GEOLOGICAL SURVEY CIRCULAR 316

RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN THE EAGLE-NATION AREA EAST-CENTRAL ALASKA, 1948

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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By Helmuth Wedow, Jr.

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ABSTRACT

Reconnaissance of radioactive deposits in sedimentary rocks of Proterozoic and Paleozoic age, and granite of Mesozoic(?) age together with its Tertiary sedimentary derivatives, was conducted in the Eagle-Nation area, east-central Alaska, in 1948. None of the rocks examined contains more than 0.003 percent equivalent uranium except for black shale beds in the upper Mississippian Calico Bluff formation and in granite of Mesozoic(?) age and its sedimentary derivatives. The more radioactive black shale beds in the Calico Bluff formation range in thickness from $\frac{1}{2}$ to 7 feet. Two units near the base of the formation appear to be persistent in the area: Radioactive unit A, with an average thickness of 6.6 feet, contains an average of 0.007 percent equivalent uranium and 0.004 percent uranium; radioactive unit B, with an average thickness of 5.2 feet, contains an average of 0.006 percent equivalent uranium and 0.003 percent uranium. Phosphatic pellets from unit B at one locality contain 0.022 percent equivalent uranium, 0.019 percent uranium, and 15 percent P_2O_5. Samples of the granite of Mesozoic(?) age and its Tertiary sedimentary derivatives average 0.005 and 0.004 percent equivalent uranium, respectively. Biotite is the chief radioactive mineral in the granite and its radioactivity is ascribed to the presence of uranium and thorium, which occur either as impurities or in minute inclusions of other, as yet unidentified, minerals. Traces of uranium and thorium in zircon, sphene, and monazite also contribute to the total radioactivity of the granite. Zircon and monazite are the major uranium- and

thorium-bearing minerals of the Tertiary sedimentary rocks derived from the granite.

INTRODUCTION

The purpose of this report is to record and discuss the results of a reconnaissance conducted in 1948 for uranium deposits in the Eagle-Nation area, east-central Alaska (pl. 1). The major objective was to search for anomalous radiation in a thick section of pre-Cambrian rocks and sedimentary rocks, and igneous rocks of Paleozoic age, with particular emphasis on formations containing beds of black shale. However, some granitic rocks of Mesozoic(?) age and their Tertiary sedimentary derivatives were also studied.

The Eagle-Nation area extends along the Yukon River from the international boundary on the southeast to the mouth of the Nation River on the northwest. It lies in the northeastern part of the Eagle quadrangle and the southeastern part of the Charley River quadrangle (Alaska reconnaissance topographic series, scale 1:250,000). The town of Eagle is the major settlement in the area and in 1948 had a permanent population of about 25 inhabitants. The town is located on the south bank of the Yukon River about 5 miles below the international boundary and is accessible by scheduled aircraft from Fairbanks. The completion of the Taylor Highway, probably in 1953, will link Eagle to the Alaska Highway near Tok Junction.

The Geological Survey party conducting this reconnaissance consisted of Helmuth Wedow, Jr., geologist; John M. Stevens, geologic field assistant; George F. Bearer, camp assistant; and Charlie R. Biederman, boatman. The party was in the field from mid-June through mid-September 1948. It assembled in Fairbanks, traveled by air to Eagle, and operated by boat along the Yukon River, using Eagle as a supply base.

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

GEOLOGY AND RADIOACTIVITY INVESTIGATIONS

The geologic setting of the Eagle-Nation area has been described primarily by Prindle (1909, 1913) and Mertie (1930, 1933, 1937, and 1942). Many of the formations are well exposed in the high bluffs along the Yukon River. Away from the river, weathering has developed a prominent residual mantle which is usually covered with thick vegetation typical of subarctic regions.

Radiation measurements in the Eagle-Nation area were made with two types of portable survey meters: a standard commercial model and a modified model developed by the Geological Survey. The latter instrument was adapted to use a probe consisting of four 1- by 18-inch brass-walled gamma tubes connected in parallel. This probe had an average background of about 1,000 counts per minute. Most rocks showing anomalous radiation in the field were analyzed for equivalent uranium in Washington by the Trace Elements laboratory of the Geological Survey. Chemical analyses of selected samples were also made in the same laboratory. Determinations of the heavy minerals in the granitic rocks of Mesozoic(?) age and the Tertiary clastic sedimentary rocks were made by B. W. Wilson of the Alaskan Geology Branch of the Geological Survey.

