NO. RA-52

RECLASSIFICATION AUTHORIZATION

In accordance with the authority delegated to me by memorandum from the General Manager, dated December 6, 1948, subject, "Security Procedures and Policies relating to the Domestic Raw Materials Program" and based on criteria for determining classification, as outlined in Appendix A attached thereto, the document(s) listed below are reclassified as indicated.

	Present Classification	Revised Classification
(1) USGS - TEI Report No. 38 --- "Trace Elements Reconnaissance along Highways in the Tanana and Upper Copper River Valleys, Alaska" by H. Wedow, Jr., and J. J. Matzko, dated March 1947	OFFICIAL USE ONLY	UNCLASSIFIED
(2) USGS - TEI Report No. 50 --- "Staats Fluorspar Mine, Beaver County, Utah (Memorandum Report)" by Donald G. Wyant, (undated).	SECRET	UNCLASSIFIED
(3) USGS - TEI Report No. 52 --- "Radioactivity of Sediments in Parts of Oklahoma and Kansas" by Garland B. Gott, September 1948.	RESTRICTED	UNCLASSIFIED

April 5, 1950

Date

Jesse C. Johnson

JESSE C. JOHNSON
Manager
Raw Materials Operations

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classification Cancelled 4/5/50 - J.C. Johnson to Unclassified - RA-52

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

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SEP 23 1949

AEC-139/0

Dr. Phillip L. Merritt, Assistant Manager
Raw Materials Operations
U. S. Atomic Energy Commission
P. O. Box 30, Ansonia Station
New York 23, New York

Dear Phil:

Enclosed are six copies of a report by Helmuth Wedow, Jr., and John J. Matzko entitled "Trace Elements Reconnaissance along Highways in the Tanana and Upper Copper River Valleys, Alaska," Trace Elements Investigations Report No. 38.

The original and a carbon copy of this report are being forwarded to Dr. John K. Gustafson in accordance with his requests of February 25, 1949 and July 13, 1949.

Sincerely yours,

Thomas B. Nolan

Thomas B. Nolan
Assistant Director

Enclosures 6

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JAN 09 2001

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TRACE ELEMENTS RECONNAISSANCE ALONG HIGHWAYS IN THE TANANA AND UPPER COPPER RIVER VALLEYS, ALASKA

by

Helmuth Wedow, Jr., and John J. Matzko

March 1947

Trace Elements Investigations - Report No. 38

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CONTENTS

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TABLE
(at end of report)

Table 1. Location and description of test stations, and equivalent uranium determinations thereat, in the trace elements reconnaissance along highways in the Tanana and upper Copper River Valleys, Alaska.

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ILLUSTRATIONS

Following page

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TRACE ELEMENTS RECONNAISSANCE ALONG HIGHWAYS IN THE TANANA AND UPPER COPPER RIVER VALLEYS, ALASKA

By Helmuth Wedow, Jr. and John J. Matzko

ABSTRACT

Prior to 1946 some information had been obtained on the radioactivity of concentrates from various placer deposits in the vicinity of Fairbanks and Livengood. Most of the samples testedwere from a collection in the Alaskan Branch of the Geological Survey which had been accumulated over a period of many years, although a few had been collected in 1945 specifically for the Trace Elements program by R. R. Coats of the Geological Survey during a reconnaissance of the Yukon-Tanana placer region. The highway reconnaissance in 1946 was the first time that a Geiger counter was used in the field in this area.

Although the present reconnaissance did not yield any further information on the source of the few samples of higher radioactivity that had been obtained previously, a few new sites were found. Further reconnaissance appears necessary before any specific areas are selected for detailed study, in order that the slower and more costly detailed work may be done at the most favorable localities. Data for all sites, regardless of favorable or unfavorable results, are presented in order that future investigators may evaluate how thoroughly negative areas have been determined. Preliminary mineralogical work suggests that the radioactivity in some rocks is due to small amounts of radioactive elements in such minerals as zircon, monazite and allanite.

Lodes of bismuth, tungsten, silver, and free-gold associated with sulphides and quartz, and antimony are not appreciably radioactive, but

zones of bismuth mineralization in the Fish Creek area of the Fairbanks district are slightly so. Graphitic schists and black shales in the areas investigated likewise seem unpromising as possible rocks in which to seek deposits of radioactive materials, although the data for these two rock types are far too meager to be conclusive. Granitic rocks at widely scattered localities, such as the Idaho Creek area in the upper Chatanika Valley, the south shore of Birch Lake in the Harding Lake-Richardson area, and along the Alaska Highway, contain some radioactive materials. Concentrates, possibly from granitic sources containing radioactive materials, have been collected from Ruth Creek in the Livengood area and from Nome Creek in the upper Chatanika Valley area. "Granitic" rocks of Pedro Dome and the area south of Gilmore Dome in the Fairbanks district, however, showed almost no content of radioactive elements. The radioactive minerals zircon, monazite and allanite are all accessories in granitic rocks.

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INTRODUCTION

The Tanana and upper Copper River Valleys are in east-central Alaska (see fig. 1) on opposite sides of the Alaska Range. The Tanana, on the north side of the range, flows northwest into the Yukon River, and the Copper River, on the south side, flows south into the Gulf of Alaska. The principal highways in Alaska either follow these two valleys or cross the intervening uplands. These highways and subsidiary roads are shown on figure 1.

Initial radioactive scanning of a collection of placer samples from Alaska in the winter of 1944-45 indicated a few sites in the Fairbanks and Livengood areas at which radioactive materials were present in stream deposits. Subsequent field sampling by R. R. Coats of the Geological Survey in 1945, during a reconnaissance of the Yukon-Tanana placer region (Fortymile, Circle, Fairbanks, and Livengood districts), increased the number of samples available from these areas but did not reveal any additional sites of relatively highly radioactive material. Information on those samples which were available prior to the 1946 reconnaissance in the Tanana and upper Copper River Valleys is summarized in an informal file report by P. L. Killeen on Trace Elements investigations in Alaska and is reproduced below.

Radioactivity of samples collected prior to 1946
in the Tanana and upper Copper River Valleys, Alaska

District	Total number of samples	Number of samples in each of three ranges of percent equivalent uranium content			Not tested
		0.02	0.02-0.01	0.01	
Tolovana	53	2	-	34	17
Fairbanks	148	4	3	89	52

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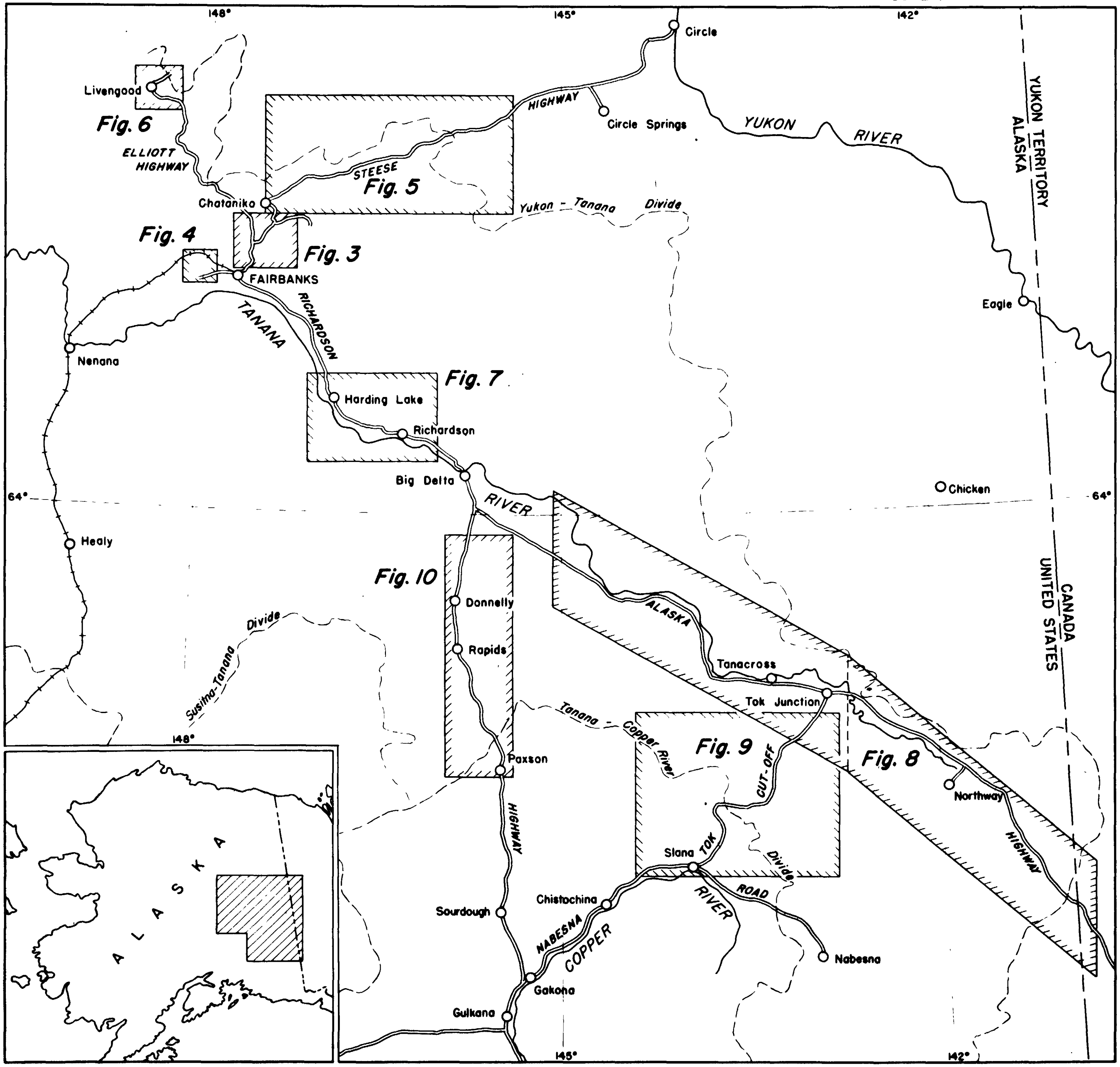


Base from U. S. A. A. F. Flight Charts compiled by U. S. Geological Survey.

INDEX MAP TO AREAS INVESTIGATED ALONG THE HIGHWAYS IN THE TANANA AND UPPER COPPER RIVER VALLEYS, ALASKA

50 0 150 Miles
Scale

In 1946, a reconnaissance for trace elements in areas accessible from the highways in the Tanana and upper Copper River Valleys was undertaken because the accessibility permitted covering a large area in the course of the field season and because information from the area between the upper Tanana and upper Copper River was either insufficient or absent. The reconnaissance had the following specific objectives:

1) To continue tests of the radioactivity of known placer deposits be collecting additional concentrates from placer areas where radioactive samples are represented in collections as well as from gravels that had not yet been sampled.

2) To expand the sampling program to include unmined streams which might contain heavy concentrates but do not carry gold or other commercially workable metals and hence have not been mined.

3) To test known areas of bedrock mineralization of various metals, masses of intrusive igneous rocks, and outcrops on hill slopes in the vicinity of the stream sites from which radioactive samples had been collected previously.

Objectives 1 and 2 not only afford the means of evaluating the stream gravels as possible sources of radioactive materials, but the concentrates also serve as guides within a drainage basin to bedrock sources of radioactive minerals of high specific gravity.

A party, consisting of Helmuth Wedow, Jr., and John J. Matzko, geologists, and Fred Freitag, camphand, was in the field from June through September 1946.

MEASUREMENT OF RADIOACTIVITY

The radioactivity of outcrops of bedrock and gravel, and of unconcentrated samples of crushed bedrock was measured with a Geiger-Mueller gamma-ray counter (GS model) in the field. The general theory, methods, calculations, and accuracy of results in the use of this instrument have been discussed by Stead. _/ Tests on samples were made at base camps where readings were not influenced by any radiation from large areas of outcrop of the material sampled. Subsequently, heavy-mineral separates of crushed rock samples and panned concentrates of crushed rock samples and panned concentrates of gravels and weathered disintegrated rock materials were prepared and tested for radioactivity by beta count in the Washington laboratory. Table 1, appended to this report, gives the location and description of each test station, the radiometric determinations made at the stations and/or on samples obtained therefrom, and the concentration ratio of the ultimate concentrate of which the radioactivity was measured. The radioactivity throughout is expressed in terms of percent equivalent uranium, abbreviated to E. U.

_/ Stead, F. W., Preliminary report on field measurement of radioactivity: U. S. Geol. Survey Trace Elements Investigations Rept. 13, unpublished, 1945.

Outcrop tests

Outcrops of both bedrock and gravel were tested for radioactivity by placing the counter tube on the surface of the material and measuring the gamma-ray count for 5-minute intervals. Background readings, with the counter tube several feet above the surface of the ground, were taken several times a day as a check. The general method of outcrop testing and the factors influencing such tests have been discussed elsewhere. _/

_/ Slaughter, A. L., and Nelson, J. M., Trace elements reconnaissance in South Dakota and Wyoming -- Preliminary report: U. S. Geol. Survey Trace Elements Investigations Rept. 20, pp. 2-4, unpublished, 1946.

The results of the gamma-ray count at each outcrop, as shown in Table 1, is expressed in terms of percent E. U. (equivalent uranium) by interpolating from a diagram similar to that used by Slaughter and Nelson.

In the construction of such a diagram (see fig. 2) the average background counting rate of the instrument that was used was determined by averaging the averages of groups of four consecutive backgrounds. The final average background was then plotted on the diagram as 0.000 percent E. U. The E. U. values of a number of crushed samples were then plotted against the gamma-ray counts obtained at the outcrops from which the samples were taken. The diagonal line, showing the probable relationship between the E. U. value and the outcrop gamma-ray count, was then drawn by inspection from the point where the average background was assumed to represent 0.000 percent E. U. Deviation of points from the diagonal is attributed either to sampling errors or to the random nature of gamma radiation over short periods of time.

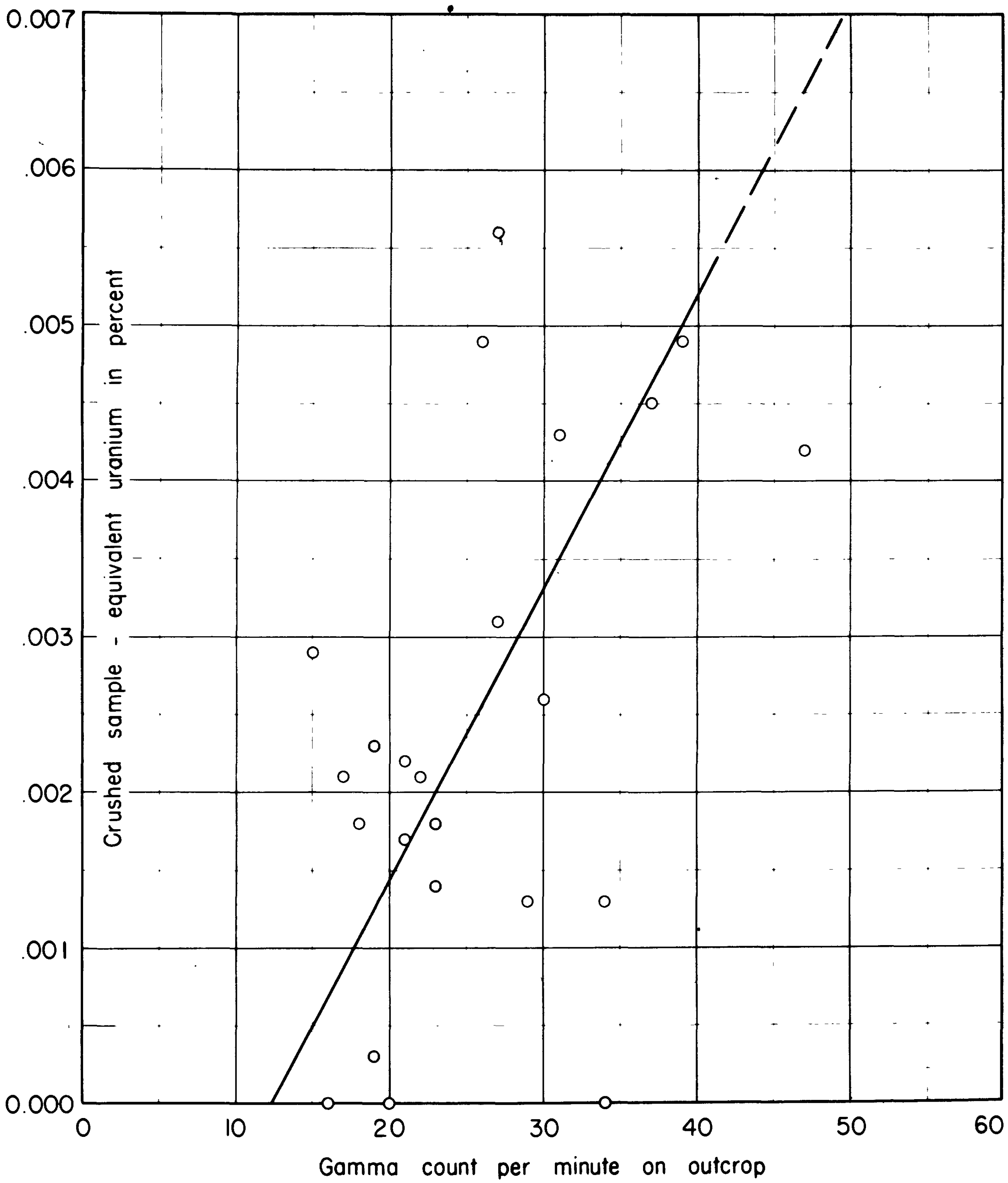


Diagram showing relationship between the equivalent uranium content of unconcentrated crushed samples and outcrop gamma counts

Unconcentrated crushed samples

Rock samples were crushed to less than 4-mesh in a jaw crusher at the Fairbanks laboratory of the Geological Survey. To determine the E. U. content of the crushed samples, 5-minute readings of background sample, a radioactive standard, sample, and background were made in that sequence.

