, before feldspar and pyroxenes, and settled to the lower part of the pipe to form the olivine-hornblende-labradorite gabbro; (3) the remainder and bulk of the magma, where uncontaminated by wallrock, crystallized as labradorite-augite gabbro; and (4) norite was formed where parts of the gabbroic magma were mixed with the enclosing slate, and augite reacted with alumina and silica to produce hypersthene and the anorthite component of plagioclase. This general reaction was discussed by Bowen (1928, p. 206).

Wide variations in petrography of the rock in the pipe are common. Buddington (1926, p. 46) gave a detailed petrographic description of a rock from the pipe that he called troctolite; it contained 55 percent labradorite, 39 percent olivine, 4 percent pyroxene, and 2 percent magnetite. Reed (1939, p. 265–266) studied 5 thin sections and 3 polished sections and noted 29 to 37 percent plagioclase, 6.7 to 32 percent olivine, 1.3 to 13.5 percent pyroxene, 3.4 to 30 percent alteration products, and 1.0 to 18.3 percent opaque minerals. Reed determined the volume of sulfides in samples from the pipe and concluded that more copper is present in the rock than could be contained in the chalcopyrite, and more nickel than could be held in the pentlandite.

DISTRIBUTION OF ROCK TYPES AND SULFIDES WITHIN THE PIPE

Most of the pipe is sulfide-poor gabbro. Sulfide-rich olivine-hornblende gabbro is found in a poorly defined zone along the lower part, or keel, of the pipe. On the DMEA-level cross section of plate 1, sulfide-rich gabbro lies west of fault D. The drill holes at the three stations east of fault D penetrated sulfide-rich rocks at depths of from 52 to 65 feet in hole U–20, 55 to 57 feet in hole U–21, 126.5 to 128.5 feet in hole U–27, 149.5 to 153 feet in U–32, 246 to 273 feet in U–35, 178 to 185 feet in U–36, 245 to 275 feet in U–37, and, for the most part, 305 to 345 feet in U–38. Wholly sulfide rock was found at a depth of 204.3 to 206.4 feet in hole U–34.

In each of these drill holes, a section of gabbro from several tens of feet to almost 200 feet long contains only sparse sulfides and lies above the metallized gabbro. This sulfide-rich zone is gradational with the overlying sulfide-poor rock, and its definite limits are not known. It appears to have a lenticular cross section from a few feet to about 20 feet long (normal to the axis of the pipe).

The distribution of nickel and copper in the pipe is shown on the assay map, plate 2. The part of the pipe east of fault D contains much less nickel and copper than the part west of the fault; most of the west part bears more than 0.50 percent combined nickel and copper. The assay data of this part of the pipe are not complete and are not oriented favorably for definitive calculations of tonnage; but a roughly ellipsoidal body of gabbro that has an axis about 360 feet long parallel to that of the pipe, a horizontal axis 60 feet long, and a third axis 40 feet long, is believed to contain from 1.0 to 2.0 percent combined nickel and copper.

Almost all the pipe east of fault D contains less than 0.10 percent combined nickel and copper.

SULFIDE-RICH GABBRO

The sulfide-rich gabbro is dark gray, massive, largely fine to medium grained, and hypidiomorphic. It consists of anhedral olivine grains 2 mm in average maximum dimension; euhedral to subhedral plagioclase laths ½ to 1 mm long; anhedral hornblende grains ½ to 1 mm long that are partly pseudomorphic after augite; anhedral sulfides; and minor anhedral biotite, chlorite, subhedral hypersthene, anhedral sericite, antigorite, anthophyllite, talc, calcite, and magnetite. The olivine contains irregular fractures along which magnetite dust is scattered. Most of the olivine is fresh, but local areas in thin sections contain wholly serpentinized olivine with minor talc and pleochroic green-brown chlorite and relict magnetite-filled fractures. N_Z of the olivine is about 1.70 and 2V=90°, which suggest a magnesian variety. Hornblende is present as fresh-appearing irregular elongate anhedra and subhedra that enclose laths of plagioclase. Several partial pseudomorphs of hornblende rimming augite were seen. For the hornblende, (−)2V=75° to 85°, $Z \wedge c=31°$, X=pale brown, Y=brown, and Z=dark reddish brown. Most of the plagioclase grains ($Ab_{38}An_{62}$) are homogeneous or only slightly zoned subhedral laths ½ to 1 mm long; a few are smaller, interstitial, and moderately to markedly continuously variable in composition, with labradorite cores and rims as sodic as oligoclase. Much of the plagioclase has been partially sericitized along minute cracks, over irregular areas, and along rims. Magnetite appears to be wholly secondary. It is found as very fine grained equant to irregular anhedra, one-fifth millimeter to dust size (about 0.005 mm and less), that occur along fractures in olivine, at boundaries of olivine and serpentine grains, and disseminated in other minerals. The sulfides embay the silicates with no alteration at contacts. The order of crystallization of major minerals probably was, with some overlapping, olivine, plagioclase, hornblende, biotite, alteration minerals and magnetite, and sulfides.

A micrometric analysis of 2.55 square inches of polished (by the Harvard process, Short, 1940, p. 32–40) surfaces showed that a typical speciman of sulfide-rich gabbro, specimen 55ABf17, contains 27 percent pyrrhotite, 2.6 percent pentlandite, 2.5 percent chalcopyrite, and 0.4 percent pyrite. Both chalcopyrite and pentlandite lie in or at boundaries of irregular to roughly equant grains of pyrrhotite that are $\frac{1}{2}$ to 10 mm in size. Chalcopyrite occurs mostly as $\frac{1}{20}$- to $\frac{1}{2}$-millimeter-thick partial rims around pyrrhotite grains, as $\frac{1}{10}$-mm irregular grains, as $\frac{1}{20}$- to $\frac{1}{10}$-millimeter-thick crudely tabular grains along pyrrhotite-pyrrhotite boundaries, and as platelets in pyrrhotite. Pentlandite is present mostly as partial rims $\frac{1}{20}$ to $\frac{1}{10}$ mm thick on pyrrhotite grains, as irregular $\frac{1}{20}$- to $\frac{1}{5}$-mm blebs at pyrrhotite-silicate and pyrrhotite-pyrrhotite boundaries, as tiny platelets $\frac{1}{40}$ mm in average thickness, and as coalescing platelets at boundaries of pyrrhotite grains. The platelets of pentlandite are parallel to each other and to those of chalcopyrite; their distribution in the pyrrhotite grains is irregular, and they form several percent of the pentlandite and about 1 percent of the chalcopyrite (estimated by eye) in the rock. Both chalcopyrite and pentlandite are seen to be homogeneous phases at a magnification of 500 diameters.

It is believed that pyrrhotite containing nickel and copper in solid solution crystallized first, corroding contiguous silicate grains, and that upon cooling pentlandite and chalcopyrite exsolved and largely migrated to boundaries of the pyrrhotite grains.

Assuming that pentlandite contains about 22 percent nickel and that chalcopyrite contains 34.5 percent copper, specimen 55ABf17 should contain about 0.80 percent nickel and 0.96 percent copper. An analysis by L. E. Reichen of the Geological Survey, however, showed 1.36 percent nickel and 0.85 percent copper. The calculated amount of copper is within limits of error, but the large amount of nickel is anomalous. Cryptocrystalline exsolution lamellae of pentlandite in pyrrhotite may be present and contain the visually unaccountable nickel. Also, there is a possibility that the visible pentlandite may contain more than 22 percent nickel. Reed (1942, p. 354) suggested that significant amounts of copper and nickel are present in the olivine. A magnetic separation of silicates and sulfides was attempted but was unsuccessful because of disseminated magnetite in the olivine. Other methods of separation were tried without success. Pyrrhotite that is free of microscopically visible pentlandite cannot be separated, and consequently X-ray methods cannot be used to demonstrate whether cryptocrystalline lamellae of pentlandite are present. The problem of the content of nickel in the olivine and that of cryptocrystalline pentlandite in the pyrrhotite has not been solved at present.

Visual estimates of the amounts of silicates and nonsulfide accessory minerals in specimen 55ABf17, which was selected as typical of the sulfide-rich gabbro, by volume are:

	Percent
Olivine	27
Labradorite	20
Hornblende	10
Biotite	2
Augite	1
Serpentine	2
Chlorite	2
Magnetite	2
Hypersthene	Trace
Talc	Trace
Anthophyllite	Trace
Calcite	Trace
Total (approximate)	67

As stated above, the volumes of sulfide minerals in this rock are:

	Percent
Pyrrhotite	27
Pentlandite	2.6
Chalcopyrite	2.5
Pyrite	.4
Total	32.5

SULFIDE-POOR GABBRO

The typical sulfide-poor gabbro is light to dark green, massive, mostly medium grained, and hypidiomorphic. Plagioclase occurs mostly as subhedral laths and partly as euhedra, 2 to 4 mm long, that form a mesh structure with intersertal pyroxene. Median andesine ($Ab_{62}An_{38}$) and sodic labradorite ($Ab_{46}An_{54}$) are of about equal abundance. Equant anhedral to subhedral augite occurs, often molded against faces of plagioclase crystals. N_Z of the augite is about 1.69 and $Z \wedge c = 38°$, which suggests a composition close to that of diopside. Partial to skeletal octahedra of magnetite-ilmenite lie partly in grains of augite, and at many of these interfaces hornblende has formed. Other hornblende has formed as incomplete pseudomorphs after augite; it is pleochroic with X=brown, Y=green, Z=dark reddish brown, and $Z \wedge c = 20°$. Biotite is present as a primary pale-brown to red-brown variety and as a secondary pale-green to dark-green type associated with chlorite. Tiny grains, most less than one-tenth millimeter, of pyrrhotite and chalcopyrite occur in amounts from traces to several percent. Apatite and zircon are accessory. A specimen from a depth of 68.5 feet in hole U–28 is composed of:

	Percent
Plagioclase	55
Augite	30
Hornblende	5
Magnetite-ilmenite	4
Biotite	3
Chlorite	2
Sulfides, accessories	1
Total	100

WALLROCK ALTERATION

Much of the quartz-sericite-biotite schist adjacent to the gabbro pipe has been thermally metamorphosed to orthoclase-cordierite hornfels. A partial aureole about 50 to 150 feet thick has formed around the pipe. The black graphitic phyllite overlying the pipe has not been transformed in this way, but has been blackened and partially recrystallized. The altered schist is a valuable guide to the gabbro, because it has formed only at the contact of gabbro with quartz-sericite-biotite schist. It is not known whether magnesia was expelled from the crystallizing gabbroic magma and reacted with muscovite and quartz to form orthoclase, cordierite, and water, or whether muscovite and biotite were heated sufficiently by the nearby magma to transform to orthoclase, cordierite, and water. The large volume of altered schist compared with the much smaller volume of magma suggests the latter reaction, nonmetasomatic thermal metamorphism, but part of the magnesia in the hornfels could have come from the magma.

The schist and phyllite around the pipe have been impregnated with traces to several percent of disseminated pyrrhotite and pyrite that probably are replacements formed by emanations from the gabbro magma. Rock similarly impregnated is not known elsewhere in the Funter Bay area. The quartzose schist and black graphitic phyllite overlying the pipe in the innermost part of the DMEA crosscut contain from 2 to 5 percent of tabular quartz pods, 1 to 25 mm thick and 6 to 250 mm long, that are oriented parallel to the schistosity. Most of these lenses lie within 20 feet of the gabbro, and they rapidly decrease in amount away from the gabbro. The wallrock here contains traces to about 2 percent of evenly disseminated pyrrhotite. Some of the wallrock in other parts of the aureole contains pyrite with pyrrhotite.

The cordierite-feldspar schist and pyrrhotite-bearing silicified schist and phyllite thus indicate proximity to gabbro. The possibility of

677–155—63——2

finding sulfide-bearing rocks adjacent to the gold-quartz veins that are found in this area must also be kept in mind.

ORIGIN OF THE SULFIDES

The gabbro pipe and associated sulfides are hypothesized to have formed in the following manner:

1. After intrusion of the liquid magma, solidification began at the top and sides of the pipe, because cooling by conduction and by groundwater was greatest immediately above the pipe.
2. Crystallization continued from the walls inward.
3. The olivine crystals that formed in the outer shell sank toward the lower part, or keel, of the pipe, where cooling, and therefore crystallization, was slower.
4. The last part of the pipe to solidify lay just above the keel and consisted of early-formed olivine crystals. For some reason, possibly because the entire pipe cooled relatively rapidly, these crystals were not resorbed or altered to hydrous minerals in their new environment, a residual magma enriched in iron, soda, potash, alumina, water and other volatiles, and an immiscible sulfide liquid.
5. While the silicate portion of this last magma fraction crystallized as hornblende, plagioclase, and biotite, the volatiles were largely forced out by second boiling. These dissolved and carried part of the immiscible sulfide phase into the outer and upper parts of the pipe and wallrock, where they deposited disseminated pyrrhotite and pyrite. The volatile constituents also altered part of the primary silicates to serpentine, chlorite, sericite, and other secondary minerals.
6. The immiscible sulfide phase crystallized last, corroding silicate grains. With further cooling, the solid solution of pyrrhotite, which contained nickel and copper, exsolved to form pyrrhotite, chalcopyrite, and pentlandite.

The above events were partly overlapping in time.

EXPLORATION FOR ANTIMONY DEPOSITS AT THE STAMPEDE MINE, KANTISHNA DISTRICT, ALASKA

By Fred Barker

The Stampede antimony mine, which is in the Kantishna district of Alaska, 112 miles southwest of Fairbanks (fig. 1, locality 2), yielded 1,729 tons of antimony in the period 1937–51 (see production figures below). The purpose of this report is to present results of an exploration program carried out at Stampede from 1953 to 1956 under a Defense Minerals Exploration Administration contract.

Geologists of the Geological Survey who collected data during this exploration work include Robert Chapman, Gordon Herreid, C. L. Sainsbury, and the writer.

PRODUCTION

The total production of antimony from the Stampede mine has been: [2]

Period of production	Ore and concentrates (tons)	Antimony (percent)	Antimony (tons)
1937–1941	2, 388. 64	49. 68–55. 01	1, 273
1942	250. 00	52. 52	131. 3
1943	139. 65	48. 37	67. 5
1944	178. 00	52. 3	73. 1
1947	33. 15	42. 68	14. 2
1948	96. 39	65. 41	63. 1
1949	72. 176	59. 70	43. 1
1951	120. 125	52. 9	63. 7
1937–51	3, 278. 13	------------	1, 729

GEOLOGY AND PREVIOUS WORK

The geology of the Stampede mine and the surrounding 25 square miles was mapped in 1941 by Donald E. White (1942) of the Geological Survey.

The U.S. Bureau of Mines carried out an exploration project in 1942 at the Stampede mine; this project was supervised by N. Ebbley, Jr., and W. S. Wright. In their report (1948), they gave many valuable assay and beneficiation data and a discussion of the geology of the mine. During the exploration 1,520 cubic yards of trenching and 740 feet of stoping and crosscutting were done. The Swanson cross fault, the abrupt bend of the Mooney ore body to the north, and the Stampede fault in the Libbey crosscuts were discovered and mapped. (These features are described below.)

Exploration work done under the Defense Minerals Exploration Administration contract consisted of 613.5 feet of drifting and crosscutting on the Lower Tunnel level, 1,397.5 feet of diamond drilling from the Lower Tunnel level, and 16,282 cubic yards of surface trenching north of the Stampede mine on the Kobuck and Pearl Harbor claims.

White (1942) showed that the area which includes the Stampede mine is underlain by mica schist, schistose quartzite, and other rocks that are known collectively as the Birch Creek schist. The Stampede mine is near the nose of an east-northeastward-trending and plunging anticline and adjacent to a northeastward-striking high-angle fault,

[2] Figures furnished by Mr. Earl Pilgrim, owner and operator of the Stampede mine.

the Stampede fault (White, 1942, pl. 49). Antimony-bearing veins have formed in a complex of faults in fine-grained quartz-sericite schist and impure quartzite immediately northwest of the Stampede fault. White (1942) determined that the following sequence of events took place: (1) formation of one(?) steeply-dipping fault striking N. 40° E. to N. 80° E., dipping 45° to 60° S., and located northwest of and at a low angle to the present Stampede fault; (2) normal faulting at nearly right angles to the initial high-angle fault, displacing it in four places with the northeast side (hanging wall) at each place dropped relative to the sourthwest side (footwall); (3) deposition, in order of decreasing abundance, of quartz, stibnite, pyrite, and arsenopyrite, mostly in the original steeply-dipping fault and partly in the cross faults; and (4) minor post-mineral movement along parts of the main fault. The Stampede fault, which branches eastward from the main vein fault at the Surface ore body, was exposed at the surface only in 1941, and its age relation to the mineralized faults could not be determined.

The mine workings consist of the Upper Tunnel (altitude of portal about 2,190 feet) (White, 1942, pl. 59), the Lower Tunnel (altitude of portal about 2,035 feet), and the associated workings. The latter consist of a shaft from the Surface ore body to the Upper Tunnel level, the Nesse and Emil winzes from the Upper Tunnel level, several sublevel drifts from the Emil winze, the Mooney winze from the Lower Tunnel level, and minor openings from both levels. The portal of the Upper Tunnel is about 210 feet south and a little west of the Lower Tunnel portal (White, 1942, pl. 50), and the Surface ore body is at an altitude of about 2,290 feet and lies about 400 feet southwest of the Upper Tunnel portal. The small Kobuck adit was driven from a surface showing of stibnite, and a few tons of ore was mined from this body.

The major ore bodies of the Stampede mine are:

1. The Surface ore body (now mined out), which was an irregular mass of almost pure stibnite with a maximum thickness of 26 feet that formed at the intersection of the Stampede fault and the northeastward-trending steep fault to the north (White, 1942, p. 342).
2. "The Nesse winze ore body, on the Upper Tunnel level consists largely of vein quartz and brecciated schist containing 10 percent or less of antimony. Six feet down in the Nesse winze, stibnite is a prominent constituent of the vein. The winze has been sunk to 20 feet below the level, where the vein consists of 1 foot of almost pure stibnite" (White, 1942, p. 345). This ore body is shown on plate 3.

3. The Emil winze ore body, also formed in the main vein fault, the richer parts of which are largely mined out, "is a definite vein, with 1 to 7 feet of medium- and high-grade ore on the Upper Tunnel and 50 foot (sub) levels," (White, 1942, p. 342). This ore body is not known to extend to the Lower Tunnel level.
4. The West and East Mooney ore bodies. (See pl. 3.) These also formed along the main vein fault. The West body "is at least 6 feet wide, * * * consists of brecciated schist containing veinlets of stibnite," and "one persistent vein of almost pure stibnite about 2 inches wide extends" along the ore body (White, 1942, p. 344–345). The East body is 5 to 10 feet thick and contains veins and stringers of stibnite a fraction of an inch to about 1 foot thick in quartz and crushed wallrock.

The ore bodies are similar to each other in their mineralogy. Stibnite (Sb_2S_3) is the chief antimony-bearing mineral. "It is commonly finely granular. Polished sections of the ore indicate an average grain size of about 0.01 millimeter in thickness and about 0.02 millimeter in the other two directions. Most of the crystals are oriented with the long dimensions parallel to the vein walls. A late generation of needlelike stibnite crystals cementing brecciated early stibnite is quantitively insignificant. The needlelike crystals are commonly several millimeters long" (White, 1942, p. 338).

Small grains of pyrite (FeS_2) are scattered in stibnite. Arsenopyrite (FeAsS) is "generally disseminated in quartz in the antimony-poor parts of the veins" (White, 1942, p. 339).

The gangue consists of milky quartz with occasional pods, stringers, or individual grains of calcite. The ore is dense, and vugs are rare.

GEOLOGIC STRUCTURE

STAMPEDE FAULT

This structure has been explored by the DMEA drift for 420 feet along its strike, as shown on plate 3, and a core drill hole from near the Mooney winze has been driven through the fault. The attitude of the fault is variable, the strike swings from about N. 85° E. south of the DMEA drift to N. 35° E. east of the DMEA crosscut and back to about N. 65° E. south of the Mooney drift and Chisholm crosscut. The western part of the fault dips about 73° to the south, and the eastern part appears to dip steeply to the north. The fault is marked by gray to dark-gray clay, slices of closely fractured wallrock, and crushed vein quartz. Traces of granulated pyrite and stibnite are present in much of the clay gouge. The fault zone may be as much as 33 feet thick south of the Mooney drift, as suggested by cores and driller's logs of hole 19, and at least 15 feet thick south of the DMEA drift.

The sulfides and vein quartz in the Stampede fault were derived either from veins originally formed in the fault or from veins and stringers formed in wallrock that has since been crushed to gouge, or both. It is not known which alternative is correct. The close relation of small stringers and pods of stibnite and quartz in wallrock adjacent to the Stampede fault in the DMEA crosscut and drift suggests that ore deposition was localized by the fault. Premineral cross faults A and B apparently displace the Stampede fault and are therefore younger. Movement along the Stampede fault thus probably began prior to the mineralization. At least some of the thick gouge zone was formed after the mineralization, because it contains crushed sulfide grains.

Neither the displacement nor direction of movement of the Stampede fault is known. From White's map (1942, pl. 49), it seems that the northwest block was dropped relative to the southeast block.

CROSS FAULTS A AND B

Cross faults A and B strike about N. 30° W. and dip 45° to 55° NE. and 75° to 85° NE., respectively. Cross fault A apparently was cut by drill hole 6, and it appears to extend upward toward the premineral cross fault mapped by White (1942, pl. 50) in the Upper Tunnel level 95 feet southwest of the Nesse winze. Cross fault B probably extends upward to the premineral steeply dipping faults that bound the southwestern edge of the Emil ore body. Both of these cross faults are concealed by lagging in the Lower Tunnel, where they are now expressed only by very weak ground. The Stampede fault appears to be offset 60 feet, measured horizontally, by cross faults A and B. It is possible, however, that the apparent offset is due to a sharp bend in the Stampede fault and that the Stampede fault is younger than the cross faults.

CROSS FAULT C

This fault zone strikes about N. 68° W. and dips steeply northeast. It consists of a 5-foot-thick zone of closely spaced parallel faults along which only minor amounts of gouge have formed. Very thin veinlets of stibnite have replaced quartz along several of these faults, and minor postmineral movement has formed slickensides on some of the stibnite veinlets.

Cross fault C displaces the Mooney ore body, the westward continuation of which may be the slightly mineralized fault that parallels the main haulageway from just south of the Mooney drift to the Lower Libbey crosscut. This cross fault, however, apparently does not displace the Stampede fault, as shown by drill hole 19 and the Chisholm crosscut. The Stampede fault, therefore, is the younger.

SWANSON CROSS FAULT

The Swanson cross fault separates the East and West Mooney ore bodies. Vein quartz with disseminated stibnite has formed along the fault, which indicates that movement preceded mineralization. The Swanson fault is marked by a zone of quartz-stibnite vein rock and sheared schist with gouge that is 6 to 18 inches thick. The dip is 65° E. at two places, and 48° E. at the southernmost wall. Hole 5 was drilled to locate the West Mooney ore body just west of this cross fault, but only minor stibnite was found in the sludge. The attitude of this hole is too nearly parallel to the ore body for drilling to be significant, even if the ore body were intersected.

FOLDS

Attitudes of beds in the DMEA crosscut and drift are gentle, and most have northerly strikes and dips toward the east. White (1942) found similar attitudes at the surface in this general area.

Several gently plunging, small drag folds were seen on the Lower Tunnel level. It is problematical whether the two drag folds in the Lower Libbey crosscut were formed in conjunction with regional folding or faulting. The folds in the main haulageway north of the Mooney drift and at the face of the blind crosscut from the east Mooney drift are markedly asymmetrical and may well be related to regional folding.

EXPLORATION OF ORE BODIES

NESSE WINZE CROSSCUT

A stibnite-rich zone was found in drill holes 2 and 3. Assays of sludge by the Territorial Department of Mines at College, Alaska, are as follows:

Drill hole 2 (core recovery 50 percent from 80–90 feet)

Depth (feet)	*Weight of sample (pounds)*	*Percent Sb*
81–82	0. 875	10. 16
82–83	1. 25	8. 51
83–84	1. 0	20. 26
84–85	1. 625	22. 56

Drill hole 3 (core recovery 98 percent from 95–100 feet)

Depth (feet)	*Weight of sample (pounds)*	*Percent Sb*
95. 5–97	2. 0	24. 76
97–98	1. 25	22. 93
98–100	1. 25	8. 10

This zone is the downward extension of the Nesse winze ore body, which here is a vein striking about N. 60° E. and dipping 60° SE. Hole 3 intersected the vein 78 feet below the Upper Tunnel level, as measured along the dip, and hole 2 struck the vein 102 feet from the Upper workings. The vein is five-eighths inch thick at the Upper Tunnel level and increases to 30 inches of high-grade ore at the bottom of the 35-foot Nesse winze (Pilgrim, oral communication). The ore body is bounded on the west by cross fault A and on the east by cross fault B. The lateral extent of the ore body is not known but is estimated to be at least 20 to 40 feet.

The assays of holes 2 and 3 given above, with footages corrected for dip, show 15.37 percent of antimony over a 3.2-foot width in hole 2 and 17.35 percent over 4.1 feet in hole 3. In both holes vein material outside of the core barrel has been loosened by the drilling water and added to the sludge; hence, there are erratic and large amounts of sludge. Fragments of core from a depth of 80 to 90 feet in hole 2 are light-gray quartz-sericite schist with disseminated pyrite and traces of stibnite. A few fragments of stibnite-bearing milky quartz were recovered. The core from a depth of 95 to 100 feet in hole 3 consists of 3 feet of stibnite-bearing schist with traces of red kermesite (?) and 1.9 feet of schist and milky quartz with only traces of stibnite and pyrite. There is considerably less stibnite in the cores than in the sludge owing to "softness" of the ore. The operator raised to this vein from the dogleg in the DMEA crosscut (this work was not done in connection with DMEA) and reported six 30-inch widths of "very good" ore that is softer than any previously mined at Stampede.

