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

By

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Trace Elements Investigations Report 56

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

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By Helmuth Wedow, Jr.

ABSTRACT

The reconnaissance of radioactive deposits in the Pre-Cambrian and Paleozoic sedimentary rocks, and Mesozoic(?) granite and 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 Mississippian Calico Bluff formation and the Mesozoic(?) granite and its sedimentary derivatives. The more radioactive black shale beds in the Calico Bluff formation range in thickness from 1/2 to 7 feet. Two units near the base of the formation appear to be persistent in the area; Unit A, with an average thickness of 6.6 feet, contains an average of 0.007 percent equivalent uranium and 0.004 percent uranium; 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 Mesozoic(?) granite 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 (fig. 1). Although the major objective of the reconnaissance was to search for anomalous radiation in a thick section of pre-Cambrian and Paleozoic sedimentary rocks, with particular emphasis on formations containing beds of black shale, some Mesozoic(?) granitic rocks 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 /. 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 via 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 about 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.

/ Alaska reconnaissance topographic series, scale 1:250,000.

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 developed primarily by the work of 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 in turn is usually covered with thick vegetation typical of sub-Arctic regions.

Radiation measurements in the Eagle-Nation area were made with a standard commercial model of a portable survey meter and a modified portable survey meter 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 were sampled and tested radiometrically in the Geological Survey's Washington Trace Elements Laboratory. Chemical analyses of selected samples were also made in the Survey's Washington Trace Elements Laboratory. Determinations of the heavy minerals in the Mesozoic(?) granitic rocks and the Tertiary clastic sedimentary rocks were made by B. W. Wilson of the Survey's Alaskan Geology Branch.

The geology and radioactivity of the various rocks examined in the Eagle-Nation area in 1948 are discussed by age below.

Pre-Cambrian rocks

The pre-Cambrian rocks of the Eagle-Nation area are strata of the Tindir group (Mertie, 1933, pp. 369-392). They are exposed along the Tatonduk River and along the southwest bank of the Yukon River below Nation (fig. 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 Proterozoic sedimentary rocks 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 (Rabbitt, 1947). According to Lang (1952, pp. 63, 65) ferruginous dolomite on McLean Bay on Stark Lake near Great Slave Lake contains monazite and pitchblende or uraninite as original constituents of the rock. Radiometric 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 (fig. 1) found no radioactive material that contains more than 0.001 percent equivalent uranium.

Undifferentiated Paleozoic rocks

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

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

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 (fig. 1). The limestone is nonradioactive. Samples from shale beds (nos. S-64 through S-72, and S-255, fig. 1), principally dark-colored and carbonaceous, contain an average of 0.003 percent equivalent uranium.

Ordovician(?) system

The only Ordovician(?) rocks tested in the course of this reconnaissance are quartzitic sandstones and black shales along the Tatonduk River (fig. 1). Although these rocks were mapped by Mertie as undifferentiated Paleozoic non-calcareous rocks (Mertie, 1933, pl. 7), several types of Ordovician(?) graptolites were found in these strata in the course of this investigation.

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. Three samples (nos. S-73 through S-75, fig. 1) of these black shales each 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, spot readings on numerous boulders in the gravels of the Tatonduk River showed no radioactivity associated with this rock type.

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 (fig. 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 in the traverse up Eagle Creek, but a sample (no. S-76, fig. 1) from the bed showing the greatest radioactivity contains only 0.003 percent equivalent uranium.

Igneous rocks

Devonian(?) igneous rocks of greenstone habit are exposed in Eagle Bluff, north of Mission Creek, just downstream from Eagle (fig. 1). According to Mertie (1933, pp. 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.

In 1948 one man was prospecting the greenstones on Eagle Bluff for lodes containing gold and nickel. Several samples of sulfide ore encrusted with cobalt bloom, purportedly from a vein on the bluff, showed no radioactivity when scanned with a portable survey meter. A traverse along the face of the bluff (fig. 1) also showed no radioactivity. The equivalent uranium content of several samples (nos. S-239 through S-243, fig. 1) of highly altered, black shaly rock from the south side of Eagle Bluff is only 0.002 percent or less.

Carboniferous system

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

Lower(?) Mississippian chert formation

The lower(?) Mississippian chert formation of Mertie (1930, pp. 88-95; 1933, pp. 416-420) consists of about 2,000 feet of thin-bedded black chert and siliceous argillite with partings of black shale. The formation was tested radiometrically on

traverses along the Yukon River just above and below Calico Bluff, on the right bank of the Yukon between Sulphur Bend and the Seventymile River, and on the Tatonduk River (fig. 1). Estimates from field readings indicate that nowhere in the Eagle-Nation area do beds of the lower(?) Mississippian chert formation 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 above Calico Bluff (sample no. S-244, fig. 1).