Pre-Cambrian rocks

The pre-Cambrian rocks of the Eagle-Nation area are strata of the Tindir group (Mertie, 1933, p. 369-392). They are exposed along the Tatonduk River and along the southwest bank of the Yukon River below Nation (pl. 1). Mertie divides the group into seven units, of which only three were accessible enough to be investigated during this reconnaissance. These three units, from youngest to oldest, are as follows (Mertie, 1933, p. 370):

> "Unit A. Principally thin-bedded limestone.
>
> Unit B. Principally siliceous dolomite and shale, with beds of dolomitic conglomerate near base.
>
> Unit C. Upper red beds, consisting of hematitic dolomite, shale, flint, tuff, and lava, with a red basal conglomerate."

The three units have an aggregate stratigraphic thickness of about 6,500 feet.

The red beds of Unit C were of particular interest in this reconnaissance in that they are similar, both lithologically and in age, to sedimentary rocks of Proterozoic age in the vicinity of Great Slave Lake, Northwest Territories, Canada (Stockwell, 1936), from which samples of reddish carbonate rocks containing 0.17 percent thorium oxide and 0.006 percent uranium had been obtained by the Geological Survey.[1] According to Lang (1952, p. 63, 65), ferruginous dolomite around McLean Bay on Stark Lake, near Great Slave Lake, contains monazite and pitchblende or uraninite as original constituents of the rock. Radioactivity traverses of the pre-Cambrian strata in the Eagle-Nation area in 1948, both on the Tatonduk River and along the Yukon River below Nation (pl. 1), revealed no radioactive material that contains more than 0.001 percent equivalent uranium.

Undifferentiated rocks of Paleozoic age

Rocks of indeterminate age, but believed to be Paleozoic (Mertie, 1930, p. 29-62), crop out along the Yukon River from the international boundary to about a mile upstream from Eagle (pl. 1). These rocks are predominantly noncalcareous, although massive beds of detrital limestone occur along the east bank of the Yukon River just south of Eagle Creek.

Traverses over these rocks revealed little or no radioactivity; the maximum found was at the locality of sample S-238 (pl. 1) in a greenish argillite. The equivalent uranium content of this sample was only 0.003 percent.

[1] Rabbitt, J. C., 1947, Interim report on thorium-bearing limestone from Great Slave Lake, Canada: U. S. Geol. Survey Trace Elements Memo. Rept. 50. [Unpubliahed.]

Cambrian system

Middle and Upper Cambrian rocks, consisting of about 2,000 feet of limestone with beds of shale and quartzitic sandstone, were traversed for radioactivity along the north bank of the Yukon River below Calico Bluff and along the Tatonduk River (pl. 1). The limestone is nonradioactive (less than 0.001 percent equivalent uranium). Samples (nos. S-64 through S-72, and S-255, pl. 1) from the shale beds are principally dark colored and carbonaceous and contain an average of 0.003 percent equivalent uranium.

Ordovician(?) system

The only Ordovician(?) rocks tested were quartzitic sandstones and black shales along the Tatonduk River (pl. 1). Although these rocks were mapped by Mertie as undifferentiated noncalcareous rocks of Paleozoic age (Mertie, 1933, pl. 7), several types of Ordovician(?) graptolites were found in these strata by the authors.

A traverse across the outcrops of the Ordovician(?) strata showed little or no radioactivity. The highest readings were obtained over the black, graptolitic shale beds. Each of three samples (nos. S-73 through S-75, pl. 1) of these black shales contain 0.003 percent equivalent uranium or less.

Silurian system

The only known Silurian rocks in the Eagle-Nation area are white- to cream-colored massive silicified limestone on the Tatonduk River near the international boundary. Although no Silurian limestone outcrops were traversed for radioactivity, readings on numerous boulders in the gravels of the Tatonduk River showed that this rock type probably contains less than 0.001 percent equivalent uranium.

Devonian system

Sedimentary rocks

Sedimentary rocks representing three different Middle Devonian horizons have been recognized along the international boundary north of the Yukon River. Only those on Eagle Creek (pl. 1) were sufficiently accessible to be investigated during this reconnaissance. The strata on Eagle Creek consist of a variety of shales including black shale with numerous concretions, nodular sandy shale, and blue-gray argillite. Some limestone, siliceous slate, and chert are also present.

Slightly anomalous radiation was detected over beds of Devonian black shale by the traverse up Eagle Creek, but a sample (no. S-76, pl. 1) from the bed showing the greatest radioactivity contains only 0.003 percent equivalent uranium.

