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GEOLOGICAL SURVEY

# RECONNAISSANCE FOR RADIOACTIVE DEPOSITS ALONG THE UPPER PORCUPINE RIVER, NORTHEASTERN ALASKA

by

Max G. White

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(in pocket)

# RECONNAISSANCE FOR RADIOACTIVE DEPOSITS ALONG THE UPPER PORCUPINE RIVER, NORTHEASTERN ALASKA

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Max G. White

## ABSTRACT

The highest equivalent uranium content found in the sedimentary rocks on the upper Porcupine River, northeastern Alaska, is 0.005 percent. Rhyolitic dikes associated with a granitic intrusive a few miles north of the Porcupine, along the international boundary, contain about 0.006 percent equivalent uranium, which is attributed to small amounts of disseminated radioactive accessory minerals. The granite also is slightly radioactive.

## INTRODUCTION

### LOCATION OF AREA

The Porcupine River, a major tributary of the Yukon River, is located in northeastern Alaska (index map of northeastern Alaska, fig. 1). It enters the Yukon from the northeast, near the town of Fort Yukon, a short distance north of the Arctic Circle. The upper two-thirds of the Porcupine is in Yukon Territory, Canada. The river waters are navigable by medium-sized river boats and scows for 280 miles above its mouth. The river distance from the mouth of the

Porcupine to Rampart House on the Alaska-Yukon boundary is about 215 miles. Only the area along the upper 80 miles of the Alaskan part of the river, from Burnt Paw to Rampart House (fig. 1), was examined in detail in the course of this investigation.

## PURPOSE AND SCOPE OF INVESTIGATION

In 1948 a Geological Survey field party carried on a trace elements reconnaissance in the Porcupine Valley to obtain:

1) General information on possible radioactive deposits.
2) Specific information on the content of radioactive material in black shale and other sedimentary rocks of pre-Cambrian and Paleozoic age.
3) Radiometric and geologic information on a granitic intrusive north of the Porcupine Valley along the international boundary.

No information on the occurrence of radioactive materials in the valley of the Porcupine River was available prior to the 1948 investigation. Work in the field extended from late June to late August and was carried on by a party consisting of Max G. White, geologist; Arthur Wahl and Glenn E. Fellows, camp assistants; and Egil Salveson and Charlie Strom, boatmen.

## GENERAL GEOGRAPHIC INFORMATION

In its lower 100 miles the Porcupine River traverses a broad flat alluvium-filled basin called the Yukon Flats. Many meanders and sloughs make the channel very tortuous and in places difficult to follow. The lowest exposure of bedrock, a bluff called Graphite Point, is 100 miles above the river's mouth.

Between Graphite Point and the mouth of the Coleen River (fig. 1), about 30 miles farther upstream, the Porcupine has cut its course through rocks that are principally limestone. The cliffs along this part of the river are 60 to 75 feet high and are known locally as the "Lower Ramparts". From the mouth of the Coleen River to Red Gate (fig. 1) the Porcupine occupies a wide meander loop across a small basin. This basin is filled partly with Quaternary alluvium and partly with gravels of Tertiary age. Red Gate is a high, dark-reddish cliff, which rises abruptly above the river to a height of 300 feet and marks the entrance to the "Upper Ramparts", where, for 52 miles, from Red Gate to 12 miles east of the international boundary, the Porcupine has cut a nearly continuous canyon 250 to 300 feet deep, with cliffs locally rising 500 feet above the valley floor.

For further information on this region, both geographic and historic, the reader is directed to Fitzgerald's report (Fitzgerald, 1944) on a general topographic reconnaissance of the Porcupine River valley.

## PREVIOUS GEOLOGIC INVESTIGATIONS

Four geologic investigations (Kindle, 1908; Maddren, 1912a, 1912b; Cairnes, 1914; and Mertie, 1941) have been made of the rocks along the Porcupine River and along the international boundary in northeastern Alaska.

Kindle's observations were made during a three weeks' round trip by canoe in 1906 from Fort Yukon to Rampart House. His paper includes a geologic map of the rocks adjacent to the Porcupine River from the "Lower Ramparts" to the international boundary.