EAST MOONEY ORE BODY

The down-dip extension of the East Mooney ore body was intersected by drill hole 4, 38 feet down the dip of the vein from the drift. Core recovery from a depth of 20 to 25 feet was 35 percent and consisted of vuggy gray sericite schist and milky quartz that contained a little stibnite; 25 percent of the core was recovered from a depth of 25 to 30 feet and was mostly milky quartz with traces of stibnite and partly dark-gray quartz-sericite schist. The sludge log (percentages estimated by Mr. Pilgrim) shows:

Depth (feet)	*Description*	*Weight of sample (pounds)*
15–23	Dark gray, no sulfides	10. 5
23–24	Light gray, 4 percent Sb	0. 5
24–25	Light gray, + 35 percent Sb	1. 0
25–27	Dark gray, low Sb	2. 4
27–28	Dark gray, + 6 percent Sb	0. 5
28–29	Dark gray, + 25 percent Sb	0. 5
29–33	Gray, slightly mineralized	2. 5

Two zones of good ore, each about 1 foot thick, are separated by 3 feet of schist, vein quartz, and gouge. Stibnite-rich rock grinds when drilled and is washed out with the sludge, so very little of it appears in the cores. The six feet of vein from a depth of 23 to 29 feet in the hole contain an average of 12 percent estimated antimony.

Ebbley and Wright (1948) gave assays for 10 samples collected across the 45-foot-long section of the East Mooney ore body from the Swanson cross fault to the sharp bend, where antimony values decrease very abruptly. These channels average 4.1 feet in length and contain an average of 10.80 percent of antimony.

SURFACE ORE BODY

The DMEA drift and the seven drill holes from it were driven in search of a possible downward extension of either the Surface ore body or a structurally similar ore body. This part of the program gave negative results.

DISSEMINATED SULFIDES ALONG STAMPEDE FAULT

Small amounts of stibnite are in wallrock near the Stampede fault at the DMEA crosscut and for about 30 feet along the DMEA drift. Veinlets as much as one-fourth inch thick and very small irregular stringers of stibnite are sparsely and irregularly scattered in the walls of the drift. A composite grab sample of this rock taken from the dump contained 3.64 percent antimony.

TRENCHING PROGRAM

Trenches were bulldozed on the Kobuck and Pearl Harbor claims, as shown on plate 4, to discover if the ore body found in the Kobuck adit extended to the north. Stibnite-quartz float was found at five places (pl. 4) in the rock float or colluvium that mantles the bedrock and partly overlies the terrace gravels. At three of these localities the stibnite-bearing fragments were found at depths of 2 to 4 feet below the surface, and at depths of 15 and 26 feet at two localities. Trenching below these occurrences of float failed to reveal any signs of more float or of veins in the underlying bedrock. Quartz-sericite schist, with gently dipping schistosity, is the bedrock in the trenches.

SOIL SAMPLING

Soil samples were taken by R. M. Chapman of the Geological Survey from the Surface ore body and trenches 1, 2, 3, 4, 7, 7½, and 8. The depths from which the trench samples were taken and the content of antimony, in parts per million, in the samples, as determined in the Denver laboratory of the Geological Survey, are shown on plate 4. Samples were collected along a line at right angles to the Surface ore body at intervals of 20 to 40 feet and at a depth of 6 inches. Three samples taken at the edges of and in the pit over the ore body contained from 1,000 to 1,500 ppm antimony. Five samples taken north of and downhill from the pit contained from 25 to 1,000 ppm antimony and averaged about 350 ppm. Excluding one sample that showed 1,000 ppm, the other four samples averaged about 170 ppm antimony. Only 2 to 4 ppm antimony was found in samples taken south of the Surface ore body.

The only notable anomalous high found in the DMEA trenches is in trench 1, where 1,000 to 2,000 ppm antimony was found in four samples. No traces of antimony-bearing or quartzose veins were found in the bedrock of this trench, and hence the anomaly may be due to stibnite from float rock.

COAL DEPOSITS ALONG THE YUKON RIVER BETWEEN RUBY AND ANVIK, ALASKA

By Robert M. Chapman

Coal deposits at seven localities along the Yukon River between Ruby and Anvik (fig. 3) were examined by the writer in the summer

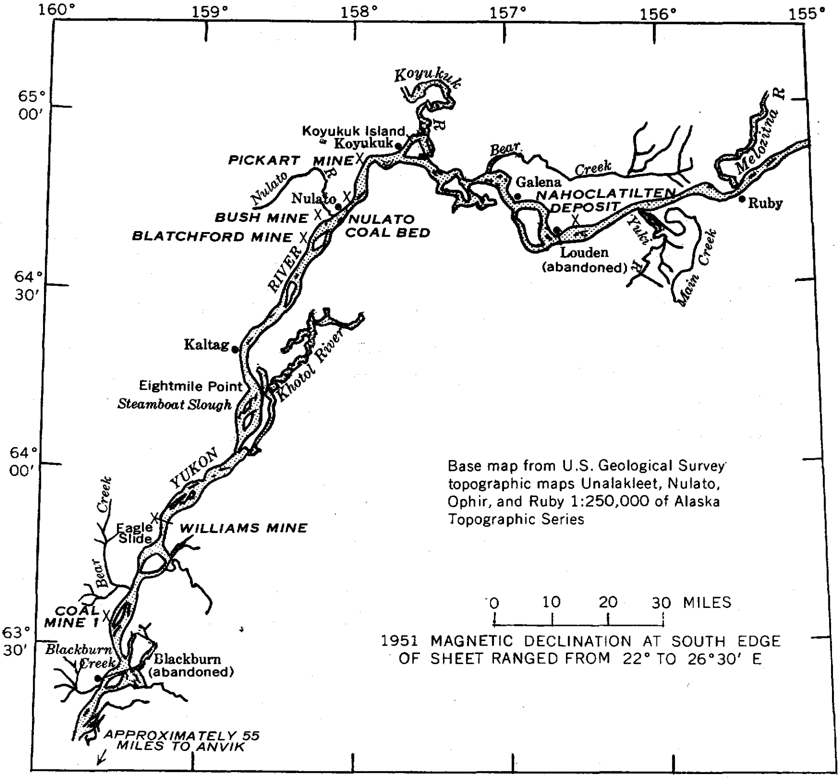


Figure 3.—Location of coal deposits along the Yukon River between Ruby and Anvik.

of 1944. The purpose of the fieldwork was to determine the accessibility and extent of the coal and whether exploratory and development work was warranted.

The coal deposits adjacent to the Yukon River were noted and briefly described previous to 1900 by several explorers and geologists. In 1902, A. J. Collier made a systematic investigation of the coal deposits along the Yukon River. Other geological investigations were made subsequent to 1902, and the results of these studies were summarized by Martin (1926, p. 395–429; 1930, p. 21–32). Structural and stratigraphic studies along the Yukon River between Ruby and Kaltag were made by W. W. Patton, Jr., and R. S. Bickel (1956a) in 1954.

Small mines were operated between 1898 and 1902, and possibly earlier, at most of the known coal exposures in the north and west banks of the Yukon River. The coal was mined chiefly for the use of river steamers, but apparently little coal was produced and the mines were abandoned before or shortly after 1902, except possibly for minor local use. Records of production are not available for most of the mines, but probably the largest output was from the Williams mine and coal mine No. 1, which produced 1,700 and 900 tons, respectively, between 1898 and 1902.

PHYSICAL SETTING

The region immediately north and west of the Yukon River between the Melozitna and Anvik Rivers is one of rounded hills dissected by large, wide river and creek valleys. The relief ranges from 600 to 1,500 feet in the Ruby and Nulato areas and from 1,000 to 3,000 feet in the Kaltag and Anvik areas. Owing to the heavy cover of trees and smaller vegetation, the general lack of steep slopes, and the relatively soft bedrock, outcrops are scarce and almost entirely limited to the bluffs along the Yukon River; consequently, the field studies were confined to the Yukon River bluffs and the hills immediately adjacent.

The region immediately south and east of this section of the Yukon River is a broad, low, swampy alluvial plain that extends to the foot of bedrock hills 4 to 30 miles from the river. A single isolated hill, Pilot Mountain, about 12 miles west of Galena, rises several hundred feet above the plain.

GEOLOGY

GENERAL FEATURES

The bedrock along the Yukon River in this region is mainly of Early Cretaceous, and possibly in part Late Cretaceous, age (Imlay and Reeside, 1954, p. 236–238; Patton and Bickel, 1956a). It consists of marine and nonmarine sediments, including graywacke, sandstone, sandy shale, silty shale, clay shale, carbonaceous and coaly shale, graywacke conglomerate, and coal, with a smaller amount of Cretaceous and Tertiary basaltic and andesitic lava and tuff and a few mafic and granitic intrusives. Some thin irregular seams of lignite are interbedded with the tuff in at least one locality (Collier, 1903, p. 57–58). Little work has been done on the igneous rocks, and the exact relationship between them and the sedimentary sequence has not been determined. Wide areas adjacent to the Yukon and its tributaries are covered by Quaternary flood-plain and terrace deposits composed of gravel, sand, and silt. Most of the hills have a mantle of eolian silt, ranging widely in thickness (Eardley, 1938, p. 327), that is part of the widespread Quaternary loess deposits in central Alaska (Black, 1951).

SEDIMENTARY ROCKS

The Cretaceous sedimentary rocks in this region are believed to be approximately 8,000 feet thick (Martin, 1926, p. 399). Smith and Eakin (1911, p. 55–60), on the basis of their work and earlier investigations, divided the sequence into a lower unit, called the Ungalik conglomerate, and an upper unit, called the Shaktolik group. Martin (1926, p. 395), on the basis of later work and many fossil identifications, divided the Cretaceous rocks along the Yukon River into four formations, which he described as follows:

Top

Kaltag formation: Coal-bearing rocks consisting of fresh-water sandstone, shale, and coal beds with possibly some thin marine members. Contains fossil plants, fresh-water invertebrates, and perhaps a few marine invertebrates. 800+ feet.

Nulato formation: Marine sandstone and shale. Contains marine invertebrates and a few plants. 3,000? feet.

Melozi formation: Fresh-water shale and sandstone. Contains fossil plants and fresh-water invertebrates. 1,000+ feet.

Ungalik conglomerate: Conglomerate, sandstone, and sandy shale. Contains worm tubes, trails, and vegetable detritus. 3,000 feet.

Bottom

Patton and Bickel (1956a) reclassified and described the Cretaceous rocks along the Yukon River between Ruby and Kaltag into two units: a border facies, which is subdivided into lower (probably marine) and upper (chiefly nonmarine) units; and an interior facies, which is subdivided into lower (marine), middle (littoral marine), and upper (nonmarine) units. The upper unit of the interior facies is roughly equivalent to Martin's Kaltag formation, and the middle and lower units are roughly equivalent to Martin's Nulato formation (W. W. Patton, Jr., and R. S. Bickel, 1957, oral communication).

The border facies is exposed along the Yukon River between the Melozitna River and a point approximately 11 miles west of the mouth of the Yuki River; a minimum thickness of 1,200 feet of the lower unit has been measured. The interior facies is exposed along the Yukon River near the mouth of the Yuki River, and between a point 11 miles west of the Yuki River and Kaltag; at least 2,500 feet of section has been measured. The sedimentary rocks exposed along the Yukon between Kaltag and Blackburn Creek are also part of the interior facies (Patton and Bickel, 1957, oral communication).

In this report the classification of Patton and Bickel has been adopted, and the coal beds lie within the upper unit of the interior facies or Martin's Kaltag formation. No attempt was made in 1944 to revise the stratigraphy as outlined in earlier reports because the fieldwork was concentrated in the immediate areas of reported coal deposits. Cursory examination of the areas between the coal localities revealed no additional significant coal beds or evidence that contradicts the stratigraphic work of earlier investigators.

The coal-bearing upper unit of the interior facies, as described by Patton and Bickel (1956a), is:

Mostly dark-gray and olive-gray shale and siltstone. Siltstone is micaceous. Near base, fine- to coarse-grained, lenticular, crossbedded, locally friable, thick-bedded, salt-and-pepper sandstone; locally some thin lenses of quartz and chert granule and pebble conglomerate. Subordinate very fine to fine-grained, micaceous, thin- to medium-bedded, gray to yellowish-orange sandstone. Bituminous coal in beds as much as 20 inches thick. Plant remains abundant. Fresh- and brackish-water mollusks.

IGNEOUS ROCKS

The igneous rocks in this region have not been studied in detail. Martin (1930) gave a Tertiary(?) age for them, and Smith and Eakin (1911) called them Tertiary to Recent. Patton and Bickel (1956a) gave the age of the intrusive near the Nahoclatilten coal deposit as Cretaceous or Tertiary.

A study of these rocks was not undertaken in connection with the present coal investigation, as none of them are directly associated with the coal outcrops. Descriptions by Smith and Eakin (1911, p. 71–72) and by Harrington (1918, p. 46–50) indicate that the rocks are predominantly olivine basalt tuffs and vesicular flows, probably with some andesite and dacite. In addition to the volcanics, a few mafic and granitic intrusives are present (Patton and Bickel, 1957, oral communication). A few dikes intrude the sedimentary rocks at various places and were interpreted by Harrington (1918, p. 48) as vents through which the lava extrusions passed. Ellipsoidal lava surfaces (Harrington, 1918, p. 49) and intercalated thin lignite seams (Collier, 1903, p. 57) suggest a littoral environment during at least part of the period of formation of the Tertiary(?) rocks.

STRUCTURE

Folding and faulting of undetermined magnitude are common in this region, and the structure is locally complex. In general the regional trend of folds in the Cretaceous strata is N. 50° E., but strikes of N. 25° E. to N. 75° E. are not uncommon. The dips of the beds generally range from 20° to 60°, but dips outside this range were noted locally.

COAL DEPOSITS

All the coal beds at the seven localities examined appear to be in the upper unit of the interior facies (equivalent to the predominantly nonmarine Kaltag formation of Martin), although thin carbonaceous layers, carbonaceous and coaly detritus, and small lenses of coal are locally present in the other Cretaceous units, and a few small lignite seams are interbedded with the volcanic rocks. The Cretaceous coal beds are relatively thin and are reported to be irregular in thickness, even pinching out locally within short distances.

The thickest bed reported is 39 inches, and another bed contains a few pockets that are 8 feet thick (Collier, 1903, p. 55); most of the beds are less than 2 feet thick. The coal is bituminous to subbituminous in rank, is friable, and slacks rapidly on exposure to air and drying.

NAHOCLATILTEN DEPOSIT

The coal deposit described by Collier (1903, p. 47–48) as the Nahoclatilten coal bed is on the north side of the Yukon River about 20 miles upstream from Galena and about 5 miles upstream from the abandoned Louden telegraph station. The name "Nahoclatilten" is no longer in local usage. Collier reported a 1-foot coal bed underlain by about 5 feet of bony coal or coaly shale with stringers of coal. Prospectors reported that three coal or coaly beds, each about 10 inches thick, were immediately adjacent to this deposit. Other occurrences of coal in this vicinity also were reported to Collier.

The coal-bearing sequence of rocks and other outcrops in the vicinity were examined by Chapman in 1944. The coal beds are exposed about a quarter of a mile north of the river bank in the face of a bluff about 200 feet above the river. The exposure, which apparently was created by a small slide, is about 300 feet long. The general strike of the beds is N. 55° E. to N. 60° E., and the dip is about 65° SE. Slumping and partial covering prevented detailed structural observations, but it appears that sharp folding, possibly accompanied by faulting, has occurred in the vicinity of the coal beds. One coal bed, which ranges from 1 to 3 feet in thickness and contains several thin shale partings, was exposed. This may be the 1-foot coal bed described by Collier. Three carbonaceous and coaly shale layers, ranging from 6 to 8 inches in thickness, lie 30 to 35 feet stratigraphically above the main coal bed. The intervening and overlying sections include interbedded brownish-gray to black shale, light-tan to light greenish-gray sandstone with small coaly and carbonaceous lenses and fragments, and light-tan to red-hued graywacke conglomerate with pebbles and granules of chert and schist. About a quarter of a mile upstream from the coal locality, small pockets of coal and a 3-inch coal layer are present in sandstone and sandy shale exposed at river level in a small bluff. Thick vegetation covers the trace of the coal beds beyond the river bluff exposures. Variations in strike and dip in this area indicate intense folding and possibly faulting, although no direct evidence of faulting was observed.

A prominent bluff a few hundred yards farther upstream and opposite the upstream end of a large island exposes a sedimentary section that is cut by a light-colored finely crystalline intrusive (Martin, 1926, p. 402). At the west end of the bluff the section includes siltstone, very fine grained sandstone, carbonaceous shale, and a 3-inch coal bed. These rocks strike N. 55° E. to N. 60° E. and dip 60° NW.

Analyses of coal samples collected from this deposit in 1902 and 1944 are shown in table 1.

PICKART MINE

The Pickart mine, one of the earliest coal mines on the Yukon River, was first opened in 1898 on the west bank about 10 miles upstream from Nulato and about 6 miles downstream from the village of Koyukuk. Neither the coal bed nor any evidence of the mine was visible in 1944. Collier (1902, p. 49) stated that the coal bed is in Upper Cretaceous rocks that are probably of fresh-water origin and about 75 feet above the contact with marine beds. The coal strikes N. 75° E., and dips 35° N. Two rolls, near which the coal is crushed and impure, were found in working the bed. The coal ranges from 18 to 36 inches in thickness but pinches to a knife-blade thickness at one of the rolls. Although the coal was said to make good coke and was classed as bituminous (table 1, analyses GS–252, –253), the irregularities near the rolls and possibly the limited market led to the abandonment of the mine in 1902 after the main gangway had been extended about 600 feet.

The rocks exposed in the river bluffs in this area are sandstone, shaly sandstone, silty shale, clay shale, coal, bone, and coaly shale. The section includes five beds of bony coal, averaging about 6 inches in thickness, and two coal beds 8 and 9 inches in thickness.

The strike of the beds ranges from N. 35° E. to N. 76° E., and the dip ranges from 25°–45° NW. The less competent beds show minor crumpling and folding, but no faults of any consequence are exposed. Structurally the section in the vicinity of the mine appears to be part of the north limb of a large anticline, the axial zone of which lies approximately 3 to 4 miles to the south.

NULATO COAL BED

Several coal beds have been reported between the Pickart mine and Nulato, but only one bed, cropping out about 1 mile upstream from Nulato, was examined by Collier (1902, p. 52). He stated that the bed has a thickness of 2.5 feet, of which 6 inches is clean coal and the rest is bony coal and clay partings. This bed was not found in 1944.

TABLE 1.—*Proximate analyses of coal from deposits along the Yukon River between Ruby and Anvik, Alaska*

Location and bed	Collector and date	Laboratory [1]	Condition [2]	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu)
Nahoclatilten 1-ft coal bed	A. J. Collier, 1902	GS-241	2	6.88	41.82	48.93	2.37	0.65	
Nahoclatilten, 1-3-ft coal bed	R. M. Chapman, 1944	C 36293	1	8.5	37.0	51.9	2.6	0.4	10,170
			2	7.9	37.3	52.2	2.6	.4	10,230
			3		40.5	56.7	2.8	.4	11,110
			4		41.7	58.3		.4	11,430
Pickart mine, 200 ft in from portal	A. J. Collier, 1902	GS-252	2	1.02	27.33	65.03	6.62	0.6	
Pickart mine, 600 ft in from portal	A. J. Collier, 1902	GS-253	2	1.64	24.98	58.18	15.20		
Pickart mine, 1-ft bed above Pickart coal (outcrop?)	A. J. Collier, 1902	GS-251	2	2.22	24.76	50.38	22.64	0.56	
Bush mine, end of tunnel	A. J. Collier, 1902	GS-254	2	11.17	29.48	52.02	7.33	0.44	
Blatchford mine, from stockpile	A. J. Collier, 1902	GS-258	2	1.36	22.44	73.98	2.22	0.52	
Blatchford mine, from outcrop of 1-ft bed	R. M. Chapman, 1944	C 36294	1	2.8	22.5	69.8	4.9	0.9	13,350
			2	2.4	22.6	70.1	4.9	.9	13,400
			3		23.1	71.9	5.0	.9	13,730
			4		24.3	75.7		.9	14,460
Adolph Muller prospect 8 miles below Kaltag	M. L. Sharp, 1925	A 15869	1	7.0	24.3	47.2	21.5	0.5	9,470
			3		26.1	50.8	23.1	.5	10,180
			4		34.0	66.0		.7	13,250
Williams mine, upper bench of 39-in. seam	A. J. Collier, 1902	GS-283	2	7.17	33.05	51.15	8.63	0.4	
Williams mine, lower bench of 39-in. seam	A. J. Collier, 1902	GS-284	2	6.15	40.46	49.86	3.53	0.53	
Coal mine No. 1, outcrop of 2½-3-ft seam	A. J. Collier, 1902	GS-288	2	4.82	34.62	55.65	4.91	0.21	
Coal mine No. 1, outcrop of 18-in. bed 150 to 200 ft above river.	R. M. Chapman, 1944	C 36295	1	4.0	33.8	53.1	9.1	0.3	12,010
			2	3.6	33.9	53.3	9.2	.4	12,060
			3		35.2	55.3	9.5	.4	12,500
			4		38.9	61.1		.4	13,820

[1] GS preceding laboratory number indicates analysis made by E. T. Allen, U.S. Geol. Survey; all others made by U.S. Bur. Mines, Pittsburgh, Pa.
[2] 1, Sample as recieved; 2, air dried; 3, moisture free; 4, moisture and ash free.

The stratigraphic section observed in the bluff near Nulato is similar to that near the Pickart mine, and the Kaltag formation is mapped in both places (Martin, 1930, pl. 87). It is possible that these two coal-bearing areas include approximately the same sequence of beds; however, such a correlation is tenuous inasmuch as the structure in the intervening area is complicated by small folds and several faults of unknown magnitude (Patton and Bickel, 1956a, structure section *J–K–L–M*).

BUSH MINE

The Bush mine is about 4 miles downstream from Nulato on the west bank of a slough behind the first island below the mouth of the Nulato River. A tunnel about 30 feet long was driven through a slide to reach the coal bed (table 1, analysis GS-254). The coal was broken and very much weathered, and the thickness of the bed could not be determined, although it appeared to be at least 4 feet (Collier, 1903, p. 52–53).

No coal or evidence of a mine was visible at this locality in 1944. Two beds of dark-gray iron-stained carbonaceous and coaly shale, 6 to 10 inches in thickness, are exposed in a bluff about 40 feet above the river level. Medium-gray sandstone and sandy shale crop out just downstream from the mine locality. These beds strike N. 28° E. and dip 40° W.

BLATCHFORD MINE

The Blatchford mine is on the west side of the Yukon River about 9 miles downstream from Nulato and at the upper end of a prominent rock bluff. The mine was below the water's edge in 1902, and mining could be done only in the winter because the portal was under water during the summer. The seam was reported to be crushed and very irregular, but included thick pockets as much as 8 feet in diameter which were mined. Probably not more than 300 tons of coal was produced prior to 1902 (Collier, 1903, p. 53–55). The following section was measured at this locality in 1944.

Section at Blatchford mine

Top, covered	Feet
Shale, sandy, medium- to dark-gray	10+
Coal, weathered and crumbled; lenticular(?) (table 1, analysis C 36294)	1
Shale, sandy	15
Sandstone, medium to light greenish-gray, medium- to fine-grained, with carbonaceous and shale fragments; beds 3–8 in. thick	25+
Silty shale and siltstone, thin-bedded, medium- to dark-gray, iron-stained. Some interbedded dark-gray to black iron-stained carbonaceous shale	10–12
Sandstone and silty shale, interbedded, similar to above	30–40
Silty shale, medium- to dark-gray, thinly laminated	3
Sandstone, massive bedded, laminated in part, similar to above	5(?)
Sandstone and shale, gray to black, with minute coaly stringers; similar to above	25–30
Shale, sandy, medium-gray, and silty shale gray to black, with fragmentary plant material	14

	Feet
Sandstone, medium- to light-greenish-gray, coarse- to fine-grained, slightly calcareous, with carbonaceous plant fragments; fractured and crossbedded	5
Shale, sandy and carbonaceous; 2-in. seam of bituminous coal at top and 6–7 in. of coaly shale at bottom	3
Sandstone, similar to above; beds 3–6 in. thick	12
Sandstone, thinly bedded, and sandstone, shaly interbedded	10
Shale, sandy, with interbedded carbonaceous shale including a 4–6 in. coal seam	12
Sandstone, massive, crossbedded, medium-grained; similar to above	7
Shale, sandy, medium-gray, thinly laminated; carbonaceous in parts	3–4
Sandstone, medium- to light-greenish-gray, iron-stained, medium- to coarse-grained; beds 1 in. to 3 ft thick, grading to thin shaly beds in upper part; fractures and slickensides common with thin calcite coatings on bedding planes and fractures	40–50
Bottom, covered	
Total	258±

The beds throughout this exposure strike N. 70° E. and dip 45° to 55° NW. The 1-foot coal bed near the top of the section is exposed close to water level at the upstream end of the bluff. The coal, which is weathered and crumbled, pinches out at water level and is covered about 20 feet from the river by a silt terrace. This section is undoubtedly part of the nonmarine upper unit of the interior facies.