Concentrated samples

To increase the proportion of heavy minerals to be tested for radioactivity at any one station, concentrates were made by panning unconsolidated materials such as stream gravel, slope wash, and disintegrated rock from both mine dumps and weathered outcrops. Later, to obtain a standard type of concentration separations of minus 20-mesh material were made in the Washington laboratory with heavy liquids (bromoform, sp. g. 2.8; methylene iodide, sp. g. 3.3). The unconcentrated crushed samples were crushed further to minus 20-mesh and also separated with heavy liquids. The percent E. U. in the resultant heavy fractions was then determined by beta-gamma count with laboratory instruments.

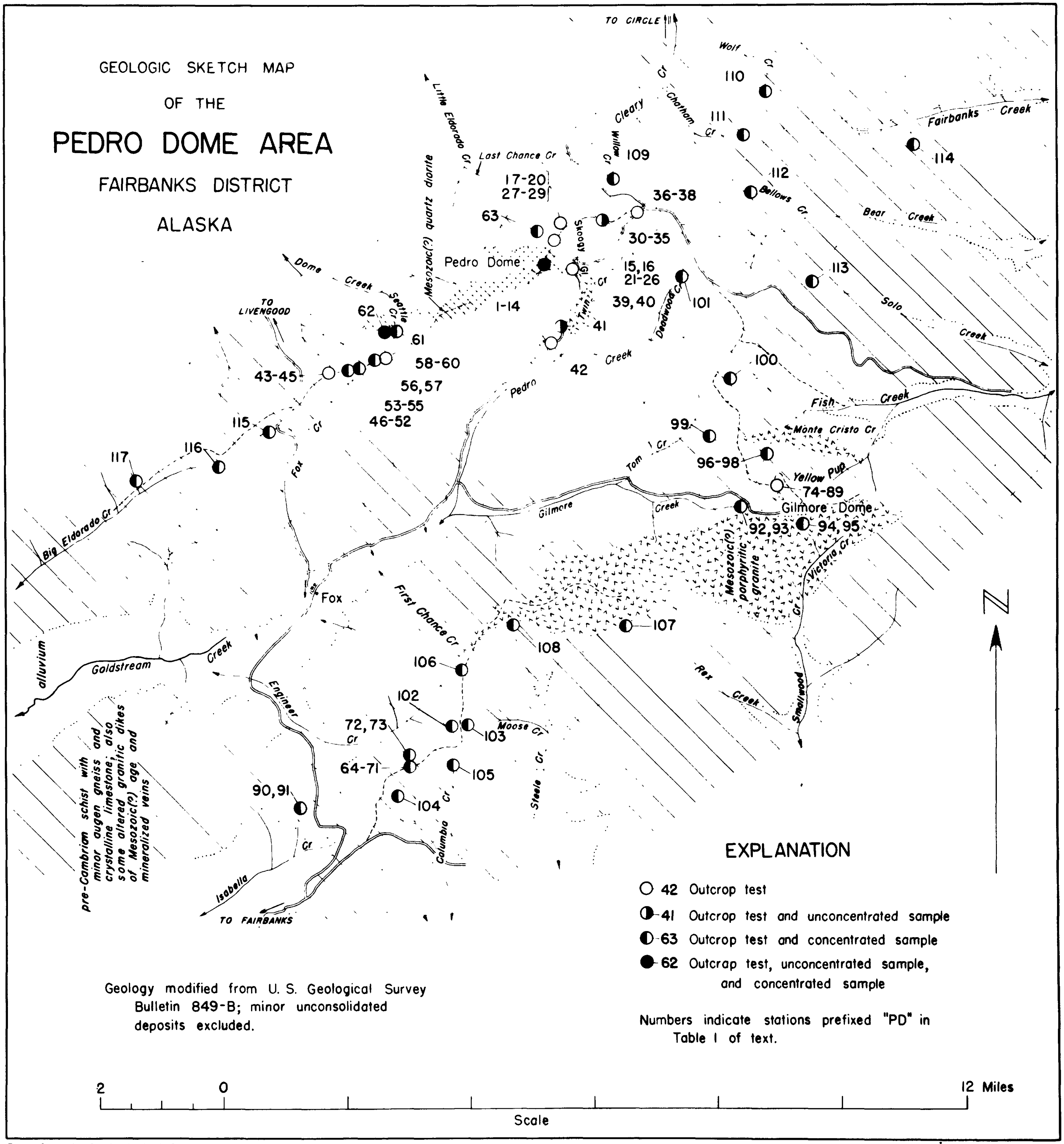
AREAS INVESTIGATED

Fairbanks district

The Fairbanks district, herein divided into the Pedro Dome area (see figs. 1 and 3) and the Ester Dome area (see figs. 1 and 4), includes about 300 square miles of territory adjacent to the city of Fairbanks.

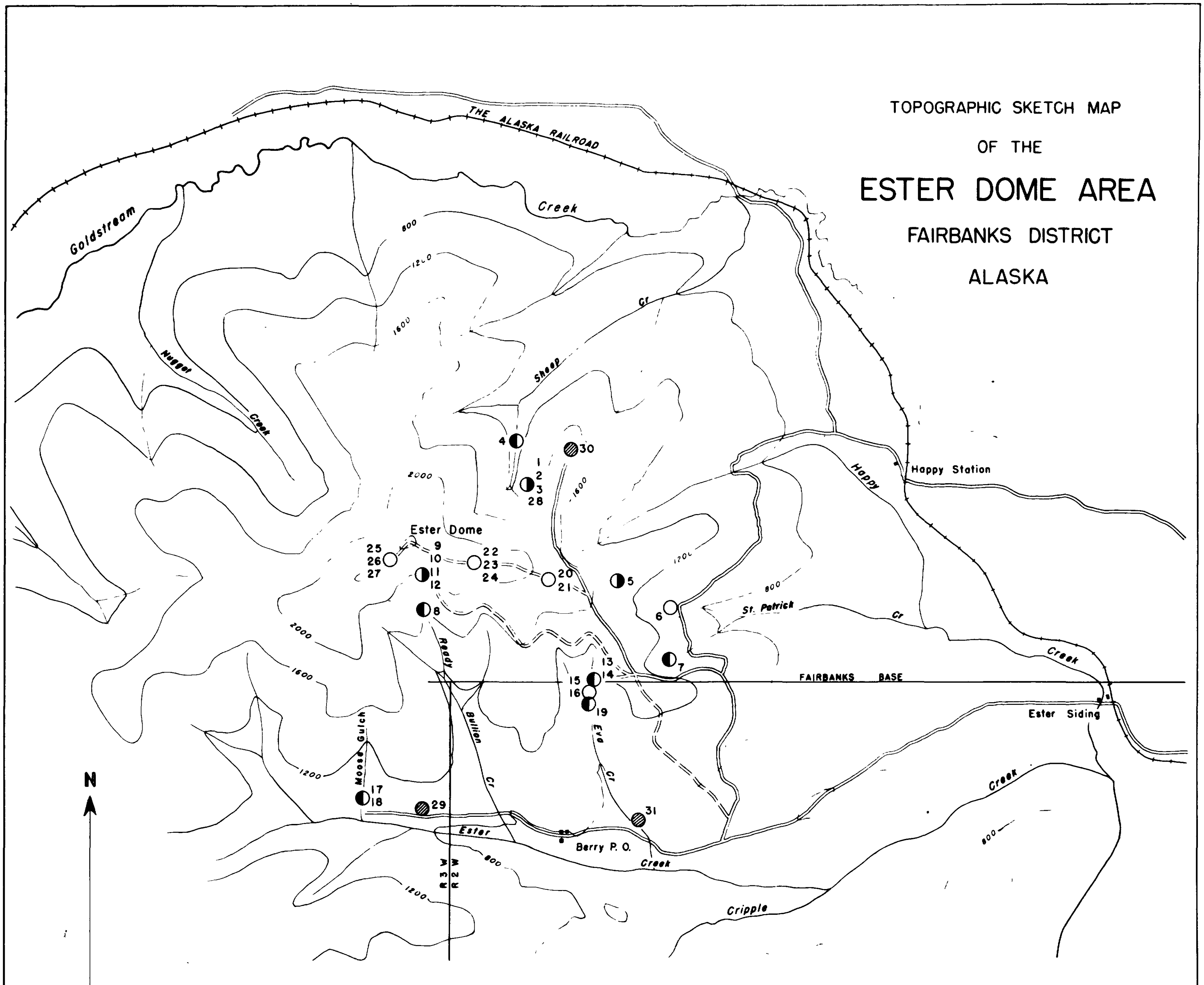
The Pedro Dome area, between 5 and 25 miles northeast of Fairbanks, roughly includes the watersheds of the streams draining the area surrounding Pedro Dome and Gilmore Dome. The main streams are: Cleary, Little Eldorado, Dome, and Vault Creeks, north-flowing tributaries of the Chatanika River; Goldstream Creek and its west-flowing tributary, Big Eldorado Creek; and Fairbanks, Fish, and Smallwood Creeks, tributaries of the Little Chena River. Mining camps now are located in most of the major valleys, and many of the smaller streams were mined in the past. The Steese Highway, traversing the area in a general northeasterly direction, has its origin at Fairbanks and leaves the area shown in figure 3 via the valley of Cleary Creek. The Elliott Highway, or Livengood Road, diverges from the Steese Highway at the little settlement of Fox. Numerous secondary roads and trails lead from the main highways to sites of both past and present mining operations.

The Ester Dome area, 10 to 15 miles west of Fairbanks, is drained by tributaries of Goldstream Creek on the northwest and by tributaries of Cripple Creek on the southeast. The area can be reached by a modern gravel road from Fairbanks, and numerous secondary roads and trails branch out to both lode and placer mining operations. A small settlement, Berry P. O., located on Ester Creek, is the center of the dredging operations of the Fairbanks Exploration Department, United States



Base from U. S. Geological Survey Alaska Map 40.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, June-July 1946.



EXPLANATION

Outcrop test

Unconcentrated sample

Outcrop test and concentrated sample

Outcrop test and unconcentrated sample

Numbers indicate stations prefixed "ED" in Table I of text

1 0 5 Miles

Scale

Base from U. S. Geological Survey Alaska Map 40.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, June-July 1946.

Smelting, Refining, and Mining Company in the Ester Dome area.

Geology: The general geology of the Fairbanks district is relatively well known as a result of studies of its gold-bearing placers and lodes. _/

_/ Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, 89 pp., 1905.

Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 337, 102 pp., 1908.

Prindle, L. M., Auriferous quartz veins in the Fairbanks district (Alaska): U. S. Geol. Survey Bull. 442-F, pp. 210-229, 1910.

Ellsworth, C. E., Placer mining in the Yukon-Tanana region (Alaska): U. S. Geol. Survey Bull. 442-F, pp. 230-245, 1910.

Prindle, L. M., Katz, F. J., and Smith, P. S., A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith: U. S. Geol. Survey Bull. 525, 220 pp., 1913.

Hill, J. M., Lode deposits of the Fairbanks district, Alaska: U. S. Geol. Survey Bull. 849-B, pp. 29-163, 1933.

Mertie, J. B., Jr., The Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 872, 276 pp., 1937

Capps, S. R., Geology of the Alaska Railroad region: U. S. Geol. Survey Bull. 907, 201 pp., 1940.

The Birch Creek schist of pre-Cambrian age is the bedrock underlying the larger part of the district. The schist is predominantly of sedimentary origin and has a considerable range of composition. The chief types, however, are quartz-mica and quartzite schist. Minor amounts of augen gneiss and crystalline limestone are also present. Igneous rocks of two main types intrude the Birch Creek schist. One is a quartz diorite, well exposed on Pedro Dome; the other is coarse-grained porphyritic granite underlying a large area south and southwest of Gilmore Dome. In the vicinity of Ester Dome only a few small bodies of porphyritic granitic rocks have been reported. Minor types of igneous rocks are represented by altered granitic dikes which are numerous but scattered. All the igneous rocks are presumably Mesozoic in age. Known lode deposits in the Gilmore Dome watershed are largely gold quartz veins, bismuth veins, and tungsten veins and replacements, all for the most part closely associated with the large intrusive mass of granite near Gilmore Dome. Extensive muck and gold-bearing gravel deposits cover most of the valley bottoms and lower hill slopes. Barren windrows of dredge tailings are now conspicuous as a result of placer mining in the valley bottoms of Goldstream, Gilmore, Pedro, Fish, Fairbanks, Cleary, and Ester Creeks. Slope wash and a heavy moss cover make natural rock exposures on the hills a rarity, except locally at the crests, where various weathering agencies have sculptured the bedrock into odd castellated shapes.

Radioactivity studies in the Pedro Dome area: Previous radiometric determinations on placer concentrates, obtained chiefly from gold mining operations, showed that some radioactive material occurs in the Pedro Dome area. Seven of the concentrate samples had more than 0.01 percent E. U. The creeks from which these better concentrates were obtained, and the determinations of E. U. in the concentrates, are as follows:

Alaskan Concentrate File No.	Creek	Percent equivalent uranium A 1/	B 2/
355	Fish Creek	0.100 3/	0.016
628	Yellow Pup	0.028	0.004
109	Gilmore Creek	0.013	0.004
965	First Chance Creek	0.029	
648c	Seattle Pup	0.096 3/	0.024
163	Cleary Creek	0.013	0.018
989	Specific locality unknown	0.014	

1/ determinations made about January 1945
2/ redetermined in April 1947
3/ indicates sample considered too small for accurate determination

The first four streams in the above tabulation are parts of the watershed that surrounds Gilmore Dome. (See fig. 3.) Cleary Creek and Seattle Pup are part of the watershed that surrounds Pedro Dome.

The recent testing in the Pedro Dome area indicated no appreciable amount of radioactivity except for two samples as follows:

1) Sample 1398

Location: Station PD 107, near head of Rex Creek.
Nature of sample: Bromoform concentrate from 50 pounds of gravel.
E. U. content: 0.066 percent.
Comparative data: outcrop test, 0.001 percent E. U.

2) Sample 1538L
Location: Station PD 41, along west side of the Steese Highway in the valley of Twin Creek about six miles northeast of Fox.

Nature of sample: Bromoform concentrate from crushed vein material on dump of abandoned scheelite mine.
E. U. content: 0.013 percent.
Comparative data: outcrop test, 0.001 percent E. U.; unconcentrated crushed sample, 0.002 percent E. U.

The radiometric data of the remaining tests in the Pedro Dome area may be summarized as follows:

1) Outcrop tests (115 stations)
   Maximum E. U. content: 0.003 percent.
   Average E. U. content: 0.001 percent

2) Unconcentrated crushed rock samples (4 samples)
   Maximum E. U. content: 0.003 percent.
   Average E. U. content: 0.002 percent.

3) Concentrated samples (35 samples)
   Maximum E. U. content: 0.006 percent.
   Average E. U. content: 0.0025 percent.

Zircon, some of which may be uranium- or thorium-bearing, is the only mineral, as yet identified in the concentrates of the Pedro Dome area, to which radioactivity can be ascribed. Thus, in most of the samples, the presence of radioactive zircon could account for the small increases in E. U. content when the heavy minerals are concentrated. It appears likely, however, that some other mineral or minerals are responsible for the E. U. values, greater than 0.01 percent, mentioned above.

The concentrate from Fish Creek (sample 355) consists of a few small nuggets obtained from a placer operation about 2½ miles northeast of Gilmore Dome. Although the original radiometric determination made in 1945 indicated 0.1 percent E. U., a second test in 1947 showed only 0.016 percent E. U. A qualitative spectrographic examination of one of the nuggets show that the major elements are bismuth and silicon with the bismuth preponderant. The nuggets, therefore, are probably mostly native bismuth with some eulytite or agricolite possibly present. The gold, listed among the minor elements in the examination, occurs as fine flakes and wires.