Igneous rocks

Devonian(?) igneous rocks are exposed in Eagle Bluff, north of Mission Creek, a short distance downstream from Eagle (pl. 1). According to Mertie (1933, p. 442, 443) these rocks are essentially basaltic greenstone with interbedded flow breccia and tuff, also altered to greenstone, and some intercalated sedimentary beds. They supposedly lie along a fault zone trending westward up Mission Creek.

Several samples of sulfide ore encrusted with cobalt bloom, purportedly collected from a gold- and nickel-bearing vein on Eagle Bluff by a prospector in 1948, showed no radioactivity when scanned with a portable survey meter. A traverse along the face of the bluff (pl. 1) also revealed no radioactivity. The equivalent uranium content of several samples (nos. S-239 through S-243, pl. 1) of highly altered, black shaly rock from the south side of Eagle Bluff is only 0.002 percent or less.

Carboniferous systems

Carboniferous rocks along the Yukon River in the Eagle-Nation area include a chert unit of lower(?) Mississippian age, the Calico Bluff formation of upper Mississippian age, an intermediate (Mississippian or Pennsylvanian) shale and chert unit, and the Pennsylvanian(?) Nation River formation.

Chert unit of early(?) Mississippian age

The lower(?) Mississippian chert formation of Mertie (1930, p. 88-95; 1933, p. 416-420) consists of about 2,000 feet of thin-bedded black chert and siliceous argillite with partings of black shale. The unit was tested for radioactivity on traverses along the Yukon River in the vicinity of Calico Bluff, on the right bank of the Yukon between Sulphur Bend and the Seventymile River, and on the Tatonduk River (pl. 1). Estimates from field readings indicate that nowhere in the Eagle-Nation area do beds of the lower(?) Mississippian chert unit contain more than about 0.002 percent equivalent uranium, except for small, spherical, phosphatic(?) concretions which contain 0.003 percent equivalent uranium. These concretions are found mostly in outcrops on the right bank of the Yukon upstream from Calico Bluff (sample no. S-244, pl. 1).

Calico Bluff formation

The upper Mississippian Calico Bluff formation (Mertie, 1930, p. 95-109) crops out at Calico Bluff, along the Yukon River between Sulphur Bend and the Seventymile River, along the Yukon opposite the mouth of the Tatonduk River, and along the lower course of the Tatonduk River (pl. 1). It consists of about 1,500 feet of alternating beds of shale and limestone. Fossils are abundant in many beds. Much of the shale, particularly in the lower half of the formation, is black and carbonaceous. Near the base of the formation several black shale units contain small phosphatic nodules, lentils, and pellets. The base of the formation is designated arbitrarily as the bottom of the lowest yellow-weathering massive limestone (Mertie, 1930, p. 89).

The Calico Bluff formation was tested for radioactivity at all of its outcrops along the Yukon River from Calico Bluff downstream to the Tatonduk River (pl. 1). It was found that almost all the black shale

beds are more radioactive than the interbedded limestone layers. However, field testing and sampling (samples S-77 through S-234, pl. 1) showed that, except for a few beds, the equivalent uranium content of most of the black shale does not exceed 0.004 percent. Most of the selected samples of the Calico Bluff formation listed in table 1 contain 0.005 percent or more equivalent uranium.

The Calico Bluff formation appears to contain two main units which are more radioactive than other parts of the formation of comparable thickness. The lower unit, about 125 feet above the base of the formation, is designated radioactive unit A in this report; the upper unit, about 150 feet above the base of the formation, is designated radioactive unit B. (See tables 1 and 2.) The average equivalent uranium and uranium contents and thicknesses of the two units are compared in table 2.

Table 1.--Data on selected samples of the Calico Bluff formation, Eagle-Nation area, east-central Alaska, most of which contain 0.005 percent or more equivalent uranium

[Analyses by members of the Geological Survey Trace Elements laboratory, Washington.]