Analyses of this coal (table 1, analyses GS–258, C 36294) indicate that it is high-grade bituminous, and reports indicate that it proved very satisfactory for river steamers and blacksmithing. Because of the intense shearing and fracturing of the rock at this locality, however, and the reported irregularity of the coal bed (Collier, 1903, p. 54), it is doubtful that the coal is continuous or uniform enough to be economically workable.

WILLIAMS MINE

The Williams mine, originally known as the Thein mine, was on the west bank of the Yukon River about 50 miles downstream from Kaltag and about 5 miles upstream from a river bluff landslide known as Eagle Slide (fig. 3). Up to the time that Collier (1903, p. 56) visited the mine in 1902, about 1,700 tons of coal had been mined. At this time a drift had been extended into the bluff on a 39-inch bed of bituminous coal, which was divided by a thin clay parting (table 1, analyses GS–283, –284). The bed was followed 400 feet into the hill without showing a change in strike or thickness (Collier, 1903, p. 55). The mine has been abandoned for many years, and in 1944 the portal and coal bed were completely obscured by slumping of the bank. A few old powder boxes and timbers gave the only clue to the probable location of the portal. Exposures of coal are limited to a few tiny stringers.

Collier (1903, p. 55) stated that the coal bed is overlain by at least 2,000 feet of sandstone, conglomerate, and black shale. It appears that at least several hundred feet of nonmarine section underlies the coal bed. The stratigraphic sequence observed along approximately 2.5 miles of low river bluffs northward from a small creek about half a mile south of the Williams mine consists of silty shale and clay shale; massive to shaly bedded sandstone, which is fractured and contains veinlets of calcite, some of which exhibit slickensides; dark brownish-gray to black carbonaceous and coaly shale; and beds and stringers of coal and bone, ranging from about 0.5 inch to 7 inches in thickness. Carbonaceous plant fragments and leaf fossils are common throughout the section. The 39-inch coal bed reported by Collier was not seen in 1944.

The general strike of the beds in this 2.5-mile section is N. 50° E. to N. 70° E., and the dip, with the exception of a few local irregularities, is 40° to 60° NW. Near the mine site the beds are overturned and dip 8° SE. and show evidence of faulting or sharp local folding. Approximately 1 mile north of the mine site, another small section shows overturned beds dipping 10° to 15° SE. Collier (1903, p. 55) also mentioned possible faulting in the area north of the coal mine.

COAL MINE NO. 1

Coal mine No. 1 was on the west bank of the Yukon River about 23 miles downstream from the Williams mine and about 16 miles upriver from the abandoned settlement at Blackburn (fig. 3). The mine was opened in 1898 by the Alaskan Commercial Co., and 900 tons of coal was produced. The mine was abandoned the same year because of difficulty in keeping water out (Collier, 1903, p. 57). The workings, which included a 9- by 7-foot slope tunnel, were filled with water at the time of Collier's visit in 1902. According to Collier, the analysis (table 1, analysis GS–288) indicates a good grade of bituminous coal. The coal bed is 2.5 to 3 feet thick and is in a sandstone section that strikes N. 60° W. and dips 35° SW.

The mine workings have been obscured by slumping, and the exact location could not be determined in 1944. A bituminous coal bed 18 inches thick, two coal beds 3 to 5 inches thick, and two coal and carbonaceous shale beds 4 to 6 inches thick crop out in a hillside about 150 to 200 feet above the river where a large slide has exposed a face approximately 250 feet long and 100 feet high. The 18-inch bed is generally uniform, although it pinches to 12 inches at one point and in a few places is bony and iron stained.

The following section is exposed in the hillside face:

Section at coal mine No. 1

	Feet
Top, covered.	
Sandstone, silty, medium- to light-gray, fine- to very fine-grained, slightly calcareous, micaceous; weathers medium reddish-brown with heavy iron stain on fracture surfaces	10+

Section at coal mine No. 1—Continued

	Feet
Sandstone, very fine grained; and sandy siltstone; both medium yellowish-gray, soft, iron stained, noncalcareous, shaly; some interbedded sandstone similar to top 10+ ft; two coal seams 3–5 in. thick	25
Clay shale, medium-gray, with two 1–3 in. coaly seams near bottom	1+
Coal, bituminous, with a 0.5 in. ferruginous clay parting in middle of bed. (Analysis C 36295.)	1. 5
Sandstone, micaceous, and silty shale; similar to above	15+
Sandstone, light yellowish-gray, fine- to coarse-grained, noncalcareous; many carbonaceous fragments and laminae; thick bedded and fractured; weathered to light reddish brown	10+
Bottom, covered.	
Total	62. 5+

Beds of similar lithology, including a 14-inch bed of hard lustrous bituminous coal, several thin coal layers, and a 16-inch carbonaceous shale bed with coaly seams, crop out at water level between the section described above and the mouth of a small creek about a quarter of a mile upriver.

About a mile above the mine site, the beds dip 20° to 23° NE.; this dip indicates an anticlinal structure with the coal bed on the southwest limb. Although faults may be present in the many covered intervals, none were seen to account for an apparent minor anticlinal flexure in the area of coal outcrops. The beds exposed in the slide area strike N. 15° W. to N. 38° W. and dip 25° to 40° SW.

OTHER COAL BEDS

According to a report received by the writer in 1944, a coal bed 2 to 3 feet thick crops out in the channel of the Melozitna River about 40 river miles above the mouth. Some of the coal was reportedly used by a blacksmith in Ruby and proved to be a good quality blacksmithing coal.

A 54-inch coal bed, described as the Adolph Muller prospect, is on the west bank of the Yukon River 8 miles below Kaltag. This bed was measured and sampled by the U.S. Bureau of Mines (1946, p. 30–31, 75) in 1925. The analysis is given in table 1. The bluff at this locality, known as Eightmile Point (fig. 3), was examined briefly in 1944, but the coal bed was not exposed. The section here, mapped as Kaltag formation by Martin (1930), consists of a light-gray to yellowish silty micaceous very fine grained sandstone in beds 1 to 18 inches thick with interbedded medium to dark yellowish-gray silty shale and sandy shale that contain abundant carbonaceous plant impressions and fragments. The beds strike N. 55° E. and dip 20° NW.

CONCLUSION

The coal beds adjacent to the Yukon River between Ruby and Anvik do not appear to merit more detailed examination or exploration. The beds, although mostly of good quality bituminous coal, are thin, apparently irregular in thickness, and of small lateral extent.

The coal is highly fractured and slacks badly on drying; consequently, it is poorly suited for shipping, handling, and many commercial uses.

When the mines were being worked, the difficulty in obtaining drainage seems to have been one of the main handicaps. This probably would become more of a problem if operations were extended downdip. The minable reserves are relatively small, and, owing to the dip of the beds, little coal could be obtained by surface stripping. In view of the presence of more abundant and accessible coal deposits in other parts of Alaska, it is doubtful that the Yukon River coal deposits will ever have economic value for other than small-scale local use.

EXAMINATION OF URANIUM PROSPECTS, 1956

By Val L. Freeman

During the summer of 1956, uranium prospects were examined in the eastern interior, southern, and southeastern parts of Alaska. The examinations were to aid prospectors as well as to gather information for the Division of Raw Materials, U.S. Atomic Energy Commission, on whose behalf they were made. The writer was assisted by H. B. Groom, Jr., and W. K. Benda.

PROSPECTS EXAMINED

The prospects examined (fig. 1, localities 3–9) were all found by detection of anomalous radioactivity; however, only two of them have yielded uranium minerals. They were brought to the attention of the writer by prospectors requesting an examination. The examinations were brief, from a few hours to three days, and no attempt was made to geologically map the surrounding areas.

SHIRLEY LAKE

Shirley Lake, about 100 miles northwest of Anchorage, lies between the Happy River and Portage Creek about a mile north of the Skwentna River (fig. 1). The region was visited by S. R. Capps in 1926 (Capps, 1935), and the prospect was previously visited by J. J. Matzko in 1954 (written communication).

Anomalous radioactivity was found in 1954 in a unit of tuff and tuff-breccia that underlies a ridge along the north side of Shirley Lake. The tuff and tuff-breccia are indurated but, except for a little epidote, do not appear to be metamorphosed. The unit is broken by many joints and by a few faults.

The radioactive areas are very small, at the most a few feet in length, and occur in and adjacent to joint surfaces. It seems likely that the radioactive rock was formed by the deposition of small amounts of uranium that migrated with subsurface water moving along joints in the tuff unit. The uranium may have been leached from the tuff and then deposited when the water partly evaporated upon reaching the surface.

Exploration work at the prospect consists of a few shallow pits in the tuff unit. The pits have not disclosed any extension of radioactive rock below the surface or away from the joints and therefore show the dependence of the radioactive rock on the joints.

The maximum amount of uranium detected in samples from Shirley Lake by the U.S. Geological Survey is 0.021 percent (J. J. Matzko, written communication). A prospector reported that a sample from the area assayed 0.29 percent uranium, which is possible considering the spotty nature of the radioactivity. The joint-controlled occurrences of the radioactive rock and its low grade are unfavorable indications for the presence of ore-grade material at Shirley Lake.

SKAGWAY

The prospect at Skagway (fig. 1) is on a steep hillside about 250 feet above the tracks of the White Pass and Yukon Railroad opposite the oil tanks of the Standard Oil Co. of California. It was discovered in the spring of 1956. The Skagway region is known to be underlain by rocks of the Coast Range batholith, but no detailed areal geological mapping has been done.

At the prospect there is an altered rhyolite(?) body of small size surrounded by medium-grained quartz diorite. The quartz diorite is cut by several large faults and intruded by fine-grained andesitic dikes. Uranium occurs adjacent to a prominent, steeply dipping fracture in the rhyolite (?), where it is associated with iron oxide staining and with globules of clay that resemble fillings of vesicles. The highest grade sample consists of olive-green clay that was probably hand picked from vesicles in the rhyolite(?). This sample contains 0.72 percent equivalent uranium and 1.2 percent uranium, as determined by the U.S. Geological Survey laboratory in Washington, D.C. (analysts: Carmen Johnson and B. A. McCall). The amount of this material found was very small. Most of the mineralized rock consists of highly altered rhyolite(?) that is stained red and yellowish brown with iron oxide minerals. It contains as much as 0.22 percent equivalent uranium. No sulfide or gangue minerals were seen except for specks of purple fluorite.

One pit at the prospect has yielded a few hundred pounds of specimens, but no reserves of ore were seen. The geologic conditions in the region are considered generally favorable for the occurrence of uranium, and further prospecting is warranted.

KENDRICK BAY

Kendrick Bay is near the southern end of Prince of Wales Island about 35 miles southwest of Ketchikan. The area was examined in

1955 and studied in detail during 1956. The present report is based on an examination in 1956 of a newly found uranium occurrence on the Marietta claim of the Little Ray group (fig. 7).

The uranium is in a fractured mass of andesite that is surrounded by granodiorite. Nearby, cutting the granodiorite, is a pegmatite dike that contains uranium-titanium minerals. A younger alkali granite is the host for a uranium-thorium deposit on the adjacent Cub (Ross-Adams) group of claims. The andesite body is poorly exposed but crops out on very steep hillsides and produces small talus slopes.

The most radioactive specimens from the prospect have come from the talus piles and from the beds of local drainage courses. Altered rock in narrow zones (as much as 6 inches thick) adjacent to three of the many fractures cutting the outcrops is radioactive but of lower grade than the float samples. A radiometric reading of the most radioactive part of the rock in place was 1.0 milliroentgen per hour. A hand sample collected from the stream gravel at the foot of a talus slope gave a reading of 2.0 mr per hr. Other samples from the float were found by the assay office of the Territory of Alaska Department of Mines to contain as much as 8.6 percent U_3O_8 (A. E. Glover, oral communication). Very little is known about the type of mineralization at this prospect. The specimens do not resemble either those from the deposits associated with pegmatite or those from the deposit on the Cub group. Uraninite was tentatively identified in a sample from this location but in an amount that could account for only a small part of the radioactivity.

Although the amount of radioactive rock seen in place is too small to be considered minable, the high grade of the pieces of float justifies exploration to determine their source. The general area is very favorable for the occurrence of uranium deposits.

O'KEEFE PLACER CLAIM

The O'Keefe placer claim is about 20 miles southwest of Chandalar Lake and near the divide between the drainages of Crooked Creek and the South Fork of the Koyukuk River. The prospect is in the Chandalar district, mapped by J. B. Mertie, Jr., in 1923 (Mertie, 1925).

The area of O'Keefe's claim is underlain by a mica schist unit that was referred by Mertie (1925) to the early Paleozoic. Near O'Keefe's claim this unit is highly deformed and is cut by many thin, discontinuous veins of quartz that contain pyrite. Other rock types in the area include gneiss and granite.

The radioactivity in the area of the prospect is higher (as much as 0.035 mr per hr) than is normal in areas of mica schist. The high radioactivity is general in the area, however, and probably is not related to a body of uranium ore.

BEDROCK CREEK

Bedrock Creek is about 4 miles east of Miller House. The area examined is about 100 yards east of the creek and 50 yards upstream from the Steese Highway bridge. The most recent geologic mapping that included this area was done in 1952 by W. S. West and J. J. Matzko (Nelson, West, and Matzko, 1954). They found the area to be underlain by the Birch Creek schist of Precambrian age, which is intruded by Mesozoic(?) granite in the headwater part of Bedrock Creek.

At the prospect, the Birch Creek schist consists of mica and quartz-mica schist cut by small discontinuous veins of quartz. A zone of schist stained by iron oxides is the most radioactive. This zone was trenched and found to be from ½ foot to 2 feet in width throughout a length of about 8 feet. The iron-stained schist gives a radiometric reading of about 0.05 mr per hr, and unstained schist from nearby outcrops gives a reading of about 0.04 mr per hr. Schist that crops out near the Steese Highway gives a reading of about 0.01 mr per hr. Samples collected from the most radioactive rock contain 0.005 percent equivalent uranium.

The prospect is on the site of a definite localized anomaly of radioactivity that is, however, of small size and low grade. The area does not appear to have potentialities for uranium ore.

MOUNT FAIRPLAY

Mount Fairplay is about 200 miles southeast of Fairbanks. The prospect is on the western slope of Mount Fairplay adjacent to the Taylor Highway between mile posts 28 and 29. The region has been mapped by J. B. Mertie (1937), and the prospect has been examined by M. G. White and A. E. Nelson (written communication). Bedrock in the area is granite surrounded by rhyolite and dacite of early Tertiary age (Mertie, 1937).

At the prospect three trenches were cut parallel to the contours to a depth of about 5 feet. Two of the trenches are along zones of iron oxide staining that give somewhat higher (as much as 0.24 mr per hr) radiometric readings than the adjacent unstained granite, which gives readings of about 0.10 mr per hr. A sample from the most radioactive rock contains 0.015 percent equivalent uranium.

Although no detailed mineralogical work was done on the rocks from the area, most of the radioactivity is believed by the author to originate in normal accessory minerals of the granite. The slight concentration of radioactivity in zones of iron oxide staining is probably due to uranium leached from the granite and then removed from solution by the iron oxide. There is probably no ore-grade rock at this prospect.

WHITE MOUNTAINS

The prospect in the White Mountains is about 60 miles northeast of Fairbanks and about 2 miles south-southwest of Lime Peak (also known as Lion Peak). It is in an area underlain by granite and is shown on a compilation map by J. B. Mertie, Jr. (1937).

In the area of the prospect, the granite is uniform in composition and free of noticeable large fractures. It gives a uniformly high radiometric reading of about 0.10 mr per hr, which, although higher than is usual from granites, is not indicative of an ore body. The writer feels that the margins of the intrusive and the adjacent rocks are more favorable for prospecting than the central part where this prospect is located.

GENERAL RECONNAISSANCE

General reconnaissance in 1956 was restricted to a radiometric traverse along the Taylor Highway from its junction with the Alaska Highway to Eagle. A carborne continuously recording scintillation counter was used for the traverse. The part of the Taylor Highway from its junction with the Alaska Highway to Chicken was previously traversed by M. G. White and A. E. Nelson in 1950 (written communication). The geology of the region is described by J. B. Mertie, Jr. (1937).

No radioactivity anomalies of significance were found during the traverse except at the prospect on Mount Fairplay. (See p. 32.) An anomaly was detected on Wade Creek where the highway crosses tailings left by a gold dredge, but it could not be found upon recrossing the area. It may have been due to a small pocket of heavy minerals in the tailings.

CONCLUSION

Although none of the prospects examined in 1956 had a minable quantity of uranium ore in sight, two of them warrant further exploration. These prospects, at Skagway and the Marietta Claim at Kendrick Bay, have yielded a small amount of ore-grade rock. No areas of interest were found during the reconnaissance along the Taylor Highway.

SUMMARY OF RECONNAISSANCE FOR URANIUM IN ALASKA, 1955

By John J. Matzko and Val L. Freeman

During 1955, the fieldwork by personnel of the U.S. Geological Survey engaged in reconnaissance for uranium in Alaska consisted of airborne-radiometric traverses, ground reconnaissance of some of the radioactivity anomalies found during the airborne work and of anomalies reported by prospectors and geologists, and a traverse along the Glenn and Sterling Highways. Anomalies found during the airborne traverses were examined on the ground in the Kobuk River area in the Lockwood Hills, near the mouth of the Kogoluktuk River, and in the Circle Hot Springs area at Circle Hot Springs. Anomalies reported by prospectors and geologists were examined on the ground in southeastern Alaska at William Henry Bay and Bokan Mountain; in southern Alaska, at Owhat River, Tiekel, and Chisik Island; and in interior Alaska, at Costello Creek and Maclaren River.

The airborne-radiometric traverses were made at an air speed of about 100 miles per hour and at an average altitude of about 100 feet with a scintillation counter connected to a continuous recorder. Thirty-three anomalies considered worth examining were found in central Alaska (table 2). The traverse along the Glenn and Sterling Highways was made with a jeep-mounted scintillation counter and a continuous recorder. During ground reconnaissance, a portable scintillation counter designed for prospectors was used.

TABLE 2.—*Radioactivity anomalies located by airborne traverses, 1955*

Quadrangle (1:250,000)	North latitude	West longitude
Kobuk River area		
Ambler River	67° 06′	157° 19′
	67° 17′	157° 30′
	67° 18′	158° 14′
Shungnak	66° 59′	156° 42′
	66° 22′	156° 16′
	66° 25′	157° 01′
	66° 18′	156° 41′
	66° 11′	156° 04′
Hughes area		
Survey Pass	67° 07′	153° 21′
Tanana	65° 52′	151° 02′
Tanana-Bettles	66° 00′	151° 02′
Bettles	66° 21′	150° 27′
	66° 30′	150° 27′
	66° 33′	150° 16′
Hughes	66° 03′	153° 55′
Melozitna	65° 35′	153° 58′
	65° 27′	153° 48′
	65° 10′	154° 04′
Cosna-Nowitna River area		
Kantishna River	64° 07′	152° 56′
	64° 10′	152° 22′
Ruby	64° 08′	153° 14′

TABLE 2.—*Radioactivity anomalies located by airborne traverses, 1955*—Continued

Quadrangle (1:250,000)	North latitude	West longitude
White Mts.-Circle Hot Springs area		
Circle	65° 28′	144° 40′
	65° 36′	146° 02′
	65° 38′	146° 45′
Livengood	65° 31′	147° 20′
Fortymile-Eagle-Goodpaster area		
Eagle	64° 29′	143° 59′
	64° 40′	143° 43′
	64° 46′	141° 15′
	64° 47′	141° 59′
Tanacross	63° 39′	142° 14′
	63° 44′	141° 30′
	63° 39′	141° 20′
	63° 39′	141° 34′

The 1955 field season extended from the latter part of May through the middle of October. The writers were aided in the field by M. N. Christensen, H. B. Groom, Jr., W. W. Patton, Jr., I. L. Tailleur, and L. R. Ladwig, all of the U.S. Geological Survey. The work was done on behalf of the Division of Raw Materials, U.S. Atomic Energy Commission, and was aided by logistic support received from the U.S. Army.

KOBUK RIVER AREA

The Kobuk River area (fig. 4) includes the northern part of the Koyukuk geosyncline (Payne, 1955) and extends north of the geosyncline into the Brooks Range geanticline (fig. 5). Several traverses with airborne radioactivity-detection equipment were flown over the area and resulted in the discovery of the eight radioactivity anomalies shown in table 2. The available logistic support permitted field examination of only two of these anomalies; one at the mouth of the Kogoluktuk River and one in the Zane Hills. Several other localities were visited to obtain a general knowledge of the area.

The part of the Kobuk River area that lies within the Koyukuk geosyncline is underlain by sedimentary rocks of Cretaceous age, dominantly graywacke, conglomerate, sandstone, and mudstone. All are more or less tuffaceous and are cut by shallow intrusive rocks of mafic and intermediate composition and a few granitic masses (Patton and Bickel, 1956a,b). The part of the area north of the geosyncline is underlain by metamorphosed sedimentary rocks of Paleozoic age or older and granitic intrusive rocks (Smith and Mertie, 1930).

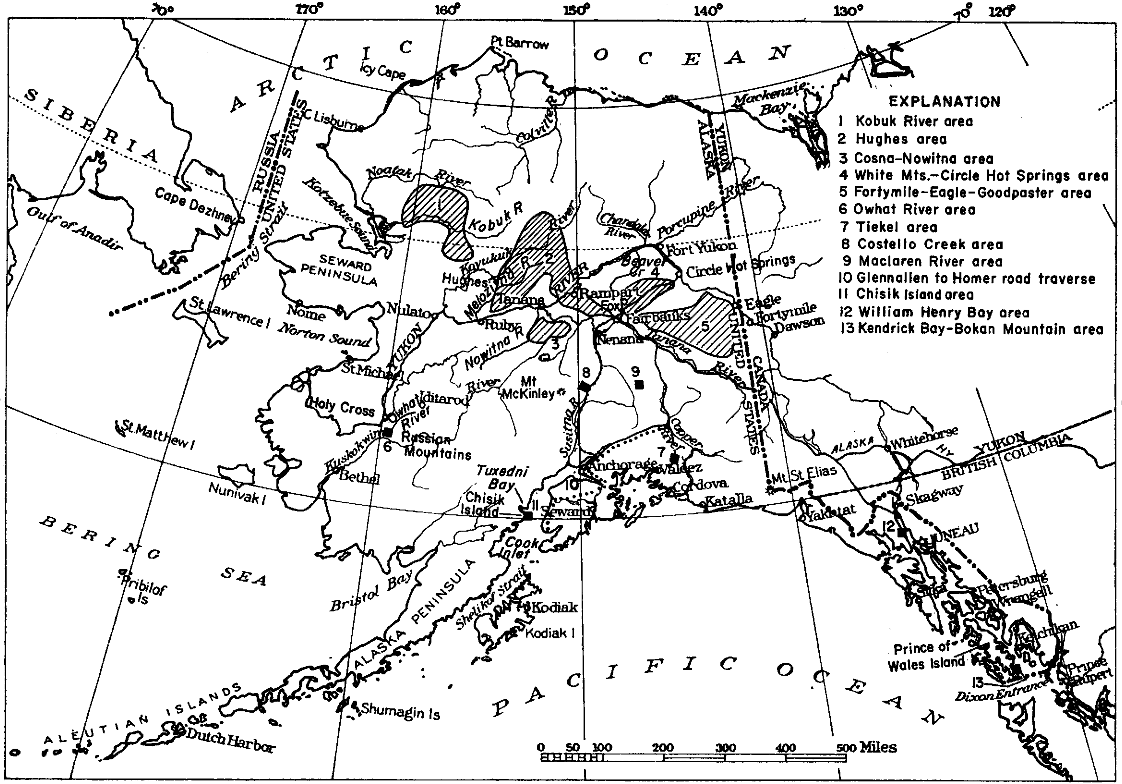


FIGURE 4.—Map showing location of areas investigated for uranium in Alaska, 1955.

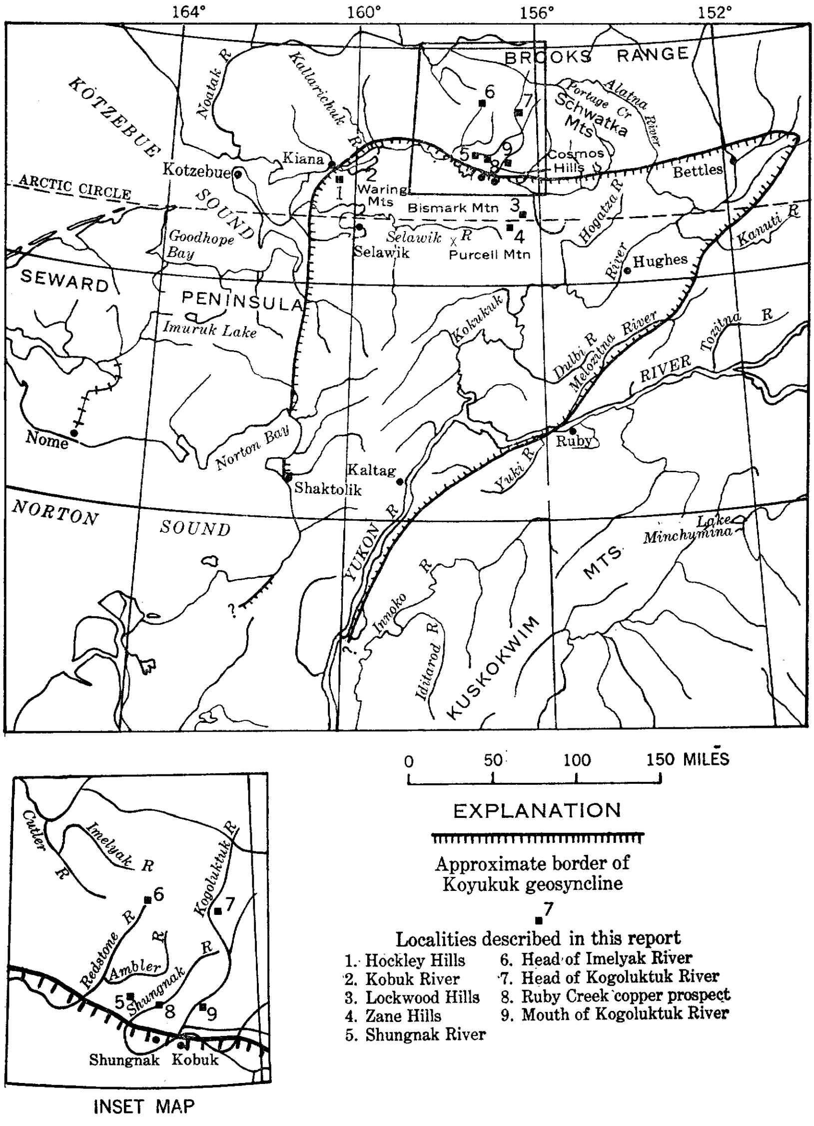


FIGURE 5.—Sketch map showing location of sites investigated in the Kobuk River area.