In 1911 and 1912 Maddren accompanied the International Boundary Survey, mapping the geology of a strip 4 miles wide straddling the boundary from the Porcupine River north to the Arctic Coast. The results of his 1911 field work (Maddren, 1912a), the study of the Porcupine-Firth River sector, were published without a map. Notes and maps for the area north of the Firth remain unpublished in the Geological Survey files (Maddren, 1912b).

Cairnes' studies along the international boundary south of the Porcupine paralleled the work of Maddren. The final published report includes geologic strip maps of the boundary from the Porcupine south to the Yukon River (Cairnes, 1914).

Mertie (1941) conducted a geologic investigation on the Porcupine River in 1941, but his material is unpublished.

## TRACE ELEMENTS RECONNAISSANCE IN 1948

Geologic data and maps from the investigations described above served as the basis for the trace elements reconnaissance in 1948. Much of this reconnaissance consisted in radiometric tests on outcrops of Silurian, Devonian, and Carboniferous black shale. All the pre-Cambrian rocks were also examined in some detail. Concentrates were taken from the gravels of most of the streams entering the Porcupine, as a check on the possible presence of radioactive materials in the areas drained by these streams. A granite mass along the international boundary 6 to 23 miles north of the Porcupine was investigated both radiometrically and geologically. Very little previous information was available about this intrusive.

The geologic maps in this report are modifications and expansions of maps already in existence. Figure 1 is modified from a map by Kindle (1908, p. 321), and figure 2 from one by Maddren (1912b).

Victoreen and Beckman counters with conventional low-count beta-gamma tubes were used for field radioactivity measurements. Continuous radiometric traverses were made on foot along most of the outcrops of the various rock types. Where counting rates seemed appreciably higher than background, stationary counts were taken on the outcrops and significant samples were taken. These samples were crushed and tested in the field with either the Beckman or a modified GS-type counter. Representative samples from outcrops that showed the presence of radioactive material were examined in the laboratory for a final check on the field results.

## GEOLOGY AND RADIOACTIVITY INVESTIGATIONS

Brief descriptions of the rocks of the various geologic systems of the upper Porcupine area are given separately below. Radioactivity studies, where made, are included with the separate descriptions.

### SEDIMENTARY ROCKS

#### Pre-Cambrian rocks

The oldest rocks on the Porcupine River are those on the upper 6 miles of the river in Alaska, near the international boundary. Cairnes (1914, pp. 44-58) assigned them to the pre-Cambrian (actually pre-Middle Cambrian) and correlates them with the Tindir group farther south along the boundary. Mertie (1930, pp. 369-392) presents an excellent description of the Tindir group in the area of its type locality.

The Tindir group on the Porcupine River consists of quartzite, usually light gray, some sandstone and siltstone, and bedded dolomite and shale. Most of this shale is black, but some red and yellow beds also are present. The quartzite is apparently more abundant in the upper and lower parts of the sequence than in the middle. The quartzite forms the cliffs 300 to 500 feet high in the vicinity of Rampart House. Weathering of the exposed surfaces of the quartzite gives this rock the appearance of massive chalky limestone. The more protected surfaces, however, are usually covered with a light-yellow film of sulfur that has accumulated from the oxidation of pyrite disseminated in the quartzite.

The sandstone and siltstone, interbedded in the quartzite, commonly are highly ferruginous, deep chocolate to yellow, and have brown spots due to weathering of enclosed iron sulfide. The dolomite and black shale each account for approximately 25 percent of the total sequence. The dolomite is cream to white and very dense; the black shale in places is highly contorted between the more competent beds of quartzite and dolomite and locally exhibits a slaty cleavage.

No evidence of significant faulting or folding was observed in the rocks of the Tindir group, which have a prevailing westerly dip of about 40°. A conservative estimate of the stratigraphic thickness of this group along the upper Porcupine River is 18,000 feet.