Uranium and thorium are listed among those elements looked for but not found. One bismuth lode is known to occur in the Fish Creek watershed above the location of this concentrate. _/ The lode is in a biotite

_/ Chapin, Theodore, Lode mining near Fairbanks (Alaska): U. S. Geol. Survey Bull. 592, pp. 330-331, 1914.

granite on the spur along the east side of Monte Cristo Creek. This lode was not investigated in the brief reconnaissance of the lodes in the Pedro Dome area, nor were concentrates taken downstream from it. Inasmuch as bismuth minerals are found associated with some types of radioactive mineral deposits_/, it is recommended that the source of the radioactive

_/ Bastin, E. S., and Hill, J. M., Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder counties, Colorado: U. S. Geol. Survey Prof. Paper 94, Chap. 8, Uranium ores, pp. 121-125, 1917.

Kidd, D. F., and Haycock, M. H., Mineragraphy of the ores of Great Bear Lake: Geol. Soc. American Bull., vol. 46, no. 6, pp. 879-960, 1935.

Fish Creek concentrate be sought in the watershed involved. Particular emphasis should be placed on the bismuth lode already known.

It is recommended, also, that additional work be done in the vicinity of the stations on Rex Creek and Twin Creek where the somewhat radioactive samples of 1946 were obtained. The field work, however, should be preceded by more mineralogical work in the laboratory.

Radioactivity studies in the Ester Dome area: Five placer concentrates from the Ester Dome area that had been tested for radioactivity prior to the field season of 1946 ranged from 0.000 - 0.002 percent E. U. Although such values are extremely low, the coverage represented by only five samples was so scant that it seemed desirable to test at least a few of the known lodes and collect a few additional placer concentrates from the area. The locations of the tests are shown on figure 4, and the results are included in table 1.

Structural conditions have limited the best metallic mineralization to the southeast flank of Ester Dome, and, therefore, both placer and lode mining activities have been restricted to this flank. Consequently, tests for radioactivity were similarly localized.

Many of the mines and prospects in the Ester Dome area have long since been abandoned, and adits have collapsed and been overgrown. of necessity, therefore, the testing of lodes has been restricted to ore materials scattered through the mine dumps. All of the known lodes are of the gold-quartz variety, and carry, in addition to free gold, varying amounts of primary sulphides. Arsenopyrite and stibnite form the bulk of these sulphides, but minor amounts of boulangerite, jamesonite, and covellite have been reported. _/ Weathered parts of the veins examined are much

_/ Hill, J. M., op. cit. (Bull. 849-B), pp. 120-152.

stained with oxides of iron, manganese, antimony, and arsenic.

The determinations of E. U. in materials from this area ranged from 0.000 - 0.007 percent. The maximum value was obtained in a bromoform concentrate from a 50-pound sample of gravel from St. Patrick Creek (station ED 7, sample 1424). As in the Pedro Dome area, the slightly higher E. U. values in the concentrates as compared to the outcrop tests may be attributed to the proportional increase in radioactive zircon resultant from concentration.

Steese Highway belt
in the upper Chatanika Valley area

The portion of the Steese Highway midway between Fairbanks and Circle lies mainly in the upper Chatanika Valley, but extends northeast to the headwater portions of Beaver, Birch, and Preacher Creeks. (See figs. 1 and 5.) As considered in this report and shown on figure 5 the belt adjacent to the highway is about 60 miles long and 15 miles wide, and has an area of about 800 square miles. In general the topography consists of long, even-topped ridges with long, broad, lateral spurs separating wide, shallow valleys. The Steese Highway enters the valley of the Chatanika River at the mouth of Cleary Creek and follows the valley northeastward. At the head of McManus Creek the highway crosses the divide into the valley of Twelvemile Creek of the Birch Creek watershed. Short roads lead from the highway to the site of dredging operations on Home Creek, and to other, smaller placer mines on Deep and Sourdough Creeks. Most of the short trails that start from the highway are for access to the Fairbanks Exploration Company ditch. The upper Chatanika Valley area has few inhabitants, who are employed mainly in prospecting and mining, or in maintaining the Fairbanks Exploration Company ditch or the Steese Highway.

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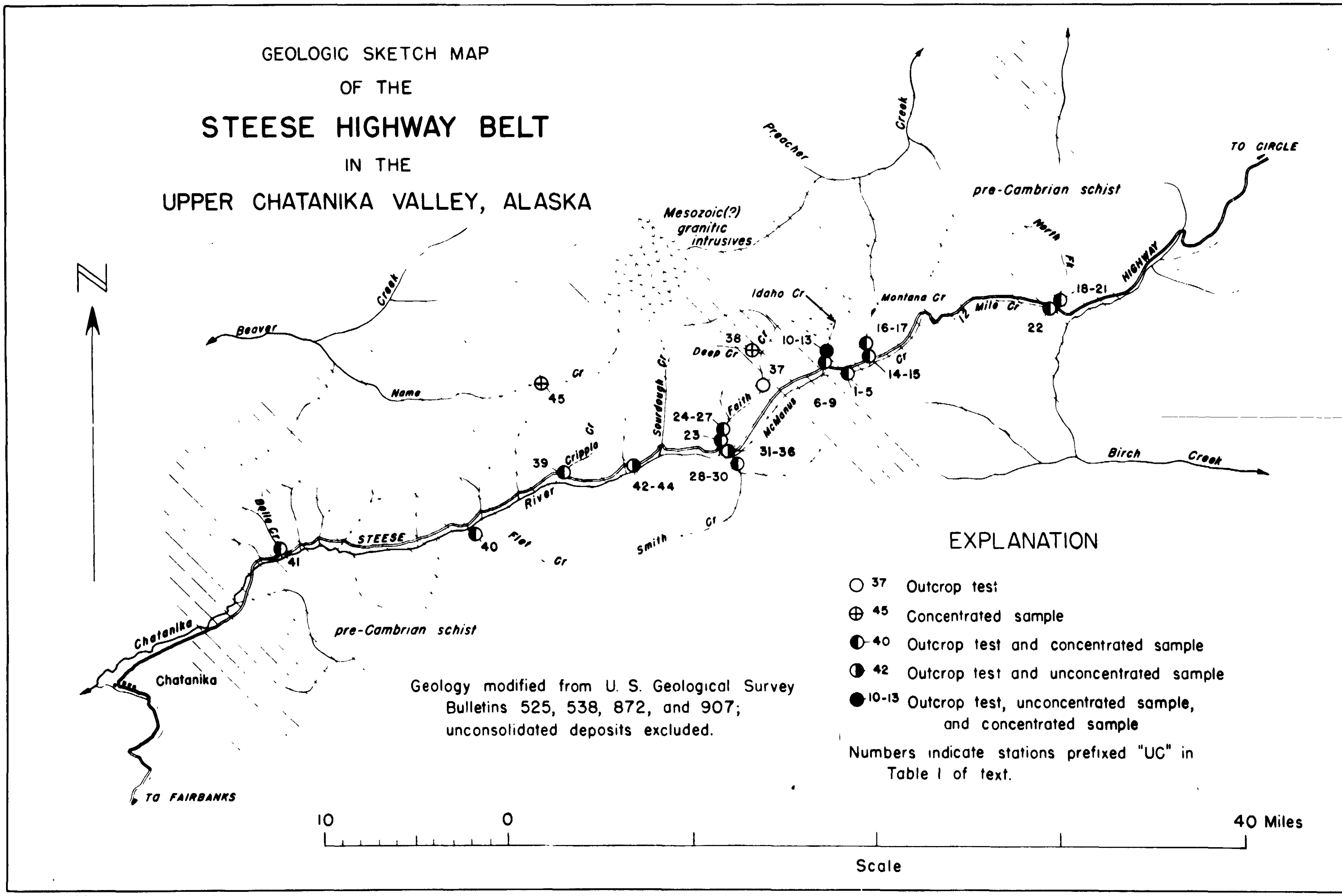
TRACE ELEMENTS INVESTIGATIONS REPORT NO. 38
FIGURE 5



Base modified from U. S. Geological Survey Alaska Maps 27, 38, and 39.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, July 1946.

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Geology: The geology of the upper Chatanika Valley is similar to that of the Fairbanks district. The Birch Creek schist (see p. 9) is again the major bedrock of the area. A large mass of intrusive granitic rock of Mesozoic(?) age crops out in the north-central part of the area in the headwater portions of Nome Creek, and tributaries of Faith and Preacher Creeks. Similar bodies of related igneous rocks are present at the head of Sourdough Creek and in the divide separating the Faith, Idaho, and Preacher Creek drainage areas. _/

_/ Prindle, L. M., Sketch of the geology of the northeastern part of the Fairbanks quadrangle (Alaska): U. S. Geol. Survey Bull. 442, pp. 203-209, 1910.

Prindle, L. M., Katz, F. J., and Smith, P. S., op. cit. (Bull. 525, pl. 8.

Prindle, L. M., A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, pl. 2, 1913.

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Radioactivity studies: Prior to the present examination of materials from the upper Chatanika Valley area, only seven placer concentrates, three from Sourdough Creek and four from Nome Creek, had been tested for radioactivity. Of the seven only a concentrate from Nome Creek has more than 0.01 percent E. U., and in this the E. U. is 0.026 percent.

The investigations in 1946 were restricted to tests of bedrock cropping out in road cuts and to tests of concentrates of gravels from streams in the immediate vicinity of the highway and secondary roads. The locations of the sites tested are shown on figure 5, and the results are included in table 1.

Several varieties of schist and granitic rocks were tested. The data of these tests may best be summarized as follows:

	Percent equivalent uranium A 1/	B 2/	C 3/
Granitic rocks			
Station UC 12, sample 1539L	0.005	0.004	0.017
19	0.001		
Graphitic schist			
Station UC 31, sample 1540L	0.003	0.001	0.003
32	0.003		
33	0.003		
42, sample 1542L	0.003	0.004	0.000
44	0.001		
Schist (other varieties)			
Station UC 13	0.001		
34	0.002		
35, sample 1541L	0.002	0.002	
43	0.000		

1/ A - outcrop tests
2/ B - tests of unconcentrated crushed rock samples
3/ C - tests of bromoform concentrates from crushed rock samples

The relatively higher values of E. U. in the granitic rocks (station UC 12, sample 1539L) is probably due to zircon which was identified in the concentrate.

A placer concentrate obtained from a dredge on Nome Creek was the only appreciably radioactive placer material from the upper Chatanika area tested in 1946. Even after further concentration by separation in methylene iodide, it contained only 0.012 percent E. U. Minerals of interest in this concentrate are relatively abundant topaz and cassiterite, and sparse tourmaline and monazite.

Although no significant amounts of radioactive materials were found in the Steese Highway area, areas of mineralization in and near the large granitic mass at the headwaters of Nome Creek should be examined at some future date.

Livengood area

The Livengood area (see figs. 1 and 6), as considered in this report, consists of an area about 10 miles square. The town of Livengood, the only settlement in the area and the northern terminus of the Elliott Highway, is 71 miles from Fox on the Steese Highway and 82 miles from Fairbanks. The Livengood area is part of the Yukon-Tanana upland and is characterized by broad, even-topped ridges from which long, gently sloping spurs descend to the valley floors. The area is drained by Livengood Creek and the Tolovana River of the Tanana drainage basin, and by tributaries of the South Fork of Hess Creek, which in turn is tributary to the Yukon River. Dredging operations of Livengood Placers, Inc., and several large scale open-cut, hydraulic operations reworking claims formerly mined only by underground methods are the principal mining activities in the area.

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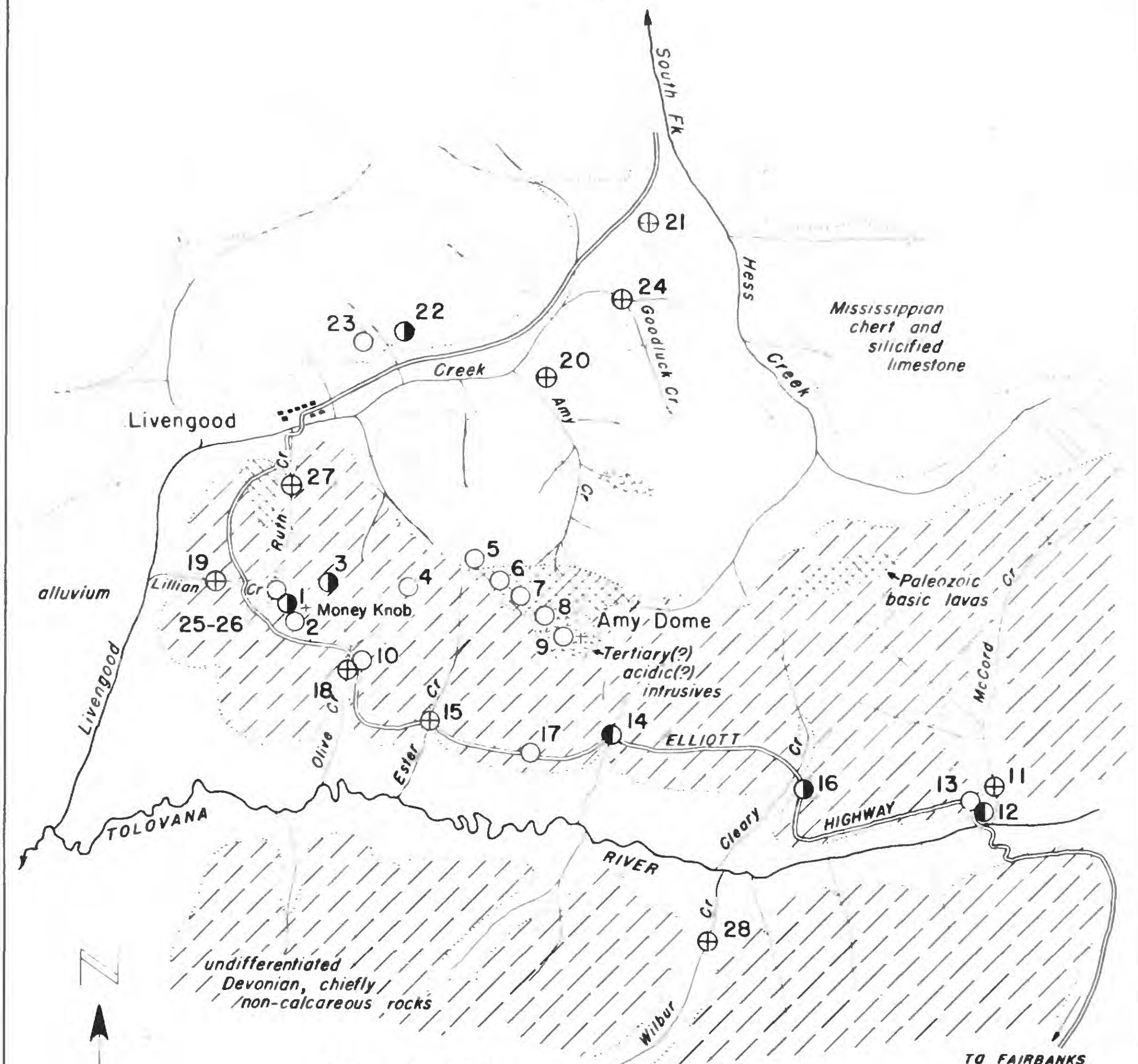
FIGURE 6

GEOLOGIC SKETCH MAP OF THE LIVENGOOD AREA ALASKA



EXPLANATION

- ○ 13 Outcrop test
- ⊕ 15 Concentrated sample
- ◐ 14 Outcrop test and concentrated sample
- ◑ 16 Outcrop test and unconcentrated sample

Numbers indicate stations prefixed "L" in Table I of text.

Geology modified from U. S. Geological Survey Bulletins 662-D, 872, and 907.

2 0 8 Miles

Scale

Base from U. S. Geological Survey Alaska Map 27.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, August 1946.

Geology: The geology of the Livengood area has been discussed in some detail elsewhere. _/ In general the sedimentary rocks of the area

_/ Brooks, A. H., Preliminary report on the Tolovana district (Alaska): U. S. Geol. Survey Bull. 642, pp. 201-209, 1916.

Mertie, J. B., Jr., The gold placers of the Tolovana district, Alaska: U. S. Geol. Survey Bull. 662-D, pp. 221-277, 1917.

Overbeck, R. M., Placer mining in the Tolovana district (Alaska): U. S. Geol. Survey Bull. 712, pp. 177-184, 1920.

Mertie, J. B., Jr., The Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 872, 276 pp., 1937.