HOCKLEY HILLS

The Hockley Hills, a westward extension of the Waring Mountains, are between the Kobuk River and Selawik Lake (fig. 5). The part of the Hockley Hills investigated is adjacent to Portage Creek along the winter trail between Kiana and Selawik. Here, a field examination showed the rocks to be mostly conglomerate with a graywacke matrix, mudstone, graywacke, and impure black shale.

None of the rocks are more than weakly radioactive; and the radioactivity tends to be inversely proportional to the grain size. A sample of black shale, the most radioactive rock type found, contains 0.003 percent equivalent uranium. The Hockley Hills must be considered as unfavorable for radioactive mineral deposits of both sedimentary and vein types. The sediments are without exception of low porosity and permeability because of an original high content of clay-sized material and because of compaction and strong induration since deposition. As no intrusive bodies were found, the Hockley Hills are considered unfavorable for vein deposits.

KOBUK RIVER TRAVERSE

The outcrops along the north bank of the Kobuk River were traversed in a small boat from near the mouth of the Kallarichuk River to Kiana (fig. 5), a distance of about 25 miles. Most of the traverse was on Cretaceous rocks that consist of conglomerate characterized by pebbles of white quartz, sandstone, carbonaceous sandstone, and shale. Coal and minor amounts of altered tuff were also examined. Near Kiana, mica schist of Paleozoic age was tested. The most radioactive of the sedimentary rocks are the carbonaceous shales and sandstone, but even these are only weakly radioactive. In sandstone ledges stained with limonite, the highest radioactivity was where the limonite had been removed by solution along fractures and from irregular blotches; however, the difference in amount of radioactivity was barely measurable. The mica schist of Paleozoic age is somewhat less radioactive than the carbonaceous sediments but more radioactive than the conglomerates.

LOCKWOOD HILLS AND ZANE HILLS

The Lockwood Hills are about 35 miles southeast of the village of Shungnak on the Kobuk River, and the Zane Hills are about 15 miles south of the Lockwood Hills (fig. 5). Both localities are underlain by tuffaceous graywackes, tuffs, breccias, and flows. They are intruded by diorite porphyritic rocks in the Lockwood Hills and by granitic rocks in the Zane Hills. The diorite porphyries, although much more radioactive than the surrounding sedimentary rocks, contain only 0.003 percent equivalent uranium. The granitic bodies in the Zane Hills and to the west of Purcell Mountain give anomalies that were detected from the air (lat 66°22′ N.; long 156°16′ W.), but samples collected contained no more than 0.004 percent equivalent uranium. The large number of intrusive stocks, some of granitic composition, indicate that these localities may contain some vein deposits. Veins of quartz were found in the Zane Hills, but they were barren of sulfide minerals and not abnormally radioactive.

MOUTH OF KOGOLUKTUK RIVER

Near the mouth of the Kogoluktuk River, where it leaves the metamorphic sediments of the Cosmos Hills and enters the valley of the Kobuk River (fig. 5), there is an intrusive of gneissic granite that gave a radioactivity anomaly reading during an airborne traverse (lat 66°59′ N.; long 156°42′ W.). A brief examination showed the granite to be uniformly radioactive, but samples from it contain only 0.005 percent equivalent uranium, which is probably in accessory minerals such as zircon.

SCHWATKA MOUNTAINS AND COSMOS HILLS

The Cosmos Hills are a few miles north of the villages of Shungnak and Kobuk and are separated from the Schwatka Mountains farther north by a broad lowland. Traverses on foot were made from camps on the Shungnak River near Bismark Mountain, at the locality near the headwaters of the Imelyak River, and at the locality between the headwaters of the Kogoluktuk and Ipmiluik Rivers (fig. 5). All the rocks traversed are moderately to strongly metamorphosed and include mica, chlorite, and graphite schists; limestone; schistose conglomerates; metamorphosed mafic intrusives; serpentine; and gneissic granite. These rocks are only weakly radioactive, and, as would be expected, the serpentine and associated asbestos are the least radioactive.

RUBY CREEK COPPER PROSPECT

A copper prospect that contains sulfide minerals in limestone is on Ruby Creek about 12 miles north of the village of Shungnak (fig. 5); it was visited for a few hours incidental to other work. This prospect was reported to contain radioactive material in veins with chalcopyrite, bornite, galena, sphalerite, and pyrite. It was investigated in 1949 (White, 1950), and ore samples collected at that time contained no more than 0.007 percent equivalent uranium, concentrated principally in the sphalerite. Additional investigations were not recommended until more work had been done at the prospect. Unfortunately, when the prospect was investigated on July 21, 1955, the owner was not present; and it is not certain, owing to the limited time spent on the prospect, that all the radioactive areas were found. After the prospect was visited in 1949, much of the surface covering was stripped off by bulldozer, but no deep cuts were made. A traverse of the stripped area revealed a radioactivity anomaly about 25 feet long and about 1 foot wide corresponding to a much weathered vein. The vein, which is made up of limonite(?) with minor secondary copper carbonates, strikes north and continues beyond the limits of the anomaly both north and south. North of the anomaly, but not in the vein, light-purple coarse-grained fluorite was found in white quartz.

The most radioactive parts of the vein gave readings of 0.20 to 0.30 mr per hr on the scintillation counter, as compared to a reading on adjacent rocks of about 0.01 mr per hr. A sample collected for further study from the most radioactive area contains 0.02 percent equivalent uranium. No uranium mineral was recognized in the highly weathered fine-grained sample. Because of the high degree of weathering, it is felt that an equivalent-uranium content of 0.02 percent may be of significance in indicating the presence of ore-grade material beneath the zone of weathering. As the weathering likely extends to considerable depth, however, and because the vein is narrow and the prospect remote, it does not seem likely that the prospect can be mined for uranium alone.

HUGHES AREA

As used in this report the Hughes area includes the Kokrine Hills, the Ray Mountains, and the area north to Survey Pass (fig. 4). The Kokrine Hills contain large areas of rock of possible Paleozoic age; smaller, granitic bodies of Mesozoic age and others of Eocene(?) age; a metamorphic complex, including quartzites of middle Paleozoic age; and, in the western part, conglomerates, sandstones, and shales of Mesozoic, probably Late Cretaceous, age (Eakin, 1916). Little is known about the geology of the Ray Mountains except that they contain granite and metamorphic rocks of Paleozoic(?) age and are bounded on the east and west by greenstone (Eakin, 1916, pl. 2). Many prominent pinnacles believed to be granite were seen from the air. Ten radioactivity anomalies (table 2) were found during airborne-radiometric traverses of the Hughes area, but it was not possible to examine any of them on the ground. From the air most of the anomalies appeared to be related to outcrops of granite and may be caused by radioactive accessory minerals in the granites.

COSNA-NOWITNA RIVERS AREA

The Cosna–Nowitna Rivers area is a highland area south of the town of Tanana that forms a northeastward extension of the Kuskokwim Mountains (fig. 4). The area is underlain by Mesozoic sedimentary rocks and by Tertiary rhyolitic and andesitic lavas and tuffs intruded by granite (Eakin, 1918). Three anomalies (table 2) were found during airborne-radiometric traverses to the south and southwest of the Cosna–Nowitna divide in an area of volcanic rocks intruded by granite. No ground examinations were made.

WHITE MOUNTAINS–CIRCLE HOT SPRINGS AREA

Circle Hot Springs is about 100 miles northeast of Fairbanks. A single airborne radiometric traverse was flown from Fairbanks along the southeastern flank of the White Mountains to Circle Hot

Springs and back to Fairbanks over the hills to the southeast of the Steese Highway (fig. 4). The area is underlain by the Birch Creek schist of Precambrian age, undifferentiated chert, quartzite, and shaly limestone of Devonian and possibly Silurian age, and granite of Mesozoic age (Mertie, 1937).

The four radioactivity anomalies found (table 2) are probably related to outcrops of granite. No anomaly was detected above prospect trenches that contain radioactive argentiferous galena on the divide between Fox and Flume Creeks, directly north of the town of Fox, even though samples from the trenches contain as much as 0.025 percent equivalent uranium (White and others, 1952, table 2), and the plane flew as low as 50 feet above the ground. One of the anomalies (lat 65°28′ N., long 144°40′ W.), about half a mile west of Circle Hot Springs, was investigated on the ground. It is in granite that was studied previously by Nelson, West, and Matzko (1954) and that is known to contain radioactive accessory minerals. On the airborne instrument this anomaly gave readings of about twice the unusually high background that is present over the granite. The area of the anomaly was traversed on the ground by 11 lines spaced about 250 feet apart, but no marked anomaly was found. A few square yards, however, characterized by float of fine-textured granite, gave a reading of 0.03 mr per hr, as compared to readings of 0.01 to 0.02 mr per hr from the surrounding medium-grained granite.

FORTYMILE-EAGLE-GOODPASTER AREA

The Fortymile, Eagle, and Goodpaster areas (fig. 4) lie between the Yukon and Tanana Rivers east of Fairbanks. The traverses crossed areas of sandstone, shale, and conglomerate of Tertiary age; the Birch Creek schist of Precambrian age; granite and quartz diorite of Mesozoic age; rhyolite and dacite of Tertiary age; and lavas of late Tertiary and Quaternary age (Mertie, 1937). Some of the eight anomalies found (table 2) occur near the contact of granite of Cretaceous age and rhyolitic flow rocks of Tertiary age. None were examined on the ground.

OWHAT RIVER AREA

The Owhat River is a tributary of the Kuskokwim River that flows southward along the west side of the Russian Mountains (fig. 4). Anomalous radioactivity was noticed in this area (fig. 6) during airborne traverses made on the west and north sides of the Russian Mountains. Two anomalies located near the Owhat River, about 12 airline miles north of its mouth, were field checked. The exposed material in the area consists of rubble of fine-grained and porphyritic mafic igneous rocks and minor amounts of granite. Ground traverses indicated an average radioactivity of about 0.009 mr per hr but did

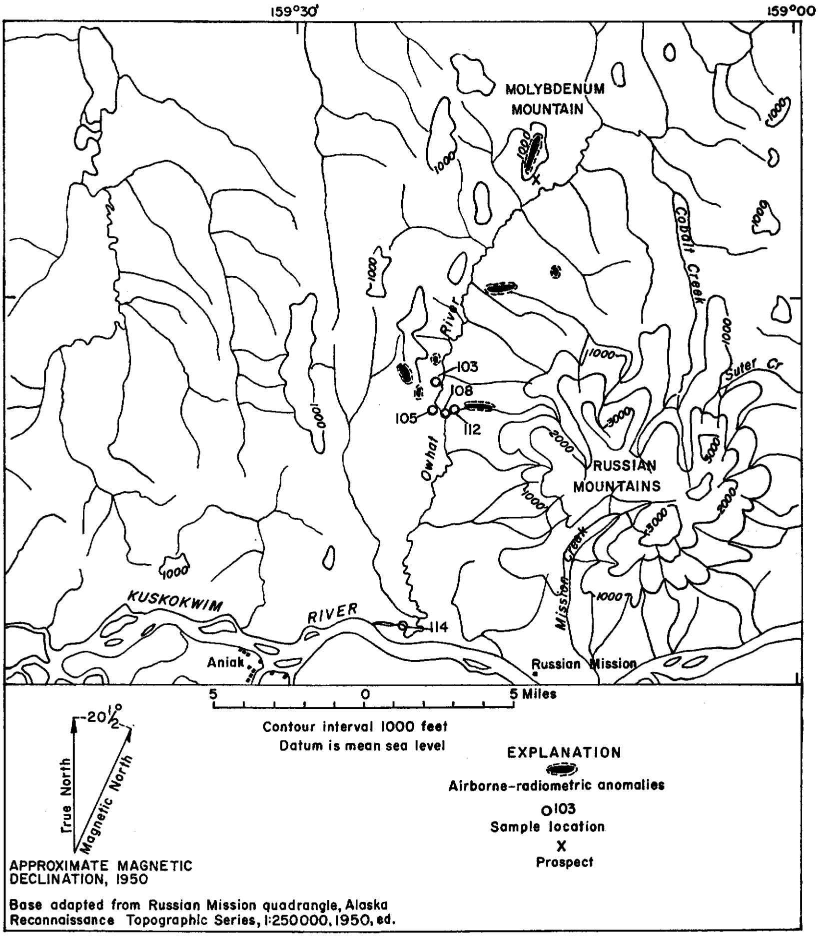


FIGURE 6.—Location of airborne-radiometric anomalies and water-sample collection sites in the Owhat River area.

not reveal any anomalies. Analyses of water samples collected from small streams draining the examined areas (fig. 6) revealed no more than 0.3 part per billion of uranium. A previous examination in a nearby area (West, 1954), made after metazeunerite was identified in a concentrate from an arsenic-copper vein in the upper tunnel of the Konechney prospect, failed to find a deposit of uranium minerals. Samples from the granite in the Russian Mountains were found to contain as much as 0.005 percent equivalent uranium.

TIEKEL AREA

In the summer of 1955 a report by prospectors of radioactivity adjacent to the Richardson Highway at about Milepost 55, near Tiekel (fig. 4), resulted in the staking of many claims. The bedrock of the general area is a contorted slaty graphitic graywacke of Cretaceous age that is cut by numerous quartz veins and by dikes and sills of diorite porphyry (Moffit, 1935). A scintillation-counter traverse of the area gave a maximum reading of 0.02 mr per hr on the slaty graywacke. Samples of the graywacke that were tested in the laboratory contained less than 0.001 percent equivalent uranium. A felsite dike about 4 feet wide gave a reading of 0.015 mr per hr. Interest in the area has lessened, and, as far as is known, no further exploratory work by prospectors is contemplated.

COSTELLO CREEK AREA

Costello Creek, a tributary of the west fork of the Chulitna River, is west of the Broad Pass station on the Alaska Railroad (fig. 4). A brief examination was made there because a sample of slightly radioactive coal had been collected by geologists studying the coal fields. The area is underlain by coal-bearing rocks of probable Eocene age (Ross, 1933). No anomalies were found during the examination, and a water sample from the stream draining the area, from which the radioactive coal was taken, contained less than 0.1 part per billion uranium.

MACLAREN RIVER AREA

A brief examination in this area was limited to the Kathleen-Margaret copper claim (Chapman and Saunders, 1954) on the Maclaren River near the terminus of the Maclaren glacier (fig. 4). The country rock is a green diabasic lava of Triassic age (Chapman and Saunders, 1954). A prominent quartz vein containing primary and secondary copper minerals and numerous prospect trenches were examined for radioactivity. A maximum reading of 0.003 mr per hr was obtained on the quartz-copper vein, and a maximum reading of 0.002 mr per hr was obtained during a traverse of the mine. Five water samples were analyzed (table 2) and found to contain no more than 0.2 part per billion uranium.

CHISIK ISLAND

Chisik Island is near the western shore of Cook Inlet at the mouth of Tuxedni Bay (fig. 4). The northern end of the island was traversed in an attempt to determine the source of a radioactivity anomaly noticed from the air. The rocks examined are the Chinitna shale and the Chisik conglomerate member of the Naknek formation of Late Jurassic age (Moffit, 1927). No anomaly was found on the ground. It is considered likely that the anomaly noticed from the air was due to the topographic effect of the steeply rising hills combined with a mass effect of radioactivity from granitic material in the thick Chisik conglomerate member.

WILLIAM HENRY BAY AREA

William Henry Bay is on the west side of the Lynn Canal about 45 miles northwest of Juneau; the area examined is on the Lucky Six group of claims located about 1 mile north of the bay at an altitude of about 1,900 feet (fig. 4). An anomaly, noted from the air by prospectors, was explored by several shallow pits and one diamond-drill hole. The bedrock in the area of the workings is metamorphosed igneous rock consisting predominantly of feldspar with streaks of white mica. Traces of thorianite, which occur in small reddish patches in the bedrock, and partially oxidized pyrite were seen. Material with 0.2 percent equivalent uranium is reported from the prospect, but no minable quantity of rock of this grade was in sight or could be inferred at the time of examination. Water samples were taken from each of 10 small streams that drain the area of the anomaly and enter Lynn Canal along a distance of about 1 mile. All these samples were found to contain less than 1 part per billion uranium.

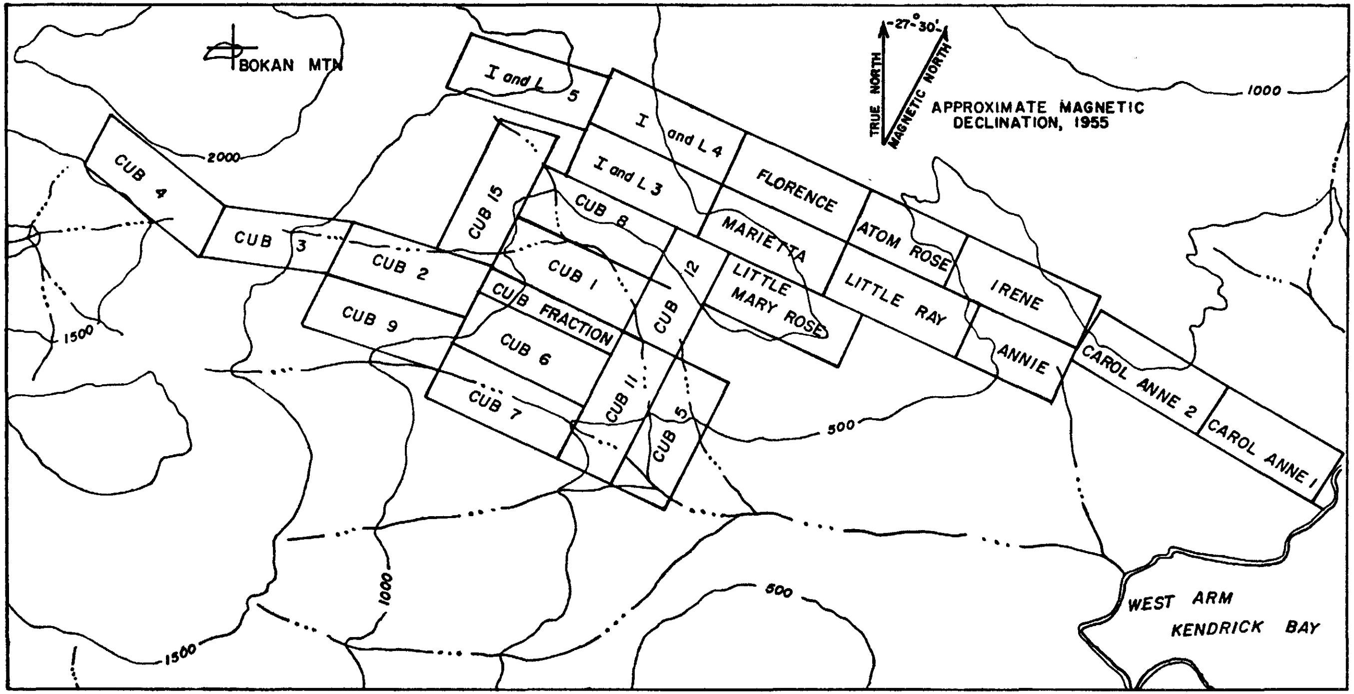
KENDRICK BAY–BOKAN MOUNTAIN AREA

The Kendrick Bay–Bokan Mountain area is near the south end of Prince of Wales Island, approximately 45 miles southwest of Ketchikan, Alaska (fig. 4). Prospecting activity in 1955 extended from the northern slope of Bokan Mountain southeast to Gardner Bay, a distance of about 10 miles. Bokan Mountain and most of the area between Bokan Mountain and the West Arm of Kendrick Bay is underlain by granitic rocks. The north shore of the West Arm is underlain by dioritic rocks cut by andesite dikes. The granite near Bokan Mountain is medium grained; many quartz crystals are larger than the feldspar crystals. Potash feldspar is dominant over plagioclase feldspar, and, in hand specimens, the mafic mineral seems to be hornblende. Quartz forms about 25 percent of the rock. Except near the margin of the intrusive, the granite is quite uniform in texture and composition. It is fractured on a large scale by several sets of prominent joints; locally it is cut by pegmatite dikes, quartz veins, and fine-grained basic dikes. The entire Kendrick Bay–Bokan Mountain area was overridden by glaciers in the recent past.

Areas of radioactivity that have been examined are on the Cub, I and L, Little Ray, and Carol Anne groups of claims (fig. 7). Other claims that have not been examined are located north and west of Bokan Mountain and south of the West Arm of Kendrick Bay.

CUB GROUP

The Cub group (Ross-Adams lode) was staked in the spring of 1955 after an anomaly was detected from the air. It consists of 12 and a fraction claims located on the southeastern slope of Bokan



All claim boundaries are approximate

V. L. Freeman, 1955

0 1000 2000 3000 FEET

CONTOUR INTERVAL 500 FEET
DATUM IS MEAN SEA LEVEL

FIGURE 7.—Claim map of the Kendrick Bay–Bokan Mountain area.

Mountain (fig. 7). The radioactive deposit on the Cub 1 claim is at an altitude of about 925 feet on a topographic bench nearly barren of vegetation. The deposit has a northerly trend and is about 150 feet long and 30 feet wide. In and near the deposit the granite has been altered and subsequently weathered. The alteration has noticeably affected the mafic minerals of the granite for a distance of about 100 feet from the deposit. The outcrops of the deposit are stained with iron oxides produced during weathering.

A closely spaced set of joints (trending N. 10°–20° W.) is prominent at the deposit and much less well developed elsewhere, but other joint sets show no relationship to the deposit. The prominence of the one set of joints at the deposit seems to be the result of localized alteration and weathering. Although the joints do not appear to be the controlling feature in the localization of the deposit, they may be the expression of a hidden fault that is the controlling feature. On aerial photographs of the area, an eastward-trending lineation, possibly a fault, is seen to pass near the deposit.

As yet the mineralogy of the deposit is not well known, especially in the part beneath the zone of weathering. Radiocative minerals have been completely leached from only the uppermost quarter of an inch. Beneath the completely leached zone, but still in a strongly weathered zone, yellow secondary minerals are along joints, and a few grains of a black shiny radioactive mineral are disseminated in the granite. Pyrite and a few grains of galena were also seen, and grains of purple fluorite have been reported by the prospectors. The primary radioactive minerals so far identified are thorianite, uranothorianite, and thorite. The secondary radioactive minerals that have been identified are bassetite, novacekite, skoldowskite, beta-uranophane, and gummite.

During the fall of 1955 the deposit was explored by diamond drilling by the Climax Molybdenum Co.

I AND L GROUP

The I and L group, consisting of the I and L claims 3, 4, and 5, is located to the north of and adjoining the Cub group (fig. 7). The entire group appears to be underlain by granitic rocks cut by a few thin pegmatite dikes and quartz veinlets. On the I and L 5 claim the granite stands in bold outcrops broken by numerous joints; on the I and L claims 3 and 4 it is mostly covered by vegetation and soil, but the cover is thin along a ridge that runs the length of the claims.

Twenty-three radioactivity anomalies have been found on the I and L claims 3 and 4 (J. A. Williams, oral communication), but only one anomaly has been found on claim 5. The anomalies are in three groups, and each group has a trend of N. 50° W. to N. 70° W. Several parallel structures with this same trend are clearly visible on the aerial photograph of the area. An examination on the I and L group revealed either a pegmatite dike or a quartz veinlet in close proximity to each anomaly. The quartz in the quartz veinlets appears to be identical with the quartz that occurs in the center of the few pegmatites that are zoned and indicates that the two types of structure are related in origin. Usually the greatest radioactivity occurs immediately alongside the pegmatite dike (including the quartz veinlets) or, when two pegmatites are very close together, in the country rock between the pegmatites. The radioactivity anomalies and related structures on the I and L group are all very small; the maximum width of high radioactivity is about 6 inches, and generally the anomalous zone is only 1 or 2 inches wide. At one locality where a pegmatite dike splits into several branches, the associated radioactivity is high through a width of nearly 2 feet but, nevertheless, concentrated in several thin zones. No subsurface work has been done on the property.