Calico Bluff formation

The Upper Mississippian Calico Bluff formation (Mertie, 1930, pp. 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 (fig. 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 placed arbitrarily at 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 (fig. 1). It was found that almost all the black shale beds are more radioactive than the interbedded limestone layers. Field testing and sampling (samples S-77 through S-234, fig. 1), however, showed that, except for a few beds, the equivalent uranium content of most of the black shale does not exceed 0.004 percent. Data on selected samples of the

Calico Bluff formation most of which contain 0.005 or more percent equivalent uranium are presented in table 1.

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 (tables 1 and 2). The average grades and thicknesses of the two units are compared in table 2.

Both radioactive units contain a small amount of phosphate and vanadium as seen in the analyses given below.

	Sample no. S-218 [1/]	Sample no. S-231 [2/]
eU	0.022 percent	0.008 percent
U	.019	.009
P_2O_5	15.1	1.9
V_2O_5	.46	.68

1/ Selected phosphatic material (small lenses, nodules, and pellets) from beds of Radioactive Unit B in outcrop on left bank of Yukon River opposite the mouth of the Tatonduk River.

2/ Grab sample of calcareous shale showing strong phosphate bloom in exposures of Radioactive Unit A on right bank of Yukon River about opposite the mouth of the Seventymile River.

As seen in tables 1 and 2 both radioactive zones found in the type section of the Calico Bluff formation are also present northwestward on the left bank of the Yukon River at the mouth of the Tatonduk River, an airline distance of about 8 miles. Another radioactive unit, tentatively correlated with 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, fig. 1). In addition to these localities,

Table 1. Data on samples of the Calico Bluff formation, Eagle-Nation area, east-central Alaska, containing 0.005 or more percent equivalent uranium. (Analyses by members of the Geological Survey Trace Elements Washington Laboratory.)

Sample no.	Thickness of bed	Stratigraphic interval above base of formation	Percent eU	Percent U	Description
Calico Bluff section:					
S-137	3.0	355.3 - 358.3	0.006	0.001	Black shale with thin beds of limestone
S-122	0.6	312.1 - 312.7	.005	.002	Black shale
S-121	0.7	311.4 - 312.1	.007	.004	Fetid argillaceous limestone
S-115	0.5	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	0.4	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	Do.; 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	.009	.004	Black shale

1/ Beds sampled are probably equivalent of beds of Radioactive Unit A at Calico Bluff.

Table 1. Data on samples of the Calico Bluff formation, Eagle-Nation area, east-central Alaska, containing 0.005 or more percent equivalent uranium. (Analyses by members of the Geological Survey Trace Elements Washington Laboratory.) Continued.

Section between Sulphur Bend and Seventymile River--continued:					
S-233	0.5	129.0 - 129.5	0.006	0.003	Gray siliceous shale
S-232	4.0	125.0 - 129.0, bottom of bed about 125 ft. above base of formation and about 50 ft. above base of exposed section	.008	.004	Black shale
S-231	Grab	Near base of exposed section, about 300 ft. downstream from S-232, about 125 ft. above base of formation	.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	104.4 - 104.9 2/	.005	.003	Black fissile shale
S-223	1.3	95.8 - 97.1	.005	.002	Gray argillaceous limestone
S-220	1.6	65.2 - 66.8 3/	.005	.002	Dark gray calcareous shale with thin lentils and nodules of phosphatic material
S-219	2.0	63.2 - 65.2 3/	.005	.002	Do.
S-218	-	63.2 - 66.8 3/	.022	.019	Selected phosphatic material from beds of samples S-219 and S-220
S-217	2.0	33.0 - 35.0 4/	.004	.006	Black fissile shale
S-216	4.5	28.5 - 33.0 4/	.008	.003	Calcareous shale with thin beds of limestone

2/ Intervals measured from base of exposed section which is approximately 125 ft. above base of formation.
3/ Beds of samples S-218, S-219, and S-220 probably equivalent to beds of Radioactive Zone B at Calico Bluff.
4/ Beds of samples S-216 and S-217 probably equivalent to beds of Radioactive Zone A at Calico Bluff.

Table 2.--Average equivalent uranium and uranium content of Radioactive Units A and B of the Calico Bluff formation.

Locality	Unit A			Unit B		
	Thickness	eU (percent)	U (percent)	Thickness	eU (percent)	U (percent)
Calico Bluff Section	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

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 in traversing intervals, 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 zones occur at this locality also, as the locality 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 are approximately 13 miles northeast of the mouth of the Tatonduk River and approximately 35 miles northeast of the mouth of the Nation River (Mertie, 1933, p. 423). However, these localities were much too inaccessible at the time of the 1948 reconnaissance to warrant investigation.