## Radioactivity studies

Radiometric readings were taken on outcrops in all traverses of the pre-Cambrian sedimentary rocks. Data on samples collected from locations with relatively high field readings are listed below. The sample localities are shown on figure 2.

| Sample no. | eU 1/ content (percent) | Rock type and location |
|---|---|---|
| S-38 | 0.004 | Black slate, Sunaghun Creek |
| S-39 | 0.002 | do |
| S-40 | 0.002 | do |
| S-41 | 0.002 | do |
| S-42 | 0.003 | Black shale, Porcupine River below Rampart House |
| S-43 | 0.003 | do |
| S-44 | 0.003 | Black shale, Porcupine River in vicinity of Fred Creek |
| S-45 | 0.002 | do |
| S-46 | 0.001 | do |
| S-51 | 0.004 | Red shale, Porcupine River below Rampart House |
| S-52 | 0.005 | Yellowish shale, Porcupine River below Rampart House |

1/ eU, equivalent uranium

In 1947 the Geological Survey received some samples of radioactive calcareous siltstone or argillite of pre-Cambrian age from Great Slave Lake, Northwest Territories, Canada. Chemical analyses of the rock (Rabbitt, 1947) show the presence of 0.17 percent thorium oxide and 0.006 percent uranium. According to Lang (1950, p. 9) monazite and pitchblende or uraninite have been identified in these rocks. He also adds that these minerals are probably original constituents of the rocks. The lithologic similarity of the pre-Cambrian sedimentary rocks at Great Slave Lake (Stockwell, 1936) to the pre-Cambrian Tindir group on the international boundary (Cairnes, 1914; Mertie, 1932) led to the search for similar thorium-bearing strata in the course of this reconnaissance of radioactive materials. The search, however, disclosed no significantly radioactive rock of any type in the pre-Cambrian sequence.

## Ordovician and Silurian strata

Kindle (1908, p. 332) states that the section of rocks immediately overlying the pre-Cambrian 6 to 10 miles downstream from Rampart House probably contains rocks of both Ordovician and Silurian age, but he was unable to separate the two systems. Cairnes (1914, pp. 55, 59) found Middle Cambrian fossils in rocks, supposed to be no older than Ordovician, that overlie the Tindir group in its type area. He also states that the strata overlying the pre-Cambrian range in age from Cambrian to Silurian. As Kindle's geologic map was used as a base in this reconnaissance, his designation of these strata as Ordovician and

Silurian is used in this report. These Ordovician and Silurian rocks, at least several thousand feet thick, are buff and bluish-gray dolomite and limestone.

Radioactivity studies

The Ordovician and Silurian carbonate rocks were tested only hastily with a Geiger-counter traverse on the way downstream at the end of the field season. These rocks appear to be essentially non-radioactive.

Silurian limestone and shale

The Silurian strata along the Porcupine River comprise about 3,000 feet of magnesian limestone or dolomite, mostly on the lower part of the river, and were not examined in this reconnaissance. At the top of the Silurian, within the area of the upper part of the river, is a minor amount of black shale which was examined at two places, one 3 miles above Burnt Paw and the other about a mile above Old Rampart (fig. 1).

Radioactivity studies

Above Burnt Paw (fig. 1) black- and chocolate-colored fissile shale is interbedded with thin layers of dolomitic limestone and a few thin layers of sandstone. The highest radiometric readings recorded in the field were obtained on outcrops of this shale. About one mile above Old Rampart (fig. 1) approximately 300 feet of black graptolitic fissile shale with a few thin beds of black limestone were also tested for radioactivity. The equivalent uranium content of Silurian black shale samples collected above Burnt Paw and near Old Rampart is as follows:

| Sample no. | eU content (percent) | Rock type and location |
|---|---|---|
| S-15 | 0.005 | Black shale interbedded with limestone, about 3 miles upstream from Burnt Paw |
| S-16 | 0.005 | do |
| S-17 | 0.000 | do |
| S-18 | 0.002 | do |
| S-19 | 0.001 | do |
| S-20 | 0.002 | do |
| S-33 | 0.003 | Black graptolitic shale, about 1 mile upstream from Old Rampart |
| S-34 | 0.003 | do |

## Devonian rocks

The Devonian rocks along the upper Porcupine River (fig. 1) consist of siliceous limestone; black, brown, gray and red shale; and a small amount of interbedded basalt.