Hand samples from the anomalies on the I and L group contain from 0.05 to 6.0 percent equivalent uranium, and fluorimetric assays show from 0.048 to 2.30 percent U_3O_8, as determined by A. E. Glover of the Territorial Department of Mines assay office in Ketchikan. A spectroscopic analysis of one sample indicated that Na, U, Al, and Fe were major constituents and Y, Ce, Mn, and Nb were minor constituents. An examination in Washington (analysts: Katherine E. Valentine and Evelyn Cisney) showed one sample to be probably metamict columbate-tantalate and another sample to be brannerite.

LITTLE RAY GROUP

The Little Ray group, comprising the Little Ray, Annie, Irene, Marietta, Florence, Atom Rose, and Little Mary Rose claims (fig. 7), is east of and adjoins the I and L group. Except for a ridgetop area on the Little Mary Rose claim, the Little Ray group is heavily covered by vegetation, and only rarely is an outcrop seen. Granitic rocks underlie the claims insofar as could be determined, except for a small dike of fine-grained mafic rock that crops out on the Little Mary Rose claim.

Several radioactivity anomalies were found on the Little Ray group, all occurring along a persistent structure that trends about N. 70° W. and that appears to be a continuation of the most prominent structure of the I and L group. The anomalies are adjacent to or within pegmatite dikes of two types. One type is zoned and consists of borders of a mafic mineral (probably hornblende) with feldspar and quartz in the center; the other type consists of quartz and feldspar in equant crystals. The anomalies are weak and their exposed areas are small. The mineralized rock on the Little Ray group contains a black shiny mineral (possibly brannerite), considerable purple fluorite and scattered specular hematite. The granite adjacent to the mineralized zone has been altered to the extent that the mafic mineral appears to be chlorite. The areas of radioactivity anomalies seen do not seem to have any commercial possibilities, but the structure is persistent and more prospecting is warranted.

CAROL ANNE GROUP

The Carol Anne group, consisting of two and a fraction claims, is between the Little Ray group and the West Arm of Kendrick Bay (fig. 7). The higher part of the group is underlain by granite and the lower part by diorite and andesitic dike rocks; the nature of the contact between the rock types could not be determined because of poor exposures. Several radioactivity anomalies were found on the Carol Anne group along a structure that trends about N. 65° W. The structure, believed to be a fault, is parallel to the structures on the Little Ray group and is probably related in origin, but the mineralized rock is of different appearance.

Where the structure cuts granite, the radioactive rock occurs as thin veins or dikes that weather in relief above the surface of the granite. It is red-hued fine-grained rock in which none of the constituents are identifiable with a hand lens. It is only weakly radioactive, but locally the veins (or dikes) form a stockwork so that at one locality nearly half of a 5-foot-wide zone of rock is vein material. A specimen of the radioactive rock contained only 0.038 percent equivalent uranium. The impervious nature of the rock suggests that there has been very little leaching due to weathering.

The radioactive material in the lower part of the Carol Anne group is similar to that in the upper part, but the veins appear to be more deeply weathered along fractures and occur with appreciable amounts of purple fluorite, pyrite, and very dark quartz. Hand samples taken from each of two pits on the structure contain 0.041 and 0.13 percent equivalent uranium. Chemical analyses of two samples collected from the Carol Anne group by J. A. Williams of the Alaska Territorial Department of Mines showed 0.02 and 0.07 percent uranium, respectively.

OTHER CLAIMS

Several other claims in the Kendrick Bay–Bokan Mountain area are known to the writers but have not been visited. Radioactivity anomalies have been found, and the area has been staked between the West Arm of Kendrick Bay and Gardner Bay. This area may be an extension of the same possible fault structure that is locally radioactive in the Carol Anne group. Other claims have been staked south of Bokan Mountain near Hessa Lake.

West of Bokan Mountain is a slightly radioactive deposit of purple fluorite along a fault contact between granite and dark fine-grained metamorphic rocks. The deposit is small and apparently of low grade (E. M. MacKevett, oral communication). North of Bokan Mountain many claims have been staked on ground having radioactive material that is reported to contain thorium minerals.

SUMMARY

In 1955 the most significant discovery of radioactive material was in the Kendrick Bay–Bokan Mountain area. Uranium and thorium mineralization occurs along a zone that extends from Bokan Mountain to about 10 miles southeast; further prospecting may be expected to enlarge this area.

It is very probable that most of, if not all, the radioactivity anomalies determined from airborne traverses in 1955 are related to felsic igneous masses containing slightly radioactive accessory minerals such as zircon. In general, the anomalies are in remote areas where the geology is little known, and they cannot be evaluated without more field data.

In the part of the Koyukuk geosyncline region that was investigated, the most likely source of radioactive material seems to be in the carbonaceous sediments that occur along the Kobuk River above Kiana.

INVESTIGATIONS FOR PERLITE IN THE ALASKA RANGE

By George Plafker, Clyde Wahrhaftig, R. A. Eckhart, and R. M. Moxham

As part of the Geological Survey's program of investigations of construction materials in the Alaska Railroad belt, the four perlite deposits described in this report were roughly mapped and sampled during the summers of 1951 and 1952 (fig. 8). The Sugar Mountain deposit was mapped and described by Wahrhaftig and Eckhart; Eckhart, Wahrhaftig, and Moxham mapped the perlite at Polychrome Pass. Open-file reports describing the deposits were released in 1952. Plafker mapped and sampled the two deposits along Calico Creek and combined the discussions of these with the descriptions of the other two deposits, adapted from the open-file releases, in the present report.

Definitions of perlite vary widely, some writers using structure only as the defining feature, others combining structure and chemical composition, and still others using combined water as the distinguishing characteristic. For the purposes of this report, the least restrictive definition will be used; perlite is a volcanic glass that expands to a light, frothy artificial pumice upon heating in the temperature range 1,400°F to 2,000°F. Most perlite has a concentric,

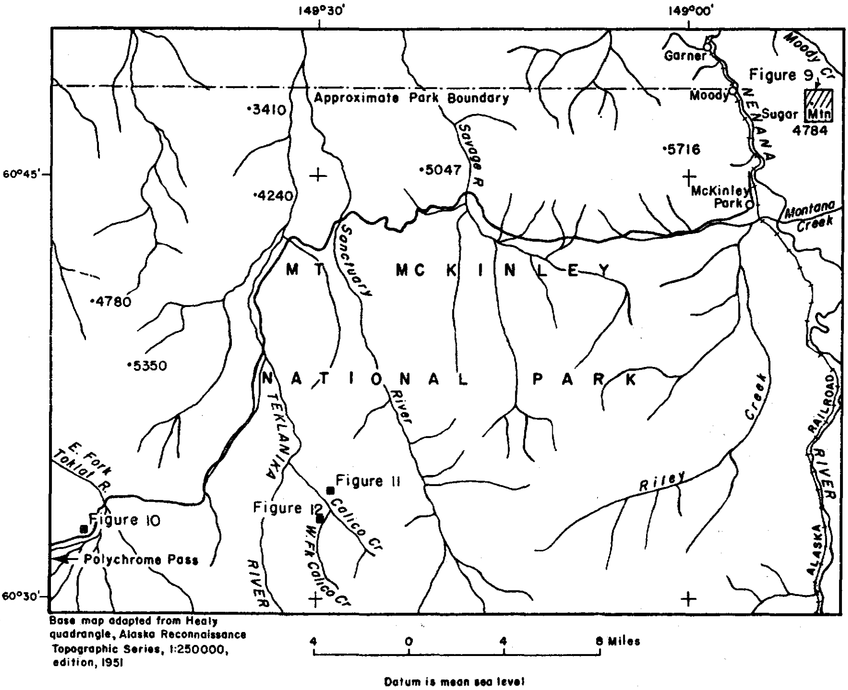


FIGURE 8.—Index map showing location of perlite deposits at Sugar Mountain (fig. 9), Polychrome Pass (fig. 10), and Calico Creek (figs. 11 and 12).

shelly (perlitic) structure and contains from 2 to 5 percent combined water, about 3 percent being the average. Pitchstone has 5 to 10 percent combined water, and obsidian and basaltic glass generally have less than 1 percent. The color of perlite is commonly shades of gray to black. Distinctive perlitic structure is thought to be the result of shrinkage cracks formed during solidification and cooling of the glass. The cracks, which may be either microscopic or visible to the unaided eye, generally cause concentric shells and, less commonly, splintery or granular textures. Perlite is commonly rhyolitic in composition, but andesitic and dacitic perlites are not uncommon.

When heated rapidly to about 1,700°F, perlite "pops", or suddenly expands, to a cellular glass that is similar to natural pumice. The optimum expansion temperatures for various glasses vary with their water content and composition; the temperatures range between the approximate limits of 1,400° and 2,200°F. For most commercial purposes, the perlite used will expand to 6 or 7 times its original volume and weighs 10 to 14 pounds per cubic foot.

The chief use for expanded perlite is as aggregate for building plaster. Here, its light weight is a distinct advantage over ordinary plaster sand, and its ease of application is an advantage over exfoliated vermiculite, which is similarly used. Perlite aggregate is also used for low-strength, lightweight concrete, which weighs 30 to 60 pounds per cubic foot. Minor amounts of perlite are used as loose-fill insulation, as a rooting medium for cuttings and young plants in nurseries, as an absorbent agent for cleaning, as an abrasive and polishing agent, in moulding sand, as a filter aid, and in fillers. Detailed information on the composition of perlites and their processing and application in industry has been given by Hastings (1947), King (1948), King, Todd, and Kelly (1948), Ralston (1946), and Huntting (1949).

SUGAR MOUNTAIN DEPOSIT

A small perlite deposit on the southeastern side of Sugar Mountain was first reported to the U.S. Geological Survey by geologists of the Territorial Department of Mines; the deposit was examined briefly on May 29, 1951. The entire description of this deposit that follows is adapted from the open-file report by Wahrhaftig and Eckhart (1952).

GEOLOGY

GEOLOGIC SETTING OF DEPOSIT

Sugar Mountain is a prominent local landmark, easily recognized by the light color of the rhyolite which makes up its top. The mountain attains an elevation of 4,450 feet, the upper 1,000 feet of which is free of vegetation. Its upper part consists largely of steep talus slopes of blocky rhyolite and partly of scattered outcrops. Small tributaries of Moody Creek drain the mountain.

Only the southeastern and northeastern sides of the mountain were examined. The western side of the mountain and a pinnacle about half a mile to the southeast. which appears to be another remnant of the same igneous complex, were not visited at the time of the examination. Scrutiny with binoculars, however, failed to indicate any sign of perlite in parts of the unexamined areas.

The country rock in the vicinity of Sugar Mountain is Birch Creek schist; this formation occupies a wide, roughly westward-trending band on the north flank of the Alaska Range. The upper part of Sugar Mountain is a complex body of rhyolite and basalt which has intruded the schist. The perlite deposit is in the rhyolite.

The only perlite observed in place is one small outcrop on the southeastern side of the mountain near the base of the rhyolite (fig. 9). The foot of this outcrop is hidden by talus, but a thickness of about 2 feet is exposed; the size of the outcrop is exaggerated on figure 9. When examined, about 6 feet of outcrop length was exposed; southwestward, however, the outcrop passed beneath a large snowbank and to the northeast it was covered by talus. Scattered perlite

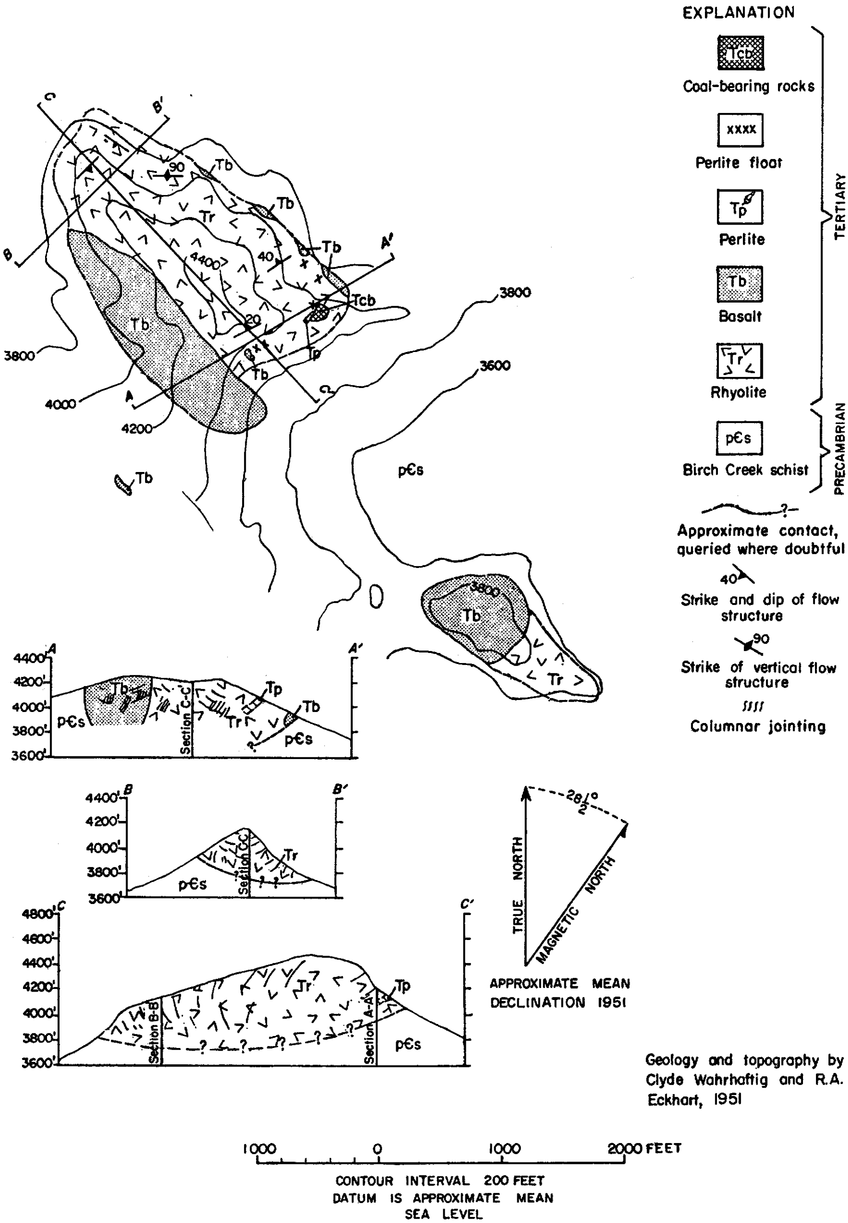


FIGURE 9.—Geologic map and sections of Sugar Mountain perlite deposit

float was observed northwestward for about 50 feet; none was observed to the southeast for several hundred feet.

In addition to the perlite mentioned above, float was found at three other places on the southeastern and northeastern sides of the mountain (fig. 9). Only a few pieces of perlite were observed at each locality and, therefore, it is very unlikely that a large perlite body exists beneath the rhyolite talus.

DESCRIPTION OF ROCK UNITS

Perlite.—The perlite is a black glassy rock that shows a fine conchoidal fracturing and contains numerous light-colored phenocrysts. It crumbles easily when struck with a hammer. Local variations of the perlite contain numerous yellowish grains of unknown composition that give the rock a yellowish cast.

In thin section the perlite is seen to consist of a colorless glass in which phenocrysts of quartz, plagioclase, orthoclase, and biotite are embedded. One phenocryst of a pyroxene mineral was also observed. In addition to the phenocrysts, small aggregates of tiny crystals of quartz, feldspar, and possibly biotite are disseminated throughout the glass. The phenocrysts are estimated to amount to about 5 percent of the section studied, and the small aggregates amount to a much smaller proportion. Calcite stringers cut several quartz and feldspar phenocrysts.

The glass shows the onionlike fracturing typical of perlite and also well-defined flow banding. The latter usually bends around the phenocrysts.

Rhyolite.—White fine-grained rhyolite forms the main part of the top of Sugar Mountain. It is apparently also on the southern side of the pinnacle half a mile southeast of the mountain. The rhyolite is made up of small phenocrysts of quartz, oligoclase, and biotite set in a fine groundmass that consists largely of quartz and orthoclase. Amygdules of single calcite crystals, as much as one-half inch in diameter, are abundant in the rock.

On the northeastern side of the mountain the rhyolite exhibits a close platy structure. This structure is probably also present on the southeastern and western sides but is masked by a well-developed columnar jointing.

Basalt.—A large mass of basalt borders the rhyolite on the southwestern side of the mountain. Several bodies of basalt, about 20 feet thick and a few hundred feet long, lie between the rhyolite and the schist on the northeastern side of the mountain. This rock appears to form the greater part of the pinnacle half a mile southeast of Sugar Mountain. As observed from Sugar Mountain, the basalt forms the northern and topographically higher part of the pinnacle and rhyolite the southern part.

As seen in thin section, the basalt consists of labradorite and basaltic hornblende phenocrysts set in a fine groundmass consisting largely of labradorite. Accessory minerals include apatite and magnetite. A few small cavities partially filled with calcite also occur in the rock.

Birch Creek schist.—Typical Birch Creek schist, consisting of quartz-sericite and quartz-chlorite schist, surrounds the Sugar Mountain intrusive on all sides. The schist is of Precambrian age.

Coal-bearing rocks.—A small body of Tertiary coal-bearing rocks was observed at the southeastern corner of the rhyolite body, just below the perlite exposure. The sediments include brown coal, coaly clay, and quartz-chert conglomerate. The total exposed thickness is 20 feet. The attitude of the coal-bearing rocks was not ascertained, but they appear to underlie the rhyolite and to lie above the basalt. No rhyolite pebbles were observed in the conglomerate, so it is unlikely that the coal-bearing rocks were deposited later than the rhyolite on the side or near the base of the mountain. A slight silicification of the coal also indicates that the rhyolite is younger than the sediments.

STRUCTURE

The structural relations inferred for the igneous complex are indicated in figure 9. From a distance the contact between the rhyolite and Birch Creek schist appears to be nearly plane and to dip 15° to 20° northward. The upper contact of the basalt body, however, at the southeastern corner of the igneous complex, dips 40° southwest; this suggests that the contact between the rhyolite and basalt at this locality may dip inward beneath the mountain. The contact between the rhyolite and the basalt to the west is nearly vertical. The structural relations of the pinnacle half a mile south of Sugar Mountain are unknown.

AGE AND ORIGIN

The rhyolite, to which the perlite is related, is younger than the coal-bearing sediments on Sugar Mountain. If rhyolite pebbles in the basal part of the Tertiary coal-bearing formation in the vicinity of the Teklanika and Savage Rivers (Wahrhaftig, 1951, p. 174), which are megascopically similar to the rhyolite of Sugar Mountain, were derived from the Sugar Mountain rhyolite, then the Sugar Mountain rhyolite probably stood up as a plug-dome in early Tertiary time. The plug-dome, therefore, was probably formed during deposition of the basal Tertiary coal-bearing sediments.

The exact relations of the basalt to the rhyolite are unknown. Apophyses of basalt into rhyolite suggest that the basalt is younger than the rhyolite, but isolated blocks of basalt in rhyolite suggest that the rhyolite may be the younger of the two. Perhaps the rhyolite and basalt are contemporaneous.

TEST DATA AND CONCLUSIONS

Two small grab samples from the perlite outcrop were subjected to expansion tests by the U.S. Bureau of Mines at Tucson, Ariz. J. C.

Clemmer, of the U.S. Bureau of Mines, summarized these tests as follows (letter to F. A. Rutledge, dated Apr. 4, 1951):

> The samples were rolls crushed through 10 mesh. As the perlite is an exploding variety, preheating was required to minimize the decrepitation during expansion. The minus 10 mesh feed and a 10 to 20 mesh fraction of the material were preheated to 500°C for one minute and were then expanded in our vibrator-actuated tube furnace at 1,100°C. The bulk weight of the expanded minus 10 and 10- to 20-mesh fractions were 12.0 and 9.6 pounds per cubic foot, respectively. The expanded minus 10-mesh material was fractionated by sink-float in water to determine the gangue content; about 2.7 percent, composed principally of quartz fragments, reported as sink. The expanded particles were white in color and appeared quite strong. The Healy perlite compares favorably with Arizona and New Mexico perlites which are being processed for plaster and concrete aggregates.

In view of its difficulty of access and its small size, commercial exploitation of the known perlite deposit is believed not feasible in spite of its favorable bloating properties. From present indications it is unlikely that any deposit of perlite of commercial size occurs in the unexposed or unexamined areas of the Sugar Mountain igneous complex.

POLYCHROME PASS DEPOSIT

A small perlite deposit occurs at the northeast end of Polychrome Pass in Mount McKinley National Park, about 46 miles by highway southwest of McKinley Park Station (fig. 8). The deposit is between 3,850 and 4,050 feet in altitude on the southwestern side of the ridge immediately west of the east fork of the Toklat River. Both the deposit and the ridge on which it is situated lie above the timberline.

On July 20, 1951, Moxham visited the deposit and collected samples. On August 28, 1951, Wahrhaftig briefly sampled the deposit and collected most of the data presented here. Wahrhaftig, assisted by A. V. Cox, also mapped the deposit and collected samples and specimens. Thin sections of the specimens were described by R. A. Eckhart. The following description is adapted from the open-file report by Eckhart, Wahrhaftig, and Maxham (1952).

GEOLOGY

GEOLOGIC SETTING OF DEPOSIT

The Cantwell formation of late Cretaceous age makes up most of the bedrock in the vicinty of Polychrome Pass. Within the Pass this formation is unconformably overlain by coal-bearing rocks of Tertiary age. The Cantwell formation has a wide distribution in the Alaska Range and consists essentially of conglomerate, sandstone and argillite with interbedded flows and tuffs, and medium- to coarse-grained intrusive rocks (Capps, 1940, p. 114). Most of the flows in the Polychrome Pass area consist of rhyolite, and it is in this rock that the perlite deposit occurs.

The perlite is exposed in a southwestward-facing bluff which rises steeply above the highway. Perlite is not exposed above the bluff, but float material was traced in a generally northeasterly direction along the top of the ridge and a short distance down the eastern side of the ridge.

The perlite deposit, where exposed, is completely enclosed by rhyolite and consists of five perlite outcrops separated by areas of yellow talus. The two largest outcrops are of about equal size, approximately 85 feet long and as much as 25 feet wide. The other perlite outcrops are much smaller (fig. 10).

The talus between the perlite outcrops consists of cobbles of rhyolite, obsidian, and perlite, and yellow bentonitic clay derived from decomposition of obsidian and perlite. The local abundance of the clayey material suggests that either perlite or obsidian or both occur beneath parts of the talus. The talus is estimated to be locally as much as 5 feet thick.

DESCRIPTION OF ROCK UNITS

Perlite.—The perlite is a moderately hard, massive greenish-gray to greenish-black rock spotted with white and glassy phenocrysts. Locally the perlite exhibits color banding.

Under the microscope the phenocrysts are seen to consist of sanidine and oligoclase and are embedded in a partly devitrified glass. A large number of microlites, probably composed of sanidine and oligoclase, a small number of tiny zircon crystals, and small limonitic masses also occur in the glass.

The glass is characterized both by "onion-skin" or concentric fractures typical of perlite and by many irregular fractures. Both types of fractures are generally filled with material that appears to be a ferruginous serpentine alteration product. This material accounts for the greenish color of the perlite. Irregular fractures lacking ferruginous serpentine also occur in most of the phenocrysts.

Obsidian.—A tiny body of obsidian is exposed at the southeastern corner of the deposit. Rhyolite borders the obsidian on the east; in other directions its contacts are concealed by talus.

The obsidian is hard, massive, black, and spotted with white phenocrysts. Under the microscope the obsidian is seen to consist of a brown glass with oligoclase phenocrysts and a very large number of microlites of unknown composition. A small amount of zircon, limonite, and ferruginous serpentine also occur in the glass. The obsidian lacks "onion-skin" fractures but exhibits a fairly well-developed flow structure.

In the field the obsidian may be distinguished from the perlite by its slightly higher specific gravity and hardness. Furthermore, the perlite of the deposit has a green color whereas the obsidian is

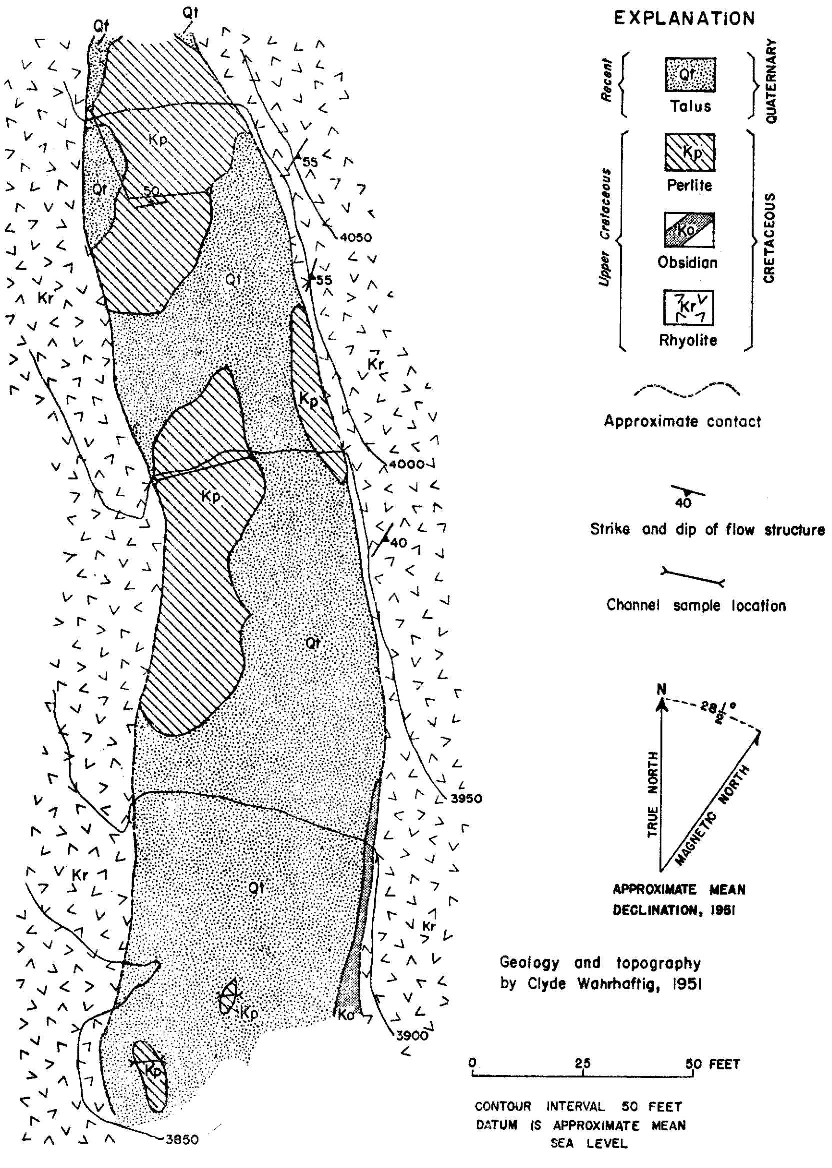


FIGURE 10.—Geologic sketch map of perlite deposit near Polychrome Pass.

black. Under the microscope the obsidian may be distinguished by its lack of "onion-skin" fractures.