Sample no.	Thickness of bed	Stratigraphic interval above base of formation	eU (percent)	U (percent)	Description
		Section at Calico Bluff			
S-137	3.0	355.3-358.3	0.006	0.001	Black shale with thin beds of limestone.
S-122	.6	312.1-312.7	.005	.002	Black shale.
S-121	.7	311.4-312.1	.007	.004	Fetid argillaceous limestone.
S-115	.5	305.5-306.0	.005	.003	Black calcareous argillite.
S-110	2.0	259.6-261.6	.007	.005	Black shale with thin beds of limestone.
S-107	2.0	252.6-254.6	.007	.004	Do.
S-104	1.0	159.0-160.0	.008	.006	Black shale; top bed of radioactive unit B.
S-103	1.0	158.0-159.0	.008	.004	Black shale.
S-102	1.0	157.0-158.0	.007	.004	Do.
S-101	1.5	155.5-157.0	.006	.004	Do.
S-100	.4	155.1-155.5	.002	.001	Do.
S-99	1.0	154.1-155.1	.005	.003	Black fissile shale.
S-98	1.0	153.1-154.1	.005	.003	Black fissile shale; bottom bed of radioactive unit B.
S-89	3.5	129.6-133.1	.006	.004	Black shale; top bed of radioactive unit A.
S-88	1.2	128.4-129.6	.004	.002	Dark gray calcareous shale.
S-87	1.7	126.7-128.4	.008	.006	Black argillite; bottom bed of radioactive unit A.
		Section between Sulphur Bend and Seventymile River[1]			
S-234	2.5	129.5-132.0	0.009	0.004	Black shale.
S-233	.5	129.0-129.5	.006	.003	Gray siliceous shale.
S-232	4.0	[2]125.0-129.0	.008	.004	Black shale.
S-231	([3])	([4])	.008	.009	Fossiliferous gray-black calcareous shale showing bluish phosphate bloom (may be same bed as sample S-232).
		Section opposite mouth of Tatonduk River			
S-229	0.5	[5]104.4-104.9	0.005	0.003	Black fissile shale.
S-223	1.3	95.8- 97.1	.005	.002	Gray argillaceous limestone.
S-220[6]	1.6	65.2- 66.8	.005	.002	Dark gray calcareous shale with thin lentils and nodules of phosphatic material.
S-219	2.0	63.2- 65.2	.005	.002	Do.
S-218	---	63.2- 66.8	.022	.019	Selected phosphatic material from beds of samples S-219 and S-220.
S-217[7]	2.0	33.0- 35.0	.004	.006	Black fissile shale.
S-216	4.5	28.5- 33.0	.008	.003	Calcareous shale with thin beds of limestone.

[1] Beds sampled are probably the equivalent of beds of radioactive unit A at Calico Bluff.
[2] Bottom of bed about 125 feet above base of formation and about 50 feet above base of exposed section.
[3] Grab.
[4] Near base of exposed section about 300 feet downstream from S-232; about 125 feet above base of formation.
[5] Intervals measured from base of exposed section which is approximately 125 feet above base of formation.
[6] Beds of samples S-218, S-219, and S-220 probably equivalent to beds of radioactive unit B at Calico Bluff.
[7] Beds of samples S-216 and S-217 probably equivalent to beds of radioactive unit A at Calico Bluff.

Both radioactive units contain a small amount of phosphorus and vanadium. Analyses for these two elements, as well as for equivalent uranium and uranium for comparison, in two selected samples (S-218 and S-231) are tabulated below; the locations and descriptions of these samples are given in table 1.

	S-218	S-231
P_2O_5	[1]15.1	[1]1.9
V_2O_5	.46	.68
eU	.022	.008
U	.019	.009

[1] Percent.

As can be seen in tables 1 and 2, both radioactive units found in the type section of the Calico Bluff formation are also present northwestward on the left bank of the Yukon River opposite the mouth of the Tatonduk River, an airline distance of about 8 miles. Another radioactive unit, tentatively correlated with radioactive unit A, was found in outcrops of the Calico Bluff formation on the north bank of the Yukon River upstream from the mouth of the Seventymile River (samples S-231 through S-234, pl. 1). In addition to these localities, it is likely that the two main radioactive units are present in the Calico Bluff formation on the north bank of the Yukon River below Sulphur Bend and on the Tatonduk River. At these two latter localities anomalous radioactivity was noted, which, though mostly concealed, appeared to lie in the lowermost part of the formation. The locality of the Calico Bluff formation on the Seventymile River, near its junction with the Yukon River, was not completely traversed. However, it is likely that the two main radioactive units occur there also, as the area lies between the two geographic extremes of the Calico Bluff formation on the Yukon River.

In summary, it appears that the main uraniferous black shale beds near the base of the Calico Bluff formation are persistent throughout the known distribution of the formation in the Eagle-Nation area. Rocks similar in age to the Calico Bluff formation occur at two localities just east of the international boundary. These areas, one approximately 13 miles northeast of the mouth of the Tatonduk River and the other approximately 35 miles northeast of the mouth of the Nation River (Mertie, 1933, p. 423), were too inaccessible at the time of the 1948 reconnaissance to warrant investigation.