Capps, S. R., Geology of the Alaska Railroad region: U. S. Geol. Survey Bull. 907, 201 pp., 1940.

are mapped as two units. An older, undifferentiated, chiefly non-calcareous Devonian sequence lies to the south of Amy Dome, and younger chert and silicified limestone of Mississippian age lie to the north of the dome. (See fig. 6.) Paleozoic basic igneous rocks, thought to be both extrusive and intrusive, are closely associated with both age groups of the consolidated sediments. Tertiary(?) granitoid rocks, predominantly felsic, intrude the older rocks in the vicinity of Amy Dome. Mineralization and metamorphic effects attributed to these later intrusives are clearly seen along the divide between Livengood Creek and the Tolovana River, and on the flanks of Amy Dome.

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Radioactivity studies: Previous tests of 30 placer concentrates from the Livengood area indicated amounts of radioactivity of less than 0.01 percent E. U., except in a concentrate from Goodluck Creek which contains from 0.031 - 0.048 percent E. U. Although a cursory examination of this concentrate prior to the beginning of the field season of 1946 failed to reveal any mineral to which the radioactivity could be ascribed, more detailed study later indicated that the activity is due to a black, pitchy-appearing, highly radioactive mineral with a conchoidal fracture.

Despite the apparently unpromising initial information, some field work appeared warranted for the purpose of completing coverage of the placers of the area in an attempt to obtain other radioactive concentrates, and for testing a few of the sedimentary and igneous rocks and the attendant lode mineralization. The locations of these concentrates and outcrop tests are shown on figure 6, and the results are included in table 1.

A concentrate donated by a placer operator on Ruth Creek (station L 27) was the only placer concentrate obtained in 1946 that contains as much as 0.01 percent E. U. Sedimentary and igneous rocks, for the most part, contain less than 0.001 percent E. U. by tests at the outcrop. Some black shale contains 0.002 percent E. U. and weathered granite 0.003 percent E. U. Results of various radiometric tests made in 1946 on the most radioactive materials found in the Livengood area may be summarized best as follows:

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Material tested	Percent equivalent uranium A 1/	B 2/	C 3/
Sluice concentrate			
Station L 27, sample 1446	-	-	0.010 0.009 4/
Panned concentrate			
Station L 19, sample 1454	-	-	0.004
Black shale			
Station L 16a, sample 1553L	0.002	0.002	0.006
Weathered granite			
Station L 3b, sample 1543L	0.003	0.005	0.003

1/ A - outcrop tests
2/ B - tests of unconcentrated crushed rock samples
3/ C - tests of bromoform concentrates
4/ tests of methylene iodide concentrate

Mineralogical examination of the sluice concentrate listed above indicates that the radioactivity is due to uranium- or thorium-bearing zircon, although a few grains of monazite also are present.

No further search for radioactive material in the Livengood area is recommended for the immediate future. However, at some later date, a more thorough search should be made for the source of the highly radioactive mineral in the sample from Goodluck Creek. Later, more detailed study of the Paleozoic black shale strata may also be warranted.

Harding Lake-Richardson area

The Harding Lake-Richardson area (see figs. 1 and 7), about 50 miles southeast of Fairbanks, is on the northeast side of the Tanana River between the lower courses of the Salcha River and Shaw Creek. The Richardson Highway traverses the area roughly parallel to the course of the Tanana River. Small settlements are located at Richardson, and at Birch and Harding Lakes. The area shown in figure 7 is approximately 400 square miles, but only a small fraction of this is easily accessible from the highway. Placer gold was first mined in this area in the early 1900's, chiefly in the valleys of Tenderfoot, Buckeye, and Banner Creeks, and in the headwater tributaries of Redmond Creek. Only one placer mine, located on claim 13 below on Tenderfoot Creek, was being worked in 1946.

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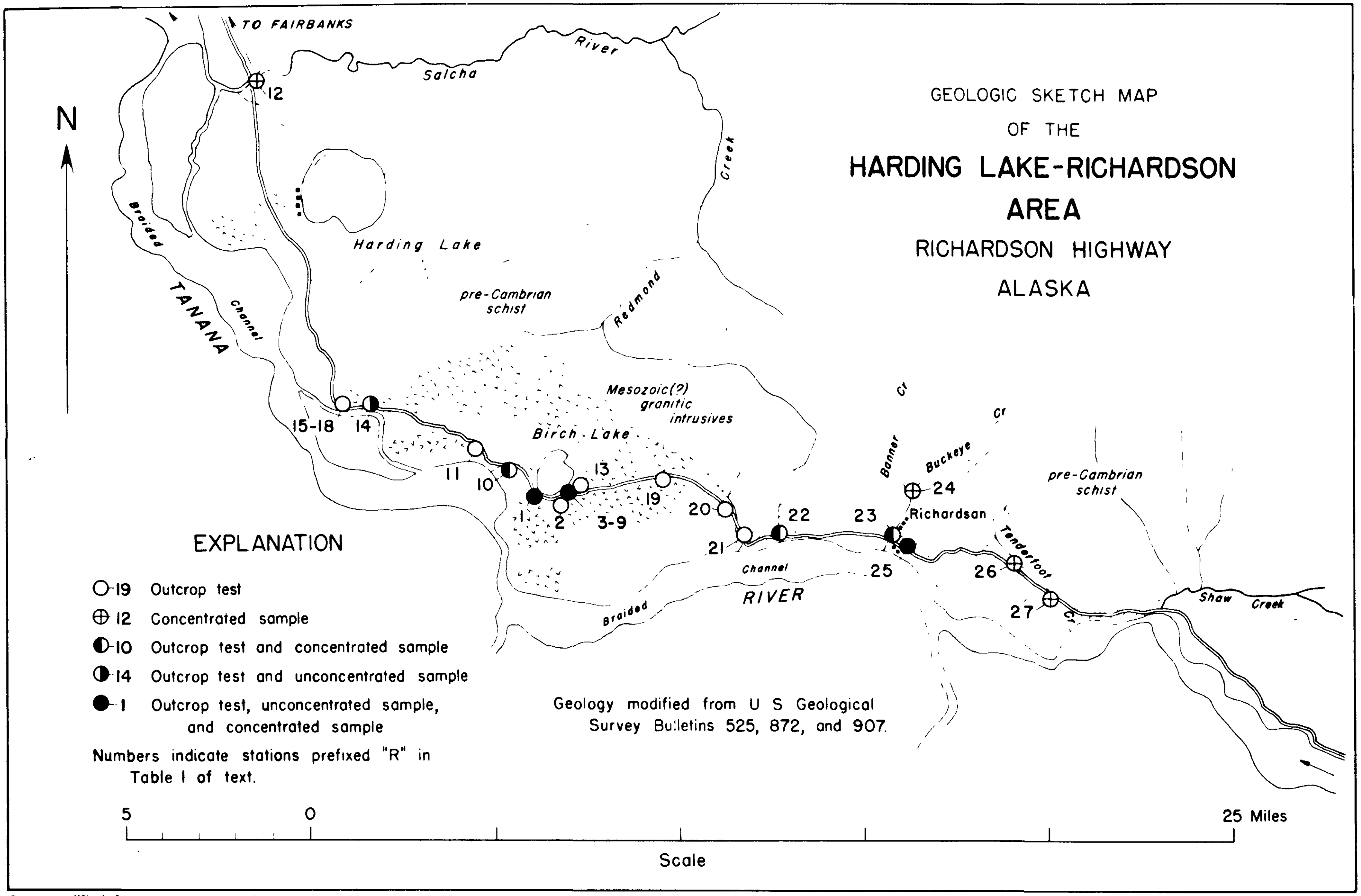
FIGURE 7



Base modified from U. S. Gealagical Survey Alaska Maps 27, 39, and 49.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, August 1946.

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<u>Geology</u>: Pre-Cambrian Birch Creek schist and Mesozoic(?) granitic rocks form the bedrock of the Harding Lake-Richardson area. _/ The

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_/ Prindle, L. M., Katz, F. J., and Smith, P. S., op. cit. (Bull. 525), pp. 35, 36, 52, 53, 140-142, pl. 8.

Mertie, J. B., Jr., op. cit. (Bull. 872), pp. 47-59, 210-215, pl. 1.

Capps, S. R., op. cit. (Bull. 907), pp. 134, 135, 145, 146, pl. 3.

Birch Creek schist in this area consists chiefly of micaceous and quartzitic schists, and intergradations between the two. Minor rock types in the Birch Creek are graphitic schist, crystalline limestone, and gneiss. Except for the gneiss, the Birch Creek is considered to be derived from sedimentary rocks. The gneiss is believed to be the metamorphic equivalent of pre-Cambrian intrusives. Quartz veins, in part gold-bearing, are associated with the schist.

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Radioactivity studies: The principal objectives of the investigations in the Harding Lake-Richard area were:

1) To test the radioactivity of the Mesozoic(?) granitic rocks and any attendant mineralization both at outcrops of bedrock and in concentrates obtained from stream gravels eroded from the intrusive masses and surrounding rocks.

2) To acquire concentrates from some of the streams formerly important as gold-producers, as this area was not previously represented in the Survey's file of Alaskan placer concentrates.

The locations of the outcrop tests and sites of samples are shown on figure 7, and the data obtained are included in table 1. A summary of the data on the most radioactive materials found in the Harding Lake-Richardson area follows:

Material tested	Percent equivalent uranium			
	A 1/	B 2/	C 3/	D 4/
Granitic rock, weathered:				
Station R 1a, sample 1459L	0.006	0.004	-	0.009
Granitic(?) dike, light-colored, fine-grained, weathered:				
Station R 4a, sample 1460L	0.005	0.002	0.060	0.110
Station R 13b, no sample	0.005	-	-	-
Granitic dike, coarse-grained:				
Station R 14a, sample 1556L	0.005	0.004	0.005	-
Graphitic schist:				
Station R 25b, sample 1557L	0.002	0.001	0.005	-
Stream and bench gravels:				
Station R 23, sample 1464	0.001	-	-	0.008
Station R 24, sample 1465	-	-	-	0.020 5/
Station R 25a, sample 1466	0.000	-	-	0.009

1/ A - tests at the outcrop
2/ B - tests of unconcentrated crushed rock samples
3/ C - tests of bromoform concentrates from crushed rock samples
4/ D - tests of panned concentrates from 100-pound samples of unconsolidated material subsequently reconcentrated with bromoform
5/ methylene iodide used for final concentration instead of bromoform

The radioactivity of the granite may be due to the presence of zircon and allanite(?) which were identified in a preliminary study of the concentrates. Scheelite is also present. Minerals of interest in the concentrate from Buckeye Creek (station R 24, sample no. 1465) are scheelite, tourmaline, rutile, zircon(?), titanite(?), cassiterite(?), and galena.

It is recommended that additional concentrates from Buckeye and Banner Creeks, and the as yet untested headwater tributaries of Redmond Creek be obtained and tested for radioactivity. Igneous rocks, particularly the acidic types, and associated mineralization should be sought in these watersheds and also checked for radioactivity. Study of the granitic intrusives along the highway should be continued, particularly in the vicinity of Birch Lake.

The Alaska Highway belt

The Alaska Highway belt (see figs. 1 and 8) consists of a long narrow area along the highway from Big Delta to the Canadian boundary, and is entirely within the drainage basin of the Tanana River. The highway is southwest of the river from Big Delta to a point a few miles east of Tok Junction; there it crosses the Tanana River and follows successively the northeast banks of the Chisana River and Scottie Creek to the boundary. The major settlements on the highway are Big Delta, Tanacross, and Tok Junction; and Northway is just south of the highway near the mough of the Nabesna River. Also, a few small native villages are scattered along the river banks.

Geology: The geology of the area now crossed by the Alaska Highway (see fig. 8) has been partly described and mapped by Mertie _/, Moffitt _/,

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_/ Mertie, J. B., Jr., The Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 872, 276 pp., 1937.

_/ Moffit, F. H., Geology of the Gerstle River district, Alaska: U. S. Geol. Survey Bull 926-B, pp. 107-160, 1942.

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and Van Alstine and Black _/. Some of this previous work, however, was

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_/ Van Alstine, R. E., and Black, R. F., Geology of the Alaska military highway from the International Boundary to Big Delta, Alaska: U. S. Geol. Survey, unpublished report, 1944; manuscript and maps in the Alaskan Section files.

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revised and extended in 1946 during the trace elements reconnaissance.

Mesozoic(?) granitic intrusives constitute the bulk of the bedrock exposed in the highway belt. These intrusives apparently cut pre-Cambrian or early Paleozoic schists and gneisses which are similar to and probably the equivalent of, the Birch Creek schist of the Yukon-Tanana upland.

Radioactivity studies: The reconnaissance investigation of radioactivity in the Alaska Highway belt in 1946 was devoted chiefly to the Mesozoic(?) granitic rocks. For convenience in discussion the area is divided into two parts:

1) Localities northwest of Tok Junction (stations AH 1 - AH 15).

2) Localities southeast of Tok Junction (stations AH 16 - AH 41).

The data are included in table 1.

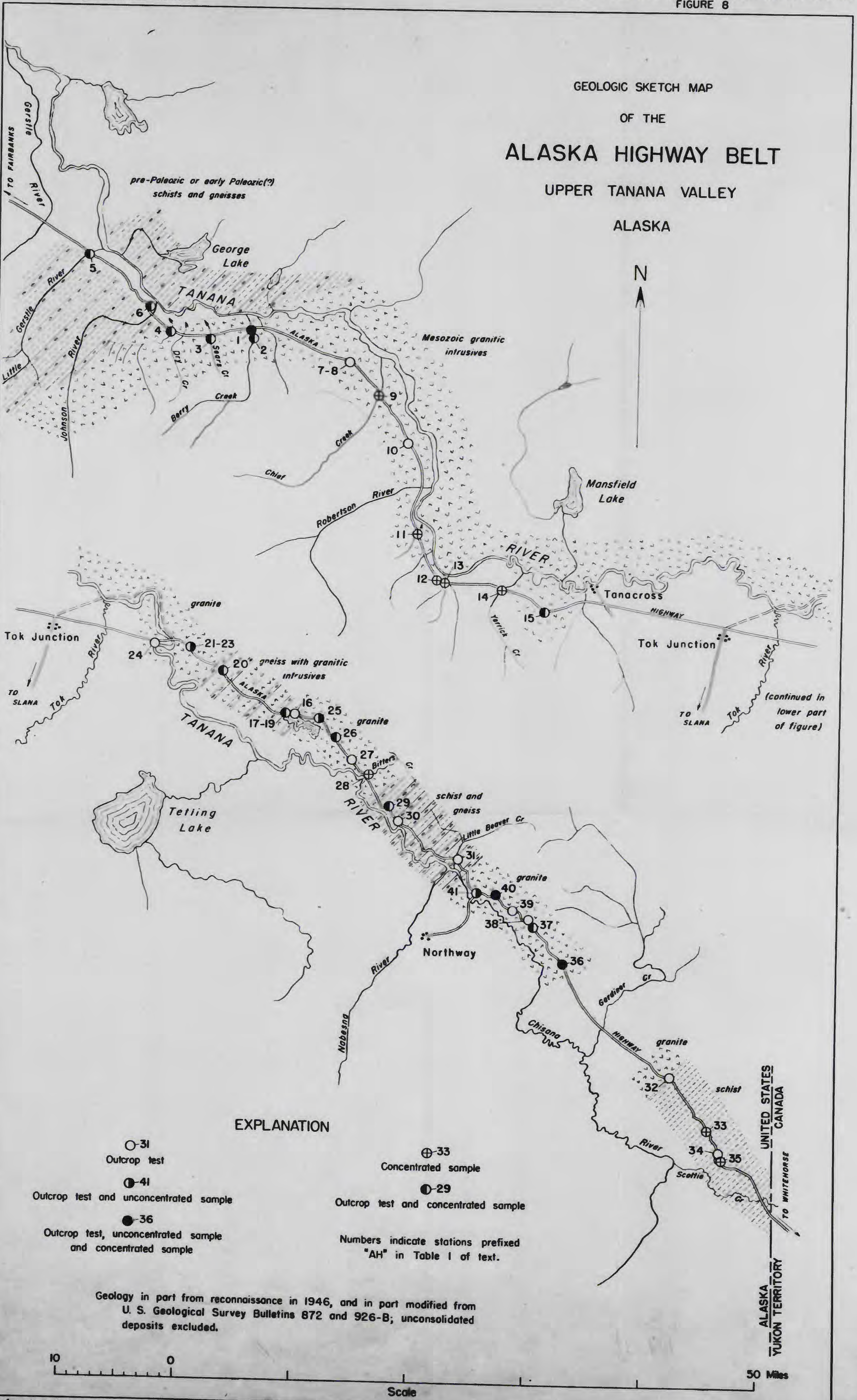
Localities northwest of Tok Junction: The radiometric data on the most radioactive materials from localities northwest of Tok Junction are summarized as follows:

Material tested	Percent E. U. A 1/	Percent E. U. B 2/
Granite, coarse-grained, weathered:		
Station AH 15b, sample 1480L	0.004	0.008 3/
Stream and bench gravels:		
Station AH 1a, sample 1469	0.002	0.014 3/
Station AH 2, sample 1470	0.002	0.011 4/
Station AH 4, sample 1472	0.002	0.008 4/

1/ A - tests at the outcrop
2/ B - tests of concentrates panned from 100-pound samples of gravel
3/ final concentration made with methylene iodide
4/ final concentration made with bromoform

A preliminary study of the mineralogy of the concentrates indicates the presence of minor amounts of zircon, a mineral which may be radioactive. All the gravels listed in the above tabulation are from streams draining areas underlain by granitic rocks.