Rhyolite.—The rhyolite is fine grained and light colored and locally contains purplish bands which probably are flow structure. As seen under the microscope, the rhyolite is made up of white, rather soft spherulites, consisting of a zeolite mineral, probably thomsonite, and a few sanidine phenocrysts set in a hard, fine-grained groundmass of quartz and a small amount of feldspar.

STRUCTURE AND ORIGIN

The perlite deposit lies on the north flank of a complex syncline which passes through Polychrome Pass. This structure trends east-west parallel to the trend of the Alaska Range. In the vicinity of the deposit, the rhyolite flows strike a little east of north and dip 40° to 55° SE.

Both the perlite and the obsidian are believed by Warhaftig and Eckhart to have formed by local rapid cooling of a molten lava flow of rhyolitic composition; the perlite formed where the water concentration was greatest.

TEST DATA

Four samples of perlite from the deposit were tested by the U.S. Bureau of Mines at Tucson, Ariz. The sample localities are shown on figure 17.

The samples were sized at 10 to 35 mesh and expanded in a vibrator actuator tube furnace at a temperature of 1,050° C. Table 3 shows the results of the test.

TABLE 3.—*Results of tests on perlite samples from Polychrome Pass, Alaska*

Sample	Bulk weight (crude)	Pounds per cubic foot (expanded)	Volume expansion ratio
51 AMx 38	82. 0	38. 0	2. 2
51 AMx 40	84. 5	42. 4	2. 0
51 AWg 70	71. 0	38. 5	1. 8
51 AWg 71	77. 7	37. 7	2. 1

Commenting on the results of the tests, Mr. C. Rampacek of the U.S. Bureau of Mines stated,

> None of the samples expanded satisfactorily. Under the same furnacing conditions, commercial perlites from U.S. deposits will expand to about 10 times their initial volume to yield 6 to 12 pounds per cubic foot products.

CONCLUSIONS AND RESERVES

Tests by the U.S. Bureau of Mines indicate that some, if not all, of the perlite does not expand satisfactorily, and therefore the deposit is considered to have no economic value as a source of material suitable for lightweight aggregate. Even if some of the untested perlite would expand satisfactorily, the commercial exploitation of the deposit is considered uneconomical for two reasons: (1) relatively small reserves of the deposit and (2) its distance from existing markets.

All calculations of reserves are based on the assumption that the specific gravity of the perlite is 2.33; that is, 13.7 cubic feet of perlite weighs one short ton.

Reserves for the two largest outcrops were calculated by constructing a vertical section parallel to the long axis of each outcrop. The lowest elevation of each outcrop was assumed as the bottom of the respective section, and an average width was determined for each outcrop. Contacts of the outcrops were assumed to be vertical. The indicated reserves for each of these two outcrops is 1,000 short tons. The three small outcrops are estimated to have a combined indicated reserve of 400 short tons. Total indicated reserves for the deposit are 2,400 short tons.

Perlite float in the talus upslope from the northernmost perlite outcrop indicates that additional reserves of perlite underlie the talus. The zone in which the perlite float was found, however, is only 5 to 10 feet wide, and, therefore, the amount of perlite beneath the talus is probably small.

CALICO CREEK DEPOSIT

On July 9, 1952, Plafker briefly examined a small perlite deposit on the east side of Calico Creek about 2 miles above its junction with the Teklanika River (fig. 8). A map was prepared by pace and compass methods, and samples of perlite were taken for bloating tests. The deposit is on a ridge between 3,760 feet and 3,940 feet altitude at the base of a prominent light-colored rhyolite knob. The entire area is above timberline.

GEOLOGY

GEOLOGIC SETTING OF DEPOSIT

Bedrock in the area is composed of a wide variety of fine-grained interbedded flows and tuffs with possible shallow intrusive rocks of rhyolitic composition. The rhyolitic rocks are associated with the Cantwell formation of late Cretaceous age (Capps, 1940, p. 129).

Perlite is exposed along the steep southeastern slope of a northeastward-trending ridge for a distance of 425 feet (fig. 11). In the largest outcrop, near the southwestern end of the deposit, the perlite attains a maximum thickness of 30 feet. Toward the northeast it is largely concealed by rhyolite talus, and by jellylike buff-colored bentonitic clay derived by decomposition of the volcanic glass. Associated with the talus and clay are "thunder-eggs" and chalcedony-lined geodes formed by silicification during alteration of the volcanic glass. The perlite occurs in a series of rhyolitic rocks consisting, from oldest to youngest, of massive felsophyric rhyolite of unknown thickness, bedded welded rhyolite tuff as much as 25 feet thick, vitrophyric perlite as much as 30 feet thick, rhyolite approximately 10 feet thick, and platy felsophyric rhyolite of unknown thickness.

DESCRIPTION OF ROCK UNITS

Massive felsophyric rhyolite.—The basal rhyolite is fine grained and greenish gray and contains many light-colored phenocrysts and

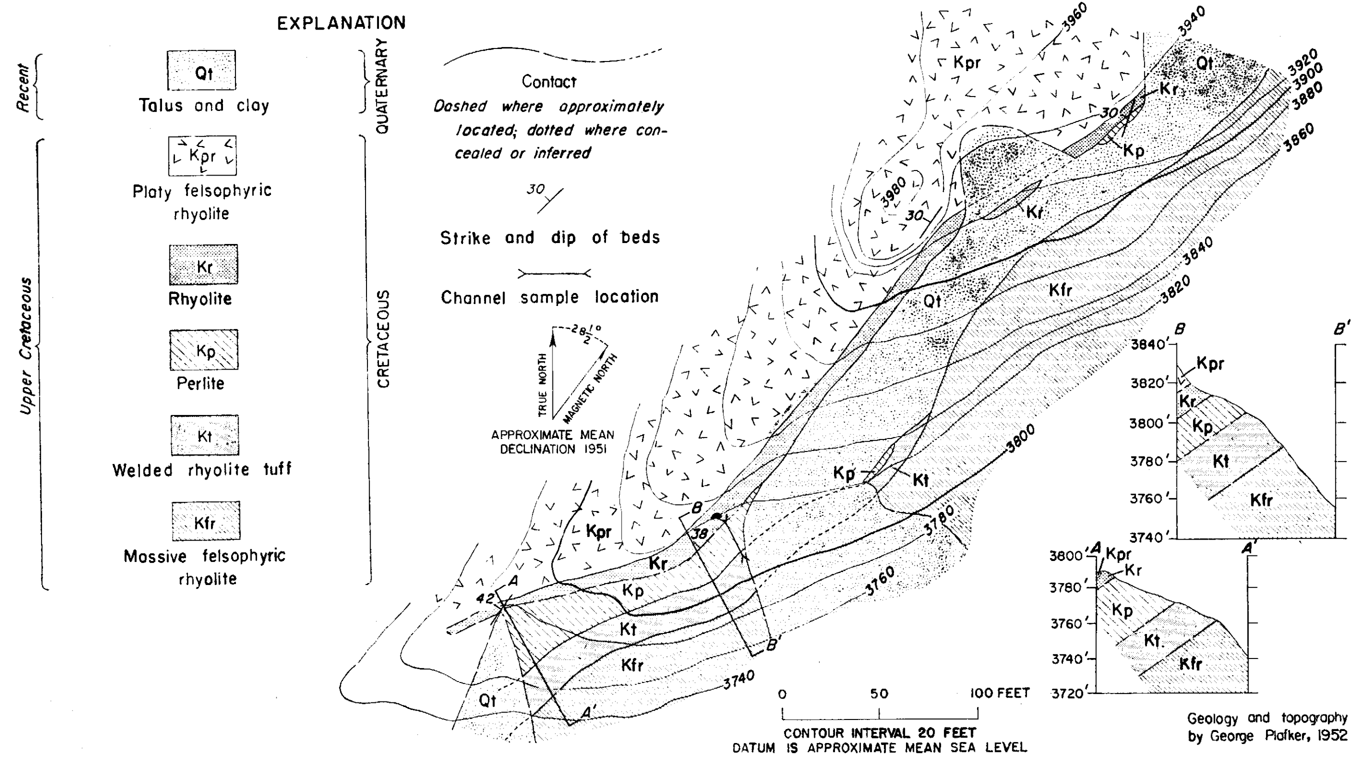


FIGURE 11.—Geologic map and sections of perlite deposit on Calico Creek.

amygdules. The rock is massive and essentially structureless. The base of the unit was not seen in the field.

In thin section the rock is seen to consist of vesicles less than 1 mm in diameter and phenocrysts less than 0.2 mm in diameter in a dense very fine grained quartz-feldspar matrix. The vesicles, which constitute approximately 15 percent of the rock, are commonly filled with single calcite crystals or are lined with fine-grained quartz. Phenocrysts total less than 5 percent of the rock. They consist of anhedral quartz, euhedral clear sanidine, subhedral twinned albite-oligoclase, and anhedral magnetite.

Welded rhyolite tuff.—The welded tuff is moderate brown to green, fine grained, dense, and streaked with elongate vesicles, flow structures, phenocrysts, and rock fragments. In thin section the welded tuff is seen to consist of phenocrysts up to 2 mm long, and rock fragments up to 3 mm diameter, and elongated vesicles and amygdules in a predominantly felsophyric matrix. Crystals of quartz, sanidine, and albite constitute about 10 percent of the rock. Lithic fragments of both rhyolitic and basaltic composition make up 15 percent of the rock. Another 15 percent of the rock consists of vesicles, many of which are filled with calcite, chalcedony, zeolites, and chlorite. The matrix consists of very fine grained quartz and feldspar, but in a few places outlines of glass shards and flow structures indicate an originally glassy rock.

Vitrophyric perlite.—The perlite is massive and black with a subvitreous luster. It contains numerous phenocrysts and large rock fragments that locally constitute up to 40 percent of the rock. In thin section the matrix glass is a deep brown color and exhibits flowbanding and poorly developed ringlike perlitic fractures. Rock fragments of rhyolitic and basaltic composition as much as 1 centimeter in diameter are abundant throughout the thin section. Phenocrysts as much as 0.8 millimeter long comprise euhedral sanidine, subhedral oligoclase, corroded quartz, and altered pyroxenes. A narrow zone of devitrified glass invariably lies between the rock fragments or phenocrysts and the matrix.

Rhyolite.—A thin flow of pale-brown very fine grained slabby rhyolite overlies the perlite. A few light-colored phenocrysts sparsely distributed throughout the rock are visible in the hand specimen. In thin section the rock is seen to be essentially a microfelsitic aggregate of quartz and feldspar with finely disseminated granular iron ore. A few phenocrysts 1 to 2 millimeters long of euhedral sanidine and some anhedral oligoclase, quartz, and altered pyroxene are distributed throughout the groundmass.

Platy felsophyric rhyolite.—Fine-grained light brownish-gray platy rhyolite forms a prominent knob on the ridge above the perlite deposit. The rock is fractured into slabs ranging from about 1 to 4 inches in thickness. Under the microscope the rhyolite is seen to consist of a few euhedral sanidine phenocrysts, magnetite grains, and altered pyroxenes in a very fine grained matrix of quartz, feldspar, and granular iron ore.

STRUCTURE, AGE, AND ORIGIN

The sequence of felsic volcanic rocks in which the perlites occur strikes from N. 30° E. to N. 40° E. and dips at angles of 30° to 42° NW. The sequence is believed to represent extrusive flows and tuffs of felsic volcanic rocks that are interbedded with sedimentary rocks of the Upper Cretaceous Cantwell formation.

TEST DATA AND CONCLUSIONS

A small channel sample of the perlite was collected at the locality shown on figure 11 and subjected to a bloating test by the U.S. Bureau of Mines Electrotechnical Laboratory at Norris, Tenn. The results of this test indicate that there is very little change of color or expansion upon heating of the specimens within a temperature range of 1,700°F to 2,400°F. The treated samples had a specific gravity of 99 pounds per cubic foot as against the natural weight of 153.9 pounds per cubic foot. Inasmuch as commercial products usually run 10 to 14 pounds per cubic foot, this material obviously has no economic value as a source of perlite.

WEST FORK CALICO CREEK DEPOSIT

The perlite deposit along the west fork of Calico Creek (fig. 8) was visited briefly by Plafker on July 10, 1952. A sketch map of the deposit was prepared and samples of the perlite were taken for testing.

The deposit is on the northwest side of the west fork of Calico Creek approximately half a mile from its junction with the main stream. The altitude of the deposit ranges from about 4,150 to 4,250 feet. Examination of stream gravels along the creek failed to show any perlite that may have been derived from exposures farther upstream.

GEOLOGY

GEOLOGIC SETTING OF DEPOSIT

The country rock in the vicinity of the perlite deposit consists of interbedded basaltic and rhyolitic volcanic rocks associated with the Cantwell formation.

Perlite float was found in the three creeks draining into the west fork of Calico Creek from the northwest, as shown on figure 12. The perlite zone is marked by a line of white or buff jellylike bentonitic clay containing rounded boulders of unweathered perlite. The distribution of clay and the topographic development on the weathered perlite indicates that the perlite is about 15 to 20 feet thick. The

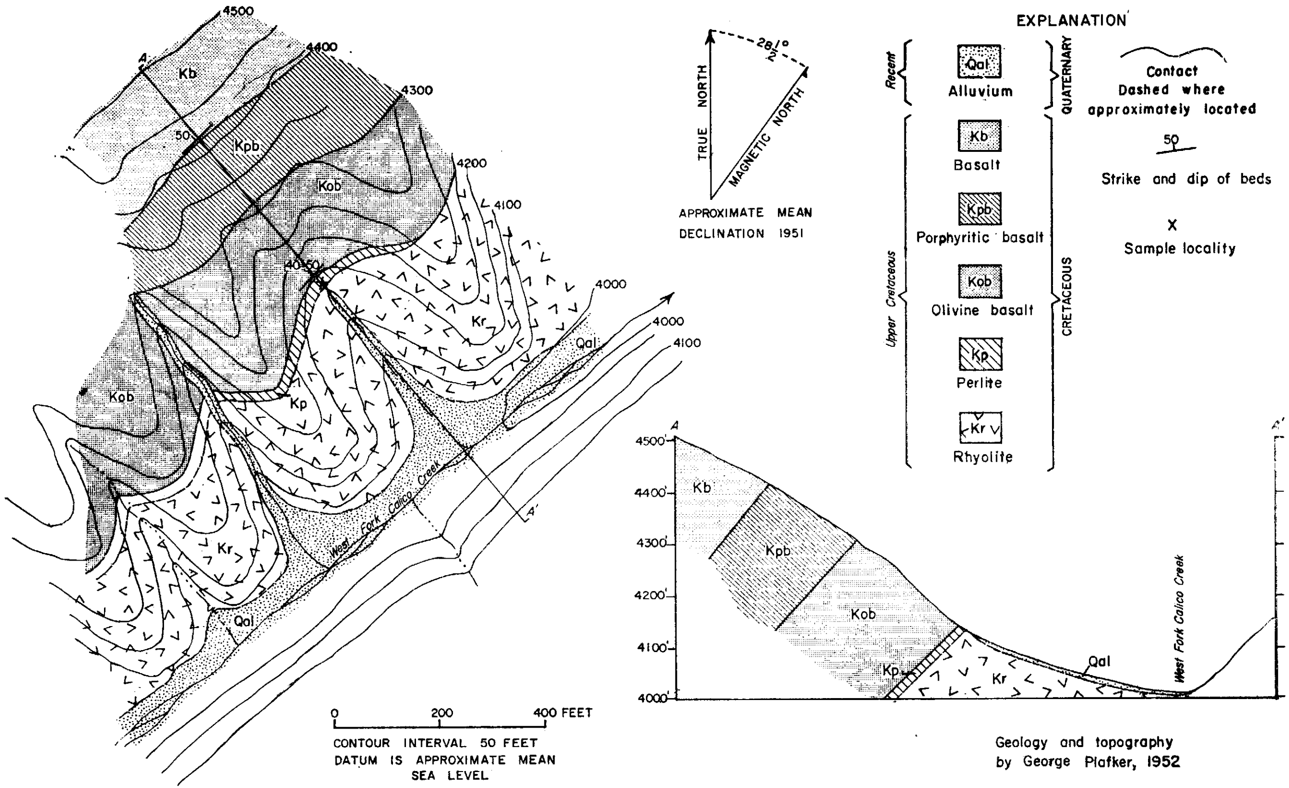


FIGURE 12.—Geologic sketch map and section of perlite deposit on West Fork Calico Creek.

zone of weathered perlite can be traced along strike for a distance of over 800 feet. It appears to pinch out toward the northeast and is concealed beneath talus and muskeg on the southeastern end of the deposit. The perlite occurs in a series of bedded volcanic rocks consisting, from bottom to top, of massive rhyolite, perlite, olivine basalt, porphyritic basalt, and basalt.

DESCRIPTION OF ROCK UNITS

Rhyolite.—The rhyolite is massive, yellowish gray, fine grained, and spotted with white phenocrysts. The thickness of the unit is not known, as the base is not exposed. In thin section the rock is seen to consist of an estimated 15 percent euhedral sanidine phenocrysts 0.6–2 millimeters long, 5 percent magnetite grains as much as 0.5 millimeter in diameter, and 60 percent spherulites as much as 1 millimeter in diameter, set in a dense microfelsitic matrix. The spherulites are pale brown in transmitted light and consist largely of radiating aggregates of chalcedony.

Perlite.—The perlite float rock consists of white phenocrysts in a matrix of vitreous black glass. Because the glass decomposes readily to bentonitic clay, it was not possible to examine the perlite in outcrop. The perlite may represent the upper chilled part of the underlying rhyolite flow. The perlite zone is about 15 to 20 feet thick along the line of section *A–A′* in figure 12.

In thin section the glass (RI–1.48) is seen to be colorless and cut by closely spaced fractures into roughly circular and rectangular areas. The typical "onion skin" or perlitic fracture is not developed. Along larger cracks and around phenocrysts the glass is devitrified to a microcrystalline aggregate consisting largely of quartz and feldspar.

Phenocrysts from 0.5 to 1.8 millimeters long constitute an estimated 20 to 25 percent of the rocks. They comprise euhredal sanidine, oligoclase, and olivine, distributed at random throughout the glass matrix. The olivine is hortonolite (Fa–65, B=1.792, 2V=60).

Olivine basalt.—Massive black very fine grained basalt overlies the perlite. The basalt is prominently jointed and has a stratigraphic thickness of about 225 feet.

Under the microscope the basalt is seen to have a typical intergranular texture. Crystals from 0.1 to 0.6 mm long of plagioclase laths (An_{50}), augite, and olivine altered to celadonite are embedded in a dark-brown microfelsitic matrix. Calcite occurs as amygdules up to 0.8 mm in diameter and is also distributed as finely divided granules throughout the matrix.

Porphyritic basalt.—This unit consists of massive fine-grained greenish-black basalt 165 feet thick that grades toward the top into 35 feet of pale olive-green amygdaloidal basalt.

In thin section the lower part of the flow is seen to consist of plagioclase (An_{55}), augite, and altered olivine phenocrysts from 0.2 to 1 mm in diameter embedded in a matrix of plagioclase microlites with granular augite, calcite, magnetite, and chlorophaeite. The phenocrysts total approximately 7 percent of the rock. In the upper part of the flow the grain is much finer and amygdules as much as 3.5 mm in diameter of calcite and hematite are embedded in a fine-grained matrix that appears to be devitrified glass.

Basalt.—The uppermost flow examined is a light-brown fine-grained partly amygdaloidal rock. The top was not seen in the field, but the flow is at least 200 feet thick.

Under the microscope the rock consists of plagioclase laths (An_{55}) 0.1 to 0.4 millimeter long embedded in a fine-grained iron-stained groundmass. Locally the rock contains amygdules of calcite or quartz and in places is cut by narrow veinlets of quartz or calcite.

STRUCTURE, AGE, AND ORIGIN

The entire sequence of volcanic rocks in which the perlite occurs trends uniformly N. 40° E. to N. 50° E. and dips 40° to 50° NW. The units described represent a series of flows, the oldest of which were rhyolitic in composition, and the youngest basaltic. The perlite probably represents the upper chilled part of the rhyolite flow. The rocks are closely associated with sedimentary rocks of the Cantwell formation that are considered by Capps (1940, p. 129) to be of Late Cretaceous age.

TEST DATA AND CONCLUSIONS

A grab sample of perlite was taken from a fresh boulder in the weathered zone at the outcrop (see fig. 12) and was subjected to expansion tests by the U.S. Bureau of Mines Electrotechnical Laboratory at Norris, Tenn. The specimen was tested in the temperature range of 1,700°F to 2,400°F. It turned to a buff at 2,000°F and to a light gray at 2,400°F. Maximum expansion occurred at 2,300°F to 2,400°F and yielded a material of about 55 pounds per cubic foot. This is much heavier than the usual commercial product, which is usually 10 to 14 pounds per cubic foot; therefore the deposits could not be profitably exploited as a source of perlite.

AIDS FOR PROSPECTORS

Perlite is a glass of volcanic origin; so obviously prospecting should be limited to areas where volcanic rocks are exposed. The viscous lavas of felsic to intermediate composition are most favorable for the formation of natural glass. The prospector should look for the vents and feeder dikes through which felsic lavas rose, because most perlite deposits occur either in or immediately adjacent to these features.

Perlite tends to alter by devitrification to rocks which do not have the expansion properties of fresh perlite; therefore, commercial deposits are most likely to be found in geologically young rocks. This is indicated by the fact that, of the deposits described, only the perlite of Tertiary age from Sugar Mountain expands satisfactorily. The other three deposits, of Cretaceous age, contain volcanic glass which is at least in part devitrified and has poor bloating qualities.

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The volcanic glasses alter by weathering to a bentonitic clay with accompanying release of silica that forms agate-filled nodules ("thunder-eggs") and irregular masses and seams of chalcedony. The prospector should watch for jellylike clay, geodes, and quartz-filled nodules in felsic volcanic rocks as favorable indications of perlite.

The search for perlite in the Alaska Range should, therefore, be concentrated in areas of felsic volcanic rocks of Tertiary age. Known rocks of this type that are accessible to the railroad occur only in the vicinity of Sugar Mountain, where small quantities of good quality perlite have been found previously (Wahrhaftig and Eckhart, 1952). A piece of perlite float from Montana Creek that resembles the perlite described from Sugar Mountain was given to Clyde Wahrhaftig of the U.S. Geological Survey. The float may indeed have been derived from the Sugar Mountain deposit, but the possibility of another perlite deposit within the drainage area of Montana Creek should be investigated.

South of the Alaska Range extensive areas of Tertiary volcanic rocks occur in the Talkeetna Mountains from Broad Pass south to the Matanuska Valley and east of the Alaska Railroad. Most of the volcanic rocks described from the Talkeetna Mountains are of basaltic composition, although glassy felsic types are also included (Capps, 1940, p. 85–86). In 1954 a small piece of perlite float was collected by G. D. Eberlein of the U.S. Geological Survey from the east fork of Iron Creek in the Talkeetna Mountains. This perlite exhibits the typical "onion skin" fracture, is free of phenocrysts, and, on the basis of preliminary tests, is believed to have excellent bloating qualities. Although not in itself economically significant, this float indicates that conditions favorable for formation of perlite in commercial quantity and quality may exist in the Talkeetna Mountains.

COPPER PROSPECT SITE IN UPPER CHITINA VALLEY

By James F. Seitz

Copper minerals have been known in the mountains of the upper Chitina Valley region for more than 60 years. Much of the region has been prospected, especially during the early part of this century, and many claims have been staked; but, as yet, no ore body has been discovered. The mineralized site described in this report was prospected and staked in 1926, and development work was carried out during the succeeding 6 years.

Previous work.—The only previous recorded geological investigation undertaken in the upper Chitina Valley region was that of a U.S. Geological Survey party in 1915 under the leadership of Fred Moffit. This party mapped an area extending from McCarthy to the Chitina Glacier. Members of the party started from McCarthy, traversed the valley of Young Creek, crossed over to the Chitina Valley, and continued up the valley to a point about 7 miles east of the terminus of Chitina Glacier. Difficulty of crossing the Chitina River caused them to confine their traverses to the north side of the valley. Members of this party found various copper minerals at many places in the mountains from Canyon Creek to the terminus of Chitina Glacier.