Intermediate formation

According to Mertie (1930, pp. 109-113; 1933, pp. 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 formation are sandy shale, argillite, slate, and some chert. Mertie (1933, pl. 7) shows this formation along the Yukon River on the north side of Eagle Bluff (fig. 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 formation were traversed for radioactivity only at the Eagle Bluff locality (fig. 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 formation 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 formation and the general field relationships of the associated formations suggest the possibility to the writer that some of the beds now mapped as intermediate formation 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 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 (fig. 1). It consists of conglomerate, sandstone, and gray clay shale, and has an aggregate thickness, according to Mertie (1930, p. 119), of between 5,000 and 6,000 feet.

The Nation River formation was examined for radioactivity at both localities mentioned above (fig. 1). It is essentially nonradioactive throughout. Three samples (nos. S-235 through S-237, fig. 1) of dark gray to black shale from beds 1-2 feet thick from the west side of the Yukon River a few miles below Eagle contain 0.002-0.003 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, pp. 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 (fig. 1). At this locality the formation consists chiefly of cream-colored to white massive limestone; some conglomerate, sandstone, and shale occur in the lower part of the formation, which has a total thickness of about 500 feet. Field tests on the Tahkandit formation indicate that its radioactivity probably does not exceed 0.001 percent equivalent uranium.

Triassic system

Adjacent to the Tahkandit limestone on the northwest in the vicinity of Nation (fig. 1) lies a belt of Upper Triassic rocks that consists principally of fossiliferous black shale interbedded with thin layers of gray to black limestone. 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 the Upper Triassic 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.

Mesozoic(?) granite

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 only at two localities: one, a small area mapped by Mertie (1930, pl. 12) at the head of Cuban Gulch (fig. 1) near the international boundary;

the other, the area on the north side of Excelsior Creek just above the junction with Mission Creek (fig. 2). This latter area is within an area of rocks mapped as pre-Cambrian by Mertie (1930, pl. 12; 1933, fig. 7). However, the complete lack of foliation wherever the writer observed the granite 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 be Mesozoic(?) in age.

The granite on Excelsior Creek is, for the most part, highly disintegrated and is covered with varying thicknesses of fine silt, which may be of eolian orgin, 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, as mentioned above, are generally concealed, most of the field tests for radioactivity were made in shallow holes (2-5 feet deep) dug through the overburden into the disintegrated rock below with a clam type post-hole digger. 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. In all, 115 test holes were dug in the Excelsior Creek area and 38 samples were collected (nos. 3137-3174, fig. 2). 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 for the probe used. 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, b dee er di in that where amma counts in Tertiar holes a roached the 75 count

