Radioactivity Investigations in the Cache Creek Area Yentna District Alaska, 1945

GEOLOGICAL SURVEY BULLETIN 1024-A

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DEPARTMENT OF THE INTERIOR
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By G. D. ROBINSON, HELMUTH WEDOW, Jr., *and* J. B. LYONS

MINERAL RESOURCES OF ALASKA

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[Plates in pocket]

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RADIOACTIVITY INVESTIGATIONS IN THE CACHE CREEK AREA, YENTNA DISTRICT, ALASKA, 1945

By G. D. Robinson, Helmuth Wedow, Jr., and J. B. Lyons

ABSTRACT

In the summer of 1945 an investigation was made for possible placer deposits of radioactive minerals on Cache and upper Peters Creeks in the Yentna district, southern Alaska. Five gravel types of different age or origin—Eocene, late Tertiary, Quaternary glacio-fluvial, Quaternary bench, and the present flood-plain deposits (including tailings from placer mining)—were examined for their content of radioactive minerals. Radioactivity was measured by gamma count, as detected by a portable Geiger-Mueller counter, at 455 field stations, and in 526 rough-screened samples from 8 to 20 per minute; the rough-screened sample gamma counts from 8 to 21. Calculations from counts of carefully screened samples and gravity concentrates tested in the field laboratory show a maximum of 0.009 percent equivalent uranium even where concentration ratios are 500 : 1 or greater. Sluice-box concentrates with an undetermined but extremely high concentration ratio obtained in 1945 have a maximum of 0.064 percent equivalent uranium. The equivalent-uranium content of the samples may be due either to particles of radioactive minerals in the mineral aggregate of pebbles or other rock fragments, or to individual mineral grains. Interest in 1945 was focussed on mineral grains, the only material recoverable by normal placer-mining methods. Mineralogic study indicates that the radioactivity is due chiefly to uranium and thorium in zircon, monazite, and uranothorianite.

INTRODUCTION

Study by Harder and Reed (written communication, 1945) of placer concentrates from the Yentna district, southern Alaska (fig. 1), collected by J. B. Mertie, Jr., in 1917 indicated that several valleys in the district might contain placer deposits of radioactive minerals. The radioactivity of the concentrates, according to Larsen (written communication, 1945, to Harder and Reed) apparently is due chiefly to monazite and a black cubic opaque mineral which may be uraninite or thorianite, or a solid mixture of the two.[1] Data on the concentrates collected before 1945 are given in table 1.

[1] Mineralogic studies since the preparation of this report show that this mineral is uranothorianite.

TABLE 1.—*Data on concentrates collected in Yentna district before 1945*

Sample no.	eU (percent)	U (percent)	ThO_2 (percent)	Location
482	0.025	----------	----------	Canyon Creek, tributary to Long Creek, tributary to Tokichitna River.
521	<.001	----------	----------	Do.
519	.019	----------	----------	Poorman Creek, tributary to Cottonwood Creek, tributary to Peters Creek.
520	.229	0.090	0.06	Do.
522	.035	----------	----------	Willow Creek, tributary to Cottonwood Creek.
260	<.001	----------	----------	Bird Creek, tributary to Peters Creek.
474	.064	----------	----------	Peters Creek, below Cottonwood Creek.
518	.029	----------	----------	Do.
473	.024	----------	----------	Cache Creek, above Gold Creek.
476	.002	----------	----------	Nugget Creek, tributary to Cache Creek
523	.030	----------	----------	Do.
475	<.001	----------	----------	Cache Creek.
250	<.001	----------	----------	Thunder Creek, tributary to Cache Creek.
478	.005	----------	----------	Do.
524	<.001	----------	----------	Do.
479	<.001	----------	----------	Dollar Creek, tributary to Cache Creek.
525	.119	.07	.035	Cache Creek, above Windy Creek.
526	.003	----------	----------	Windy Creek.
517	.237	.14	.05	Sholan Bar, Kahiltna River, 2 to 3 miles below Cache Creek.
480	.036	----------	----------	Round Bend Bar, Kahiltna River.
481	.023	----------	----------	Do.
527	.190	.08	----------	Do.
254	.005	----------	----------	Mill Creek, tributary of Lake Creek.

In the summer of 1945 a field party was organized to search for concentrations of radioactive minerals in the placer deposits of the Yentna district. G. D. Robinson and Helmuth Wedow, Jr., geologists, and Fred Freitag and S. H. Dane, camphands, spent from June 21 to September 20 in the area. After the transfer of Robinson to another project, the preparation of the report was carried on by Wedow. J. B. Lyons made the alpha-ray and mineralogic studies and prepared the section on mineralogy. The investigations were part of the Geological Survey's Trace Elements program which was being conducted for the Manhattan Engineer district, predecessor of the U. S. Atomic Energy Commission.

Grateful acknowledgment is given to the mine operators in the area, C. W. Bradley, Martin Carlson, Hans Erickson, F. D. Haugham, Joseph Krummenacher, C. P. Morgan, W. C. Stroll, A. J. Taraski, Ed Wagner, and G. H. Weatherell, for their aid and cooperation.

Placer gold has been mined in the Yentna district since 1905; before 1916 hydraulic methods were used for all mining. From 1916 to 1926 a dredge operated on Cache Creek from above Windy Creek to below Nugget Creek. After 1926 a dragline was installed in the "bowl" at the mouth of the Peters Creek canyon in the Peters Hills and operated until 1941. About 10 hydraulic plants were operating in the area in the summer of 1945.

LOCATION AND GEOGRAPHY

The Cache Creek-upper Peters Creek area in the Yentna district is about 30 miles west-northwest of Talkeetna, a station on the Alaska Railroad (fig. 1). Cache and Peters Creeks are southward-flowing tributaries of the Kahiltna River, which is a tributary of the Yentna

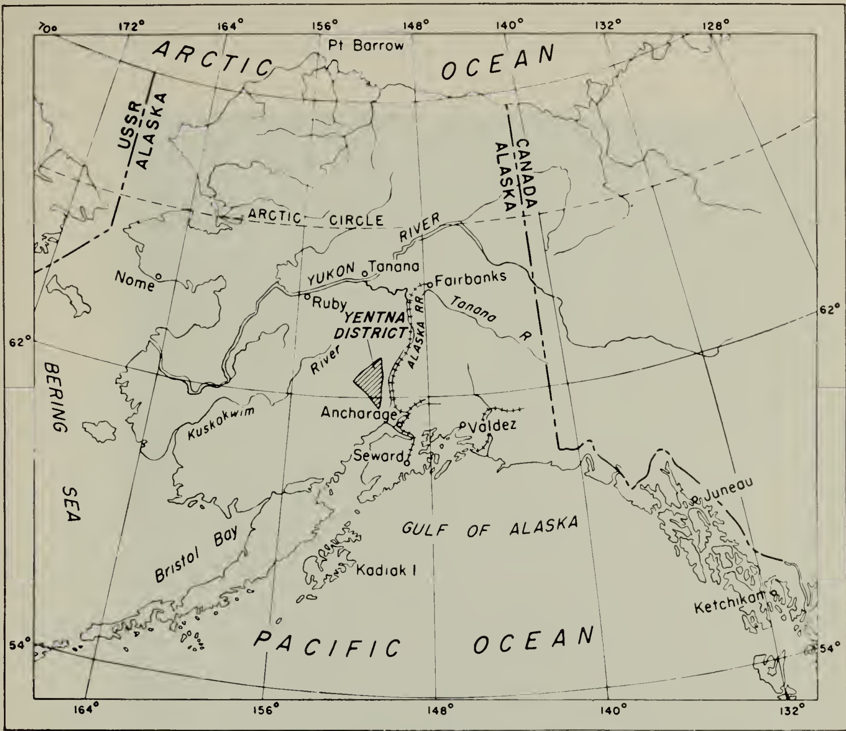

FIGURE 1.—Index map of Alaska showing location of the Yentna district.

River. Cache and upper Peters Creeks have cut their valleys in the gently undulating surface of a troughlike basin that trends northeast and separates the Dutch Hills on the northwest from the Peters Hills on the southeast (fig. 2). The basin surface slopes gently from an average altitude of about 2,400 feet at the northeast to an average altitude of about 2,000 feet at the southwest. The main streams are incised as much as 400 feet below the basin surface. The Dutch Hills rise abruptly about 1,800 to 2,500 feet above it. Principal tributaries of Cache Creek are the southward-flowing Dollar, Falls, Thunder, Rambler, Nugget, and Gold Creeks (named from west to east), and the westward-flowing Spruce, Windy, and Long Creeks. The main tributaries of upper Peters Creek are southeastward-flowing Bird Creek and southwestward-flowing Cottonwood Creek.

