GEOLOGICAL SURVEY CIRCULAR 255

RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN THE LOWER YUKON-KUSKOKWIM HIGHLANDS REGION ALASKA

UNITED STATES DEPARTMENT OF THE INTERIOR
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RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN THE LOWER YUKON-KUSKOKWIM HIGHLANDS REGION, ALASKA, 1947

By M. G. White and P. L. Killeen

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CHAPTER A.—RADIOACTIVITY INVESTIGATIONS IN THE VICINITY OF FLAT

ABSTRACT

Investigations in 1947 in the Lower Yukon-Kuskokwim region, Alaska found that previously reported radioactivity in the vicinity of Flat is due to uraniferous zircon, an accessory mineral in monzonite. The monzonite intrudes mafic igneous and Upper Cretaceous sedimentary rocks. The maximum equivalent-uranium content of the zircon is 0.14 percent, and the average content is probably near 0.13 percent. Chemical analysis of one sample of the most radioactive zircon indicates approximately 0.12 percent uranium and 0.03 percent thoria. The radioactive elements apparently are most commonly associated with reddish-brown inclusions within the zircon crystals.

Tests of sulfide-bearing veins, black shales, and other rock types in the area around Flat showed no significant amount of radioactive material.

Although there is little likelihood of finding high-grade uranium deposits in the area covered by the 1947 investigation, the fact that the predominant radioactive element in the monzonite is uranium may indicate that other intrusives of the same age in the Lower Yukon-Kuskokwim region might also contain uraniferous material. Possibilities of concentrations in attendant contact-metamorphic or vein deposits are suggested by a previously reported occurrence of zeunerite in a copper lode in this same general belt of intrusives.

INTRODUCTION

Flat, a settlement of about 70 permanent residents, is in the Iditarod quadrangle[1], Lower Yukon-Kuskokwim region, Alaska (fig. 1). It is about 360 miles southwest of Fairbanks (fig. 1) and is located on Otter Creek, about 6 miles southeast of Iditarod Landing. Flat has a good 3,500-foot long airstrip and is accessible by commercial air service from Fairbanks and Anchorage.

Before 1947 the Geological Survey's Alaskan concentrate collection contained only 14 samples from the placer gold-mining operations in the vicinity of Flat. Six of the samples contain from 0.03 to 0.092 percent equivalent uranium; the remaining eight have 0.006 percent or less equivalent uranium. Of the samples containing 0.03 or more percent equivalent uranium, two are from Willow Creek, two from Flat Creek, one from Chicken Creek, and one from Happy Creek (fig. 2). The Happy Creek sample contained 0.092 percent equivalent uranium; chemical analysis of this sample showed a content of 0.073 percent uranium and 0.013 percent thoria (Harder and Reed, 1945, p. 5, sample no. 61). Mineralogic study of the other samples indicated that the radioactive elements were probably associated with the accessory minerals of monzonite in the Flat area. Zircon was later discovered to be the chief radioactive mineral in the area.

Two sluice-concentrates from placer-mining operations near Flat, obtained by Skidmore in reconnaissance for the Union Mines Development Corporation during the summer of 1944, were reported (Skidmore, 1944) to contain 0.08 percent equivalent uranium.

Study of all available data on the pre-1947 samples from the vicinity of Flat suggested the presence of a northeast-trending radioactive zone, conceivably of late-stage formation along a structural feature, in the monzonite.

In 1947, therefore, investigations were undertaken in the vicinity of Flat to:

1. Locate and investigate any zones in or differentiate phases of the monzonite which might contain significant concentrations of radioactive material.

2. Determine the quantity and distribution of radioactive minerals in the surface part of the monzonite, and determine whether recovery could be easily effected.

3. Determine by radiometric reconnaissance whether any other rocks or occurrences of metallic minerals in the area were sufficiently radioactive to warrant additional study.

To conduct these investigations a field party consisting of Max G. White and P. L. Killeen, geologists, and Glenn Fellows, camp assistant, was in the area from June 30 to September 10. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Previous geologic investigations at Flat and vicinity have been of a reconnaissance nature, made in connection with investigations of more regional scope. The studies were initiated by Maddren (1911) and continued by Eakin (1913, 1914), Smith (1915, 1917), Mertie and Harrington (1916, 1924), and Mertie (1936).

GEOLOGY

Clastic sedimentary rocks, mafic igneous rocks, and monzonite are the major types of bedrock exposed

[1] Alaska reconnaissance topographic series, scale 1:250,000.