Present work.—The present report is a result of a brief investigation in July 1956 of copper mineralization at the site of claims staked near the terminus of Chitina Glacier. No geological investigation of these claims had been made previously; so a brief study in this little-known region was considered worth undertaking. The party carrying out this work consisted of the writer and his assistant, Peter Stauffer.

Acknowledgments.—The writer wishes to express his appreciation to Mrs. Margaret Harrais of Valdez, Alaska, for her permission to use the cabin at the site of the claims for living quarters while working in the area. He also wishes to express his appreciation to Jack Wilson, pilot, of Chitina, Alaska, for his skill in operating from the rough landing strip in the area.

GEOGRAPHY

The area described in this report lies in the upper Chitina Valley, 60 miles upstream from the junction of the Chitina and Nizina Rivers and 20 miles west of the international border (fig. 1, locality 10). It is surrounded by rugged mountains that rise to a maximum altitude of 19,000 feet and extend continuously for 40 miles to the north, 80 miles to the east, and 70 miles to the south. The valley of the Chitina River opens to the west and extends 100 miles to the mountains bordering the Copper River on the west.

The site studied is adjacent to the terminus of the Chitina Glacier and lies about 2,000 feet above sea level. The mountains flanking either side of the valley rise rather abruptly to an altitude of about 9,000 feet. Their slopes up to an altitude of about 3,000 feet are covered with forests of spruce, birch, cottonwood, and poplar trees, and their highest valleys bear active glaciers. The valley floor is flat and ranges from 4 to 6 miles in width. Its gravel cover is kept bare by the constant shifting of the river channel, and, as a result, dust storms are common on windy days.

The quickest and most economical way to get to the area described here is by means of a light airplane that can land and take off from the rough gravel river fan. The closest point where an airplane can be obtained is Chitina, 105 miles to the west. In 1930 a landing strip was roughed out on the fan about a quarter of a mile from the Harrais cabin, but the main distinction between the strip (which is nearly invisible from the air) and the rest of the fan is that some of the largest boulders have been removed.

One can also get to the area with pack horses by traveling over 65 miles of old trail from McCarthy; however, the trip would be slow and possibly difficult in places.

HISTORY OF DEVELOPMENT

In 1926 claims were located and staked in the area immediately north of the terminus of Chitina Glacier where the limestone contains copper minerals in a few places. Subsequently, exploratory and development work were carried out by blasting and drifting in two localities. Most of the work was done in the canyon of Margaret Creek: surfaces on the canyon walls were blasted clean in places, and six drifts ranging from 3 to 30 feet in length were driven into the limestone on the west wall. Some blasting and sampling were done in Dry Gulch about a quarter of a mile west of Margaret Creek.

In addition to the exploration accomplished, an excellent log cabin, a water reservoir and aqueduct, and a high cache were constructed. The water supply system no longer functions, but the cabin and the high cache are still completely serviceable.

Work on the claims was discontinued in 1932. Since that time probably only occasional prospectors have visited the area. Interest in mineralization in the entire region undoubtedly waned when the Copper River and Northwestern Railroad, connecting McCarthy to a seaport, was abandoned in 1937.

GEOLOGY

The bedrock at the site investigated is part of a formation of limestone and calcareous schist that totals several thousand feet in thickness. The formation forms a belt that strikes northwest and dips steeply northeast. Moffit (1918) found that the limestone is underlain on the southwest by a granitic body and is overlain on the northeast by a thick formation of greenstone. At one place the limestone was observed to be underlain by a tuffaceous sandstone. The contact area is so faulted that it was not possible to determine whether or not the sandstone is a lower member of the limestone formation.

The formations mentioned have thus far yielded no fossils, but a comparison with those of the lower Chitina Valley indicated to Moffit that the greenstone formation is probably correlative with the greenstone that underlies the Nikolai greenstone in the lower Chitina Valley and is therefore of Permian and Triassic(?) age. He thought the underlying limestone formation to be of Carboniferous age or older.

Where observed, the bedrock is much faulted, and little was determined of the structure. The limestone is massive and has no bedding or other evidence of its attitude. The schist shows bedding in only a few places, and even the trend of its foliation varies widely owing to faulting. The schist was derived from impure beds intercalated in the limestone, and most of it is graphitic; a small amount is chloritic.

MINERAL DEPOSITS

Mineralization on the claims consists of small pods, zones, and aggregates that contain, in places, chalcopyrite, galena, sphalerite, bornite, pyrite, silver or a silver sulfide, malachite, and azurite. These mineralized areas are confined largely to shear zones in the bedrock. Of 10 sites of mineralization located, 8 are in coarse-grained white limestone, and 2 are in graphitic calcareous schist. Mineralization is patchy, sparse, and localized.

Malachite and, to a lesser extent, azurite coatings are the most conspicuous form of mineralization in the area; they were found at 7 of the 10 mineralized sites located. For the most part, the malachite and azurite form thin coatings on the seams and fractures in the limestone and schist. Discontinuous networks of these coatings extend for as much as 15 feet in shear zones, but, as the coating is paper thin, the networks contain only a small total amount of copper. In a few places, where the copper carbonate minerals are associated with pods of sulfide minerals, the malachite forms irregular webs that make up an appreciable percentage of the rock, although only in volumes of a few cubic centimeters.

The common occurrence of the sulfide minerals is as a dissemination of grains in calcite in small aggregates measuring an inch or so in diameter at the most. These aggregates are isolated from each other and are exceedingly scarce. On the west side of Margaret Creek, where most of the development work has been done, only five such sulfide concentrations were found over a distance of 150 feet. As these areas of mineralization are isolated spots and do not form a vein or other continuous body, a channel sample along this wall would yield barren rock unless by chance it included one of these sulfide aggregates. Even then it would show only a minute proportion of the sulfide and copper carbonate minerals.

The most promising type of mineralization occurs as a concentration of sulfide minerals in either pod-shaped masses or tabular zones along a fault. One such pod, found in the east wall of Margaret Creek, consisted of a concentration of sulfide and oxide minerals in a mass about 10 inches in diameter and one to four inches thick. The minerals present included galena, sphalerite, chalcopyrite, bornite, pyrite, malachite, azurite, and limonite. The entire mass was removed and was found to weigh about 20 pounds. No extension of the sulfide minerals was seen on the cliff face around the pod, although thin, sparse coatings of malachite extended from it along a shear zone to a point 15 feet above it.

An assay of this pod by the Alaska Territorial Department of Mines yielded the following results: copper, 4.78 percent; lead, 6.53 percent; and zinc, 13.15 percent.

A sulfide mass in tabular form was found along a shear zone 200 feet west of Dry Gulch. Here, sulfide mineralization was distributed through a zone about 5 inches thick, 3 feet high, and 4 feet long. Although two borders were concealed, the mineralization obviously dwindles in all directions. The sulfide and copper carbonate minerals make up only part of this zone, as much coarse-crystalline calcite is mixed with them. The minerals here include galena, malachite, azurite, and possibly sphalerite and chalcopyrite. Silver may also be present, as a sample from this vicinity showed silver when assayed.

DISCUSSION OF LOCALITIES

MARGARET CREEK

Most of the development work was done along Margaret Creek. Six drifts were driven in the west wall of the canyon, 5 of them ranging from 3 to 6 feet in length and one extending 30 feet (fig. 13). All were driven along shear zones and probably were started on outcrops showing sulfide masses similar to those described. None now contains more than a minute spot or two of disseminated sulfide grains or a faint streak of malachite. Apparently all promising rock was removed and tunneling stopped when no more was encountered. No drift showed any sulfide minerals at its far end.

Drift No. 1 is on a shear zone where black graphitic schist is faulted against white crystalline limestone. Two blocks of brecciated white limestone within the schist several feet from the main fault contact show a slight stain of malachite. The blocks may have been stained before the final faulting that moved them into the schist, but more likely the copper-bearing solution came in through the sheared and permeable schist after the faulting and deposited on the limestone where it could pick up the carbonate ion. Throughout the area the mineralization appears to have been subsequent to the shearing and faulting. In the float at the entrance to drift No. 1, several fragments of sulfide rock were found which indicate that the drift was probably driven on the basis of mineralization visible on the outcrop.

Between drift No. 1 and drift No. 2 a small mass of sulfide minerals, similar to that described from the east side of the creek, appears on the cliff face. It amounts to only a few square inches but has malachite stains extending for several feet above and below it.

Drift No. 2 is barren of sulfide and copper carbonate minerals. It follows a fault parallel to drift No. 1 but is only 6 feet deep.

Between drifts No. 2 and No. 3 the rock is barren except for a small patch of malachite adjacent to drift No. 2.

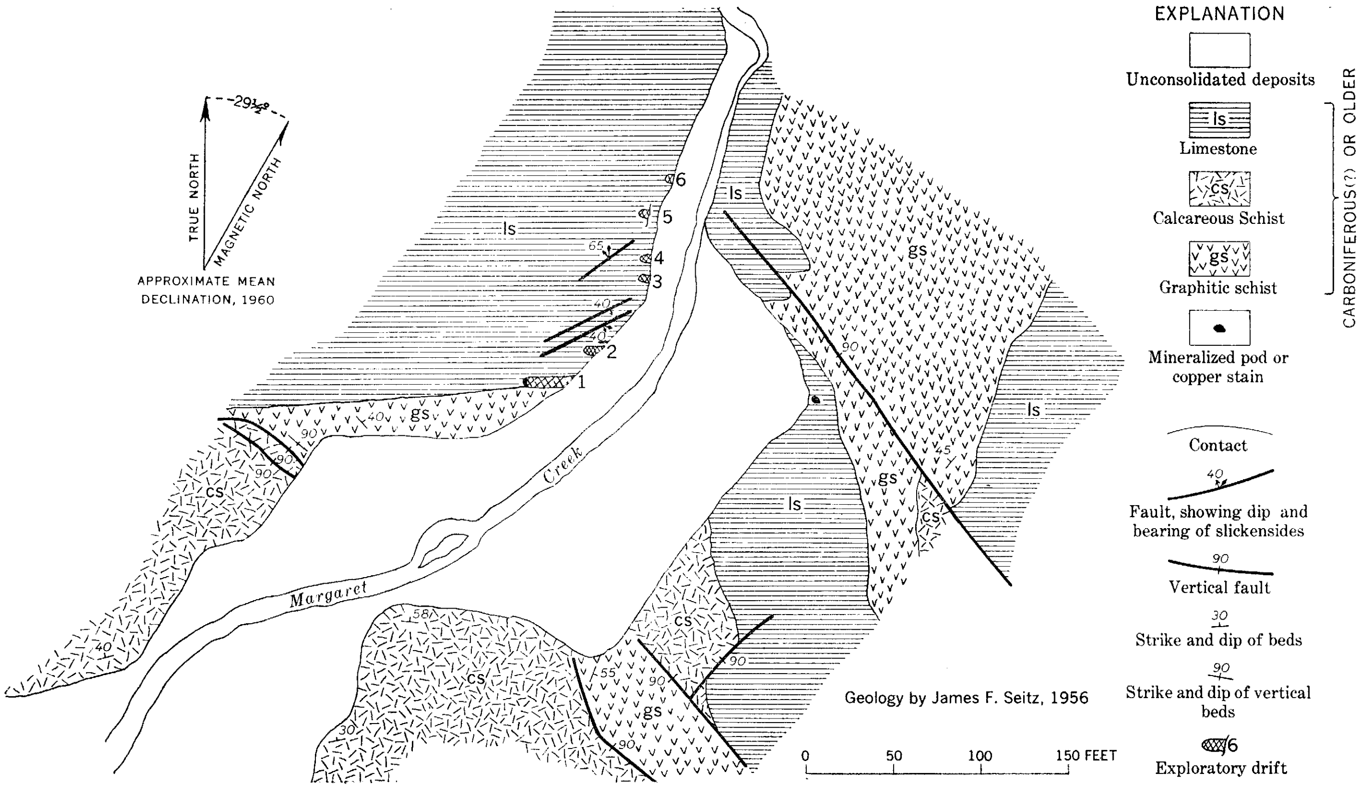

FIGURE 13.—Sketch map showing geology along Margaret Creek.

Drift No. 3 is on a zone of sheared, soft gouge adjacent to a zone of altered rock. The gouge is barren, but the altered rock contains a small amount of galena.

Between drifts No. 3 and No. 4 the rock shows no mineralization. Drift No. 4 contains a few scattered grains of sulfide minerals.

Drifts No. 5 and No. 6 contain neither sulfide nor copper carbonate minerals.

The zone of mineralization on the east side of Margaret Creek that has already been described and a stain of malachite on the schist on the west side of the entrance to Margaret Creek Canyon are the only other mineralized localities observed along Margaret Creek.

DRY GULCH

Dry Gulch is 1,200 feet west of Margaret Creek. Here, at an altitude of 2,200 feet, a small drift has been driven about 15 feet on a shear zone in black, graphitic limestone. The shear zone is 4 feet wide, and the rock in it is much iron stained. Malachite staining was found at one small place near the entrance to the drift, but none was seen in the drift; no sulfide minerals were found either in or around the drift. Development work apparently stopped here, as in the other drifts, when no more mineralized rock was found.

The other creeks covered by claims were studied, but no mineralization was found. East of Margaret Creek these creeks include Clear Creek, two unnamed creeks, and Fourth of July Creek; to the west, Douglas Creek. The same belt of schist and limestone, much faulted and sheared, is cut by the lower parts of all these creeks.

The above described localities include all the places where mineralization was found during four days of investigation in this area. The exposed mineralization is extremely meager at best and hardly seems to justify the development work expended on it. This, coupled with the fact that what little mineralization is present does not occur in any distinct vein, body, or form, renders unlikely the possible existence of a minable ore body in the area.

TUNGSTEN PROSPECT ON KODIAK ISLAND, ALASKA

By James F. Seitz

Recent discoveries of scheelite mineralization on Kodiak Island have stimulated interest in the potential mineral resources of the island and have led a group of men from Kodiak to organize and stake claims. To determine the mineral potential of the area, personnel of the U.S. Geological Survey investigated it briefly in the summer of 1956. The writer, assisted by Peter Stauffer, spent 7 days and 1 night mapping and studying the area; Robert Chapman, assisted by Fred Wyller, spent 2 days collecting soil samples for geochemical studies. The results of the investigation, described in detail below, indicate that exposures of tungsten-bearing rock are of insufficient grade and size to warrant further exploration or development at this time (1956).

The mineralized area investigated is about 10 miles west of the town of Kodiak (fig. 1, locality 11). It lies on the west ridge of a U-shaped mountain that rises to 1,952 feet above sea level about 4 miles south of the head of Anton Larsen Bay. This mountain has no name, but, for convenience in this report, it will be called Chalet Mountain, with reference to the ski chalet on its east ridge.

Vegetation in the area is luxuriant, and valleys and mountain slopes up to an altitude of about 1,500 feet are covered with high grass and dense brush, including alder, salmonberry, willow, wild rose, and devilsclub. Grass grows to exceptional height; by early August it is 6 feet tall, and by the end of the growing season it is reported to attain considerably greater heights. The combination of grass, brush, and steep slopes makes hiking difficult.

The Chalet Mountain area can be reached from Kodiak by a 10-mile drive over a partly paved and partly gravelled road and a 2-mile hike and 1,500-foot climb from the road up a good trail on the mountain.

GEOLOGY

Most of Kodiak Island, and Afognak Island as well, is underlain by a sequence of slate and graywacke that is thousands of feet thick (Capps, 1937). The section exposed in the areas studied is apparently typical of the whole unit, which consists of interbedded slate and graywacke. On the basis of lithology, the sequence is tentatively correlated with rocks on the Kenai Peninsula that were included in the Sunrise series of former usage and were considered to be Late Cretaceous in age.

The central part of Kodiak Island is made up of a mass of granitic rock that extends the length of the island and forms a belt 8 miles wide and 70 miles long (Capps 1937, p. 155). The rock is principally diorite but ranges in places to granodiorite and to granite. According to Capps (1937, p. 160), this granitic body was intruded at the close of the Mesozoic era, after deposition of the Upper Cretaceous sediments and before deposition of the Eocene(?) sediments.

The north end of the main granitic body lies about 12 miles due west of Chalet Mountain. Two other granitic bodies, both less than 2 miles long, lie 6 miles west and 6 miles north, respectively, of Chalet Mountain. Granitic dikes or other bodies were not observed in the areas investigated.

The bedrock in the area studied is made up of slate and graywacke in alternate layers ranging from a few inches to hundreds of feet in thickness. The graywacke is a massive granular rock with no cleavage and almost without visible bedding. The slate is very fine grained, has prominent bedding, and has an intensely developed cleavage that splits the rock into almost paper-thin sheets upon weathering.

In texture and physical characteristics the graywacke resembles a quartzite, but most of it contains enough dark mineral grains to color it a uniform dark gray. It is composed of clastic grains ranging from 0.1 to 0.5 mm in diameter and consisting largely of quartz, feldspar, biotite, and pyroxene, with some pyrite, arsenopyrite, and pyrrhotite. The rock grades to quartzite in scattered small patches where nearly pure quartz sand was deposited in pockets. The graywacke is a strong, tough rock and hard enough to ring when struck by a hammer.

The slate is exceedingly fine grained and highly fissile. It was derived from argillaceous material and displays well-delineated beds ranging from a small fraction of an inch to several inches in thickness. Throughout the area the strike and dip of the cleavage remain fairly constant, and in general the beds are parallel to the cleavage. Where the beds are folded, the axes of the folds remain parallel to the cleavage. Minerals making up the slate include chlorite, mica, quartz, feldspar, and graphite (as individual mineral grains are sub-microscopic in size, X-ray diffraction methods were employed for their identification). The mineral assemblage indicates that the rocks of the region were metamorphosed in the chlorite zone (epizone), and the fissility of the slate indicates that its metamorphism included intense stress.

In the Chalet Mountain area the bedrock is cut by many faults, most of which strike about due east and dip from 70° south to 90°. Horizontal movement has been eastward on the north sides of the faults, and displacements of 3 to 6 feet were observed. Quartz has been introduced along many of the faults so that tabular quartz veins in sheets ranging from paper-thin to 2 inches in thickness are numerous throughout the area.

MINERALIZATION

The scheelite on Chalet Mountain is found as thin coatings on quartz veins and fracture surfaces in a few places, and in others as disseminated grains scattered through quartzitic zones in the graywacke (fig. 14). A traverse made at night with ultraviolet lights revealed 16 places where some scheelite showed. Fifteen of these are roughly along the strike of the slate and graywacke beds in an area 300 feet wide by 1,600 feet long.

Where scheelite grains are disseminated through the graywacke, the graywacke itself is lighter colored and more quartzitic in composition. This is especially apparent where the scheelite is confined to an oblate pod less than 2 feet long. Five of the occurrences are of this type, with minute scheelite grains scattered uniformly but very

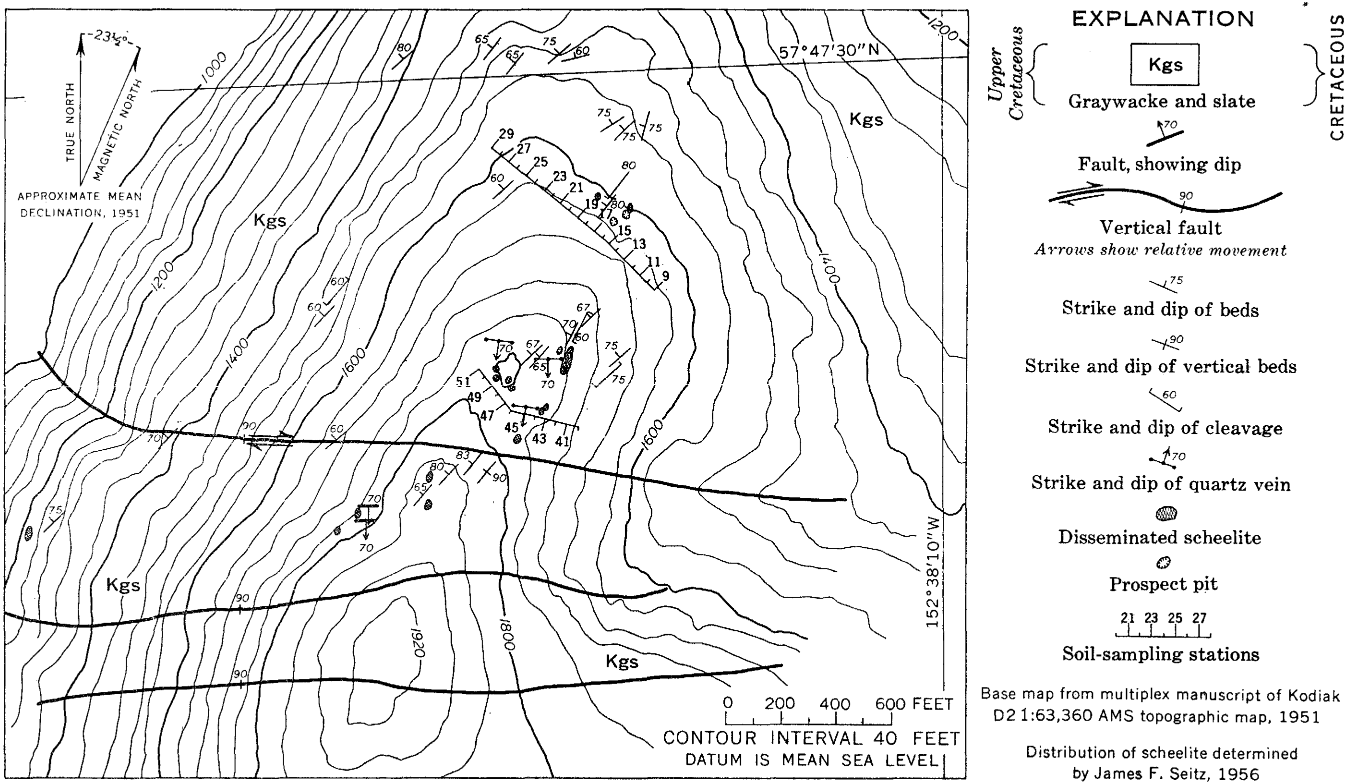

FIGURE 14.—Scheelite distribution on Chalet Mountain, Kodiak Island.

sparsely through the pod. Although pods of lighter rock are fairly common, those containing scheelite are rare. In places where scheelite is disseminated in graywacke, no well-defined pod is visible, but the scheelite is generally confined to thicknesses of 2 feet and areas not more than 6 feet across. These zones do not appear to be related to any fractures or structures in the bedrock, with the exception of one which is bounded by two parallel faults 3 feet apart. None of these zones shows any suggestion that it may be part of a larger continuous body, vein, or zone.

The source of the scheelite and the means of its introduction are not known at present, but the scheelite mineralization appears to be related to the quartz veins. This is indicated by the presence of thin coatings of scheelite on the surfaces of quartz veins and by the abundance of quartz veins in the vicinity of scheelite-bearing graywacke. The fact that the scheelite is found only on the surfaces of the veins and not within them indicates that it was introduced later than the quartz. If the scheelite and quartz were derived from a common source, such as the nearby diorite, the scheelite introduction may have been a continuation of the process that brought in the quartz. If the sources were unrelated, the two may have been introduced at widely separated times, and their juxtaposition may be due to their both following the same favorable channels. This latter possibility seems the more likely, as only an infinitesimal fraction of the quartz bears scheelite.

The means by which the scheelite migrated to pods and zones in the graywacke is not apparent, as each of these mineralized places lacks connection with any visible mineralized channel or seam.

Channel samples taken from two adjacent shallow exploratory pits contain percentages of tungsten oxide as given below. The mineralized zone in each pit is 2 feet wide, extends to a depth of about 2 feet, and is less than 8 feet long.

Locality	*Pit*	*Sample*	*Percentage of* WO_3
20	Lower	320A	0.56
20	Lower	320B	.16
20	Upper	320C	.05
20	Upper	320D	.06

GEOCHEMICAL SOIL SAMPLING

In the course of the investigation on Chalet Mountain, Robert Chapman of the U.S. Geological Survey collected a total of 33 soil samples along two separate traverses across the ridge, as shown on figure 14. These samples were analyzed for their tungsten content with the idea that any anomalously high percentages could then be checked as a possible indication of tungsten mineralization in the bedrock upslope from the sample site. All samples yielded less than

0.002 percent tungsten, with the exception of four which yielded 0.003, 0.003, 0.002, and 0.006 percent, respectively (table 4).

TABLE 4.—*Tungsten content of 33 soil samples collected by Robert M. Chapman on Chalet Mountain*

[The sample locations are shown on fig. 14]

Sample	Tungsten (percent)	Sample	Tungsten (percent)
09	0. 003	26	<0. 002
10	<. 002	27	<. 002
11	<. 002	28	<. 002
12	<. 002	29	<. 002
13	. 003	40	<. 002
14	<. 002	41	<. 002
15	<. 002	42	<. 002
16	<. 002	43	. 002
17	<. 002	44	<. 002
18	<. 002	45	. 006
19	<. 002	46	<. 002
20	<. 002	47	<. 002
21	<. 002	48	<. 002
22	<. 002	49	<. 002
23	<. 002	50	<. 002
24	<. 002	51	<. 002
25	<. 002		

RADIOMETRIC INVESTIGATIONS ALONG THE TAYLOR HIGHWAY AND PART OF THE TANANA RIVER, ALASKA

By MAX G. WHITE, ARTHUR E. NELSON, and JOHN J. MATZKO

In 1950, reconnaissance investigations were made along the Taylor Highway from its junction with the Alaska Highway to Chicken (fig. 15) and along the Tanana River from Tanacross to Little Gerstle River (fig. 16). These investigations were conducted by the U.S. Geological Survey on behalf of the Division of Raw Materials, U.S. Atomic Energy Commission; fieldwork was done by Max G. White and Arthur E. Nelson, geologists, and Fred Freitag and Egil Salveson, camphands. A 2- by 40-inch Geiger tube and portable Geiger counter were used. For the traverse along the highway the large tube was mounted in a jeep, and for the traverse along the river the large tube was set up in a boat. This report was prepared by John J. Matzko from the notes of the field geologists.