The usual transportation route into the area during the mining season is from Talkeetna where the Susitna River is crossed by boat. A truck road, maintained by the Alaska Road Commission, extends from the west bank of the Susitna River past Petersville, a small mining camp at the mouth of Peters Creek canyon, to the mouth of Long Creek. Tractor trails branch from the road to the different mining properties. Ferry service across the Susitna River, and truck and

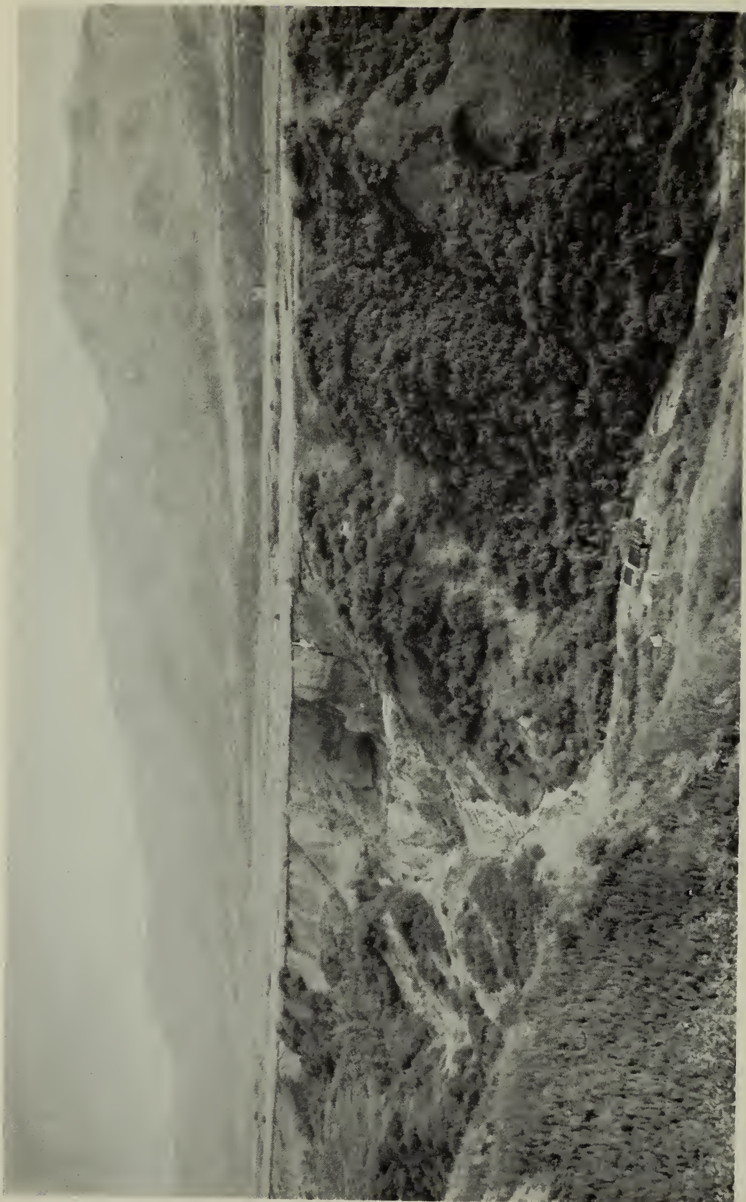

FIGURE 2.—View looking east showing valley of Thunder Creek. Fred Haughman's placer workings in high-level late Tertiary bench gravels. Peters Hills are shown in background.

tractor service into the Cache Creek area are operated by G. H. Weatherell of Talkeetna. In 1945 landing strips for small aircraft were located and constructed near the mouth of Bird Creek and at Petersville.

Bedrock and gravel deposits are well exposed in the canyon walls and in the cut banks of the two major streams and their larger tributaries. The broad upland areas separating the narrow stream valleys are largely "niggerhead" flats interrupted by swampy "muskegs."

The geography and climate of the area have been described by Capps (1913, p. 11–22) and Mertie (1919, p. 234–235).

GEOLOGY

The general geology of the Cache Creek–upper Peters Creek area has been described in considerable detail by Capps (1913, p. 22–47) and Mertie (1919, p. 236–240).

The bedrock of the area consists of two major units. The older unit is a sequence of slate and graywacke, containing minor amounts of quartzite and conglomerate, in which the rocks are much fractured and in most places tightly folded. Quartz veins and several kinds of light-colored dikes cut the rocks of this sequence. Fossils found by Mertie (1919, p. 237) indicate that these beds are of Mesozoic age and probably are, at least in part, of Cretaceous age. These deformed but only mildly metamorphosed sedimentary rocks, called "hard bedrock" by the miners in the area, are the predominant country rocks of the Dutch and Peters Hills, and are generally well exposed in the upper or canyon parts of the major streams and their larger tributaries.

The younger of the two major bedrock units is a sequence of pebble gravels, arkosic sands, organic clays, and lignite, wholly or in part of Eocene (Kenai) age (Capps, 1913, p. 28–33). These beds are only slightly deformed, and dip gently to the southeast with only local reversals of dip to the northwest. It is estimated that more than 300 feet of these sediments are exposed along the valley of Cache Creek and in the lower reaches of its tributaries. These slightly consolidated rocks are known locally as "soft bedrock," but the sequence includes a well-cemented gravel bed, several tens of feet thick, which crops out on Cache Creek near the mouth of Gold Creek. Similar cemented gravel crops out along lower Nugget Creek and at several places on Cache Creek between Nugget and Windy Creeks.

Overlying the bedrock units are many gravel deposits of diverse origin and age. The oldest of these is a sequence of clay-matrix gravels and boulder-studded clays that is younger than the Eocene rocks but older than the Quaternary glacial deposits. For convenience, this sequence is called "late Tertiary" in this report (figs. 2, 3).

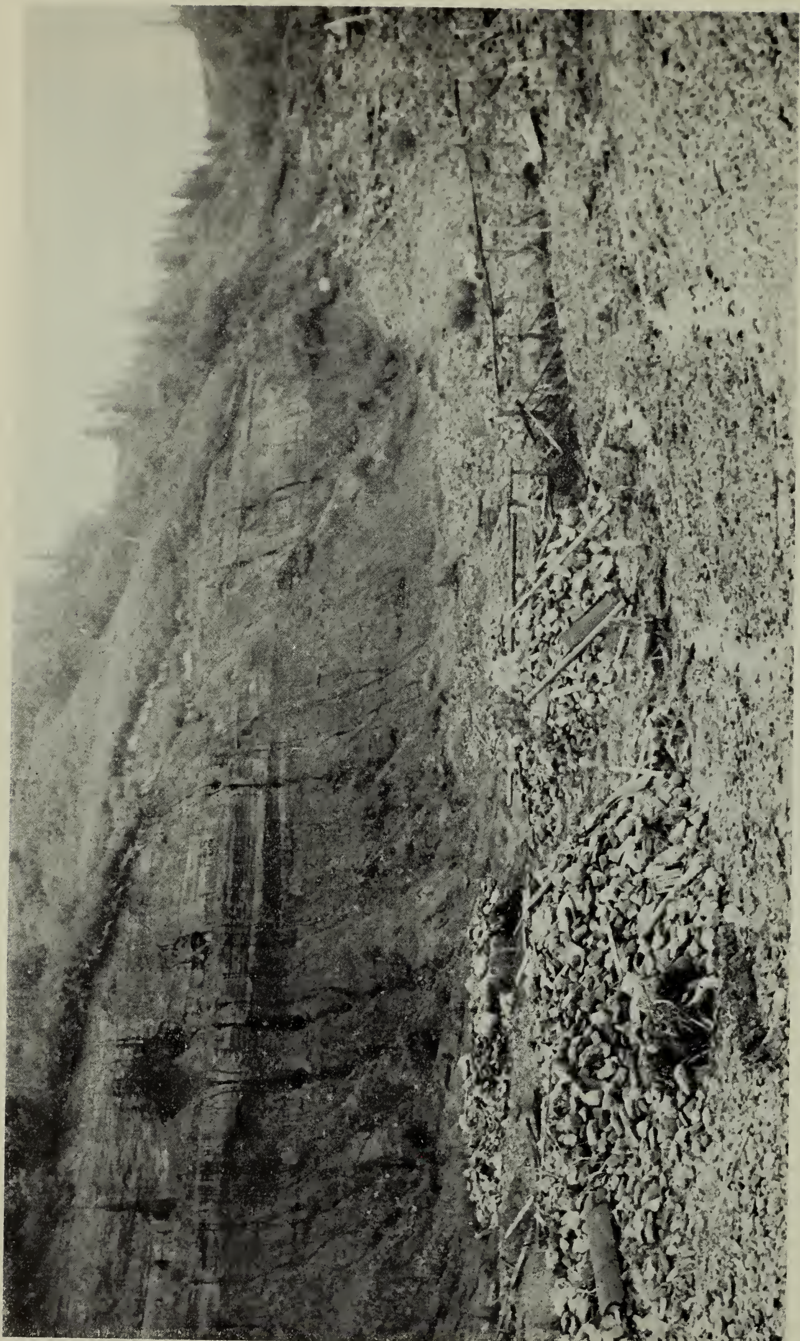

FIGURE 3.—Late Tertiary gravels in Joseph Krummenacher's placer workings in Cheechako Gulch.