Localities southeast of Tok Junction: The radiometric data on the most radioactive materials from localities southeast of Tok Junction are summarized as follows:



Base from U. S. Geological Survey Alaska Maps 49 and 52

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, August 1946.

Materials tested	Percent equivalent uranium A 1/	B 2/	C 3/	D 4/
Granite, coarse-grained, weathered:				
Station AH 40, sample 1490L and sample 1547L	0.004	0.001	0.013	0.074
Station AH 17a, sample 1481L	0.005	-	-	0.064
Station AH 37, sample 1489L	0.004	-	-	0.027 5/
Station AH 26, sample 1483L	0.003	-	-	0.025
Station AH 36b, samples 1488L and 1546L	0.004	0.000	0.023	0.010
Felsitic(?) dike, weathered:				
Station AH 31b, sample 1662L	0.003	0.003	0.010	-

1/ A - tests at the outcrop
2/ B - tests of unconcentrated crushed rock samples
3/ C - tests of bromoform concentrates from crushed rock samples
4/ D - tests of panned concentrates from 100-pound samples of unconsolidated material subsequently reconcentrated with methylene iodide
5/ bromoform used for final concentration instead of methylene iodide

Subsequently, sample numbers 1481L and 1490L in the above tabulation were concentrated further by removing a magnetic fraction with an Alnico hand magnet. The content of E. U. in the resultant non-magnetic fractions of these two samples was then determined to be 0.65 and 0.89 percent, respectively.

Preliminary mineralogical studies of the concentrates from the granitic rocks show the presence of zircon in all samples from the five localities, usually in large amount. Although it is presumed that the concentration of the zircon is to a large extent responsible for the increased radioactivity of the concentrates, other Alaskan Trace Elements studies _/ have shown that the E. U. in pure zircon fractions of concen-

_/ Moxham, R. M., and West, W. S., Trace elements investigations in the Serpentine-Kougarok area, Seward Peninsula, Alaska: U. S. Geol. Survey Trace Elements Investigations Rept. 39, unpublished, manuscript in preparation.

~~FOR OFFICIAL USE ONLY~~

White, M. G., Trace elements investigation in the vicinity of Flat, Alaska: U. S. Geol. Survey Trace Elements Investigations Rept. 46, unpublished, manuscript in preparation.

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trates was found to range only from 0.1 to 0.15 percent. Hence, zircon alone probably cannot account for the total radioactivity in samples 1481L and 1490L mentioned above. Allanite, another mineral which at other places is uranium- and thorium-bearing, has been identified also in these two concentrates (samples 1481L and 1490L) as well as in a third (sample 1483L). It too is deemed insufficiently radioactive to be the major source of the radioactivity in the samples. Therefore, it is likely that other, as yet unidentified, more highly radioactive minerals are present. Other heavy minerals of interest in the concentrates from the granitic rocks are epidote, tourmaline, and axinite(?).

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Further field study of the Mesozoic(?) granitic rocks in the Alaska Highway belt appears to be warranted, but not before additional mineralogical work is completed on the samples at hand. Emphasis in future work should be placed on the granite outcrop areas between stations AH 17 and AH 28 and between Little Beaver and Gardiner Creeks. (See fig. 8.) Field radioactivity studies with a high background, traverse-type counter would aid in determining whether the bulk of the radioactive material associated with the granitic rocks occurs in widely disseminated accessory minerals or is limited to some possible vein system or facies of the granite.

Highway area between Slana and Tok Junction

The highway area between Slana and Tok Junction (see figs. 1 and 9) lies across the divide between the Copper River and Tanana River basins. This new road, about 70 miles long and known informally as the "Tok Cutoff", connects the Alaska Highway with the old Nabesna Road by way of Mentasta Pass (elevation approximately 2300 feet above sea level). Originally constructed by the Army Engineers of the Alaska Department, and more recently improved and maintained by the Alaska Road Commission, it opens up country formerly accessible only by pack train. The area is drained chiefly by the Tok River, a north-flowing tributary of the Tanana River, and by the Slana River, a south-flowing tributary of the Copper River. Only a few white inhabitants are in the area, and a small native village is located on the shore of Mentasta Lake.

Geology: The geology of the area between Slana and Tok Junction has been described by Moffit _/ in conjunction with surveys in the Copper

_/ Moffit, F. H., Geology of the Slana-Tok district, Alaska: U. S. Geol. Survey Bull. 904, 54 pp., 1938.

River basin. The bedrock of the Slana-Tok district is a part of the core of the Alaska Range which here has a northwesterly trend. Moffit _/ states:

_/ Moffit, F. H., op. cit. (Bull. 904), p. 1.

"The rocks of the district are prevailingly sedimentary but include tuff beds and lava flows and many masses of intruded granitic rocks, most of which are diorite and related types rather than granite. Some of these rocks are highly metamorphic. Others are greatly folded yet not notably altered. The structure is complex and not clearly understood. The rocks range in age from pre-Cambrian or early Paleozoic to late Mesozoic. In places they are concealed by Recent unconsolidated waterlaid and glacial deposits."

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FIGURE 9

GEOLOGIC SKETCH MAP

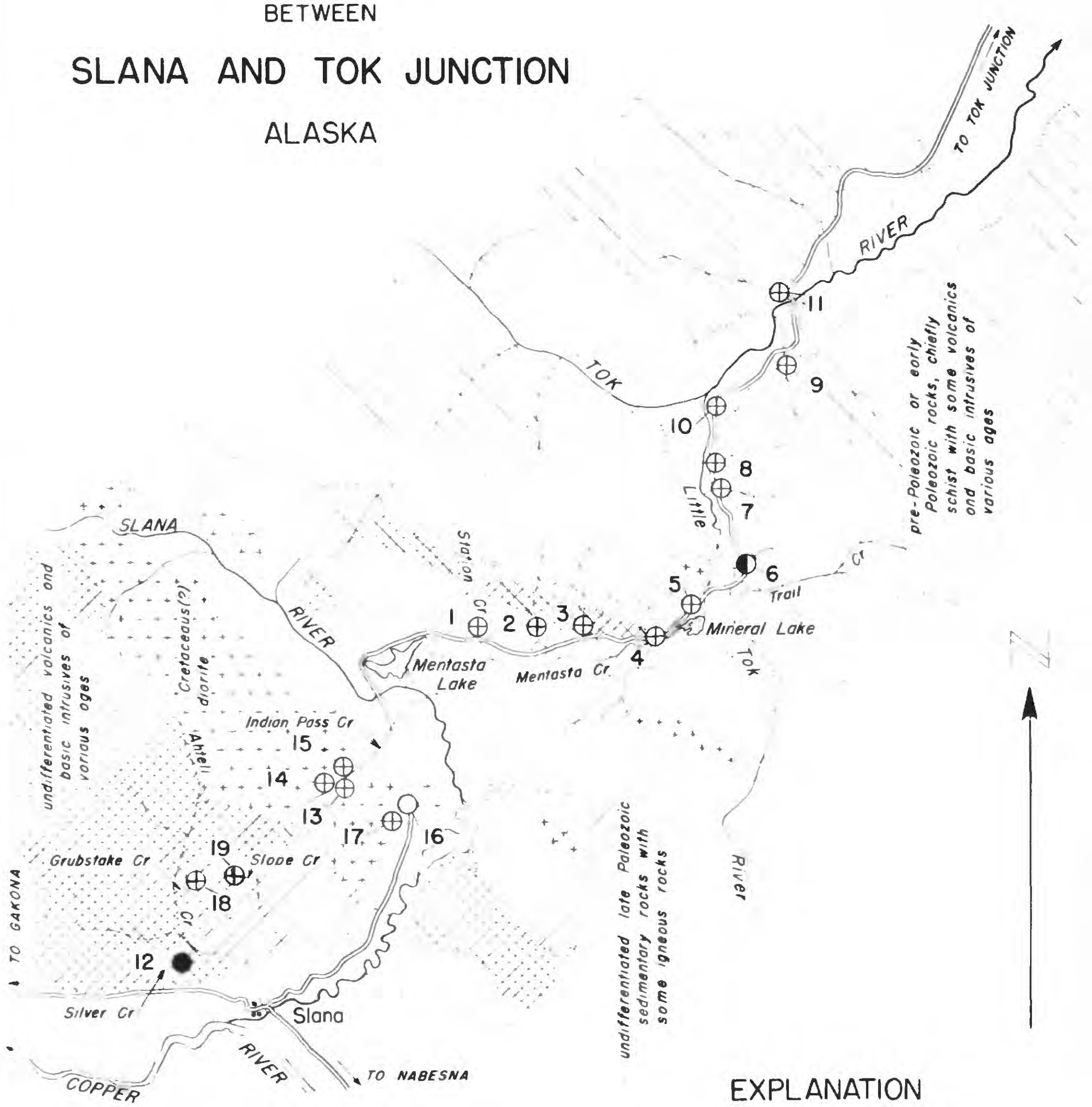
OF THE

HIGHWAY AREA

BETWEEN

SLANA AND TOK JUNCTION

ALASKA



EXPLANATION

○ 16 Outcrop test

⊕ 18 Concentrated sample

◐ 19 Outcrop test and concentrated sample

● 12 Outcrop test, unconcentrated sample, and concentrated sample

Numbers indicate stations prefixed "TC" in Table I of text.

Geology modified from U. S. Geological Survey Bulletin 904; minor unconsolidated deposits excluded.

10 0 30 Miles

Scale

Base from U. S. Geological Survey Alaska Map 48.

Trace elements field work by Helmuth Wedow, Jr., and J. J. Matzko, August-September 1946.

The distribution and age of the various rock types are shown on the geologic sketch map of the area. (See fig. 9.)

<u>Radioactivity studies</u>: Tests for radioactivity in the area along the Slana-Tok highway were made principally on concentrates from gravels in tributaries of the Slana and Tok rivers. The locations at which the concentrates were taken, as well as the few other tests on a lode deposit, are shown on figure 9. The data are included in table 1.

The values of E. U. in 20 concentrates from gravels in the Slana-Tok highway area range from 0.000 percent to 0.003 percent, and average 0.001 percent. A silver prospect _/ on Silver Creek, a small tributary of Ahtell Creek near Slana, was also tested for radioactivity. The mineralization consists of silver-bearing quartz veins in a fault zone. The country rock is chiefly medium-grained gray diorite and a dark basaltic-appearing rock that is probably igneous. The metallic minerals reported in the lode are the sulphides, sphalerite, pyrite, and galena, and the sulphantimonide, tetrahedrite. The silver is probably associated with the tetrahedrite. Tests on materials from the Silver Creek lode indicate that the radioactivity is less than 0.001 percent E. U. An unconcentrated crushed sample of the country rock near the lode (station TC 12c), however, shows 0.005 percent E. U., but the bromoform concentrate from this sample has only 0.001 percent E. U.

_/ Moffit, F. H., op. cit. (Bull. 904, pp. 46, 47.

Donnelly Dome-Paxson area

The Donnelly Dome-Paxson area, as considered in this report, is a narrow strip along the Richardson Highway about 70 miles in length between Donnelly Dome on the north and Paxson on the south. (See figs. 1 and 10) It is drained by the Delta River and its tributaries except at the most southerly end where it lies in the watershed of the Gulkana River, a tributary of the Copper River. Roadhouses are located at Rapids and Paxson.

Geology: The geology of the Donnelly Dome-Paxson area has been described in reports of broader regional scope. _/ The northern part of

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_/ Moffit, F. H., Headwater regions of the Gulkana and Susitna Rivers, Alaska: U. S. Geol. Survey Bull. 498, 82 pp., 1912.

Moffit, F. H., Geology of the Gerstle River district, Alaska: U. S. Geol. Survey Bull. 926-B, pp. 107-160, 1942.

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the area is underlain by schists and gneisses of pre-Paleozoic or early Paleozoic age, which in part may be equivalent to the Birch Creek schist of the Yukon-Tanana region. The southern part of the area, although covered to a considerable degree by unconsolidated glacial and glaciofluviatile deposits, is underlain by Carboniferous sedimentary rocks and lavas. Granitic rocks, considered to be pre-Tertiary in age, intrude the schists in the northeast corner of the area. Jurassic(?) intrusives of dioritic affinities are associated with the Carboniferous rocks in the southern part of the area. In the vicinity of Donnelly Dome and Jarvis Creek Tertiary coal-bearing sediments unconformably overlie portions of the metamorphic basement, and both are covered with a thin veneer of glacial debris.

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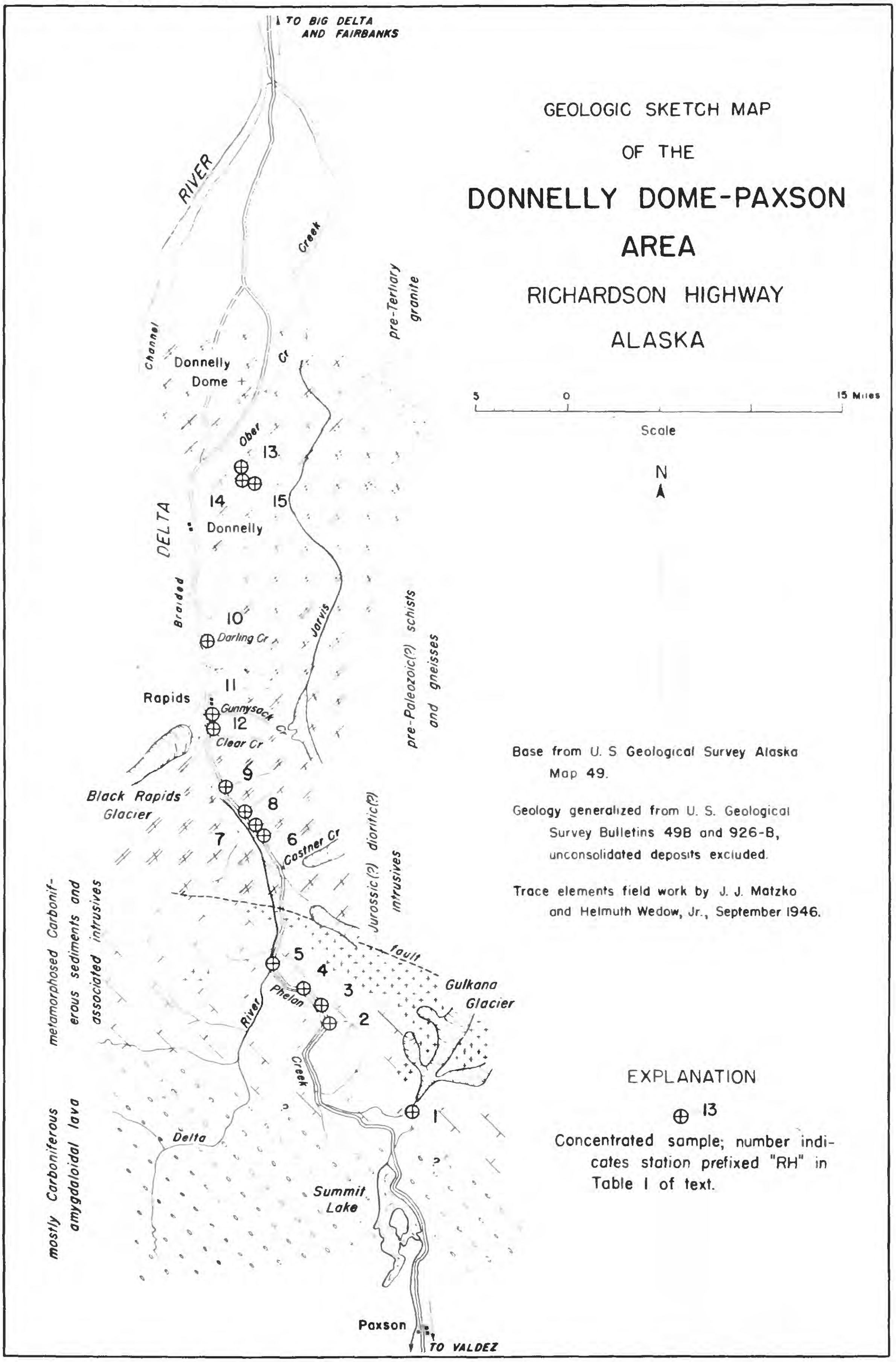
FIGURE 10



Prospecting for placer gold in the Donnelly Dome-Paxson area has been carried on intermittantly since about 1900. The most promising streams are Jarvis, Ober, and Macomber Creeks, although gravels of several other streams are known also to contain placer gold. Activity in 1946 was limited to prospecting of claims on Ober Creek by Chas. DeWitt, and to operations by the Yukon Corporation on the east bank of the Delta River about a quarter of a mile below the mouth of Phelan Creek.