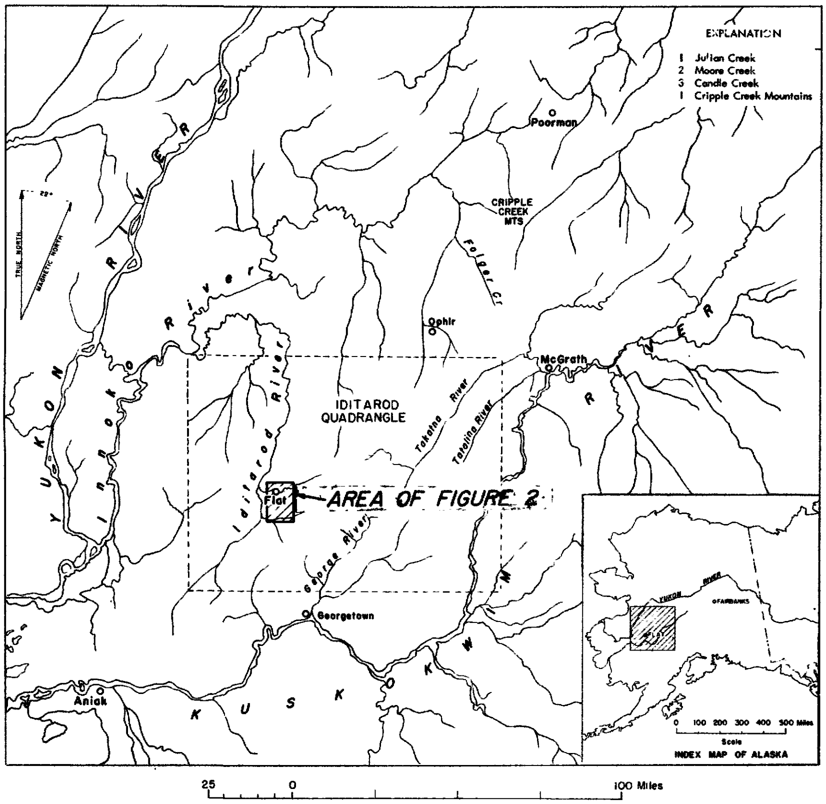

Figure 1.—Sketch map of the Lower Yukon-Kuskokwim Highlands region, Alaska.

in the vicinity of Flat (fig. 2). As significant amounts of radioactive material are found only in the monzonite, this rock type alone will be discussed in detail in this report.

Sedimentary rocks

Sedimentary rocks in the vicinity of Flat are gray and black shale of Late Cretaceous age interbedded with sandy shale and sandstone. Near contacts with intrusive rocks the shale is more indurated and has a flinty character. In many places the sandstone is massive and hard, and in part altered to quartzite.

Mafic igneous rocks

The Mafic igneous rocks of the Flat area are types that are widely distributed throughout the Lower Yukon-Kuskokwim region. According to Mertie (Mertie and Harrington, 1924, p. 66), these rocks are mainly of intrusive origin and consist of diorite, gabbro, diabase, and pyroxenite, as well as some andesite and basalt. Convenience and lack of detailed information require that all rocks of these types be mapped as an undivided group (figs. 2, 3, and 4). Many of the rocks of this group intrude the Upper Cretaceous clastics and, therefore, are younger than the sedimentary rocks.

Monzonite

Monzonite of Tertiary(?) age intrudes both the undivided mafic igneous rocks and the Upper Cretaceous clastic strata. It was first described by Mertie (Mertie and Harrington, 1924, p. 70), who reported its mineralogic composition as follows:

Orthoclase.
Plagioclase
(ranging from oligoclase to labradorite).
Quartz
(in small amount).
Augite.
Hornblende.
Biotite.

Accessory minerals:
Magnetite.
Apatite.
Zircon.

In the vicinity of Flat, monzonite is found on Cottonwood Creek (fig. 2); at the heads of Flat, Happy, and Chicken Creeks (figs. 2 and 3); and around Discovery on Otter Creek (figs. 2 and 4). This rock exhibits somewhat different characteristics at each of the three localities. The major differences and similarities of the monzonite at each locality are readily seen in the descriptions given in table 1. The monzonite on Cottonwood Creek is a more uniformly mafic mass than that at the two other localities. Study of the Cottonwood Creek body was discontinued when preliminary reconnaissance discovered that the monzonite is considerably less radioactive there than elsewhere in the Flat area.

Despite the differences between the monzonite at Discovery and that at the head of Flat Creek (table 1), the overall similarity of their texture, mineral content, and characteristics of their accessory minerals leads to the assumption that they are parts of the same monzonite stock and were derived from the same parent magma. As there is a proportionately greater amount