Ancient stream channels filled with these clay-matrix gravels are exposed by postglacial stream erosion. In places the deposits are more than 300 feet thick; they are commonly only a few tens or hundreds of feet wide. Away from the channels the gravel deposits are much thinner but underlie large areas to thicknesses of a few feet or tens of feet. The gravels are of the type deposited by streams in areas undergoing valley glaciation, and the clays seem to be glacial outwash. The late Tertiary gravels and clays are commonly, but not invariably, conformable with the Eocene rocks.

The uppermost surface of the basin between the Dutch and Peters Hills is thinly covered by till and poorly sorted gravel, apparently deposited during the retreat of a great glacier which occupied the basin during part of the Quaternary period. Gravels of this sequence of deposition are herein designated Quaternary glacio-fluvial gravels.

The streams of the area, in reaching their present courses, cut and built a series of terraces or benches below a gently undulating surface left by the retreating Quaternary glacier. As many as seven bench levels are preserved in a vertical interval as much as 300 feet below the postglacial surface. The benches below this surface and above the present stream courses are commonly capped with a few feet of stream-laid deposits herein designated Quaternary bench gravels. These gravels are locally several tens of feet thick (fig. 4).

The youngest gravel deposits are those of the present flood plains. Much of the gravel at stream level has been mined, and large volumes of rock have been contributed to the streams by the mining of higher benches. As a result, the flood-plain gravels are now slightly sorted and redistributed tailings.

FIELD METHODS

THE SAMPLING PROBLEM

To test the gravels throughout the area with any hope of achieving representative results would be a project requiring many seasons. On the other hand, to confine work merely to localities actively being mined or to sands and gravels of the present flood plains might fail to give a true evaluation of the distribution of radioactivity and heavy minerals in the gravels of the area.

Some gold has been produced from gravels of every age and origin in the district. No gravel has yielded spectacular amounts, although the district has been intensively prospected and mined. The bulk of the production has been from Quaternary gravel and the least production has come from Eocene beds. Well-defined paystreaks in any of the gravels are reportedly rare, although gold values are consistently highest near bedrock. Large yardage of low-grade gravels have made moderately profitable hydraulic and dredge operations possible.

FIGURE 4.—Low-level Quaternary bench gravels in C. P. Morgan's placer workings on Cache Creek at the mouth of Falls Creek.

Only about 10 claims were being mined in 1945. Most of the operators are sluicing Quaternary bench gravel, but some work is being done on glacio-fluvial deposits and in deposits of high-level late Tertiary channel gravel (figs. 2, 3, 4).

Because most of the gold is coarse and the grade of the gravels low, the miners commonly push as much rock through the boxes as possible, using all the hydraulic head available. By doing so they tend to blast everything out of the riffles except gold and lead shot, and much of the other heavy minerals, if present, are scattered in the tailings. In the past, few operators saved the heavy minerals that remained in the riffles at the cleanup, so that there is little concentrate available for testing.

For preliminary reconnaissance purposes, the low-level Quaternary bench gravels probably offer the best source of radioactive mineral resources. Whatever heavy minerals the older gravels contain should be further concentrated in the younger beds largely derived from them; this has evidently been the case with the gold. The low-level benches have also the obviously practical advantage of being relatively near stream level, making it possible to work rapidly the considerable volumes of gravel needed for the sampling procedure (fig. 4). In reaching this conclusion much preliminary testing was done on higher level and older gravels.

Although occasional check traverses were made on present flood-plain deposits and tailings, and on older gravels, systematic testing was mainly restricted to (1) sizable areas of Quaternary gravel, whether or not currently being mined, and (2) the vicinity of present workings, regardless of the age or origin of the gravels being worked.

THE INSTRUMENT

The radioactivity of the gravel and the placer samples was measured by a portable Geiger-Mueller gamma counter designed by the Geological Survey. The techniques developed in the use of this instrument are discussed below. Because of inclement weather and hard usage, it was necessary to protect the instrument in the field by a paraffin-sealed wooden carrying case, designed to permit easy operation and removal of the instrument. A small canvas sling held the counter tube against the side of the wooden box which was then covered with a paraffined canvas skirt. Even with these precautions moisture occasionally would get inside the instrument and short-circuit some of the batteries.

SAMPLING PROCEDURES

The general plan of sampling was to test selected areas of exposed gravels at regular intervals. Samples from sites of relatively high radioactivity in the field were then tested in a local field laboratory for semiquantitative determination of the equivalent-uranium content.

FIELD-STATION METHOD

During the first weeks of the season the gravels were tested by taking the instrument to the traverse station. In each area to be tested a traverse was laid out and at regularly spaced stations on the traverse gamma counts over a 5-minute period, or rarely a 10-minute period, were taken with the counter tube laid against the gravel or the underlying bedrock. Air-background readings with the instrument held from 1 to 4 feet above the ground surface were occasionally interspersed with the regular station readings. Samples for testing in the field laboratory were taken at stations giving relatively high counts, and occasionally, as a check, at stations giving indifferent counts. This method of determining the gamma count of the natural gravel or bedrock was abandoned when it was decided, after comparison of a considerable number of field-station and field-laboratory data, that the count was being influenced by "pebble effect" (p. 18) and perhaps by mass effect of the surrounding rocks. Essentially, it appeared that the effects on the counter of any small but possibly significant amounts of heavy radioactive minerals, which could be recovered by hydraulic methods, were masked by the effects of volumetrically overwhelming proportions of pebbles and larger rock fragments.

ROUGH-SCREENED SAMPLE METHOD

To eliminate part of the pebble effect a screened fraction of the gravel from each traverse station was tested. For this purpose the rough-screened sample or "can sample" method was devised.

When a gravel bench, exposed for about 1,000 feet on both sides of a stream valley, was to be tested, an instrument station was set up on the valley bottom midway along the exposure. Sampling locations were surveyed by tape-compass methods at about 100-foot intervals along both banks, and the section at each location was measured and described. As each location was made, a sample was taken at the base or lowest exposed part of the gravel bed and at 5-foot vertical intervals if the section was thick enough. A sample was made by passing one-half cubic foot of gravel through a 4-mesh screen and collecting a 1-quart, 14-ounce can full of the screenings. Eight empty cans were carried in a 5-gallon gasoline can attached to a packboard. When the eight cans were filled and taken to the instrument station, they were tested while another group was being collected. The sample was poured into a slightly larger can in which the Geiger-Mueller counter tube, protected by a waterproofed canvas pouch, had been placed. Five-minute readings were taken, interspersed with background readings taken with the tube in the empty can. The "can samples" were discarded after testing.

In addition to the elimination of some of the pebble effect and any possible mass effect, adoption of the rough-screened sample method greatly increased the average number of traverse stations which could be tested in a day and greatly decreased the danger to the instrument. Removing and handling gravel in the rough-screened sample method introduce volume increases which tend to reduce the gamma count per unit volume of gravel; this reduction, however, does not affect in any significant degree the relative concentrations of radioactive material among the different sample localities.

FIELD-LABORATORY SAMPLE METHOD

The method of sampling for tests in the field laboratory varied to some extent during the season, but became standardized about the same time that the rough-screened sample method was adopted. Early in the season, gravel samples one-half cubic foot in volume were taken at field stations which had gamma counts of three to four or more above the air background. As a check against the reliability of field-station tests, similar samples were taken from some field stations regardless of the gamma count at the station. The sample was washed through a 4-mesh screen, the coarser material weighed and discarded, and the screenings dried. The minus 4-mesh material was next screened through 7-mesh, and the resultant fractions tested with the counter. The minus 7-mesh material was further screened through 12-mesh and again the resultant fractions tested. The tests were made over 5-minute intervals and were in the following sequence: background; plus 7-mesh fraction; minus 7-mesh fraction; field standard; plus 12-mesh fraction; minus 12-mesh fraction; background. Any fraction in this sequence which ran more than three counts per minute above background was rerun with background and field standard in the following sequence: background; fraction; field standard; fraction; background. If the gamma count of any fraction of a sample appeared significant, a concentrate of the heavy minerals, about 175:1 by volume, was made at the location by running 3 cubic feet of gravel through a rocker and panning the cleanup down to 30 cubic inches.