Radioactivity studies: As only a few days were available toward the close of the 1946 field season for the investigation of the Donnelly Dome-Paxson area, the work consisted only of the procurement of concentrates from various stream gravels. No concentrates had been available for study prior to the 1946 field season. The stations at which the concentrates were obtained are plotted on figure 10, and the data are included in table 1.

The content of E. U. in 12 bromoform concentrates (stations RM 1-12) from stream gravels south of Donnelly (see fig. 10) ranges from 0.000 - 0.004 percent and averages about 0.002 percent. The E. U. content of four concentrates (stations RH 13-15) obtained from prospecting operations on Ober Creek ranges from 0.003 - 0.011 percent and averages about 0.006 percent. The radioactivity is apparently due to the presence of small quantities of monazite which was identified in the concentrates. Tourmaline, zircon, fluorite, and epidote also occur in the Ober Creek concentrates.

SUMMARY AND RECOMMENDATIONS BY AREA

1) Fairbanks district: Recent tests of lodes and placers in the Fairbanks district showed significant amounts of uranium or thorium at only two localities. One, a concentrate obtained from gravel near the head of Rex Creek, contains 0.066 percent E. U.; the other, a concentrate from vein material of a scheelite mine near Fox, contains 0.013 percent E. U. Additional mineralogical work on these two samples is suggested before more field work is attempted.

A detailed study of the small, upper watershed of Fish Creek should be made to determine the source of the bismuth and bismuth silicate(?) nuggets originally reported to contain 0.1 percent E. U., but later redetermined to contain 0.016 percent E. U. Particular emphasis should be placed on the known bismuth lode on the spur along the east side of Monte Cristo Creek.

2) Steese Highway belt in the upper Chatanika Valley area: A dredge concentrate from Nome Creek in the upper Chatanika Valley area contains 0.012 percent E. U. which may be due to small quantities of monazite. A bromoform concentrate from crushed porphyritic biotite granite pebbles and boulders in Idaho Creek yielded 0.017 percent E. U. probably in radioactive zircon. Further study of the granitic intrusive masses and any attendant mineralization in the watershed including the headwater parts of Nome and Idaho Creeks is recommended.

3) Livengood area: In the Livengood area a sluice concentrate from Ruth Creek has 0.01 percent E. U., and a sample collected in an earlier year from Goodluck Creek shows 0.031 - 0.048 percent E. U. The radioactive material in the Ruth Creek concentrate seems to be zircon

and minute quantities of monazite, whereas that of the Goodluck Creek sample appears to be a black, pitchy, highly radioactive mineral with a conchoidal fracture. A bromoform concentrate of a sample of Paleozoic black shale showed 0.006 percent E. U. No further search for radioactive materials in the Livengood area is recommended for the immediate future. At some later date, however, a more detailed study of the Goodluck Creek watershed and Paleozoic black shale outcrops should be made.

4) Harding Lake-Richardson area: Granitic rock on the south shore of Birch Lake in the Harding Lake-Richardson area contains 0.006 percent E. U. on the outcrop, 0.004 percent E. U. in an unconcentrated crushed sample, and 0.009 percent E. U. in a concentrate from a 100-pound sample of weathered rock. A fine-grained granitic(?) dike, also on the south shore of Birch Lake, contains 0.005 percent by measurement at the outcrop, 0.002 percent E. U. as measured in an unconcentrated crushed sample, and 0.110 percent E. U. in a concentrate from a 100-pound sample of weathered rock. The radioactivity may be associated with the content of zircon and allanite(?). A concentrate obtained from Buckeye Creek contains 0.02 percent E. U. which also is attributed to zircon. Additional concentrates should be obtained from Buckeye and Banner Creeks, and the headwater tributaries of Redmond Creek, and checked for radioactivity. Igneous rocks, particularly the acidic types, and associated mineralization should be sought in these watersheds and checked for radioactivity. Study of the granitic intrusives along the highway should be continued, particularly in the vicinity of Birch Lake.

5) <u>The Alaska Highway belt</u>: A maximum of 0.014 percent E. U. was obtained in tests northwest of Tok Junction in the Alaska Highway belt. This maximum value was found in a concentrate from gravel in a stream draining an area of granitic rock and is probably due to radioactive zircon. Southest of Tok Junction concentrates from granitic rocks average 0.034 percent E. U. with a maximum of 0.074 percent. The non-magnetic fractions of two of the concentrates average 0.77 percent E. U. Preliminary mineralogical studies indicate that the radioactivity may be due partly to zircon and allanite and partly to an as yet unidentified more radioactive mineral. Further study of the Mesozoic(?) granitic rocks is suggested, particularly in the outcrop areas between stations AH 17 and AH 28 of this report and between Little Beaver and Gardiner Creeks.

6) <u>Highway area between Slana and Tok Junction</u>: No appreciable concentration of radioactive material was found in the highway area between Slana and Tok Junction, and no recommendations are made for immediate additional study in this area.

7) <u>Donnelly Dome-Paxson area</u>: A concentrate obtained from prospecting operations on Ober Creek contains 0.011 percent E. U. The radioactivity is due to small quantities of monazite. In view of the extremely high concentration necessary to obtain these small quantities, and the fact that the gravels from which the concentrate was obtained are reworked glacial debris, additional study of this area in the immediate future does not seem warranted.

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SUMMARY OF MATERIALS TESTED

Granitic rocks and placer concentrates are the only materials tested in this reconnaissance that contained significant amounts of radioactive material. Black shale, carbonaceous or graphitic schist, and mineralized veins, known at some localities to have associated radioactive material, were only slightly radioactive. The small amount of testing of all rock types, however, is inconclusive. A summary of the most significant results for the materials tested follows:

Types of material and area	Range of percent E. U. in: Outcrop tests and unconcentrated samples	Range of percent E. U. in: Concentrated samples
Granitic rocks:		
Fairbanks district	0.000 - 0.003	0.002 - 0.004
Upper Chatanika Valley area	0.001 - 0.005	0.017
Livengood area	0.000 - 0.005	0.003
Harding Lake-Richardson area	0.002 - 0.006	0.005 - 0.11
Alaska Highway belt	0.000 - 0.005	0.004 - 0.074
Highway area between Slana and Tok Junction	0.001	no test
Donnelly Dome-Paxson area	no test	no test
Mafic rocks:		
Fairbanks district	0.000 - 0.001	no test
Upper Chatanika Valley area	no test	no test
Livengood area	0.000	no test
Harding Lake-Richardson area	0.002 - 0.003	no test
Alaska Highway belt	0.001 - 0.003	0.004
Highway area between Slana and Tok Junction	0.000 - 0.005	0.000
Donnelly Dome-Paxson area	no test	no test
Mineralized veins and vein material:		
Fairbanks district	0.000 - 0.005	0.000 - 0.013
Upper Chatanika Valley area	no test	no test
Livengood area	0.000	0.000
Harding Lake-Richardson area	0.003	no test
Alaska Highway belt	no test	no test
Highway area between Slana and Tok Junction	0.000 - 0.001	0.000
Donnelly Dome-Paxson area	no test	no test

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Schist, quartzitic and micaceous varieties:		
Fairbanks district	0.000 - 0.002	no test
Upper Chatanika Valley area	0.000 - 0.003	0.003
Livengood area	no test	no test
Harding Lake-Richardson area	0.001 - 0.002	no test
Alaska Highway belt	0.000 - 0.002	no test
Highway area between Slana and Tok Junction	no test	no test
Donnelly Dome-Paxson area	no test	no test
Schist, graphitic:		
Fairbanks district	0 0.002	0.004
Upper Chatanika Valley area	0.001 - 0.004	0.000
Livengood area	no test	no test
Harding Lake-Richardson area	0.001 - 0.002	0.005
Alaska Highway belt	no test	no test
Highway area between Slana and Tok Junction	no test	no test
Donnelly Dome-Paxson area	no test	no test
Black shale:		
Fairbanks district	no test	no test
Upper Chatanika Valley area	no test	no test
Livengood area	0.000 - 0.002	0.006
Harding Lake-Richardson area	no test	no test
Alaska Highway belt	no test	no test
Highway area between Slana and Tok Junction	no test	no test
Donnelly Dome-Paxson area	no test	no test
Stream and bench gravels, and slope wash:		
Fairbanks district	0.000 - 0.003	0.000 - 0.066
Upper Chatanika Valley area	0.000 - 0.001	0.000 - 0.012
Livengood area	0.000 - 0.001	0.000 - 0.01
Harding Lake-Richardson area	0.000 - 0.001	0.001 - 0.02
Alaska Highway belt	0.001 - 0.002	0.000 - 0.014
Highway area between Slana and Tok Junction	0.000	0.000 - 0.003
Donnelly Dome-Paxson area	no test	0.000 - 0.011

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TABLE 1

Location and description of test stations, and equivalent uranium determinations thereat, in the trace elements reconnaissance along highways in the Tanana and upper Copper River Valleys, Alaska.

NOTES: Letter prefixes of test stationnumbers indicate areas as follows:

PD - Pedro Dome area (fig. 3)
ED - Ester Dome area (fig. 4)
UC - Steese Highway belt in the upper Chatanika Valley area (fig. 5)
L - Livengood area (fig. 6)
R - Harding Lake-Richardson area (fig. 7)
AH - Alaska Highway belt (fig. 8)
TC - Highway area between Slana and Tok Junction (fig. 9)
RH - Donnelly Dome-Paxson area (fig. 10)

Abbreviations in sub-headings under "Percent equivalent uranium" indicate the following:

OT - outcrop test
UCS - unconcentrated crushed sample
BC-CS - bromoform concentrate from crushed sample
BC-PC - panned concentrate from 50- to 100-pound samples of gravel or disintegrated rock material subsequently reconcentrated with bromoform; also includes sluice concentrates obtained from placer mine operators

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TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	DGS	BC-GS	BC-PC	Concentration ratio	Description and location
PD 1	-	0.001	-	-	-	-	Weathered quartz diorite; on road to summit of Pedro Dome
2	-	0.000	-	-	-	-	do , 200' S. of PD 1
3	-	0.001	-	-	-	-	do , 300' do
4	-	0.000	-	-	-	-	do , 500' do
5	-	0.001	-	-	-	-	do , 700' do
6	-	0.001	-	-	-	-	do , 800' do
7	1401L	0.001	-	-	0.002	570:1	do , 900' do
8	-	0.001	-	-	-	-	do , 1000' do
9	-	0.000	-	-	-	-	do , 1100' do
10	-	0.002	-	-	-	-	do , 1200' do
11	-	0.001	-	-	-	-	do , 1300' do
12	-	0.001	-	-	-	-	Quartz diorite talus; on road to summit of Pedro Dome, 1400' S. of PD 1
13	1527L	0.003	0.003	0.004	-	3.5:1	do
14	-	0.002	-	-	-	-	do
15	-	0.001	-	-	-	-	Quartzitic schist; in stripped area about 0.6 mile N. E. of Pedro Dome
16	-	0.001	-	-	-	-	do
17	-	0.001	-	-	-	-	Weathered vein quartz; in series of old prospect pits about 1 mile N. E. of Pedro Dome
18	-	0.001	-	-	-	-	do
19	-	0.000	-	-	-	-	Weathered schist; same locality as PD 17
20	-	0.001	-	-	-	-	Weathered vein quartz; same locality as PD 17
21	-	0.001	-	-	-	-	Weathered quartzitic schist; same locality as PD 15
22	-	0.001	-	-	-	-	do
23	-	0.000	-	-	-	-	Weathered micaceous schist; same locality as PD 15

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TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	BCS	BC-CS	BC-PC	Concentration ratio	Description and location
PD 24	-	0.001	-	-	-	-	Weathered phyllite; same locality as PD 15
25	-	0.000	-	-	-	-	Weathered schist; same locality as PD 15
26	-	0.001	-	-	-	-	do
27	-	0.001	-	-	-	-	Weathered schist; same locality as PD 17
28	-	0.001	-	-	-	-	do
29	-	0.000	-	-	-	-	do
30	-	0.001	-	-	-	-	Weathered vein quartz and schist; in old prospect pits W. of road about 1.5 miles N. E. of Pedro Dome
31	-	0.001	-	-	-	-	do
32	1537L	0.002	0.002	0.004 1/	-	3.9:1	Thin bed of graphitic schist; in stripped area along E. side of road about 1.5 miles N. E. of Pedro Dome
33	-	0.001	-	-	-	-	do
34	-	0.001	-	-	-	-	Fractured quartz vein; same locality as PD 32
35	-	0.002	-	-	-	-	Graphitic schist; same locality as PD 32
36	-	0.000	-	-	-	-	Iron-stained quartz vein; Boyle's prospect near junction of Fairbanks Creek road and Steese Highway
37	-	0.000	-	-	-	-	do
38	-	0.001	-	-	-	-	Disintegrated rock on mine dump; same locality as PD 36
39	-	0.000	-	-	-	-	Weathered schist; in road cut on Steese Highway in Skoogy Gulch
40	-	0.000	-	-	-	-	do
41	1538L	0.001	0.002	0.013	-	336:1	Vein material on mine dump; Eagan scheelite mine on Twin Creek

1/ methylene iodide used instead of bromoform for concentration

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
PD 42	-	0.001	-	-	-	-	Iron-stained schist; in old prospect pit along Steese Highway near mouth of Twin Creek
43	-	0.001	-	-	-	-	Weathered quartz and schist on mine dump; at old prospect shaft on ridge between Fox Creek and Seattle Pup about 0.85 mile E. of road
44	-	0.000	-	-	-	-	do
45	-	0.000	-	-	-	-	do
46		0.001					
47	1408	0.001	-	-	0.003	1,150:1	Slope wash(?); in bull-dozed trench 0.6 mile E. of station PD 43
48		0.001					
49	-	0.000	-	-	-	-	Weathered vein quartz and schist on mine dump; at old prospect shaft near station PD 46
50	-	0.001	-	-	-	-	do
51	-	0.001	-	-	-	-	Slope wash; in trench about 300' E. of station PD 46
52	-	0.001	-	-	-	-	do
53	-	0.000	-	-	-	-	Weathered vein quartz and schist on mine dump; at old prospect shafts 0.7 mile E. of station PD 43
54	1409L	0.001	-	-	0.002	1,200:1	do
55	-	0.001	-	-	-	-	do
56	-	0.001	-	-	-	-	Same as PD 53, but 0.3 mile farther E.
57	1410L	0.001	-	-	0.003	1,530:1	do
58	-	0.001	-	-	-	-	Same as PD 53, but 0.45 mile farther E.
59	-	0.001	-	-	-	-	do
60	-	0.001	-	-	-	-	do
61	1411	0.001	-	-	0.001	770:1	Angular gravel from test pit; Seattle Pup

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium UT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
PD 62	1412L	0.001	-	-	0.002	270:1	Weathered rock on minde dump; at prospect shaft on divide between Seattle Pup and Moose Creek
	1536AL	-	0.001	0.001	-	9.5:1	Sulphide-enriched limestone; at station PD 62
	1536BL	-	0.003	0.001 1/	-	1.05:1	do
63	1413	0.001	-	-	0.003	700:1	Angular gravel from wst pit; on south tributary of Last Chance Creek
64	-	0.001	-	-	-	-	Disintegrated rock on mine dump; on ridge between Engineer and Steele Creeks
65	-	0.000	-	-	-	-	do
66	-	0.001	-	-	-	-	do
67	-	0.001	-	-	-	-	do
68	-	0.000	-	-	-	-	do
69	-	0.001	-	-	-	-	do
70	-	0.001	-	-	-	-	do
71	1397L	0.002	-	-	0.006	1,410:1	do
72	1396	0.001	-	-	0.000	15,620:1	Slope wash from test pit; on ridge between Engineer and Steele Creeks
73	-	0.000	-	-	-	-	do
74	-	0.000	-	-	-	-	Tungsten vein in drift; Gilmore Dome
75	-	0.001	-	-	-	-	Bedrock in same drift; Gilmore Dome
76	-	0.000	-	-	-	-	Tungsten vein in second drift; Gilmore Dome
77	-	0.000	-	-	-	-	Tungsten vein 500' in from moth of third drift; Gilmore Dome
78	-	0.001	-	-	-	-	Rock on dump of third drift; Gilmore Dome
79	-	0.000	-	-	-	-	Mafic rock in dump of shaft at summit: Gilmore Dome
80	-	0.001	-	-	-	-	Tungsten vein in open cut near summit; Gilmore Dome