### Radioactivity studies

The Devonian shale section at the mouth of the Rapid River (fig. 1) was traversed radiometrically but proved barren of significantly radioactive beds. Black shale samples (nos. S-35 and S-36, fig. 1) from two beds with the highest field readings contain only 0.002 percent equivalent uranium. The basalt and siliceous limestone are nonradioactive.

## Carboniferous limestone and shale

The Carboniferous strata exposed on the upper Porcupine River (fig. 1) are interbedded limestone and shale. Some of the limestone beds are gray- to cream-colored, somewhat massive, and contain some chert; some are bluish-black to gray, and, locally, fissile or slaty, calcareous or sandy, or graphitic. Although no estimate of the thickness of the Carboniferous rocks has been made because these beds usually have been highly disturbed, the Carboniferous section doubtless includes many hundreds of feet of sedimentary beds.

## Radioactivity studies

Radiometric traverses on foot along all exposures of Carboniferous rocks on the upper Percupine disclosed no beds of shale or other rock that contained more than 0.003 percent equivalent uranium. The equivalent uranium values of samples taken from Carboniferous beds showing the greatest radioactivity on the outcrop are listed below.

| Sample no. | eU content (percent) | Rock type and location |
|---|---|---|
| S-21 | 0.003 | Black shale, at east side of mouth of Coleen River |
| S-23 | 0.003 | Black shale, north side of Percupine River upstream from Coleen River |
| S-24 | 0.001 | do |
| S-25 | 0.001 | do |
| S-26 | 0.002 | Black shale, south side of Percupine River downstream from Salmontrout River |
| S-27 | 0.002 | do |
| S-28 | 0.002 | do |
| S-29 | 0.002 | do |
| S-30 | 0.002 | do |
| S-31 | 0.003 | Black shale, north side of Percupine River opposite mouth of Salmontrout River |
| S-32 | 0.003 | do |
| S-62 | 0.003 | Black shale, south side of Percupine River opposite mouth of Coleen River |

## Tertiary sediments

A wide belt of Tertiary sediments between Fish Creek and Red Gate (fig. 1) is comprised of about 40 feet of sand, gravel, and drab clay with 6- to 10-inch beds of low-grade lignite; underlain by 50 feet of soft, finely laminated, drab-colored clay. Similar beds occur on the north bank of the Porcupine below the Coleen River.

## Radioactivity studies

Several of the lignite beds, cropping out between Fish Creek and Red Gate and below the mouth of the Coleeen River, were tested radiometrically in the field and found to be nonradioactive.

## Quaternary alluvium

Concentrates were taken from gravels (Quaternary alluvium) of streams draining into the Porcupine River in an attempt to determine whether heavy radioactive minerals were being eroded from rocks in the watersheds of those streams. The locations of such concentrates are plotted on figures 1 and 2. Between 40 and 100 pounds of stream gravels at each location were panned to semiconcentrates in the field. Such semiconcentrates were further concentrated in the laboratory by the use of bromoform (sp. gr. 2.8).

### Radioactivity studies

The equivalent uranium content of the heavier-than-bromoform mineral fractions of the semiconcentrates of the stream gravels was determined radiometrically in the laboratory. No significant amounts of radioactive material were detected in any of these heavy mineral fractions. Data on these samples are shown in table 1.

## IGNEOUS ROCKS

Two main types of igneous rock are found in the Porcupine River area. One type is a granitic intrusive of Mesozoic(?) age, which occurs along the international boundary 6 to 23 miles north of the Porcupine (figs. 1 and 2); the other type consists of lava flows of Tertiary age which form the bulk of the "Upper Ramparts" of the Porcupine from Howling Dog Creek northeastward to a point 10 miles west of the international boundary (fig. 1).

### Mesozoic(?) granitic rocks

The Mesozoic(?) granitic body north of the Porcupine was first located by the International Boundary Survey in 1911 (Maddren, 1912a). This body is the westward extension of a large granite mass in the Old Crow Mountains of Canada, and intrudes pre-Cambrian sedimentary rocks consisting mainly of quartzite and black shale.