Later, the minus 4-mesh samples obtained by the rough-screened sampling method were reduced to a volume of about 90 cubic inches by splitting. This split sample was then dried and screened through 7-mesh, but not through 12-mesh as was the earlier practice. If the material at the field station was sand or clay, rather than gravel, and the gamma count was relatively high, a sample of about 90 cubic inches was taken directly and dried, and then tested in field laboratory in the usual sequence.

Still later, the method of taking the field-laboratory samples of gravel was finally standardized as follows: A half-cubic-foot sample was taken at each locality which gave a rough-screened sample reading of 4 or more counts above air background. If no rough-screened sample tested 4 or more counts above air background in any traverse as much as 1,000 feet long, at least one representative field-laboratory sample was taken in the traverse as a check against the rough-screened sample data. The sample was washed through a 4-mesh screen. The plus 4-mesh material was weighed and discarded; pebble counts were made on some. The minus 4-mesh material was weighed and split to 90 cubic inches. A cubic foot of gravel was put through a rocker at each locality and the concentrate was panned down to 30 cubic inches; then a 9 cubic-foot sample was similarly concentrated; at a few sites a cubic yard of gravel was so treated.

The split from the half-cubic-foot sample was dried and separated into two fractions with a 7-mesh sieve. Parts of the fractional split and of the rocker concentrate sufficient in volume for quantitative comparison with the radioactive standard container were taken. Five-minute readings on these parts were run in the following sequence: Background; plus 7-mesh fraction; minus 7-mesh fraction; standard; 1-cubic-foot rocker sample; 9-cubic-foot rocker sample; background. Any fraction or concentrate having 3 or more counts above background was rerun in the sequence: background; fraction; standard; fraction; background.

A traverse involving the collection of 25 to 35 rough-screened samples and two or three complete laboratory-sample and rocker-sample sets, was ordinarily completed in 1 day.

Late in the season it was decided that enough data had been collected on the weight of each size-fraction of the half-cubic-foot samples, and these samples were omitted thereafter.

DISCUSSION OF SAMPLING DATA

The sampling data have been plotted on a series of sketch maps (pls. 1–6). On these maps the grade of the different samples, as determined from field-laboratory data, has been plotted in percent equivalent uranium. The field data have been plotted as total gamma counts per minute. For each traverse the stated air background was determined by averaging all background readings taken in the traverse area. Brief descriptions of the traverses are given in table 2.

SIZE-FRACTIONS OF THE GRAVEL TYPES

The proportions of the different size-fractions in many of the field-laboratory samples was determined as a byproduct of the effort to discover whether the radioactivity of the samples was due to grains of radioactive minerals or to radioactive minerals in pebbles. The average percent of the arbitrary size-fractions in the different gravel types is given in table 3.

Because rock fragments of maximum dimension greater than about 5 inches were avoided in collecting the samples, the Quaternary bench

TABLE 2.—*Location and description of traverses*

[FS indicates that the gravels were tested by the field-station method; C indicates that gravels were tested by the rough-screened sample method]

Traverse	Method of testing	Location and description
1–1	FS	Largely Eocene gravel in a cut bank on the right limit of Cache Creek upstream from Nugget Creek (pl. 2).
1–5	FS	Low-level Quaternary bench gravel and Eocene bedrock on Cache Creek for 4,000 feet upstream from Gold Creek; some tailings also tested (pl. 2).
1–6	FS	Low-level Quaternary bench gravel and Eocene bedrock on Cache Creek between Gold and Long Creeks; includes Erickson's workings at the mouth of Gold Creek; some tailings also tested (pl. 2).
1–7	FS and C	Low-level Quaternary bench gravel and Eocene bedrock on Cache Creek between Long and Nugget Creeks (pl. 2).
1–8	C	Quaternary bench gravel at Bradley workings on Cache Creek about 1.85 miles upstream from Gold Creek (pl. 2).
2–1	FS	Tailings piles and Eocene clay on Nugget Creek about 2,000 feet upstream from its mouth (pl. 3).
2–2	FS	Tailings, Quaternary bench gravel, and Eocene bedrock in a low cut bank on the left limit of Nugget Creek about 2,500–3,500 feet upstream from its mouth (pl. 3).
2–3	FS	Low-level Quaternary bench gravel on top of late Tertiary gravel in a left-limit cut bank on Nugget Creek about 4,000 feet upstream from its mouth (pl. 3).
2–4	FS	Gravel (largely reworked tailings) on small incipient flood plains in the lower part of the canyon of Nugget Creek (pl. 3).
2–5	FS	Low-level Quaternary bench gravel, tailings, and Eocene bedrock on Nugget Creek for about 1,000 feet upstream from its mouth (pl. 3).
3–1	FS	Mesozoic slate and graywacke, late Tertiary gravel, and Quaternary glacio-fluvial gravel in Morgan's workings on the uppermost bench on the right limit of Nugget Creek downstream from the canyon (pl. 3).
4–1	FS	Late Tertiary gravel and Quaternary glacio-fluvial gravel in a gully on the left limit of Nugget Creek downstream from the mouth of the canyon and opposite Morgan's workings (pl. 3).
5–1	FS	Quaternary glacio-fluvial gravel on the uppermost bench on the left limit of Nugget Creek near the mouth of the valley (pl. 3).
5–2	FS	Late Tertiary gravel about 25 feet vertically below traverse 5–1 (pl. 3).
5–3	FS	Quaternary glacio-fluvial gravel and late Tertiary gravel on the uppermost bench on the left limit of Nugget Creek about 2,500 feet upstream from the mouth of the valley (pl. 3).
6–1	C	Continuous and largely on low-level Quaternary bench gravel on Cache Creek from Nugget Creek downstream almost to Trout Creek; some tailings were tested and a few readings were made on Eocene bedrock; traverse 6–5 includes Traski's workings (pl. 4).
6–2	C	Do.
6–3	C	Do.
6–4	C	Do.
6–5	C	Do.
6–6	C	Do.
6–7	C	Quaternary bench gravel on the left limit of Cache Creek about 1,000 feet upstream from Rambler Creek; Weatherell's workings (pl. 4).
7–1	C	Flood-plain gravel, Quaternary bench gravel, and late Tertiary gravel on Thunder Creek from its mouth to the mouth of the canyon (pl. 5).
7–2	C	Do.
7–3	C	Late Tertiary gravel in Haugham's workings on the uppermost bench on the left limit of Thunder Creek about 2,500 feet upstream from the mouth of the Thunder Creek canyon (pl. 5).
8–1	C	Quaternary bench gravel in Morgan's workings on Cache Creek at Falls Creek (pl. 5).
8–2	C	Quaternary bench gravel on the right limit of Cache Creek for about 1,500 feet upstream from Falls Creek (pl. 5).
9–1	C	Late Tertiary gravel in Krummenacher's workings in Cheechako Gulch (pl. 5).
10–1	C	Late Tertiary gravel in Carlson's workings on Falls Creek about 2½ miles upstream from its mouth (pl. 5).
11–1	C	Flood-plain gravel on Cache Creek at Dollar Creek (pl. 5).
12–1	C	Flood-plain gravel (mostly reworked tailings) on Bird Creek for a distance of 1,200 feet upstream from its mouth (pl. 6).
12–2	C	Late Tertiary gravel in Wagner's workings on high bench on the right limit of Bird Creek about 2,800 feet upstream from its mouth (pl. 6).
13–1	C	Quaternary glacio-fluvial(?) gravel on the left limit of Peters Creek about 2,200 feet upstream from the mouth of the canyon (pl. 6).
13–2	C	Flood-plain gravel at Petersville (pl. 6).
14–1	C	Flood-plain gravel on Willow Creek about 1.6 miles upstream from its mouth (pl. 6).

gravels and the late Tertiary gravels actually average slightly less minus 4-mesh material than is indicated in table 3. Large cobbles and boulders are not common in Quaternary glacio-fluvial gravels, and are rare in Eocene gravels, and therefore the size distribution given for them approaches the true proportions.

The data indicate that the gravel types are not readily distinguishable on the basis of size distribution for the mesh-sizes used.

PEBBLE COMPOSITION OF THE GRAVELS

The pebble compositions of the several types of gravel were determined by counts of 100 pebbles selected at random from the coarse fraction (plus 4-mesh) of each of a number of the half-cubic-foot field-laboratory samples.