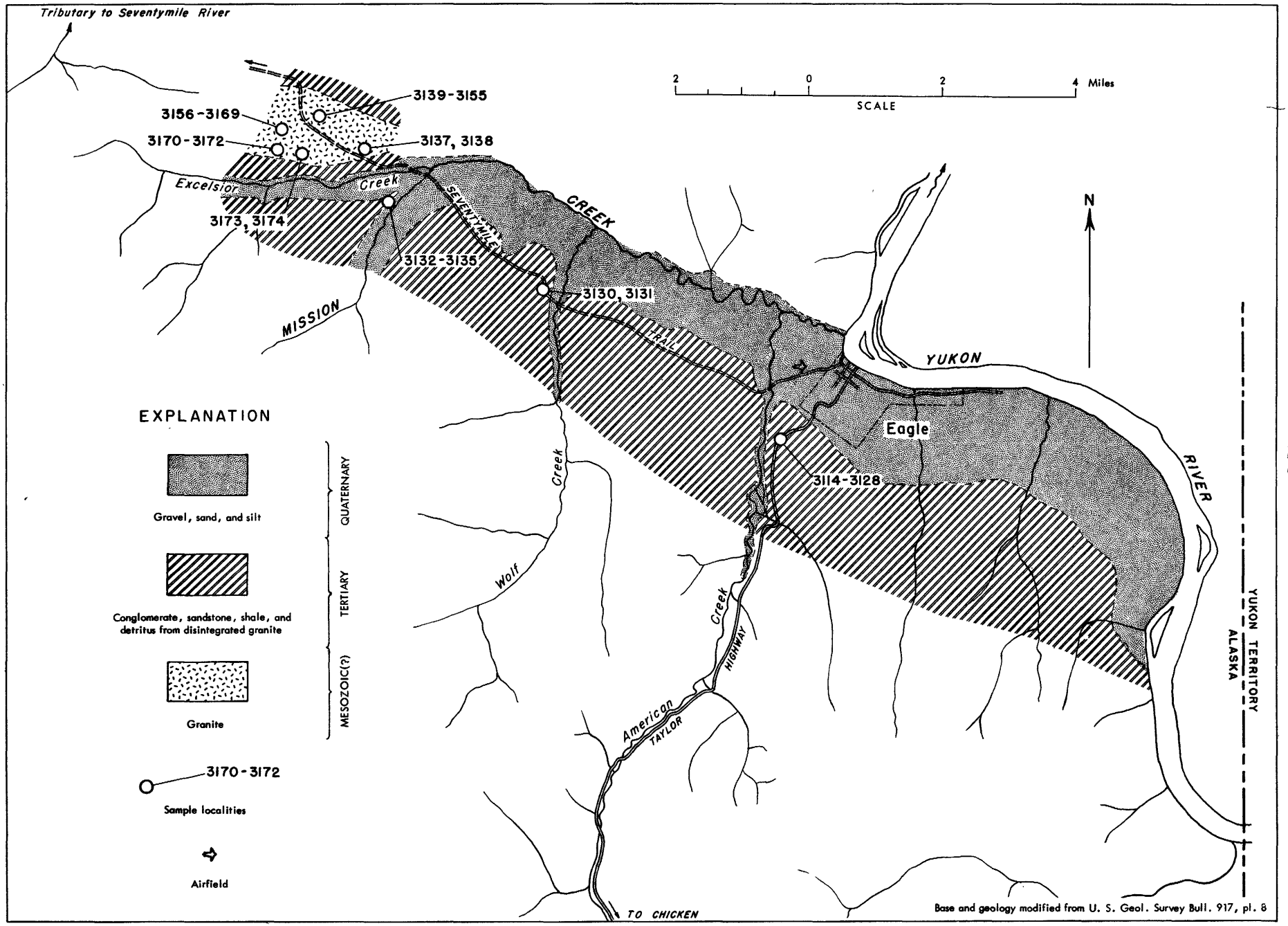

Figure 2.--SKETCH MAP OF MESOZOIC(?) GRANITE AND TERTIARY ROCKS IN THE VICINITY OF EAGLE

per minute maximum for these holes, the bottom of the original hole was close to the contact with the granite. In a 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.

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 (specific gravity 2.89) and methylene iodide (specific gravity 3.3). Radioactivity analysis of the several fractions indicated that the radioactive elements occur chiefly in the so-called "iodide-light" fraction (that between 2.89 and 3.3 specific gravity). The several iodide-light fractions analyzed contain in the 0.0X range of percent equivalent uranium. 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 other minerals, as yet unidentified, occurring as inclusions in the biotite. The "iodide-heavy" fraction (that greater than 3.3 specific gravity) is also radioactive, but to a lesser degree that 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.

Tertiary rocks

The Tertiary rocks of the Eagle-Nation area, described in detail by Mertie (1942), occur in a wide belt along the southwest side of the Yukon River (Mertie, 1942, pl. 8). 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, according to Mertie, consist mainly of materials derived mostly from the schist and granite areas of the Yukon-Tanana plateau to the south (Mertie, 1937).

Concentrates from quarries in Tertiary conglomerate near the road along American Creek (fig. 2) obtained prior to the 1948 investigation 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. 2), along the trail west from Eagle to Excelsior Creek and for a short distance up Mission Creek above the mouth of Excelsior Creek (fig. 2), and at several localities along the banks of the Yukon River (fig. 1). For the most part the Tertiary sandstone, conglomerate, and shale, in place, contain only as much as 0.002 percent equivalent uranium.

Locally, on the American Creek Road, and on Wolf and Mission Creeks, beds of slightly consolidated wash from the erosion of a nearby body of granite, possibly the granite on Excelsior Creek discussed above, showed anomalous radiation during traversing. In regard to the deposits on Mission Creek and the American Creek Road,

Mertie (1942) 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." (p. 227)

> "..........Just below the coaly horizons (on the American Creek Road) 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." (p. 229)

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, and 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

In the course of traversing in the Eagle-Nation area, concentrates (samples 3105-3113, fig. 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 does not exceed 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.

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 equivalent uranium)
Pre-Cambrian	
Limestone, dolomite, shale, and hematitic rocks of various types	< 0.001
Undifferentiated Paleozoic rocks	
Argillite	.003
Cambrian	
Limestone	< .001
Carbonaceous shale	.003
Ordovician(?)	
Carbonaceous shale and quartzitic sandstone	.003
Silurian	
Limestone	< .001
Devonian	
Shale of various types, including carbonaceous beds, and volcanic rocks of greenstone habit	.003
Carboniferous	
Lower(?) Mississippian rocks	
Shale and chert	.003
Upper Mississippian Calico Bluff formation	
Limestone	.001
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	
Tahkandit limestone	< .001
Triassic	
Carbonaceous shale and limestone	< .001

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

Age and type of material tested	Maximum radioactivity (percent equivalent uranium)
Mesozoic(?)	
Granite	0.007
Tertiary	
Conglomerate, sandstone and shale	.002
Coarse granitic detritus interbedded with minor amounts of carbonaceous shale and fine-grained sandstone	.005
Quaternary	
Concentrates from present stream gravels	.003

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