Table 1. — Data on heavier-than-bromoform fractions of concentrates from gravels of streams tributary to the upper Porcupine River, northeastern Alaska.

| Field no. (see figs. 1 and 2) | ATE File no. | eU content (percent) | Concentration ratio | Location |
|---|---|---|---|---|
| 48AWe63 | 3178 | 0.000 | 2,300:1 | David Creek |
| 73 | 3177 | 0.000 | 1,600:1 | Howling Dog Creek |
| 80 | 3179 | 0.000 | 3,400:1 | Rapid River |
| 84 | 3180 | 0.000 | 1,200:1 | White Mountain Creek |
| 85 | 3181 | 0.000 | 1,000:1 | Campbell River |
| 87 | 3182 | 0.003 | 600:1 | Sunaghun Creek, near mouth |
| 129 | 3183 | 0.002 | 1,300:1 | Sunaghun Creek, lower part |
| 130 | 3184 | 0.002 | 3,000:1 | do |
| 131 | 3185 | 0.002 | 800:1 | do |
| 132 | 3186 | 0.000 | 650:1 | do |
| 133 | 3187 | 0.000 | 300:1 | do |
| 134 | 3188 | n.d.1/ | ? | do |

1/ sample too small for determination of eU content

Table 1. — Data on heavier-than-bromoform fractions of concentrates from gravels of streams tributary to the upper Porcupine River, northeastern Alaska. (Continued)

| Field no. (see figs. 1 and 2) | ATE File no. | eU content (percent) | Concentration ratio | Location |
|---|---|---|---|---|
| 48AWe135 | 3189 | n.d. [1/] | ? | Sunaghun Creek, lower part |
| 136 | 3190 | 0.001 | 7,600:1 | do |
| 137 | 3191 | n.d. [1/] | ? | do |
| 139 | 3192 | 0.001 | 700:1 | Sunaghun Creek, middle part |
| 141 | 3193 | 0.005 | 800:1 | do |
| 170 | 3205 | 0.006 | 1,100:1 | First south tributary of Porcupine River below Rampart House |
| 171 | 3204 | 0.005 | 2,400:1 | Second south tributary of Porcupine River below Rampart House |
| 172 | 3203 | 0.000 | 500:1 | Third south tributary of Porcupine River below Rampart House |
| 174 | 3202 | 0.001 | 3,800:1 | First north tributary of Porcupine River above third south tributary (sample 172) below Rampart House |

1/ sample too small for determination of eU content

Table 1. — Data on heavier-than-bromoform fractions of concentrates from gravels of streams tributary to the upper Porcupine River, northeastern Alaska. (Continued)

| Field no. (see figs. 1 and 2) | ATE File no. | eU content (percent) | Concentration ratio | Location |
|---|---|---|---|---|
| 48AWe177 | 3201 | 0.003 | 1,100:1 | North tributary of Porcupine River opposite mouth of Fred Creek |
| 178 | 3200 | 0.000 | 1,300:1 | Fred Creek |
| 200 | 3199 | 0.006 | 850:1 | North tributary of Porcupine River about 1¼ miles below Fred Creek |

Within the area examined (fig. 2), the granite is medium- to coarse-grained, and contains small amounts of biotite and hornblende and very small amounts of the accessories apatite, zircon, and magnetite. Most of the orthoclase feldspar and much of the biotite in the granite has been partly replaced by minute sericitic aggregates.

Rhyolitic dikes, locally aplitic in texture, appear on the borders of the granite, cutting into the pre-Cambrian sedimentary rocks. The largest of these dikes observed is at the head of White Mountain Creek (fig. 2).

Field evidence indicates that the granite mass underlies the thick covering of Tertiary lava flows that appears a few miles to the west. The granite contact probably veers gradually to the north and then northeast, to cross the international boundary at a point approximately 23 miles north of the Porcupine River.

The age of the granite is not yet known, but it is thought to be younger than Carboniferous and older than Tertiary, and therefore Mesozoic(?).

## Radioactivity studies

Although the granitic rocks in the upper Porcupine area contain minor amounts of radioactive materials, no zones of high concentrations were found. The rhyolitic rocks are slightly more radioactive than the coarser-grained phases of the granite. Consequently, the field studies were extended to all borders of the granite where the rhyolitic dikes are located. The equivalent uranium content and other data of all samples collected by the author in the area of the granite are shown in table 2.