Intermediate unit

According to Mertie (1930, p. 109-113; 1933, p. 423, 424) an intermediate or transitional formation of sedimentary rocks lies between the Mississippian Calico Bluff and Pennsylvanian(?) Nation River formations. The rocks of this unit are sandy shale, argillite, slate, and some chert. Mertie (1933, pl. 7) mapped this unit along the Yukon River on the north side of Eagle Bluff (pl. 1), on the north and south sides of the Seventymile River southwest of Calico Bluff, and in the hills north of Nation. The rocks of the unit were traversed for radioactivity only at the Eagle Bluff locality (pl. 1). No samples were taken for equivalent uranium analyses because the field readings indicated that the equivalent uranium content of the material tested would not exceed 0.002 percent.

The thin-bedded black carbonaceous shale in the intermediate unit described by Mertie (1930, p. 109) on the south side of the Seventymile River was not examined. The inconclusive data on the precise stratigraphic position of the intermediate unit and the general field relationships of the associated formations suggest the possibility to the writer that some of the beds now mapped as the intermediate unit could well be pre-Calico Bluff or early Calico Bluff in age. If this is so, the possibility then exists that the black shale on the Seventymile River may contain the stratigraphic equivalent of either of the radioactive units that occur in the lower part of the Calico Bluff formation on the Yukon River.

Nation River formation

The Pennsylvanian(?) Nation River formation is well exposed along the Yukon River a few miles below Eagle and from Montauk Bluff to below the mouth of the Nation River (pl. 1). It consists of conglomerate, sandstone, and gray clay shale, and has an aggregate thickness of between 5,000 and 6,000 feet (Mertie, 1930, p. 119).

The Nation River formation was examined for radioactivity at both localities mentioned above. It is essentially nonradioactive throughout. Three samples (nos. S-235 through S-237, pl. 1) of dark-gray to black shale from beds 1 to 2 feet thick from

Table 2.—Average equivalent uranium and uranium contents and thicknesses of radioactive units A and B of the Calico Bluff formation

Locality	Unit A			Unit B		
	Thickness (feet)	eU (percent)	U (percent)	Thickness (feet)	eU (percent)	U (percent)
Section at Calico Bluff	6.4	0.006	0.004	6.9	0.006	0.004
Section between Sulphur Bend and Seventymile River	7.0	.008	.004	---	---	---
Section opposite mouth of Tatonduk River	6.5	.007	.004	3.6	.005	.002
Average	6.6	.007	.004	5.2	.006	.003

the west side of the Yukon River a few miles below Eagle contain 0.002 to 0.003 percent equivalent uranium, the maximum radioactivity noted anywhere in the Nation River formation in the Eagle-Nation area.

Permian system

Tahkandit limestone

In the Eagle-Nation area the Tahkandit limestone (Mertie, 1930, p. 121-130) of Permian age was traversed for radioactivity at its type locality along the west bank of the Yukon River just above the mouth of the Nation River (pl. 1). At this locality the formation, which has a total thickness of about 500 feet, consists chiefly of cream-colored to white massive limestone, although some conglomerate, sandstone, and shale occur in the lower part. Field tests on the Tahkandit limestone indicate that its radioactivity probably does not exceed 0.001 percent equivalent uranium.

Triassic system

A belt of Upper Triassic rocks that consists principally of fossiliferous black shale interbedded with thin layers of gray to black limestone lies adjacent to the Tahkandit limestone on the northwest in the vicinity of Nation (pl. 1). Mertie (1930, p. 131) states that much of the black shale at this locality is oil-bearing. Many of the numerous fossils seen in these rocks are Pseudomonotis subcircularis and Halobia sp., both typical of Upper Triassic rocks in Alaska. The equivalent uranium content of the Upper Triassic rocks in the Eagle-Nation area, by field test, is less than 0.001 percent.

Granite of Mesozoic(?) age

Granitic rocks of Mesozoic(?) age are widespread in the Yukon-Tanana region (Mertie, 1937, pl. 1). Within the Eagle-Nation area, as delineated in this report, granitic rocks are known at only two localities: a small area mapped by Mertie (1930, pl. 12) at the head of Cuban Gulch (pl. 1) near the international boundary, and the area on the north side of Excelsior Creek just above the junction with Mission Creek (fig. 1). This latter locality is within an area of rocks mapped as pre-Cambrian by Mertie (1930, pl. 12; 1933, fig. 7). However, the complete lack of foliation in the granite wherever observed by the writer and the general similarity of this rock to other Mesozoic(?) granitic rocks of the eastern Yukon-Tanana region suggest that the granitic rock on Excelsior Creek may also by Mesozoic(?) in age.