Igneous rocks exposed in the areas traversed are granite and quartz diorite of Mesozoic age, rhyolite and dacite of early Tertiary age, and basaltic dikes of Tertiary age. Other rock types exposed include schist and associated metaigneous rocks of Precambrian age and a small area of undifferentiated rocks (mainly limestone) of Devonian age (Mertie, 1937).

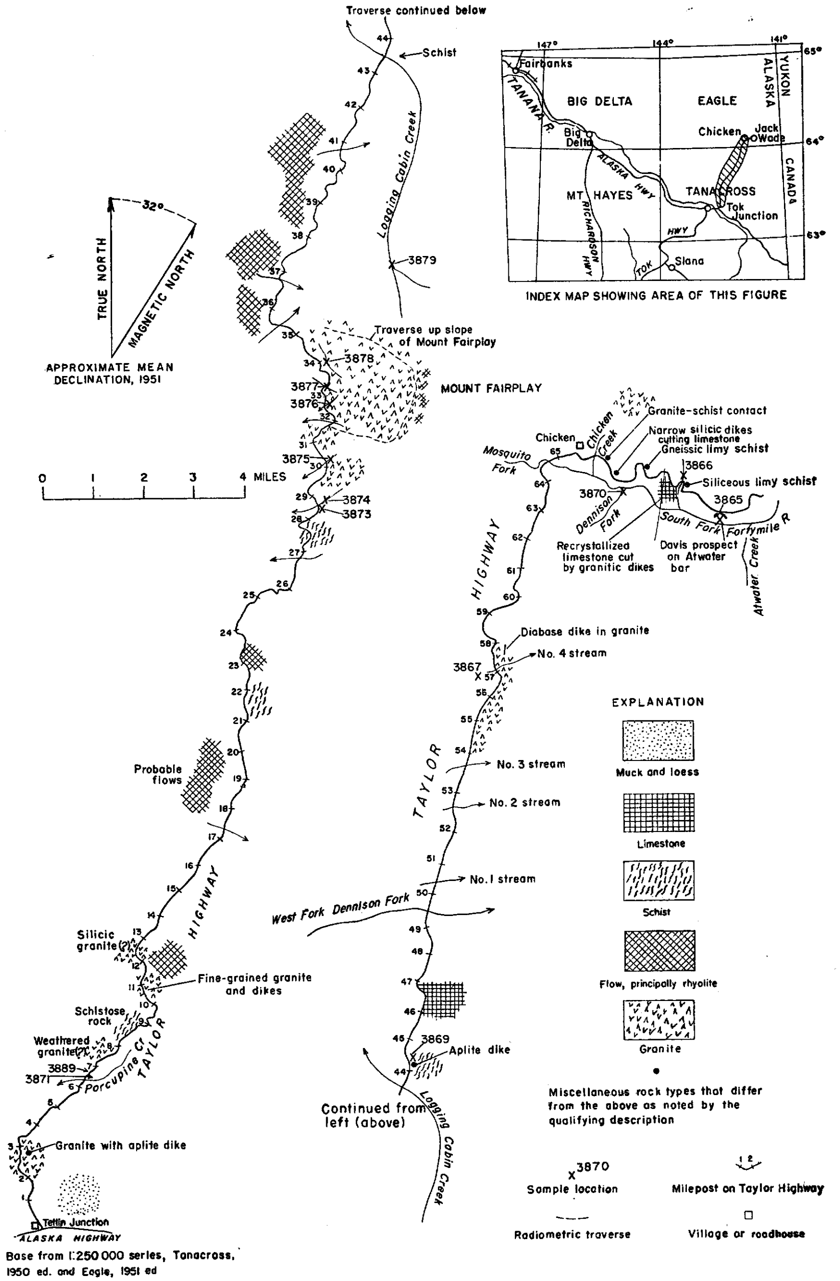

FIGURE 15.—Sketch map showing radiometric traverse of Taylor Highway from Tetlin Junction to Chicken.

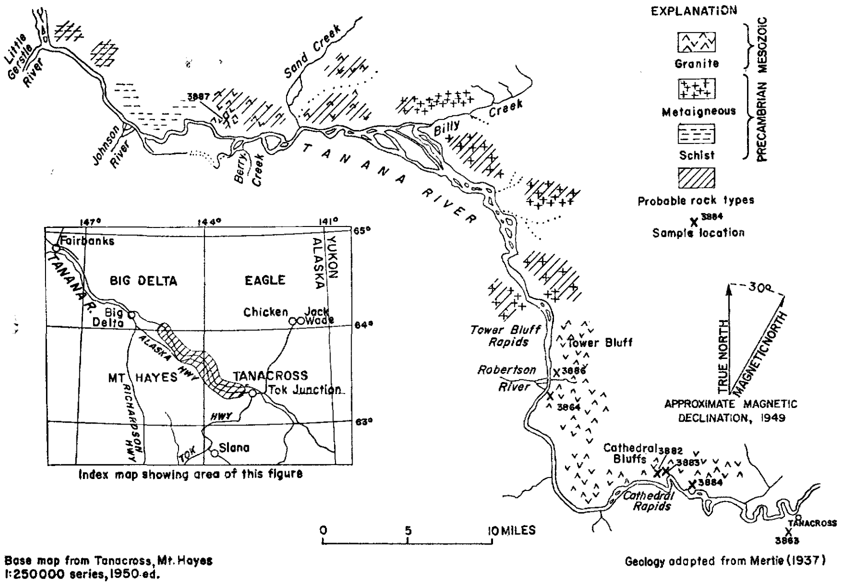

FIGURE 16.—Sketch map showing radiometric traverse of Tanana River from Tanacross to Little Gerstle River.

TAYLOR HIGHWAY TRAVERSE

Exposures of granitic rock of Mesozoic age, rhyolite and dacite flows of Tertiary age, limestone of Devonian age, and schistose rock of Precambrian age were tested along part of the Taylor Highway (fig. 15).

Radioactivity anomalies with a maximum of 0.015 percent equivalent uranium were noted in the area underlain by granitic rock just southwest of Mount Fairplay, between mileposts 28 and 29, and from a weathered aplite dike north of Logging Cabin Creek, between mileposts 44 and 45 (fig. 15). A radiometric traverse around the upper part of Mount Fairplay revealed no anomalies greater than these two. A fine-grained granitic rock on the low knob south of the main pinnacle of Mount Fairplay, however, gave twice the reading of the megascopically very dissimilar coarse-grained granitic rock at the road level. The top 75 feet of Mount Fairplay is composed of andesitic flows which contain about 0.001 percent equivalent uranium according to the field readings. The felsic flows extend from north of the north peak of Mount Fairplay to the vicinity of milepost 34 on the highway.

Results of equivalent-uranium analyses and mineralogic studies of selected samples from the Taylor Highway area are shown in tables 5 and 6, respectively. In addition to the minerals listed in table 6, Wedow and others (1954) reported thorianite and monazite from placers in the Fortymile area. A single age determination made on zircons concentrated from granite near Mount Fairplay indicates that the age of the granite is about 99 million years, which dates it as Cretaceous in age (H. W. Jaffe, personal communication).

TABLE 5.—*Equivalent-uranium content of selected samples from the Taylor Highway-Tanana River areas, Alaska*

Sample	Location	Equivalent uranium (percent)
	Eagle quadrangle	
3865	Atwater Bar, a 2-pan concentrate from Davis prospect, South Fork Fortymile River, east of Chicken near milepost 79 (fig. 15).	0.002
3866	3-pan stream concentrate from first stream above Atwater Bar near milepost 71 (fig. 15).	<.001
3867	Stream sample from the left fork headwaters of stream No. 4 near milepost 57 (fig. 15).	.002
	Tanacross quadrangle	
3863	First stream west of Tanacross junction (fig. 16)	0.002
3864	Stream sample from east of Robertson River, about half a mile from mouth and on east side of Tanana River (fig. 16).	.003
3869	Weathered aplite dike, about one-fourth of a mile north of milepost 44 (fig. 15).	.015
3871	2-pan stream concentrate from Porcupine Creek, about 100 ft from road near milepost 6 (fig. 15).	<.001
3873	Granite float, south of Mount Fairplay, on east side of highway north of milepost 28 (fig. 15). Data not available on unconcentrated sample. Iodide heavy concentrate contains 0.010 percent equivalent uranium (concentrated).	.010
3874	2-pan stream concentrate, about 3 miles southwest of Mount Fairplay and north of milepost 28 (fig. 15).	.012
3875	3-pan stream concentrate from second stream south of Mount Fairplay near milepost 30 (fig. 15).	.001
3876	2-pan stream concentrate, from unnamed stream draining south part of Mount Fairplay north of milepost 32 (fig. 15).	.006
3877	2½-pan stream concentrate, from unnamed stream draining the northwest part of Mount Fairplay near milepost 33 (fig. 15).	.002
3878	3-pan stream concentrate from stream near milepost 34 (fig. 15).	.003
3879	6-pan stream concentrate from headwaters of Logging Cabin Creek (fig. 15).	.001
3881	Granitic float south of Mount Fairplay and east of highway near milepost 29 (fig. 15). Equivalent uranium data not available on the unconcentrated sample; the iodide heavy fraction has 0.02 percent equivalent uranium (concentrated).	.02
3882	Coarse-grained granite from second bluff of Cathedral Bluffs (fig. 16).	.005
3883	Granite from bluff, 50 ft east of sample 3882 (fig. 16)	.006
3884	Quartz diorite, a few miles southeast of Cathedral Bluffs (fig. 16).	.005
3886	Aplite dike opposite the mouth of Robertson River (fig. 16).	.004
3889	Aplite dike, about one-fourth of a mile north of Porcupine Creek, north of milepost 6 (fig. 15).	.005

TABLE 5.—*Equivalent-uranium content of selected samples from the Taylor Highway-Tanana River areas, Alaska*—Continued

Sample	Location	Equivalent uranium (percent)
	Big Delta quadrangle	
3887	Vein-filled material in granite about 4 miles west of the mouth of Sand Creek (fig. 16).	0.002

TABLE 6.—*Mineralogic data, in estimated volume percent, of selected samples from the Taylor Highway area, Alaska*

[Samples are all bromoform heavy concentrates (sp. gr. >2.89). --, mineral not noted or detected; trace amount, less than 1 percent]

Mineral	Sample			
	3865 [1]	3869 [2]	3870 [3]	3873 [4]
Anatase	--	2	--	--
Apatite	2	--	2	5
Augite	20	4	10	20
Biotite	Trace	1	--	20
Brookite	--	2	--	--
Diopside	Trace	--	Trace	--
Epidote	5	3	10	3
Fluorite	--	--	--	Trace
Garnet	5	2	7	Trace
Hematite	Trace	--	--	Trace
Hypersthene	5	Trace	8	Trace
Hornblende	28	--	9	2
Ilmenite	10	Trace	30	--
Limonite	Trace	20	Trace	Trace
Magnetite	12	60	Trace	Trace
Malachite	Trace	Trace	Trace	Trace
Pyrite	Trace	1	Trace	3
Rutile	Trace	--	Trace	--
Scheelite	Trace	--	Trace	--
Sphene	10	3	10	Trace
Staurolite	--	--	--	1
Tremolite	Trace	Trace	Trace	Trace
Zircon	1	1	1	Trace

[1] 3865: Atwater Bar at Davis prospect, 2-pan concentrate.
[2] 3869: aplite dike near milepost 44, Taylor Higoway.
[3] 3870: natural concentrate from foot of bluff at junction of Dennison Fork and Mosquito Fork Rivers.
[4] 3873: granitic rock between mileposts 28-29, Taylor Highway.

TANANA RIVER TRAVERSE

In June 1950, 3 days were spent along the Tanana River in a reconnaissance investigation, principally of exposures of granitic rocks of Mesozoic age and the Birch Creek schist and metaigneous rocks of Precambrian age.

The traverse of the river was begun at Tanacross and completed at the mouth of the Little Grestle River (fig. 16). Most of the study had to be made on the east side of the river because of shallow water near the opposite bank. The maximum radioactivity noted in the traverse was from granite near Cathedral Bluffs that contained 0.006 percent equivalent uranium. Table 5 shows the equivalent-uranium content of some of the samples collected along the Tanana River.

RADIOMETRIC TRAVERSE ALONG THE YUKON RIVER FROM FORT YUKON TO RUBY, ALASKA, 1949

By Max G. White, John M. Stevens, and John J. Matzko

A large variety of material, including alluvial deposits, greenstone, and sedimentary, metamorphic, and granitic rocks, ranging in age from Devonian and pre-Devonian to Quaternary, are either exposed along the Yukon River or within easy access of it. An argentiferous galena prospect occurs on Quartz Creek, and gold-bearing placers occur in the Grant Creek and Morelock Creek areas.

For the investigation, a 35-foot poling boat with a 22-horsepower outboard motor was used. A 2- by 40-inch Geiger tube was mounted in the boat; detailed checking was done with portable Geiger counters. The party conducting the investigation along the Yukon River, from Fort Yukon to Ruby, Alaska, consisted of M. G. White and J. M. Stevens, geologists, and Egil Salveson and R. D. Olson, camphands. The work was done in June 1949 on behalf of the Division of Raw Materials, U.S. Atomic Energy Commission. This report was prepared by John J. Matzko.

AREAS INVESTIGATED

Areas contiguous to the Yukon River and to tributary streams navigable by the 35-foot poling boat were examined for radioactivity content. The investigation was begun at Fort Yukon and terminated near Ruby, Alaska (fig. 17).

Concentrates for heavy mineral study were obtained from selected areas by panning gravels in the field. Radiometric results from the study of these and other samples collected during the course of the investigation are tabulated in table 7.

FORT YUKON TO STEVENS VILLAGE

QUATERNARY DEPOSITS

Deposits of Quaternary age were traversed from Fort Yukon (not shown on fig. 17) to Stevens Village. No anomalous radioactivity was detected in any of these detrital deposits, which include silt, sand, and gravels, but consist principally of gravels (Mertie, 1937).

DEVONIAN OR CARBONIFEROUS DEPOSITS

Greenstone of Devonian or Carboniferous age is exposed near Fort Hamlin in the bend of the Yukon River. The greenstone on the north and west bank of the river was examined, but no anomalous radioactivity was noted.

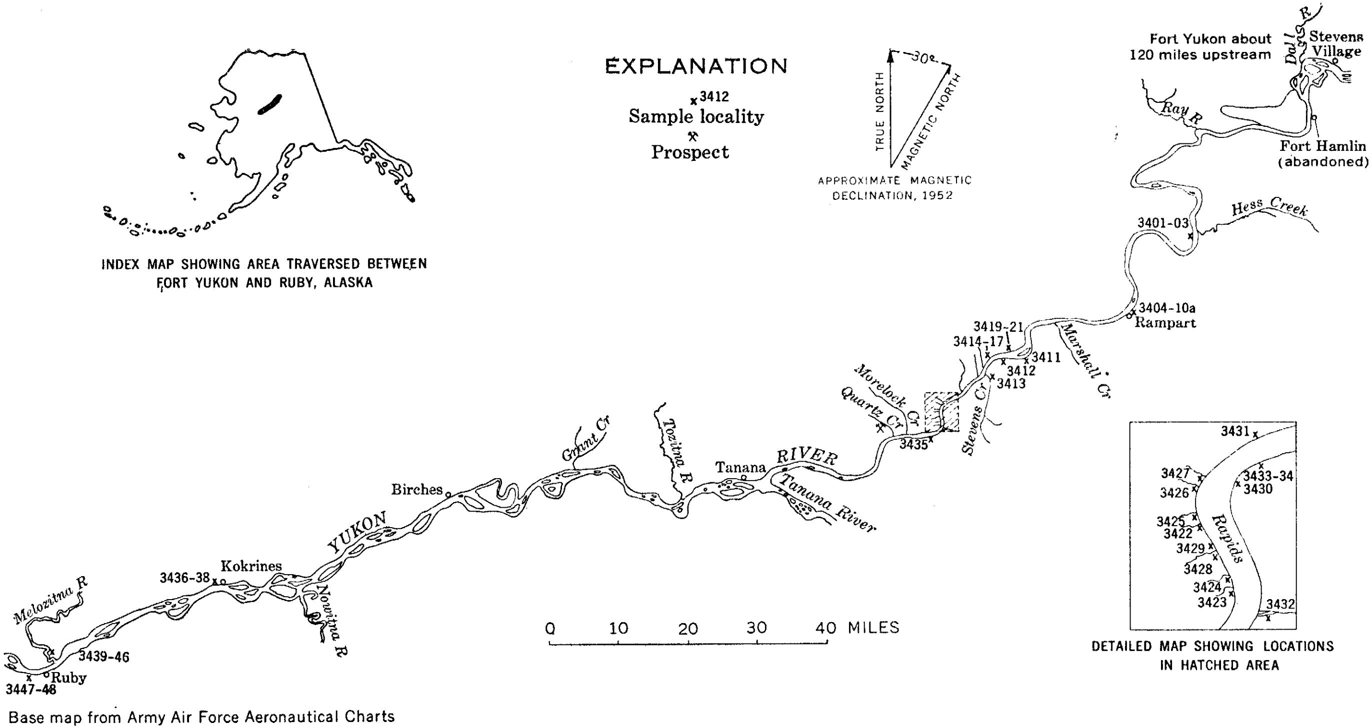

FIGURE 17.—Yukon River, showing sample localities between Stevens Village and Ruby.

TABLE 7.—*Radioactivity of samples collected during the traverse of the Yukon River from Fort Yukon to Ruby, Alaska*

File	Description	Equivalent uranium (percent)
	Quaternary deposits	
3413	Stevens Creek, about 1.5 miles from mouth	0.004
3422	From first creek upstream from camp in middle of Yukon River rapids, 2-pan concentrate.	.005
3424	From second creek downstream from camp, 1-pan concentrate.	.014
3425	From second creek upstream from camp, 3-pan concentrate.	.002
3426	From third creek upstream from camp, immediately above rapids, 3-pan concentrate.	.015
3427	From fourth creek upstream from camp, 2-pan concentrate.	.007
3428	First creek downstream from camp, 2-pan concentrate	.005
3429	Just below camp, north bank of Yukon River, a natural concentrate.	.004
3431	Dried creek bed downstream from camp, about 1-pan concentrate.	.007
3432	Southeast bank of Yukon River, a large creek coming in on bend below camp, about half a mile from mouth, 2-pan concentrate.	.015
3436	North bank of Yukon River, below Kokrines, and downstream from exposures of gneissic granite, 3-pan concentrate.	.010
3439	From Melozitna River canyon, 7-pan concentrate	.010
3447	Wash from granitic dikes below Ruby, on Yukon River, 2½-pan concentrate.	.015
	Cretaceous deposits	
3440	Grit, of Cretaceous age, from Melozitna River canyon.	0.017
3441	do	.002
3442	do	.003
3443	do	.002
3444	do	.001
3445	Shale with limestone, from Melozitna River canyon	.001
3446	Black carbonaceous material, from Melozitna River canyon.	.002
	Tertiary deposits	
3401	Conglomerate across from mouth of Hess Creek, on Yukon River.	0.001
3402	do	.001
3403	do	.001
3404	Conglomerate, south bank of Yukon River, upstream from Rampart.	.002
3405	do	.007
3406	do	.010
3407	do	.014
3408	do	.009
3409	do	.004
3410	do	.007
3410a	do	.005

TABLE 7.—*Radioactivity of samples collected during the traverse of the Yukon River from Fort Yukon to Ruby, Alaska*—Continued

File	Description	Equivalent uranium (percent)
	Devonian or Carboniferous deposits	
3411	About 20 miles below Rampart, mafic gneissic rock interbedded with schist and slates.	0. 002
3414	Monzonite, across from mouth of Stevens Creek on Yukon River.	. 006
3415	do	. 003
3416	do	. 003
3417	do	. 003
3419	do	. 008
3420	do	. 003
3421	do	. 003
3430	Monzonite in Yukon River rapids	. 003
3433	Dark coarse-grained monzonite, just above Rapids	. 002
3434	Finer grained dark monzonite, just above Rapids	. 005
3437	Granite from near Kokrines on northwest bank of Yukon River.	. 001
3438	do	. 001
3448	Granitic dike intruding schist, below Ruby	. 004
	Devonian and pre-Devonian deposits	
3412	About 20 miles below Rampart, phyllite or slate	0. 001
3435	Mineralized zone in black schist just below Rapids	. 001

STEVENS VILLAGE TO TANANA

QUATERNARY DEPOSITS

The large areas of alluvial gravels of Quaternary age that are exposed along the Yukon River were tested. No radioactivity was detected.

TERTIARY DEPOSITS

Three exposures of sedimentary rocks of Tertiary age were examined, and an exposure of quartz monzonite was tested. In the banks of the Yukon River opposite the mouth of Hess Creek, lignite is interbedded with thin-bedded shales and sandstone. The lignite has been mined locally and contains fossils determined to be of Eocene age (Eakin, 1916, p. 52). Conglomerate and grit tested in the area gave what were essentially background readings that indicated about 0.001 percent equivalent uranium or less; slightly higher readings were obtained from the lignite (table 7).

Another outcrop of rocks of Tertiary age occurs on the east bank of the Yukon River and above Rampart. These beds include conglomerates, friable sandstones, clays, and thin seams of lignite and dark shales. They contain fossils identified as Eocene in age (Eakin, 1916, p. 52). No appreciable radioactivity was detected.

The exposure of quartz monzonite examined near Stevens Creek is of middle Tertiary age, possibly Eocene (Mertie, 1937). Granite on the opposite side (northwest bank) of the Yukon River, however, was mapped by Eakin (1916, pl. 2) as Paleozoic, probably Devonian or Carboniferous. No appreciable radioactivity was detected in either body.

DEVONIAN OR CARBONIFEROUS DEPOSITS

A very large area of greenstone of Devonian or Carboniferous age that is composed largely of altered mafic flows and tuffs, diabase, and impure limestone, is exposed along the Yukon River from about Fort Hamlin to Rampart (Eakin, 1916, pl. 2). No abnormal amount of radioactivity was detected in the greenstone, and readings only slightly above background were noted in areas of movement where the rock is crushed and has a shaly appearance.

Granitic intrusive rocks of Devonian age(?) (Eakin, 1916) were examined in an area near the rapids about midway between Rampart and Tanana on the Yukon River (fig. 17). The radioactivity was about the same as for the monzonite that crops out along the Yukon River opposite Stevens Creek; higher readings were noted on the finer grained variety of monzonite.

DEVONIAN AND PRE-DEVONIAN DEPOSITS

Dark tough schistose metamorphic rocks of pre-Devonian age crop out in sections along the Yukon River upstream from Stevens Creek. Readings slightly above background were obtained on the metamorphic rocks examined in the field, but results obtained from laboratory analyses show no appreciable radioactivity.

PROSPECT

Also examined was the argentiferous galena prospect reported by Eakin (1916, p. 82) on Quartz Creek (fig. 17). He noted that most of the veins occur as small stringers cutting limestone. Radiometric tests were made around the adit, tailings, dumps at prospect pits, on ore in a box at the cabin, and on the nearby hills, but no anomalies were noted.

TANANA TO RUBY

QUATERNARY DEPOSITS

Alluvial deposits of Quaternary age constitute most of the exposures in the banks of the Yukon River between Tanana and Ruby. No appreciable radioactivity was detected.

CRETACEOUS DEPOSITS

Sedimentary rocks of Cretaceous age are exposed in the Melozitna River canyon (fig. 17). Radiometric tests on conglomerate, sandstone, quartzose grit, black shale, and limestone in this area indicated about 3 times the radioactivity of other rock types tested farther upstream on the Yukon River. The grit gave the maximum reading in the field, but tests made in the laboratory show a low radioactivity content (maximum of 0.017 percent eU) for all the various rock types examined (table 7).

DEVONIAN OR CARBONIFEROUS DEPOSITS

The gneissic intrusive rocks that crop out along the right bank of the Yukon River a few miles below Birches were examined (fig. 17). The gneiss is probably of Devonian age (Eakin, 1916, pl. 2) and can be divided into a light-colored coarse-grained rock and a dark-colored fine-grained somewhat schistose gneiss. The radioactivity of both type of rock was only slightly higher than that of the metamorphic complex tested in the immediate area (table 7). A gneissic tourmaline granite found as talus below Birches was not abnormally radioactive.

Downstream from Ruby for a distance of about 1½ miles, the schist and metamorphic rocks are intruded by granitic dikes. The age of the dikes is not known and is listed here tentatively as Devonian or Carboniferous. None of the dikes is more than 10 feet thick. The radioactivity of the dikes is slightly above the background, about 0.004 percent eU.

DEVONIAN AND PRE-DEVONIAN DEPOSITS

The schist and metamorphic complex of Devonian and pre-Devonian age that occurs near Ruby and Kokrines (fig. 17) was examined, but no anomalies were detected. Crystalline limestone in the bluff at Ruby also was not appreciably radioactive.

The metamorphic rocks in the Grant Creek area were examined in 1946 by Killeen and White (Wedow, Killeen, and others, 1954). No radioactive material was found.

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