TABLE 3.—*Percent distribution of several size-fractions in four gravel types*

Age and type of gravel	Number of samples	Percent by weight		
		Plus 4-mesh	Minus 4- and plus 7-mesh	Minus 7-mesh
Eocene	9	71	8	21
Late Tertiary	28	67	13	20
Quaternary glacio-fluvial	10	72	12	16
Quaternary bench	13	65	13	22
All samples (weighted)	60	68	12	20

The types of pebbles recognized were:

- Slate and graywacke
- Schistose rock
- Chert and quartzite
- Cemented conglomerate
- Igneous rock, fresh
- Igneous rock, weathered
- Vein quartz
- Clay and lignite

The pebbles of slate and graywacke, characteristically subangular, are apparently derived from the Mesozoic bedrock exposed in the Dutch and Peters Hills. The schistose pebbles are chloritic and probably are metamorphosed graywacke.

The chert pebbles are usually well-rounded and are commonly light gray to black. The quartzite pebbles are also well-rounded and are generally made up of well-cemented fine sand grains; fresh fracture surfaces are light gray or yellowish white. The cemented conglomerate forms distinctive pebbles consisting of small, well-rounded fragments of chert, quartzite, and vein quartz well-cemented in a matrix of argillite or graywacke. The chert, quartzite, and cemented conglomerate may be derived from Paleozoic sedimentary rocks exposed in the Alaska Range.

Igneous pebbles are mainly coarse-grained granitic and dioritic rocks, but include aphanitic, fine-grained porphyritic and aplitic rocks. The pebbles grouped as weathered igneous rocks are well-rounded masses of limonitic material and quartz grains, apparently representing fragments of coarse-grained granitic rocks that were subjected to extreme weathering after fluvial transportation and deposition.

The vein quartz pebbles are usually white, and range from well-rounded fragments apparently derived from reworked older gravels to subangular fragments from the recent erosion of veins in the Mesozoic bedrock.

The clay and lignite fragments are derived from the Eocene bedrock. The clay is in blue-gray to gray balls, and the lignite occurs as brown to black fragments, commonly splinter shaped.

The average pebble composition of four of the gravel types are shown in table 4.

The tabulated compositions show that Eocene and Quaternary bench gravels are readily distinguishable from the late Tertiary and the Quaternary glacio-fluvial gravels as well as from one another on the basis of pebble composition. There is essentially no difference in pebble composition between the late Tertiary and the Quaternary glacio-fluvial gravels, thus suggesting a similar origin for them.

The gravels also show differences in other sedimentary characteristics. The pebbles of Eocene gravels are well-sorted and usually well-rounded. Many pebbles are polished and many others superficially stained bright yellow-brown.

The pebbles of the late Tertiary gravels are not as well-sorted as those of the Eocene gravels and are usually only subrounded. Boulders as much as 2 feet long occur locally, although most of the rock fragments are less than 6 inches long. Portions of the late Tertiary gravels have been deeply weathered as shown by their yellowish color and by the relative abundance of soft friable pebbles.

TABLE 4.—*Average pebble composition of four gravel types, in percent*

Types of pebbles	Eocene	Late Tertiary	Quaternary	
			Glacio-fluvial	Bench
Slate and graywacke	29	87	86	62
Schistose rock	2	4	4	4
Chert and quartzite	14		½	5
Cemented conglomerate	10		2½	5
Igneous rock, fresh	35	3½	2½	13
Igneous rock, weathered		2½	1	
Vein quartz	9	2½	2½	7
Clay and lignite	1	½	3	4

The pebbles in the Quaternary glacio-fluvial gravels are subrounded; some are striated. These gravels are poorly sorted and in many places contain boulders as much as 1 foot or rarely several feet in length. The larger boulders are almost invariably granitic or dioritic types of igneous rocks.

The Quaternary bench gravels and the gravels of the present flood plains are poorly sorted. Some of the pebbles and cobbles are well-rounded, but most are subrounded to subangular.

The large amount of igneous rock material in the Eocene gravels indicates that the gravels were largely derived from the core of the main Alaska Range. During late Tertiary time the source of the thick gravel deposits was closer to the basin of deposition and presumably was the Dutch and Peters Hills where large areas of Mesozoic slate and graywacke were exposed. The pebble composition of the glaciofluvial gravels points to a local origin for these deposits; they apparently were laid down during Quaternary glaciation when local ice masses in the Dutch and Peters Hills were eroding the exposed bedrock of Mesozoic age. The Quaternary bench and the flood-plain gravels have clearly been derived from the erosion of all the older bedrocks and gravels.

RADIOACTIVITY

FIELD TESTS

A total of 981 field tests were made in which the counter was taken to the traverse area. Of these, 455 were field-station tests and 526 were rough-screen sample tests. The gamma-count data obtained in these field tests are summarized in table 5.

FIELD-LABORATORY TESTS

More than 350 equivalent-uranium determinations were made on different size-fractions and gravity concentrates of placer samples in the field laboratory; most of these are shown on plates 1–6. A total of 339 of these determinations was used in the compilation of the summary of equivalent-uranium data given in table 6. No significant variation in the equivalent-uranium content of the different gravels is apparent. The slight increase in equivalent-uranium content as the gravels are concentrated by gravity methods (see weighted averages, table 6) supports the belief that essentially all the radioactivity present is in the smaller size heavy minerals of the placers. Plates 1 and 6 show the number of pounds of gravity concentrate per cubic yard recovered in the samples having the highest degree of concentration obtained at each sample location. As the heavy minerals in these concentrates are diluted by a considerable volume of lighter minerals and rock fragments, the radioactivity is also low, and the highest test on a concentrate shows but 0.009 percent equivalent uranium.

Gravity concentration of the moderately heavy minerals (as distinguished from such minerals of high specific gravity as gold) by panning and rocking is not efficient. It is probable that from 10 to 50 percent of the heavy minerals originally present are lost during concentration. Such losses, however, are largely inherent in any inexpensive method of working gravels, and determinations from sampling of this sort are thus probably fairly indicative of expectable recovery by common placer-mining methods.

TABLE 5.—*Summary of gamma-count data by types of material tested*

[FS, indicates field-station method; C, indicates rough-screened sample method]

Age and type of material tested	Methods of testing	Number of tests	Range	Weighted average (gamma counts per minute)	Main traverses on which materials were tested
Mesozoic slate and graywacke	FS	17	11–17	13.8	3–1
Do	C	0	--------	------------	
Eocene gravel and sand	FS	47	11–18	14.3	1–1, 1–5, 1–6, 1–7, 2–2, 2–5, 6–1
Do	C	19	11–16	13.4	
Eocene clay and lignite	FS	28	8–19	14.1	
Do	C	1	12	12.0	
Late Tertiary gravel	FS	100	10–17	13.4	1–5, 1–6, 2–3, 3–1, 4–1, 5–2, 5–3
Do	C	72	10–20	14.1	7–1, 7–3, 9–1, 12–2
Quaternary glacio-fluvial gravel	FS	50	8–18	13.2	3–1, 4–1, 5–1, 5–3
Do	C	4	10–16	13.0	13–1
Quaternary bench gravel	FS	129	10–20	14.4	1–5, 1–6, 1–7
Do	C	213	8–19	13.1	1–7, 1–8, 6–1 to 6–7, 8–1, 8–2
Recent flood-plain gravel and tailings.	FS	84	9–18	14.3	(1)
Do	C	217	8–21	13.4	(1)
Weighted average for all tests	FS	455	8–20	14.0	
Do	C	526	8–21	13.4	

[1] Tested on most traverses on Cache, Peters, and Bird Creeks.