The granite on Excelsior Creek is for the most part highly disintegrated and covered with varying thicknesses of fine silt, which may be of aeolian origin, and moss. It appears to be lapped on all sides by Tertiary conglomerates which are also highly disintegrated locally. On the north side of the granite area the conglomerates dip a few degrees to the north; on the south side, along the north bank of Excelsior Creek, the conglomerate dips steeply to the south.

Because the granitic rocks are generally concealed, most of the field tests for radioactivity were made in holes 2 to 5 feet deep dug with a clam-type post-hole digger through the overburden into the disintegrated rock below. Gamma counts were made in each hole and samples of the disintegrated rock at the bottom of selected holes were taken for radioactivity analysis and mineralogic studies. A total of 115 test holes were dug in the Excelsior Creek area and 38 samples were collected (nos. 3137-3174, fig. 1). The gamma counts in the test holes ranged from a low of 50 per minute to a high of 175 per minute against a background of about 25 per minute. In general, the minimum gamma count for test holes in the disintegrated granite was about 75 per minute, although the average range was between 100 and 125 per minute. All holes in the overlapping disintegrated Tertiary rocks gave gamma counts of less than 75 per minute, mostly between 50 and 60 per minute. It was demonstrated by deeper digging that, where gamma counts in Tertiary holes approached the 75 count per minute maximum for these holes, the bottom of the original hole was close to the contact with the granite. In the few holes where this could not be demonstrated in the field it was concluded that some detritus from the disintegrated radioactive granite had become intermixed with the Tertiary gravel when it was deposited.

The equivalent uranium content of the 38 samples taken in the Excelsior Creek area ranges from 0.001 to 0.007 percent. The samples of the Tertiary gravels contain from 0.001 to 0.002 percent equivalent uranium; those of the disintegrated granite contain from 0.003 to 0.007 percent and average 0.005 percent equivalent uranium. The analyses, thus, are directly proportional to the gamma counts obtained in the test holes.

In order to isolate and identify the radioactive mineral or minerals in the granitic rocks of the Excelsior Creek area, selected samples of this rock having a relatively high equivalent uranium content were crushed to minus 20-mesh and separated into three gravity fractions with bromoform (sp gr 2.89) and methylene iodide (sp gr 3.3). Radioactivity analysis of the several fractions indicated that the radioactive elements occur chiefly in the so-called "iodide-light" fraction (between 2.89 and 3.3 sp gr). The equivalent uranium content of the several iodide-light fractions analyzed is in the 0.0X percent range. As this mineral fraction consists of over 99 percent biotite, the radioactivity is ascribed to the occurrence of uranium and thorium either as impurities in the biotite or in minute grains of unidentified minerals which occur as inclusions in the biotite. The "iodide-heavy" fraction (greater than 3.3 sp gr) is also radioactive but to a lesser degree than the iodide-light fraction. The radioactivity of this fraction is attributed to the presence of minor amounts of radioactive elements that probably occur as impurities in zircon and traces of sphene. A trace of monazite was found in only one sample.

Other minerals in the heavy-mineral fractions of the granitic rocks of the Excelsior Creek area are ilmenite and magnetite, minor amounts of brookite, garnet, apatite, and anatase, and traces of rutile, hypersthene, and hornblende.