Table 2. — Data on samples related to the granitic intrusive on the international boundary north of the Porcupine River, northeastern Alaska.

| Field No. (see fig. 2) | ATE file no. | eU content (percent) Crushed rock | Heavy-mineral fraction 1/ | Concentration ratio | Description and location |
|---|---|---|---|---|---|
| 48AWe89 | 3194 | - | 0.045 | 3,500:1 | Concentrate from stream gravels in northeast headwaters fork of Sunaghun Creek |
| 90 | 3195 | - | 0.016 | 8,200:1 | Concentrate from stream gravels in Sunaghun Creek about ½ mile west of international boundary |
| 99 | 3196 | - | 0.060 | 2,000:1 | Concentrate from disintegrated rhyolitic dike near Sunaghun Creek about ½ mile west of the international boundary |
| 100 | 3217-L | 0.006 | 0.030 | 450:1 | Crushed fragments of fresh rock from same locality as sample 48AWe99 |
| 101 | 3218-L | 0.003 | 0.004 | 6:1 | Crushed granite from ridge west of Sunaghun Creek about ¼ mile west of international boundary |
| 107 | 3219-L | 0.003 | 0.009 | 6:1 | Crushed granite from highest point on ridge about 2 miles west of international boundary |
| 108 | 3197 | - | 0.010 | 1,000:1 | Concentrate from stream gravels in northwest headwater fork of Sunaghun Creek |

1/ Fraction heavier than bromoform (sp. gr. 2.8)

Table 2. — Data on samples related to the granitic intrusive on the international boundary north of the Porcupine River, northeastern Alaska.

| Field No. (see fig. 2) | AEC file no. | eU content (percent) Crushed rock | eU content (percent) Heavy-mineral fraction 1/ | Concentration ratio | Description and location |
|---|---|---|---|---|---|
| 48AWe111 | 3220-L | 0.006 | 0.002 | 10.1 | Crushed rhyolitic rock from saddle between Sunaghun and White Mountain Creeks |
| 112 | 3221-L | 0.006 | 0.035 | 85:1 | do |
| 117 | 3198 | - | 0.052 | 2,700:1 | Concentrate from stream gravels in a southeast tributary of the Rapid River |

1/ Fraction heavier than bromoform (sp. gr. 2.8)

Radioactive minerals

Z. S. Altschuler and T. W. Stern of the Geological Survey's Trace Elements Laboratory examined six moderately radioactive samples (nos. 48AWe89, 90, 99, 100, 108 and 117, fig. 2 and table 2) from the granitic rock area on the international boundary in an attempt to determine which minerals cause the radioactivity. Subsequently the author examined a seventh sample (48AWe112, fig. 2 and table 2) for the same purpose. The radioactive minerals found in these samples are as follows:

Biotite. -- The radioactivity of sample 48AWe112 is restricted to the biotite part of the heavy mineral fraction. The sample is from a large rhyolitic dike at the head of White Mountain Creek (fig. 2).

Clarkeite(?). -- Reddish-brown uraniferous grains, tentatively identified as clarkeite ($UO_3 \cdot nH_2O$) by its optical properties, appears to be the only radioactive mineral in sample 48AWe89.

Hematite. -- The hematite in sample 48AWe99 is reported to contain some uranium as an impurity.

Pyrite. -- Fluoresence tests of the heavy minerals in sample 48AWe100 indicate that pyrite grains, which are oxidized and altered although euhedral, are radioactive, mostly on the surfaces and in minute fractures within the grains. Crushed fragments show minute amounts of quartz and another material within the fractures. Fluorimetric analysis shows the presence of 0.027 percent uranium. Whole grains of pyrite were used in this analysis. A second fluoresence test made on crushed grains disclosed no uranium, bearing out the hypothesis that the uranium is only in the surficial, weathered part of the pyrite.

Rutile(?). — Fluoresence tests indicate that material tentatively identified as altered rutile(?) is probably the only uranium-bearing mineral in sample 48AWe117. This mineral, however, is too altered and heterogeneous to yield a good X-ray pattern. It is called altered rutile(?) on the basis of an incomplete spectrographic determination. Optically, however, it resembles eschynite.