TABLE 6.—*Summary of equivalent-uranium data on size-fractions and gravity concentrates of materials tested*

Material tested	Number of samples	Equivalent-uranium range	Average (percent)
Eocene gravel and sand:			
Size-fraction:			
Minus 4-, plus 7-mesh	9	<0.001–0.004	0.0012
Minus 7-mesh	13	<.001–.003	.0012
Gravity concentrate:			
>25:1 to <200:1	9	<.001–.004	.0021
Eocene clay:			
Size-fraction:			
Minus 7-mesh	5	<.001–.003	.0012
Late Tertiary gravels:			
Size fraction:			
Minus 4-, plus 7-mesh	27	<.001–.005	.0020
Minus 7-mesh	27	<.001–.004	.0013
Gravity concentrates:			
>25:1 to <200:1	21	<.001–.004	.0017
>500:1	8	.001–.004	.0026
Quaternary glacio-fluvial gravels:			
Size fraction:			
Minus 4-, plus 7-mesh	11	<.001–.005	.0020
Minus 7-mesh	11	.001–.004	.0022
Gravity concentrates:			
>25:1 to <200:1	3	<.001–.003	.0010
>500:1	2	.003–.004	.0035
Quaternary bench gravels:			
Size-fraction:			
Minus 4-, plus 7-mesh	41	<.001–.007	.0017
Minus 7-mesh	41	<.001–.006	.0014
Gravity concentrate:			
>25:1 to <200:1	24	<.001–.004	.0021
>500:1	20	<.001–.007	.0029
Recent flood-plain gravels and tailings:			
Size fraction:			
Minus 4-, plus 7-mesh	18	<.001–.003	.0009
Minus 7-mesh	19	<.001–.004	.0010
Gravity concentrate:			
<25:1 to >200:1	16	<.001–.004	.0019
<500:1	14	.001–.009	.0046
Weighted average for all tests:			
Size fraction:			
Minus 4-, plus 7-mesh	106	----------------	.0016
Minus 7-mesh	116	----------------	.0014
Gravity fractions:			
<25:1 to >200:1	73	----------------	.0019
<500:1	44	----------------	.0034

Field-laboratory tests were made on 24 sluice-box concentrates collected from several hydraulic-mining operations in the area. Also tested were 17 panned cuttings from drill holes put down by the Alaskan Exploration and Mining Company in the vicinity of the Bird Creek workings. The data on these concentrates are shown in table 7 and the locations of those collected in the Cache Creek watershed are plotted on plate 1. The gravel yardage in the table is only approximate, having been derived from rough estimates furnished by the operators. Much of the material of mineral-grain size is lacking in the sluice-box concentrates, particularly the very fine, heavy "blowings," which probably contain a high proportion of any radioactive minerals present.

PEBBLE EFFECT

The pebble effect mentioned earlier in the discussion of sampling methods is apparent in the summary of the field gamma-count data (table 5). The weighted average gamma count per minute for the rough-screened sample tests is 0.6 counts per minute less than that of the field-station tests. This average lower counting rate is attributed to the screening out of the pebbles, although it may also be due to a lessening of the total mass affecting the instrument. The slight difference in the equivalent-uranium content of the minus 7-mesh and minus 4-, plus 7-mesh size-fraction (table 6) is also ascribed to the removal of coarser material. Thus, it is concluded that a closer approximation of the radioactivity of recoverable minerals in placer deposits can be made by the use of the counter on material screened down to mineral-grain size.

TABLE 7.—*Data on sluice-box and similar concentrates obtained from placer-mining operations in Yentna district, 1945*

[Cubic yards of gravel worked unknown unless shown. Age: LT, late Tertiary gravels; M, Mesozoic bedrock; Q, Quaternary bench gravels; R, Recent flood-plain gravels]

Sample no.	Cubic yards of gravel worked	Age	Percent eU	Mesh size	Nature of sample	Locality
A	--------	LT	<0.001	---------	Grab sample from concentrate pile.	Morgan's upper-bench cut Nugget Creek.
Ba	--------	LT	<.001	−7	-----do-----	Do.
Bc	--------	LT	.002	+7	-----do-----	Do.
Ca	--------	(?)	<.001	−7	-----do-----	Mouth of Iron Creek.
Cc	--------	(?)	.002	+7	-----do-----	Do.
Da	--------	(?)	<.001	−7	-----do-----	North bank of Cache Creek, 1,000 feet upstream from Nugget Creek.
Dc	--------	(?)	<.001	+7	-----do-----	Do.
E	--------	M	.002	---------	Crushed pyrite from bedrock.	Morgan's upper-bench cut, Nugget Creek.
Fa	20,000	Q	.023	−7	Sluice-box concentrate, some blowings.	Taraski's workings on Cache Creek, opposite Lucky Gulch.
Fc	20,000	Q	--------	+7	-----do-----	Do.
G	--------	Q	.003	---------	Sluice-box concentrate----	Weatherell's cut on Cache Creek, opposite Rambler Creek.
Ga	--------	Q	.024	(1)	Blowings from concentrate	Do.
H	2	Q	.006	---------	Sluice-box concentrate----	Weatherell's cut on Cache Creek, 1,600 feet downstream from Taraski's workings.

TABLE 7.—*Data on sluice-box and similar concentrates obtained from placer-mining operations in Yentna district, 1945*—Continued

Sample no.	Cubic yards of gravel worked	Age	Percent eU	Mesh size	Nature of sample	Locality
J1	30,000	LT	<.001	+4	Tailings from panning of sluice-box concentrate.	Haugham's upper-bench cut, Thunder Creek.
J2	30,000	LT	<.001	−4	do	Do.
J3	30,000	LT	.003	−4	Concentrate from panning of sluice-box concentrate.	Do.
Ka	1,000	LT	.006	−7	Sluice-box concentrate	Krummenacher's workings in Cheechako Gulch.
Kc	1,000	LT and Q	.002	+7	do	Do.
L	5	Q	.027		do	Weatherell's cut on Cache Creek, 1,600 feet downstream from Taraski's workings.
M	12,000	LT	.03	−12	Mostly blowings from sluice-box concentrate.	Haugham's workings on lower Thunder Creek.
N	8,000	LT	.023	−12	do	Haugham's upper-bench cut, Thunder Creek.
O		Q	.011		Sluice-box concentrate	Weatherell's cut on Cache Creek, opposite Rambler Creek.
P		LT?	.001	(?)	do	Upper-bench cut on south bank of Bird Creek.
Q		LT?	.002	(?)	do	Do.
Ra		LT?	.001	−7	do	Do.
S		LT?	<.001	(?)	do	Do.
T1		LT?	.002	−7, +12	do	Do.
T2		LT?	.003	−12	do	Do.
U1		LT?	.001	+12	do	Do.
U2		LT?	.002	−12	do	Do.
V		LT?	<.001		Concentrate	Do.
W1 [2]			.002			H7, L15.
2			.002			H8, L14.
3			.001			H8, L15, 38–40 feet.
4			.001			H8, L15, 65–108 feet (bedrock 114 feet).
5			.002			H15, L? (probably H?, L15).
6			.001			H5, L15, 0-9 feet.
7			.001			H9, L15.
8			.001			H4, L15.
9			.002		Amalgation residue	H9, L15.
10			.002			H6, L13.
11			<.001			H9, L13.
12			.001			H5, L15, 91–201 feet (bedrock).
13			<.001			H10, L13.
14			.001			H9, L14.
15			<.001			H6, L15.
16			.001			H6, L15.
17			.003		Amalgation residue	H5, L15; H8, L15; H6, L13; H8, L14 samples combined to fill container.
18			.001		do	H7, L14; H8, L14, H9, L14 samples combined.
X	4,000	R	.064		Sluice-box concentrate	Peters Creek at Petersville; one-half from Patricia Bowl and one-half from Little Bowl.
Y	4,000	Q and R	.032		do	Peters Creek at Petersville; three-fourths from low-bench cut west of canyon mouth and one-fourth from Little Bowl.
Z	10	Q?	<.001		do	Peters Creek at Petersville; Little Bowl.

[1] Fines.
[2] Samples W1–W18 are panned drill cuttings from holes put down by the Alaskan Exploration and Mining Co.; locality given by hole no. and line no.; samples have been screened through 7-mesh.

LABORATORY STUDIES

METHODS

Most of the field-laboratory samples collected in the Yentna district were taken to Washington, D. C., for additional study, particularly for identification of the radioactive minerals. For this purpose several concentrates showing relatively high radioactivity were selected from each gravel type. From each of these a grain-size portion (minus 40-, plus 100-mesh) was selected and five fractions prepared using heavy liquids (bromoform, sp gr 2.8; and methylene iodide, sp gr 3.3) and a magnetic separator.

Light, specific gravity <2.8.
Specific gravity >2.8, <3.3; magnetic.
Specific gravity >2.8, <3.3; nonmagnetic.
Specific gravity >3.3; magnetic.
Specific gravity >3.3; nonmagnetic.

Portions of these five fractions of several of the samples were then mounted in bakelite on glass slides and exposed by contact to alpha-ray spectroscopic plates for periods of 4 to 14 days to determine specifically which grains were radioactive.