1/ methylene iodide used instead of bromoform for concentration

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	UCS	BC-CS	BC-PC	Concen-tration ratio	Description and location
PD 81	-	0.000	-	-	-	-	Tungsten vein in open cut near summit; Gilmore Dome
82	-	0.001	-	-	-	-	do
83	-	0.001	-	-	-	-	Mafic rock in dump of shaft at summit; Gilmore Dome
84	-	0.000	-	-	-	-	do
85	-	0.001	-	-	-	-	Tungsten vein in first drift; Gilmore Dome
86	-	0.000	-	-	-	-	Bedrock in first drift; Gilmore Dome
87	-	0.000	-	-	-	-	Tungsten vein in second drift; Gilmore Dome
88	-	0.000	-	-	-	-	Bedrock in second drift; Gilmore Dome
89	-	0.001	-	-	-	-	Mafic rock in dump of shaft at summit; Gilmore Dome
90	1400	0.002	-	-	0.003	2,940:1	Angular gravel from test pit; north tributary of Isabella Creek
91	-	0.002	-	-	-	-	do
92	1402	0.002	-	-	0.003	550:1	Stream gravel from test pit; Gilmore Creek
93	-	0.001	-	-	-	-	do
94	1403	0.001	-	-	0.004	1,030:1	Angular gravel from test pit; north tributary of Victoria Creek
95	-	0.001	-	-	-	-	do
96	-	0.001					
97	1404	0.000	-	-	0.000	17,450:1	Stream gravel (slope wash?) from several closely spaced gullies; Monte Cristo Creek
98		0.001					
99	1405	0.002	-	-	0.005	3,340:1	Stream gravel from test pit; East Fork of Tom Creek
100	1406	0.001	-	-	0.004	1,860:1	Stream gravel from test pit; West fork of Fish Creek
101	1407	0.001	-	-	0.001	460:1	Stream gravel from test pit; Deadwood Creek
102	1391	0.000	-	-	0.003	5,790:1	Angular gravel from test pit; east headwater tributary of Engineer Creek

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	DCS	BC-CS	BC-PC	Concentration ratio	Description and location
PD 103	1392	0.000	-	-	0.003	1,740:1	Angular gravel from test pit; west headwater tributary of Moose Creek
104	1393	0.001	-	-	0.004	4,580:1	Angular gravel from test pit; middle fork of northwest tributary of Columbia Creek
105	1394	0.003	-	-	0.005	240:1	Angular gravel from test pit; Columbia Creek
106	1395	0.000	-	-	0.002	1,470:1	Angular gravel from test pit; Engineer Creek
107	1398	0.001	-	-	0.066	5,030:1	Stream gravel from test pit; Rex Creek
108	1399	0.002	-	-	0.003	2,600:1	Angular gravel from test pit; middle fork of Steele Creek
109	1414	0.000	-	-	0.000	470:1	Stream gravel; Willow Creek
110	1415	0.001	-	-	0.004	1,240:1	Angular gravel in placer cut; Wolf Creek
111	1416	0.001	-	-	0.003	1,470:1	Stream gravel; Chatham Creek
112	1417	0.000	-	-	0.000	120:1	Angular gravel; Bellows Creek
113	1418	0.001	-	-	0.001	330:1	Angular gravel; Solo Creek
114	1419	0.001	-	-	0.001	540:1	Angular gravel; south tributary of Fairbanks Creek
115	1420	0.000	-	-	0.000	1,770:1	Angular gravel from cut in stream bank; west tributary of Fox Creek
116	1421	0.001	-	-	0.005	1,510:1	Angular gravel from test pit; Big Eldorado Creek
117	1422	0.000	-	-	0.000	830:1	Angular gravel from test pit; northwest tributary of Big Eldorado Creek
ED 1	1530L	0.001	0.000	0.000	-	19:1	Massive quartz vein in drift; Michley mine on Sheep Creek
2	1531L	0.002	0.002	-	-	-	Shear zone in schist; Michley mine on Sheep Creek
3	1532L	0.001	0.002	0.002	-	48:1	Mineralized part of quartz vein; Michley mine on Sheep Creek
4	1423	0.001	-	-	0.004	390:1	
5	1533L	0.002	0.002	0.004	-	28:1	Rock material from mine dump; Bondholder mine
6	-	0.002	-	-	-	-	Rock material on mine dump; Mohawk(?) mine

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	DCS	BC-CS	BC-PC	Concentration ratio	Description and location
ED 7	1424	0.002	-	-	0.007	400:1	Stream gravel; St. Patrick Creek
8	1425	0.001	-	-	0.004	810:1	Stream gravel from test pit; Ready Bullion Creek
9	-	0.002	-	-	-	-	Rock material on mine dump; Farmer(?) mine at head of Ready Bullion Creek
10	-	0.001	-	-	-	-	do
11	1534L	0.003	0.003	0.005	-	19:1	do
12	1535L	0.001	0.000	0.000	-	24:1	do
13	1426L	0.004	-	-	0.005	1,080:1	Rock material on mine dump; Clipper mine on Eva Creek
14	-	0.004	-	-	-	-	do
15	-	0.001	-	-	-	-	Rock material on mine dump; drift below Clipper mine on Eva Creek
16	-	0.004	-	-	-	-	do
17	1427	0.001	-	-	0.004	1,100:1	Stream gravel from test pit; Moose Gulch
18	-	0.001	-	-	-	-	do
19	1428	0.002	-	-	0.004	1,240:1	Stream gravel from test pit; Eva Creek below Clipper mine
20	-	0.002	-	-	-	-	Mine dump; at prospect shaft on trail to summit of Ester Dome
21	-	0.003	-	-	-	-	do
22	-	0.002	-	-	-	-	Weathered schist; trench near station ED 20
23	-	0.003	-	-	-	-	do
24	-	0.001	-	-	-	-	Weathered antimony ore; trench near station ED 20
25	-	0.002	-	-	-	-	Mine dump; at inclined shaft about 0.2 mile S. W. of summit of Ester Dome
26	-	0.002	-	-	-	-	do
27	-	0.001	-	-	-	-	Selected pieces of sulphide ore; same location as station ED 25
28	1523L	-	0.005	0.000	-	3:1	Vein material(?); Michley mine

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-FC	Concen-tration ratio	Description and location
ED 29	1524L	-	0.001	0.003	-	8:1	Vein material(?); Hudson mine
30	1525L	-	0.002	-	-	-	Vein material(?); Sanford prospects
31	1529L	-	0.000	0.001	-	7:1	Vein material(?); Little Eva mine
UC 1	1429	0.001	-	-	0.000	7:1	Stream gravel; McManus Creek about halfway between Montana and Idaho Creeks
2	1430	0.001	-	-	0.000	100:1	do
3	-	0.000	-	-	-	-	do
4	-	0.001	-	-	-	-	do
5	-	0.001	-	-	-	-	do
6	-	0.001	-	-	-	-	Stream gravel from prospect pit; Idaho Creek about 250' above highway bridge
7	-	0.001	-	-	-	-	do
8	1431	0.001	-	-	0.000	90:1	do
9	-	0.001	-	-	-	-	do
10	-	0.001		-	-	-	Stream gravel from prospect pit; Idaho Creek about 3000' above highway bridge
11	1432	0.001	-	-	0.000	130:1	do
12	1539L	0.005	0.004	0.017	-	267:1	Porphyritic biotite granite boulders and pebble; same location as station UC 10
13	-	0.001	-	-	-	-	Schist boulders; same location as station UC 10
14	-	0.001	-	-	-	-	Stream gravel; Montana Creek about 25' above highway bridge
15	1433	0.001	-	-	0.000	120:1	do
16	-	0.001	-	-	-	-	Stream gravel; Montana Creek about 0.5 mile above highway bridge
17	1434	0.001	-	-	0.002	160:1	do
18	-	0.001	-	-	-	-	Stream gravel; North Fork of Twelvemile Creek (Circle district)

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
UC 19	-	0.001	-	-	-	-	Weathered igneous cobbles (granite?); North Fork of Twelvemile Creek (Circle district)
20	-	0.000	-	-	-	-	Stream gravel; same location as station UC 19
21	1435	0.001	-	-	0.000	45:1	do
22	1436	0.000	-	-	0.000	90:1	Stream gravel; Twelvemile Creek (Circle district) above mouth of North Fork
23	1437	0.001	-	-	0.001	110:1	Bench gravel; Faith Creek, trench in N. E. bank about 0.5 mile above mouth
24	-	0.001	-	-	-	-	Bench gravel; trench about 400' N. E. of station UC 23
25	1438	0.001	-	-	0.002	280:1	Bench gravel; trench about 100' E. of station UC 24
26	-	0.001	-	-	-	-	do
27	-	0.001	-	-	-	-	Bench gravel; trench about 200' N. E. of station UC 25
28	-	0.001	-	-	-	-	Stream gravel; Smith Creek about 0.25 mile above mouth
29	1439	0.001	-	-	0.004	380:1	do
30	-	0.001	-	-	-	-	Bench gravel; same location as station UC 28
31	1540L	0.003	0.001	0.003	-	133:1	Weathered gray-black micaceous schist (fault gouge?) Steese Highway, mile 70.2
32	-	0.003	-	-	-	-	do
33	-	0.003	-	-	-	-	do
34	-	0.002	-	-	-	-	Weathered quartz mica schist; Steese Highway, mile 70.2
35	-	0.002	-	-	-	-	do
36	1541L	0.002	0.002	-	-	-	do
37	-	0.000	-	-	-	-	Stream gravel; Faith Creek about 5 miles above mouth
38	-	-	-	-	0.001	?:1	About 1/2 cu. ft. sluice concentrates after removal of gold; Deep Creek workings of Deep Creek Mining Co.

TABLE 1 (continued)

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Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
UC 39	1440	0.001	-	-	0.001 1/	95:1	Stream gravel; Cripple Creek about 50' above highway bridge
40	1441	0.001	-	-	0.002	350:1	Bench gravel; Flat Creek
41	1442	0.001	-	-	0.002	190:1	Stream gravel; Belle Creek about 100' above highway bridge
42	1542L	0.003	0.004	0.000	-	7:1	Weathered graphitic schist; Steese Highway, Mile 64.3
43	-	0.000	-	-	-	-	Weathered gray schist; Steese Highway, Mile 64.3
44	-	0.001	-	-	-	-	Graphitic schist; Steese Highway, Mile 64.3
45	1443	-	-	-	0.012 1/	2:1	Dredge concentrate; Deadwood Mining Company mining operations on Nome Creek
L 1a	1555L	0.001	-	0.000	-	1.4:1	Mineralized zone in altered limestone; prospect shaft on Money Knob
1b	-	0.000	-	-	-	-	do
2	-	0.000	-	-	-	-	Iron-stained chert; prospect shaft on Money Knob
3a	-	0.001	-	-	-	-	Altered shale; Livengood Ridge
3b	1543L	0.003	0.005	0.003	-	187:1	Weathered granite float; Livengood Ridge
4	-	0.001	-	-	-	-	Black shale; Livengood Ridge
5	-	0.000	-	-	-	-	Black siliceous rock; west spur of Amy Dome
6	-	0.000	-	-	-	-	Shear zone in basic volcanic rocks; W. spur of Amy Dome
7	-	0.000	-	-	-	-	Basic volcanic rocks; W. spur of Amy Dome
8	-	0.000	-	-	-	-	Coarse-grained diorite; Amy Dome
9a	-	0.000	-	-	-	-	Diorite; Amy Dome
9b	-	0.000	-	-	-	-	Weathered diorite; Amy Dome
10	-	0.001	-	-	-	-	Black shale; Livengood Road at Olive Creek
11	1447	-	-	-	0.000	1,500:1	Stream gravel; McCord Creek near mouth
12	1448	0.001	-	-	0.000	1,300:1	Bench gravel on bedrock; low bench of Tolovana River downstream from mouth of McCord Creek

1/ methylene iodide used instead of bromoform for concentration

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TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	DCS	BC-CS	BC-PC	Concentration ratio	Description and location
L 13	-	0.001	-	-	-	-	Fissile black shale with thin beds of gray sandstone; Livengood Road just north of Tolovana River
14	1449	0.000	-	-	0.000	250:1	Stream gravel from test pit; small unnamed tributary of Tolovana River on S. side of Amy Dome, 2.1 miles E. of Ester Creek
15	1450	-	-	-	0.000	570:1	Stream gravel; Ester Creek near bridge over Livengood Road
16a	1553L	0.002	0.002	0.006	-	152:1	Black shale; Livengood Road near Cleary Creek
16b	-	0.000	-	-	-	-	do
16c	-	0.000	-	-	-	-	Conglomerate lens in black shale; Livengood Road near Cleary Creek
17a	-	0.001	-	-	-	-	Black shale; Livengood Road about 1.2 miles E. of Ester Creek
17b	-	0.001	-	-	-	-	do
18a	1452	-	-	-	0.003	?:1	Sluice concentrate; Parkers' claims on Olive Creek
18b	1453	-	-	-	0.001	?:1	Sluice concentrate after retorting; Parkers' claims on Olive Creek
19	1454	-	-	-	0.004	1,800:1	Stream gravel on bedrock; Jurich's claim on Lillian Creek
20	1455	-	-	-	0.000	?:1	Sluice concentrate; Nell's cut on Amy Creek
21	1456	-	-	-	0.000	8,790:1	Bench(?) gravel; from gravel pit on divide between Livengood and Moss Creeks
22	1544L	0.001	0.000	0.001	-	17:1	Weathered chert; south slope of Livengood Dome
23	-	0.000	-	-	-	-	do
24a	1457A	-	-	-	0.002	?:1	Gravel from rift dump pile; drift on Goodluck Creek
24b	1457B	-	-	-	0.002	200:1	Tailings; drift on Goodluck Creek
25a	-	0.000	-	-	-	-	Mineralized vein in altered limestone; north slope of Money Knob
25b	-	0.000	-	-	-	-	do

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-FC	Concentration ratio	Description and location
L 26	-	0.000	-	-	-	-	Rock material on mine dump; from drift on vein at same location as station L 25
27	1446A	-	-	-	0.010	?:1	Coarse fraction of sluice concentrate; Radak's cut on Ruth Creek
	1446B	-	-	-	0.009[1]	?:1	Fine fraction of sluice concentrate; Radak's cut on Ruth Creek
28	1451	-	-	-	0.003	?:1	Sluice concentrate; Benn Falls' workings on Wilbur Creek
R 1a	1459L	0.006	0.004	-	0.009	1,910:1	Weathered granite; S. shore of Birch Lake on S. side of Richardson Highway
1b	-	0.004	-	-	-	-	do
1c	-	0.004	-	-	-	-	Fine-grained granitic dike; same location as station R 1a
2a	-	0.004	-	-	-	-	Porphyritic granite; about 1 mile E. of station R 1 on S. side of Richardson Highway
2b	-	0.002	-	-	-	-	Mafic inclusion in granite; same location as station R 2a
2c	-	0.004	-	-	-	-	Pegmatitic phase of granite; same location as station R 2a
2d	-	0.005	-	-	-	-	Fine-grained phase of granite; same location as station R 2a
3	-	0.003	-	-	-	-	Weathered granite; about 500' E. of station R 2 on N. side of Richardson Highway
4a	1460AL	0.005	0.002	0.060	-	185:1	Fine-grained light-colored (granitic?) dike; same location as station R 3
	1460BL	-	-	-	0.110	?:1	do

1/ methylene iodide used instead of bromoform for concentration

~~FOR OFFICIAL USE ONLY~~

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-FC	Concentration ratio	Description and location
R 5a	-	0.004	-	-	-	-	Same as station R 4a
7a	-	0.003	-	-	-	-	do
8a	-	0.004	-	-	-	-	do
9a	-	0.004	-	-	-	-	do
5b	-	0.003	-	-	-	-	Weathered granite on N. W. side of fine-grained dike; same location as station R 3
7b	-	0.003	-	-	-	-	do
8b	-	0.002	-	-	-	-	do
4c	-	0.003	-	-	-	-	Weathered granite on S. E. side of fine-grained dike; same location as station R 3
5c	-	0.003	-	-	-	-	do
8c	-	0.002	-	-	-	-	do
9c	-	0.003	-	-	-	-	do
6	-	0.003	-	-	-	-	Mafic zone along side of dike; same location as station R 3
10a	1461	0.001	-	-	0.001	450:1	Bench(?) gravel of Tanana River; S. side of Richardson Highway, Mile 309.4
10b	-	0.000	-	-	-	-	do
11a	-	0.003	-	-	-	-	Weathered porphyritic granite; S. side of Richardson Highway, Mile 310.7
11b	-	0.003	-	-	-	-	do
11c	-	0.002	-	-	-	-	Mafic inclusion in granite; same location as station 11a
12	1462	-	-	-	0.004	430:1	Stream gravel; left bank of Salcha River about 300' above highway bridge.
13a	-	0.004	-	-	-	-	Weathered granite; E. shore of Birch Lake on N. side of Richardson Highway
13d	-	0.003	-	-	-	-	do