Unknown mineral No. 1. — A mineral, herein designated "Unknown mineral No. 1", contains most of the radioactive material in the heavy mineral fraction of sample 48AWe99. Identification of this mineral by optical or X-ray methods appears to be impossible. It is probably hexagonal, although pseudo-orthorhombic in appearance, and is orange and translucent with a dull luster. In addition to uranium, this mineral contains calcium and phosphorus.

Unknown mineral No. 2. — The only radioactive mineral in sample 48AWe90 has not yet been identified. For the purpose of this report it is called "Unknown mineral No. 2". This altered mineral contains iron, titanium, aluminum, and silicon as determined by spectrographic analysis, and uranium by fluoresence test.

Unknown mineral No. 3. — Unknown mineral No. 3 apparently is the only uranium-bearing mineral in sample 48AWe108. It is black and opaque, and spectrographic analysis indicates that its major constituents are iron, manganese, aluminum, and silicon.

## Tertiary lava flows

Tertiary lava flows, which form the bulk of the "Upper Ramparts", extend from 10 miles west of the international boundary westward to Howling Dog Creek. The flows are over 300 feet thick and are exposed in the steep cliffs that rise abruptly from river level. At one place above Old Rampart there are at least 15 different flows distinguishable in the canyon wall. The lava rests on a very irregular surface of Paleozoic rocks. Exposures of Paleozoic rocks such as those at the mouths of Rapid and Campbell Rivers represent localities on the pre-lava erosion surface that were of sufficient relief to be only thinly covered, if at all, by the flows.

## SUMMARY OF MATERIALS TESTED

Shale, granitic rock, and concentrates from gravels of streams draining areas of granitic rocks are the only materials tested in the reconnaissance of the Porcupine River area that contained at least minor amounts of radioactive material. The search did not reveal any deposit that would be considered a commercial source of uranium ore. A summary of the results for the material tested follows:

| Rock types and age of material tested | Radioactivity (values given are in percent eU) |
|---|---|
| **Sedimentary and other bedded rocks:** | |
| Pre-Cambrian (Tindir group) | |
| Quartzite | Nonradioactive |
| Dolomite | Nonradioactive |
| Black shale | 0.001-0.004 |
| Red shale | 0.004 |
| Yellow shale | 0.005 |
| Ordovician and Silurian | |
| Dolomite and limestone | Nonradioactive |
| Silurian | |
| Magnesian limestone (dolomite) | Nonradioactive |
| Black shale (above Burnt Paw) | 0.000-0.005 |
| Black shale (above Old Rampart) | 0.003 |
| Devonian | |
| Black shale | 0.002 |
| Basalt | Nonradioactive |
| Siliceous limestone | Nonradioactive |
| Carboniferous | |
| Black shale | 0.001-0.003 |
| Limestone | Nonradioactive |
| Tertiary | |
| Lignite | Nonradioactive |
| **Igneous rocks:** | |
| Mesozoic(?) | |
| Medium- to coarse-grained granite | |
| Unconcentrated | 0.003 |
| Heavy-mineral fractions | 0.004-0.009 |
| Rhyolite dike rock | |
| Unconcentrated | 0.006 |
| Heavy-mineral fractions | 0.002-0.060 |
| Tertiary | |
| Lava | Nonradioactive |

| Rock types and material tested | Radioactivity (values given are in percent eU |
|---|---|
| **Heavy-mineral concentrates from stream gravels:** | |
| From gravels of Porcupine River tributaries which drain areas underlain mostly by sedimentary strata and basaltic rocks | 0.000-0.006 |
| From gravels of streams draining area of granitic rocks along the international boundary | 0.010-0.052 |

## CONCLUSIONS

Although this reconnaissance disclosed the presence of minor amounts of radioactive materials associated with shale beds of pre-Cambrian and Paleozoic age, and Mesozoic(?) granitic rocks, the equivalent-uranium contents are not of sufficient significance to warrant additional study. It is probable that the Porcupine River area of this report does not contain deposits that can be considered as a commercial source of uranium.

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