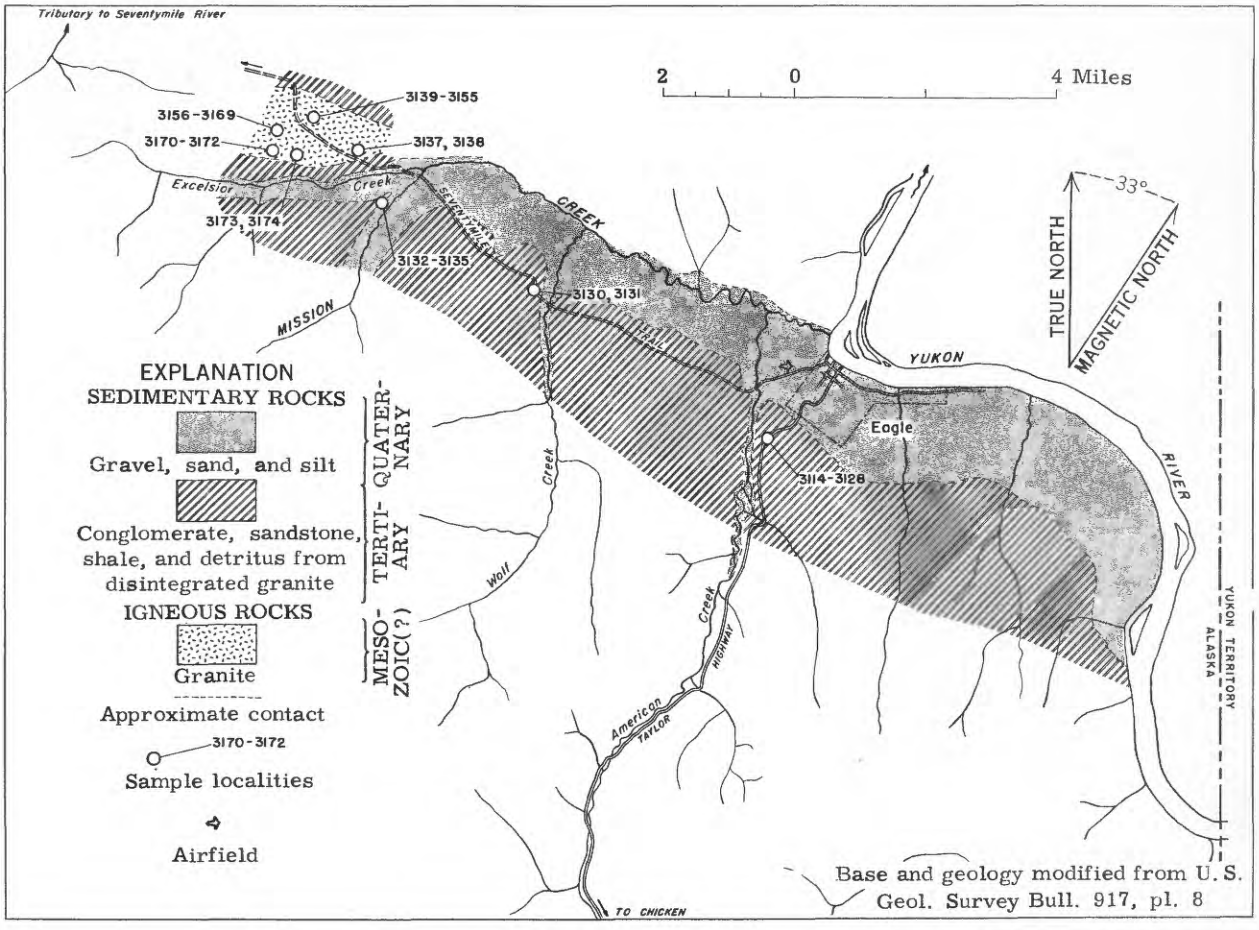

Figure 1. —Sketch map of Mesozoic(?) granite and Tertiary rocks in the vicinity of Eagle.

Tertiary rocks

The Tertiary rocks of the Eagle-Nation area occur in a wide belt along the southwest side of the Yukon River. They consist chiefly of sandstone, conglomerate, and shale in a sequence several thousand feet thick; beds of lignitic coal occur locally. The sandstone and conglomerate consist mainly of materials derived from the schist and granite areas of the Yukon-Tanana plateau to the south (Mertie, 1937, pl. 1). (See Mertie, 1942.)

Concentrates obtained prior to the 1948 investigation from quarries in Tertiary conglomerate near the road along American Creek (fig. 1) contained as much as 0.16 percent equivalent uranium. In an attempt to determine whether specific beds of the Tertiary rocks contained concentrations of the radioactive materials found in the earlier concentrates, traverses were made along the American Creek Road (fig. 1), along the trail west from Eagle to Excelsior Creek and for a short distance up Mission Creek above the mouth of Excelsior Creek (fig. 1), and at several localities along the banks of the Yukon River (pl. 1). For the most part the Tertiary sandstone, conglomerate, and shale, in place, contain a maximum of only 0.002 percent equivalent uranium.