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TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	DCS	BC-CS	BC-FC	Concentration ratio	Description and location
R 13b	-	0.005	-	-	-	-	Fine-grained light-colored (granitic?) dike; same location as station R 13a
13c	-	0.004	-	-	-	-	do
14a	1556L	0.005	0.004	0.005	-	65:1	Coarse-grained granitic dike; Richardson Highway, Mile 313.9
14b	-	0.004	-	-	-	-	do
14c	-	0.002	-	-	-	-	Fine-grained border zone of granitic dike; same location as station R 14a
14d	-	0.002	-	-	-	-	Quartz mica schist adjacent to granitic dike; same location as station R 14a
15	-	0.003	-	-	-	-	Granitic dike; Richardson Highway, Mile 314.5
16	-	0.001	-	-	-	-	Yellow-stained zone in schist adjacent to fractured quartz vein; Richardson Highway, Mile 314.7
17	-	0.003	-	-	-	-	Weathered igneous (granitic?) dike in schist; Richardson Highway, Mile 314.8
18	-	0.002	-	-	-	-	Fine-grained mafic dike in schist; Richardson Highway, Mile 314.85
19a	-	0.004	-	-	-	-	Weathered granite; Richardson Highway, Mile 304.65
19b	-	0.003	-	-	-	-	Iron-stained quartz vein in granite; Richardson Highway, Mile 304.65
19c	-	0.003	-	-	-	-	do
20	-	0.002	-	-	-	-	Altered limestone with streaks of graphitic schist and a few thin quartz veins; Richardson Highway, Mile 302.65
21	-	0.000	-	-	-	-	Dark-colored dune sand; Richardson Highway, Mile 301.75
22	1463	0.001	-	-	0.004	950:1	Stream gravel; unnamed tributary of Tanana River at Mile 299.8, Richardson Highway
23	1464	0.001	-	-	0.008	660:1	Bench gravel; Banner Creek about 100' above highway bridge

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
R 24	1465	-	-	-	0.020 1/	1,590:1	Gravel from old drift dump; near mouth of Buckeye Creek
25a	1466	0.000	-	-	0.009	1,180:1	Bench gravel on bedrock; Tanana River at Mile 296.9, Richardson Highway
25b	1557L	0.002	0.001	0.005	-	2.5:1	Graphitic schist; same location as station R 25a
26	1467	-	-	-	0.005	590:1	Gravel from old drift dumps; Tenderfoot C eek at Mile 293.7, Richardson Highway
27	1468	-	-	-	0.005	790:1	Gravel from bottom of 100' shaft; claim 13 below at Mile 292.1, Richardson Highway
AH 1a	1469	0.002	-	-	0.014 1/	1,830:1	Bench gravel; Berry Creek about 300' above highway bridge
1b	1558L	0.001	0.000	0.004	-	3.5:1	Coarse-grained granite in bank of creek; same location as station AH 1a
1c	-	0.002	-	-	-	-	Stream gravel; same location as station AH 1a
1d	-	0.002	-	-	-	-	Bench gravel; same location as station AH 1a
2	1470	0.002	-	-	0.011	790:1	Stream gravel; Berry Creek about 0.25 mile above highway bridge
3	1471	0.001	-	-	0.006	1,630:1	Stream gravel; Sears Creek about 0.25 mile above highway bridge
4	1472	0.002	-	-	0.008	1,010:1	Stream gravel; Dry Creek about 250' above highway bridge
5	1473	0.001	-	-	0.001 1/	670:1	Stream gravel; Little Gerstle River about 300' above highway bridge
6	1474	0.001	-	-	0.003	560:1	Glacial gravel; Alaska Highway, mile 1387, near mouth of Johnson River
7	-	0.002	-	-	-	-	Granite; Alaska Highway, Mile 1368.9

1/ methylene iodide used instead of bromoform for concentration

~~FOR OFFICIAL USE ONLY~~

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-GS	BC-FC	Concentration ratio	Description and location
AH 8	1559L	0.003	0.003	0.005	-	8:1	Granite; Alaska Highway, Mile 1368.7
9	1475	-	-	-	0.007	520:1	Stream gravel; Shlef Creek about 75' above highway bridge
10a	-	0.001	-	-	-	-	Granite, unweathered; Alaska Highway, Mile 1359.3
10b	-	0.002	-	-	-	-	Granite, weathered; Alaska Highway, Mile 1359.3
11	1476	-	-	-	0.003	280:1	Stream gravel; unnamed tributary of Tanana River at Mile 1350, Alaska Highway
12	1477	-	-	-	0.003	340:1	Stream gravel; flood channel of unnamed tributary of Tanana River at Mile 1345, Alaska Highway
13	1478	-	-	-	0.003	400:1	Stream gravel; main channel of same creek as at station AH 12, crosses Alaska Highway at Mile 1344.6
14	1479	-	-	-	0.003	260:1	Stream gravel; Yerrick Creek about 100' above highway bridge
15a	-	0.003	-	-	-	-	Granite (slope wash?); in road metal quarry about 0.5 mile E. of intersection of old road with Alaska Highway near Mile 1335
15b	1480	0.004	-	-	0.008 1/	180:1	do
16a	-	0.002	-	-	-	-	Weathered gneiss; Alaska Highway, Mile 1292.1
16b	-	0.001	-	-	-	-	Crushed zone (gouge?) in weathered gneiss; Alaska Highway, Mile 1292.1
17a	1481L	0.005	-	-	0.064 1/	2,200:1	Weathered granite; Alaska Highway, Mile 1292.8
17b	-	0.003	-	-	-	-	do
17c	-	0.004	-	-	-	-	do
18	-	0.003	-	-	-	-	Mafic (basalt?) dike in weathered granite: Alaska Highway, Mile 1292.9
19a	-	0.002	-	-	-	-	Weathered mafic (basalt?) rock along fracture in weathered granite; Alaska Highway, Mile 1293.0

1/ methylene iodide used instead of bromoform for concentration

~~FOR OFFICIAL USE ONLY~~

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
AH 19b	-	0.003	-	-	-	-	Yellow-brown rock in fracture zone in weathered granite; 25' N. of location of station AH 19a
20	1482	0.001	-	-	0.000	130:1	Dark-colored wind-blown silt(?); Alaska Highway, Mile 1299.7
21a	-	0.002	-	-	-	-	Weathered granite; Alaska Highway, Mile 1304.0
21b	-	0.002	-	-	-	-	Iron-stained fracture zone in weathered granite; Alaska Highway, Mile 1304.0
22	-	0.002	-	-	-	-	Cemented breccia zone in weathered granite; Alaska Highway, Mile 1304.2
23	1660L	-	0.003	0.004	-	20:1	Mafic dike in weathered granite; Alaska Highway, Mile 1304.4
24	-	0.003	-	-	-	-	Brown-black stained zone in weathered granite; Alaska Highway, Mile 1308.5
25a	-	0.003	-	-	-	-	Weathered granite; Alaska Highway, Mile 1290.0
25b	1581L	0.004	0.005	0.007	-	236:1	Light-colored felsitic dike; Alaska Highway, Mile 1290.0
25c	-	0.001	-	-	-	-	Mafic dike; Alaska Highway, Mile 1290.0
25d	-	0.004	-	-	-	-	Weathered granite; Alaska Highway, Mile 1290.0
26	1483L	0.003	-	-	0.025 1/	2,700:1	Weathered granite; Alaska Highway, Mile 1286.9
27a	-	0.003	-	-	-	-	Weathered fine-grained granite (dike?); Alaska Highway, Mile 1283.8
27b	-	0.003	-	-	-	-	Weathered coarse-grained granite; Alaska Highway, Mile 1283.8
28	1484	-	-	-	0.002	360:1	Stream gravel, but includes some reworked dark-colored wind-blown silt(?); Bitters Creek at Mile 1282.2, Alaska Highway, about 300' above highway bridge
29a	-	0.004	-	-	-	-	Weathered granite gneiss; Alaska Highway, Mile 1278.7

1/ methylene iodide used instead of bromoform for concentration

~~FOR OFFICIAL USE ONLY~~

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
AH 29b	1485	0.004	-	-	0.005 1/	5,600:1	Slope wash from weathered granite gneiss; Alaska Highway, Mile 1278.7
30	1661L	0.003	0.004	0.004	-	80:1	Rhyolite(?) dike; Alaska Highway, Mile 1277.0
31a	-	0.000	-	-	-	-	Hornblende(?) schist; Alaska Highway, Mile 1269.8
31b	1662L	0.003	0.003	0.010	-	1,120:1	Weathered felsitic(?) dike; Alaska Highway, Mile 1269.8
32a	-	0.002	-	-	-	-	Granite near contact with schist; Alaska Highway, Mile 1238.9
32b	-	0.002	-	-	-	-	Quartzitic schist; Alaska Highway, Mile 1238.9
32c	-	0.001	-	-	-	-	Schist near granite contact; Alaska Highway, Mile 1238.9
32d	-	0.001	-	-	-	-	Granite; Alaska Highway, Mile 1238.9
33	1486	-	-	-	0.006	930:1	Slope wash from schist; Alaska Highway, Mile 1232.5
34a	-	0.001	-	-	-	-	Weathered iron-stained rock (igneous?) in schist; Alaska Highway, Mile 1230.3
34b	-	0.000	-	-	-	-	Schist; Alaska Highway, Mile 1230.3
35	1487	-	-	-	0.002 1/	4,930:1	Slope wash from schist; Alaska Highway, Mile 1229.4
36a	-	0.003	-	-	-	-	Hematite-stained granite; Alaska Highway, Mile 1253
36b	1546L	0.004	0.000	0.023	-	55:1	Weathered granite; Alaska Highway, Mile 1253.2
	1488L	0.004	-	-	0.010 1/	7,820:1	do
37	1489L	0.004	-	-	0.027	5,670:1	Weathered granite; Alaska Highway, Mile 1257.4
38	-	0.004	-	-	-	-	Weathered granite; Alaska Highway, Mile 1257.7
39	-	0.004	-	-	-	-	Weathered granite; Alaska Highway, Mile 1261.0
40	1547L	0.004	0.001	0.013	-	12:1	Weathered granite; Alaska Highway, Mile 1263.1
	1490L	0.004	-	-	0.074 1/	1,680:1	do
41	1560L	0.001	0.003	0.002	-	21:1	Sulphide-rich zone in granite; Alaska Highway, Mile 1265.0 (Northway Junction)

1/ methylene iodide used instead of bromoform for concentration ~~FOR OFFICIAL USE ONLY~~

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
TC 1	1491	-	-	-	0.001	680:1	Stream gravel; Station Creek about 0.5 mile above highway bridge
2	1492	-	-	-	0.001	680:1	Stream gravel; unnamed tributary of Mentasta Creek about 2.5 miles E. of Station Creek, about 1 mile above highway bridge
3	1493	-	-	-	0.001	270:1	Bench(?) gravel; unnamed tributary of Mentasta Creek about 4.5 miles E. of Station Creek, about 0.5 mile above highway bridge
4	1494	-	-	-	0.002	550:1	Fan gravel; unnamed tributary of Mentasta Creek about 6.6 miles E. of Station Creek
5	1495	-	-	-	0.003	890:1	Fan gravel; unnamed tributary of Mentasta Creek about 9.2 miles E. of Station Creek
6	1496	0.000	-	-	0.001	170:1	Fan gravel from test pit; unnamed tributary of Little Tok River about 1 mile below Trail Creek, about 100' above highway bridge
7	1497	-	-	-	0.002	590:1	Fan gravel in cut bank of stream; unnamed tributary of Little Tok River about 4 miles below Trail Creek, above highway bridge
8	1498	-	-	-	0.002	590:1	Fan gravel in cut bank of stream; unnamed tributary of Little Tok River about 5.5 miles below Trail Creek, above highway bridge
9	1499	-	-	-	0.003	350:1	Fan gravel in cut bank of stream; unnamed tributary of Tok River about 5.5 miles N. E. of location of station T C 6
10	1500	-	-	-	0.000	230:1	Glacio-fluvial gravel; in road cut, Tok River Valley, at mouth of Little Tok River
11	1501	-	-	-	0.003	670:1	Stream gravel; unnamed tributary of Tok River about 5.5 miles below Little Tok River

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium CT	DCS	BC-CS	BC-PC	Concentration ratio	Description and location
TC 12a	-	0.001	-	-	-	-	Weathered rock on mine dump; Silver Creek about 0.5 mile above tractor trail
12b	1503	0.000	-	-	0.000	140:1	Angular gravel (slope wash?) on low bench; same location as station TC 12a
12c	1562L	0.000	0.005	0.001	-	3:1	Weathered bedrock; same location as station TC 12a
12d	1561L	0.001	0.000	0.000	-	19:1	Sulphide-rich quartz vein; same location as station TC 12a
12e	1502	-	-	-	0.000	135:1	Stream gravel; same location as station TC 12a
13	1504	-	-	-	0.000	66:1	Fan gravel from cut bank; First right limit tributary of "Indian Pass" Creek
14	1505	-	-	-	0.000	140:1	Fan gravel; Third left limit tributary of "Indian Pass" Creek
15	1506	-	-	-	0.000 1/	8,530:1	Fan gravel from test pit; First left limit tributary of "Indian Pass" Creek
16	-	0.001	-	-	-	-	Weathered diorite(?); Tok Cutoff Road near Mile 12
17	1507	-	-	-	0.000	200:1	Bench gravel on bedrock; Second right limit tributary of Slana River above Porcupine Creek
18	1508	-	-	-	0.001	?:1	Sluice concentrate; upper workings on Grubstake Creek
19	1552A	-	-	-	0.000	?:1	Sluice concentrate; Bronniche's workings on Slope Creek
	1552B	-	-	-	0.000	?:1	Coarse fraction of sluice concentrate; Bronniche's workings on Slope Creek
RH 1	1509	-	-	-	0.000	120:1	Glacio-fluvial gravel; Gulkana River about 1 mile below toe of glacier
2	1510	-	-	-	0.000	400:1	Fan gravel; right limit tributary of Phelan Creek about 4.5 miles above mouth of Phelan Creek

1/ methylene iodide used instead of bromoform for concentration

TABLE 1 (continued)

Test station	Sample file number	Percent equivalent uranium OT	UCS	BC-CS	BC-PC	Concentration ratio	Description and location
RH 3	1511	-	-	-	0.001	250:1	Fan gravel; right limit tributary of Phelan Creek about 3.5 miles above mouth of Phelan Creek
4	1512	-	-	-	0.000	350:1	Fan gravel; right limit tributary of Phelan Creek about 2 miles above mouth of Phelan Creek
5	1513	-	-	-	0.000	300:1	Bench gravel; Delta River about 0.25 mile below mouth of Phelan Creek, Yukon Corp. workings
6	1514	-	-	-	0.003	480:1	Stream gravel; right limit tributary of Delta River about 2.25 miles below Castner Creek
7	1515	-	-	-	0.003	500:1	Stream gravel; right limit tributary of Delta River about 3.25 miles below Castner Creek
8	1516	-	-	-	0.002	310:1	Stream gravel; right limit tributary of Delta River about 4.25 miles below Castner Creek
9	1517	-	-	-	0.002	360:1	Stream gravel; right limit tributary of Delta River about 6.25 miles below Castner Creek
10	1518	-	-	-	0.003	410:1	Stream gravel; Darling Creek about 0.25 mile above highway bridge
11	1519	-	-	-	0.004	480:1	Fan gravel in cut bank; Gunnysack Creek about 0.25 mile above highway bridge
12	1520	-	-	-	0.003	7:1	Stream gravel; Clear Creek below falls near highway
13a	1521	-	-	-	0.004	430:1	Stream gravel; Ober Creek Valley at DeWitt's workings
13b	1444	-	-	-	0.007	7:1	Concentrates from drill hole pannings; Ober Creek Valley, DeWitt's workings
14	1522	-	-	-	0.003	7:1	Stream gravel on bedrock; Ober Creek Valley, old Miller cut near mouth of Mineral Creek
15	1522A	-	-	-	0.011 1/	7:1	Panned concentrates obtained from operator; Ober Creek Valley, old cut about 300' above location of station RH 14

1/ minus 60-mesh fraction tested instead of minus 20-mesh fraction