MINERALOGY

COMMON CONSTITUENTS OF CONCENTRATES

The concentrates from the several gravel types studied are much the same in mineral composition. The proportions of the different minerals, however, vary to some extent, and the variation apparently is characteristic of certain of the gravel types. The following minerals are the abundant and common constituents of the concentrates: zircon, hornblende, hypersthene, augite, epidote, garnet, pyrite, ilmenite, chromite (or a chrome spinel), cassiterite, magnetite, quartz, and altered feldspar. The minor and erratic constituents are gold, tourmaline, andalusite, biotite, chlorite, iron oxides, allanite(?), arsenopyrite, copper, stibnite(?), apatite, sphene, monazite, graywacke fragments, iddingsite, prehnite, rutile(?), marcasite, galena, and two unidentified minerals—one of them brown and wedge-shaped, the other whitish and anhedral. Platinum has been reported by Mertie (1919) in some of the placers of the Yentna district, but was not found in the samples collected in 1945.

The Eocene sands and gravels characteristically have heavy-mineral suites low in sulfide minerals, and lacking in tourmaline and apatite. Heavy-mineral fractions from the late Tertiary gravels are rich in pyrite, whereas Quaternary bench gravels have heavy-mineral fractions characteristically high in andalusite and cassiterite. Apatite, tourmaline, monazite, allanite(?) and iddingsite(?) are more abundant in the flood-plain gravels than in the other gravel types

RADIOACTIVE MINERALS

The source of the radioactivity in the samples collected in 1945 apparently is due chiefly to monazite which normally contains from a few percent to about 11 percent thoria (Frondel and Fleischer, 1952,

p. 7). The monazite occurs as lemon-yellow, euhedral, wedge-shaped monoclinic crystals.

Zircon, which is extraordinarily abundant, may possibly be slightly radioactive and responsible in part for the radioactivity measured, but direct evidence is lacking. According to Frondel and Fleischer (1952, p. 16) zircon may contain several percent uranium and thorium, although it is usually low in these elements. The zircon is characteristically in euhedral, tetragonal prisms and pyramids, generally colorless although some crystals are tinted purple, blue, yellow, and brown.

The only strongly radioactive mineral noted occurs in black, lustrous, anhedral grains and is tentatively identified as uraninite.[2] It is the only mineral which darkens an alpha-ray spectroscopic plate after 2 weeks exposure. Only a few grains of the uraninite(?) were seen. More than likely it is the same mineral identified as uraninite(?) by Larsen (written communication, 1945, to Harder and Reed).

CONCLUSION

In conclusion the writers believe that the placer deposits examined in the Cache Creek-upper Peters Creek area do not contain sufficient amounts of radioactive minerals to be considered as important reserves of uranium and thorium. However, because the studies made in 1945 did not investigate the sites of radioactive placers on Canyon and Poorman Creeks, and on the Kahiltna River (table 1), it cannot be positively assumed that all placers in the Yentna district are unfavorable for the occurrence of significant concentrations of radioactive minerals. The occurrences on Poorman and Canyon Creeks should be considered in specific regard to the relationship of the placer deposits to possible mineralized zones in the bedrock (Mertie, 1919, p. 257–262). The deposits on the Kahiltna River are at sites where it would be possible to work great quantities of gravel by large-scale placer methods. The radioactivity of the Kahiltna River placers is also due to the occurrence of monazite and uraninite(?). The equivalent-uranium content of the samples apparently is due to considerably more uranium than thorium (table 1). In addition to the uraninite(?) and monazite, Larsen (written communication, to Harder and Reed 1945), indicates that the Kahiltna River concentrates contain varying amounts of apatite, cassiterite, feldspar, pyroxene, quartz, sphene, spinel, tourmaline, and zircon. They also contain garnet, gold, hematite, ilmenite, limonite, magnetite, and platinum (Mertie, 1919, p. 262, 263). (See also appendix for mineralogic analysis of sample

[2] Subsequent mineralogic studies have shown that this mineral is uranothorianite. See p. 22.

obtained subsequent to the preparation of this report.) Inasmuch as the Kahiltna River placers may offer possibilities for working large yardage of gravels it is possible that the total value of recoverable economic minerals may be sufficient to warrant further prospecting of the placers in the present flood plain and low-level bench gravels from the confluence of the Kahiltna with the Yentna River to the toe of the Kahiltna Glacier.

LITERATURE CITED

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Frondel, J. W., and Fleischer, Michael, 1952, A glossary of uranium- and thorium-bearing minerals, [2d ed.]: U. S. Geol. Survey Circ. 194.

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APPENDIX

SUBSEQUENT MINERALOGIC ANALYSIS, 1950

Since the preparation of this report a prospector's sample was received in 1950 which may be a concentrate from one of the holes drilled at Red Hill Bar on the Kahiltna River in 1917 (Mertie, 1919, p. 263) across the river from Round Bend Bar. The size of the sample received was too small to permit an accurate analysis of the radioactivity, but qualitative tests showed that it was extremely radioactive. A mineralogic analysis of the sample by M. G. White is given below.

Mineral	Estimated volume (percent)	Mineral	Estimated volume (percent)
Ilmenite	25	Cassiterite	3
Monazite	20	Sphene	2
Zircon	15	Rutile	(1)
Magnetite	15	Hornblende	(1)
Platinum	5	Crocoite(?)	(1)
Scheelite	5	Biotite	(1)
Uranothorianite	5	Gold	(1)
Garnet	5		