Locally, on the American Creek Road and along Wolf and Mission Creeks, beds of slightly consolidated detrital material derived from the erosion of a nearby body of granite, possibly the granite on Excelsior Creek discussed previously, showed anomalous radiation during traversing. In regard to the deposits on Mission Creek, Mertie (1942, p. 227) states:

> "Along the west bank of Mission Creek, between a quarter and a half mile upstream from its confluence with Excelsior Creek, is a bluff about 90 feet high composed of angular, slightly consolidated detritus, mainly of granitic character, some of the larger fragments of which are as much as 2 feet in diameter. The finer material of this deposit is likewise of granitic character, and chert, usually the commonest type of pebble in the Tertiary rocks, is absent. Some thin beds of gray sandstone and clay shale containing carbonaceous material are interbedded with the conglomerate...This deposit...(is) derived evidently from a local source. The base of this conglomerate probably lies directly upon pre-Tertiary granitic rocks."

Table 3.—Summary of pertinent data on the radioactivity of materials tested in the Eagle-Nation area, 1948

Age and type of material tested	Maximum radioactivity (percent eU)
Pre-Cambrian rocks:	
Limestone, dolomite, shale, and hematitic rocks of various types	0.001
Undifferentiated rocks of Paleozoic age:	
Argillite	.003
Cambrian system:	
Limestone	<.001
Carbonaceous shale	.003
Ordovician(?) system:	
Carbonaceous shale and quartzitic sandstone	.003
Silurian system:	
Limestone	<.001
Devonian system:	
Shale of various types, including carbonaceous beds, and volcanic rocks of greenstone habit	.003
Carboniferous systems:	
Lower(?) Mississippian rocks:	
Shale and chert	.002
Phosphatic(?) concretions	.003
Upper Mississippian Calico Bluff formation:	
Limestone	.007
Carbonaceous shale	.009
Phosphatic pellets in carbonaceous shale	.022
Intermediate or transitional formation:	
Shale and chert	.002
Pennsylvanian Nation River formation:	
Sandstone, conglomerate, and shale	.001
Carbonaceous shale	.003
Permian system:	
Tahkandit limestone	<.001
Triassic system:	
Carbonaceous shale and limestone	<.001
Mesozoic(?) era:	
Granite	.007
Tertiary system:	
Conglomerate, sandstone, and shale	.002
Coarse granitic detritus interbedded with minor amount of carbonaceous shale and fine-grained sandstone	.005
Quaternary system:	
Concentrates from present stream gravels	.003

Concerning deposits on the American Creek Road, he writes (1942, p. 229):

> "Just below the coaly horizons some decomposed residual granite crops out, which apparently represents a part of the basement rock, upon which the Tertiary rocks in this vicinity were deposited. This granite consists of sericitized microcline, biotite, a little oligoclase, and calcite, the calcite acting as a matrix for the arkosic material and constituting about 30 percent of the rock. The uppermost 60 feet of the section, at the west end of the coal cut, consists of grit composed of granitic materials, together with some carbonaceous shales."

The radioactivity of these sedimentary derivatives of the granitic rock corresponds closely with that of the disintegrated granite on Excelsior Creek discussed above. Radioactivity analyses of 23 samples from the three localities show that the equivalent uranium content of the granitic detritus ranges from 0.003 to 0.005 percent, averaging about 0.004 percent. The heavy-mineral fractions contain ilmenite, iron oxides, zircon, minor amounts of garnet and anatase, and traces of epidote, hornblende, hypersthene, rutile, biotite, apatite, tourmaline, and monazite. The radioactivity is doubtless due to uranium and thorium in the zircon and monazite. The relatively large amount of radioactive biotite, which characterizes the granite on Excelsior Creek, was not found. It was apparently carried outside of the basin of sedimentation in which the granitic detritus was deposited.

Quaternary unconsolidated deposits

Concentrates (samples 3105-3113, pl. 1) were taken from gravels of some of the small tributaries of the Yukon River to determine whether radioactive minerals were being eroded from rocks in the more inaccessible portions of the drainage basins of these streams. The maximum radioactivity of these concentrates is 0.003 percent equivalent uranium.

SUMMARY AND CONCLUSIONS

Data on the radioactivity of the various types of material tested in the Eagle-Nation area in 1948 are summarized in table 3. The only rocks exhibiting abnormal radioactivity were black shale beds in the upper Mississippian Calico Bluff formation and granitic rocks of possible Mesozoic age and their Tertiary sedimentary derivatives.

Although the radioactive Carboniferous black shale is somewhat comparable in uranium content to similar deposits in continental United States, the grade and areal extent of the radioactive beds are not sufficient to warrant further interest except from an academic standpoint. The location of these deposits in a relatively remote part of Alaska also lessens the desirability of additional consideration.

The above factors also apply to the radioactive granitic materials found in the Eagle-Nation area.

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