1 Trace.

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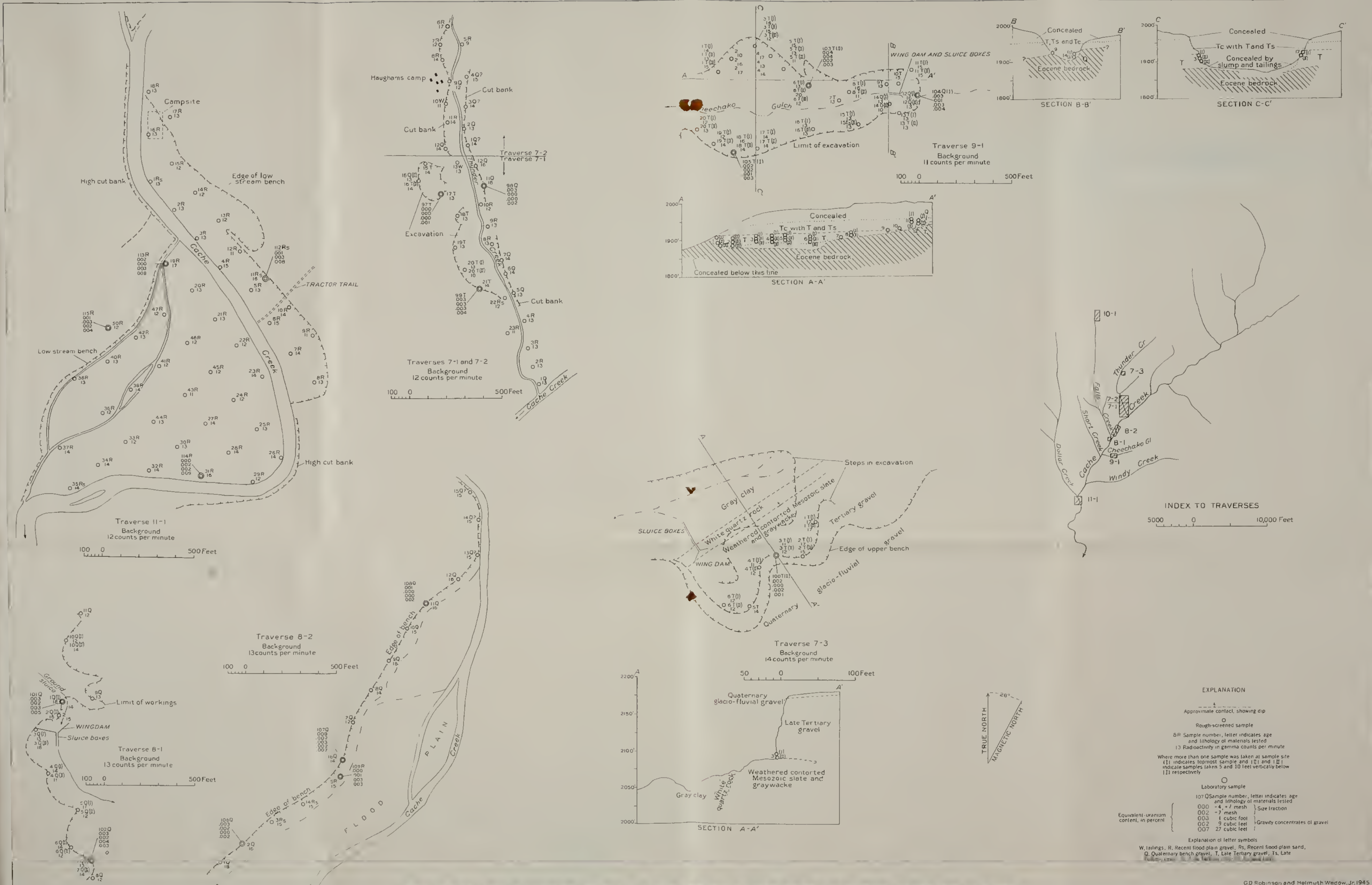
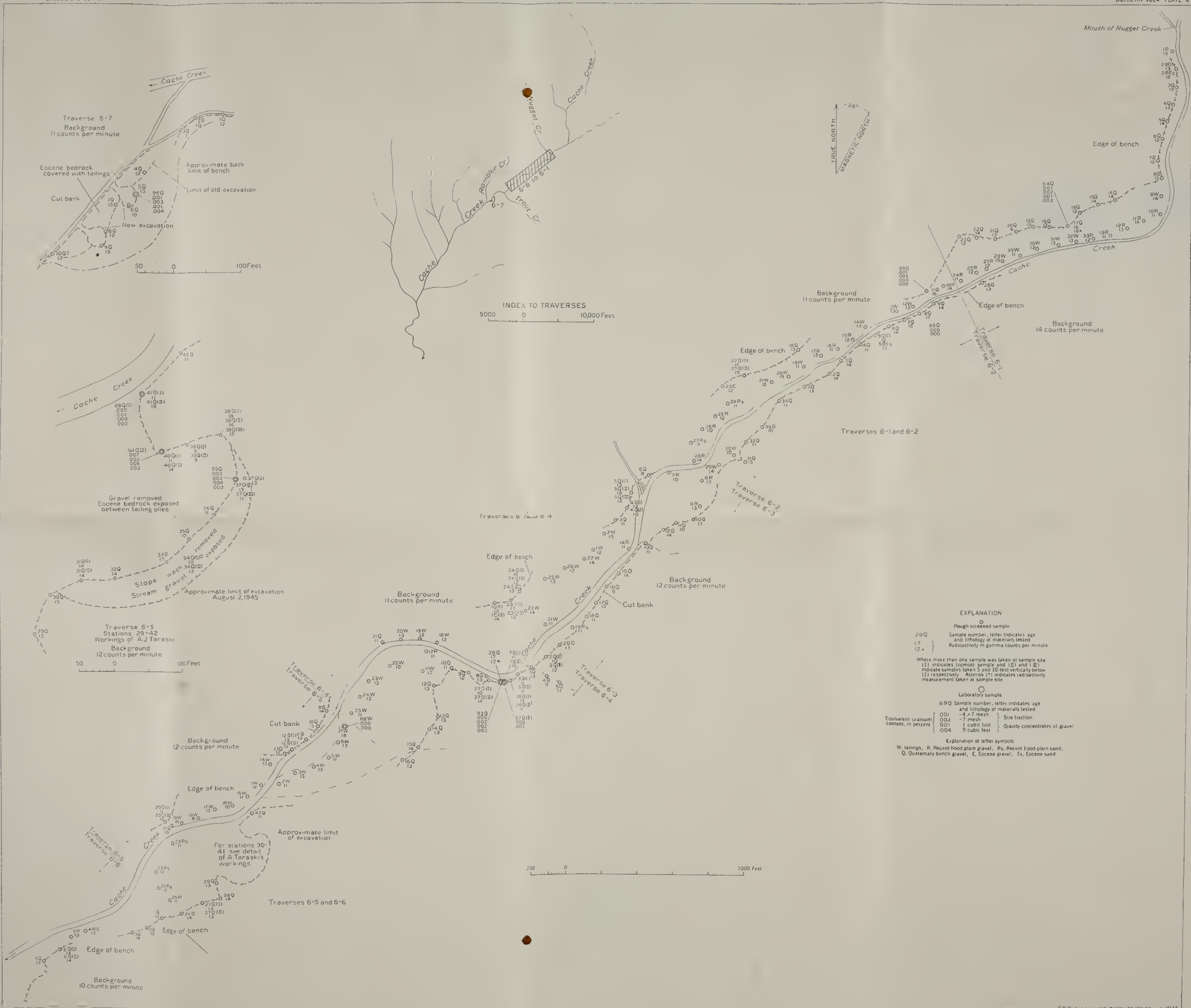
MAPS AND TRAVERSES, UPPER PETERS CREEK AND TRIBUTARIES, YENTNA DISTRICT, ALASKA

326900 O - 55 (In pocket) No. 6



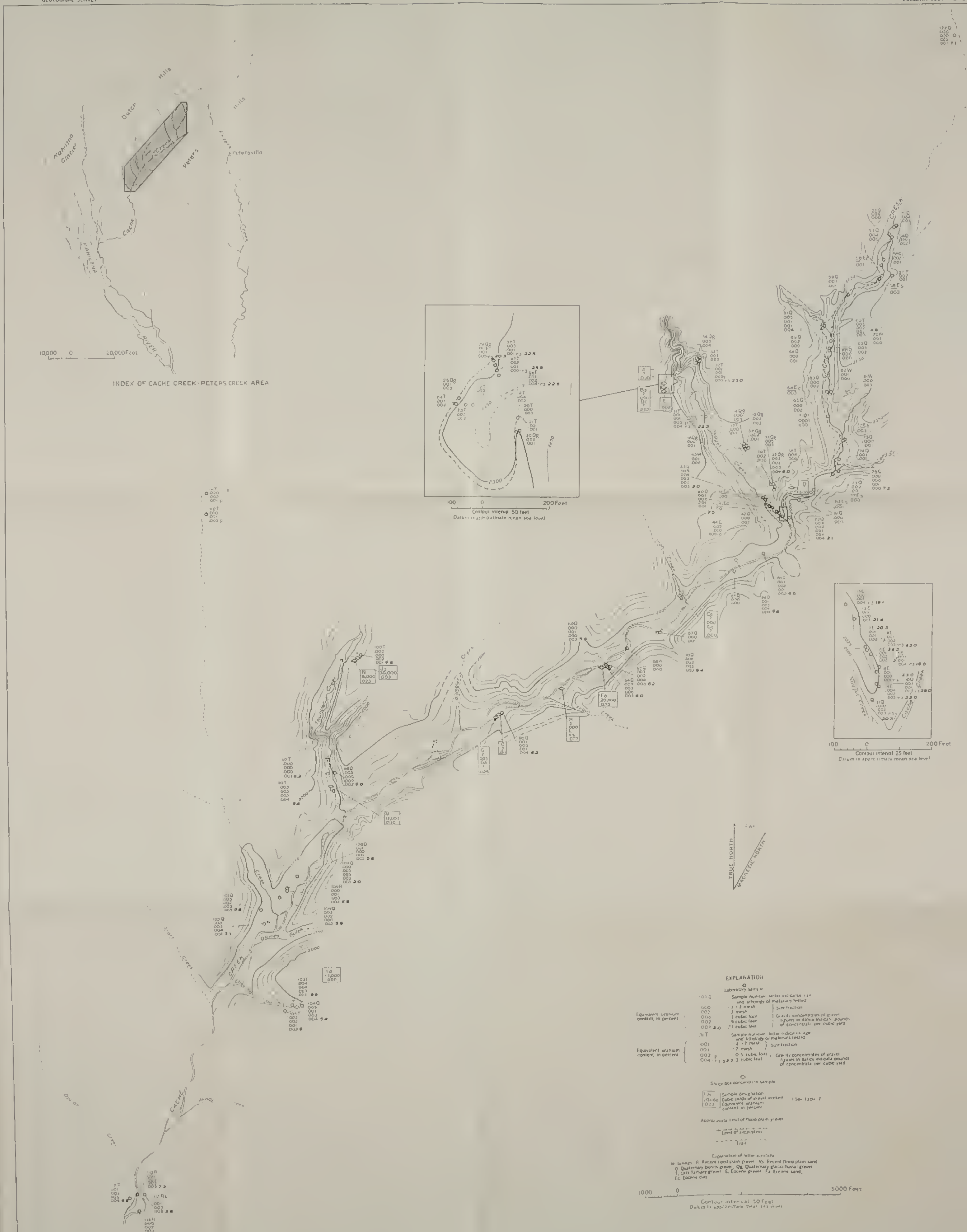
TRAVERSES ON THUNDER CREEK AND PART OF CACHE CREEK, YENTNA DISTRICT, ALASKA

326900 O - 55 (In pocket) No. 5



TRAVERSES ON CACHE CREEK BETWEEN RAMBLER CREEK AND NUGGET CREEK, YENTNA DISTRICT, ALASKA

326900 O - 55 (In pocket) No. 4



TOPOGRAPHIC MAP OF THE CACHE CREEK AREA, SHOWING SAMPLE LOCALITIES, YENTNA DISTRICT, ALASKA