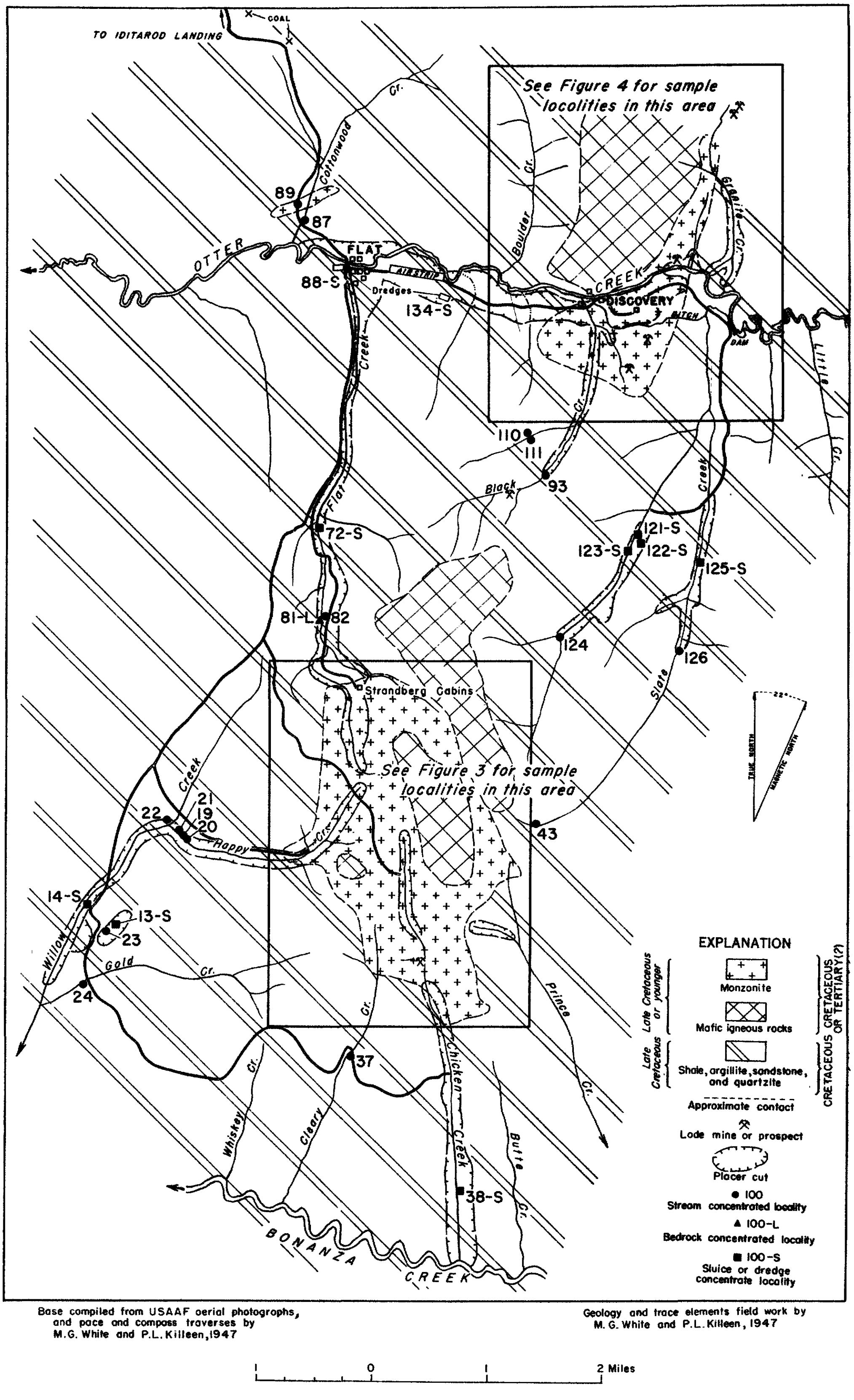

Figure 2. Geologic sketch map of Flat and vicinity, Alaska.

Table 1.—Description of three monzonite bodies in the vicinity of Flat, Lower Yukon-Kuskokwim region, Alaska

	Location		
	On Cottonwood Creek, about 1 mile north of Flat (fig. 2).	On Otter Creek in the vicinity of Discovery, about $2\frac{1}{2}$ miles east of Flat (figs. 2 and 4).	In vicinity of headwaters of Flat, Happy, and Chicken Creeks, about 5 miles south of Flat (figs. 2 and 3).
General description-----	Elliptical-shaped exposure oriented northeast-southwest, about 1 mile long and $\frac{1}{4}$ mile wide; limits inferred from surface float.	Triangular-shaped exposure with a prong extending northward up Malamute Pup to the head of Granite Creek; about $1\frac{1}{4}$ square miles in area.	Roughly elliptical-shaped exposure of about $2\frac{1}{2}$ square miles; oriented north-south.
Texture, mineralogic description, and miscellaneous information.	Uniformly medium-grained dark-colored, containing relatively large amounts of biotite and augite and a small amount of olivine; magnetite and apatite occur in very limited amount as accessory minerals; zircon is rare; no quartz veins.	Ranges from dark-colored coarse-grained to light-colored, very fine-grained, highly feldspathic rock containing very few heavy minerals; contains quartz veins with scheelite, cinnabar, stibnite, and arsenopyrite; on the whole more felsic and finer-grained than the mass on Flat Creek though it shows a greater variety of texture and composition in a more limited areal extent.	Occurs in a light-colored and a dark-colored facies, both ranging in texture from coarse- to fine-grained; contains higher proportion of disseminated heavy minerals than the mass at Discovery, but has considerably less vein quartz with associated sulfides.

of radioactive material available in the monzonite at the head of Flat Creek, that body is the main source of data for this report. At both Discovery and the head of Flat Creek the monzonite is disintegrated to an average depth of 3 to 5 feet, although, locally, the disintegration extends to a depth of 30 feet. Some residual concentration of the heavy minerals has taken place in the mantle, largely by the settling of the minerals through the disintegrated bedrock.

The principal mineralogic studies of the monzonite were made on minerals with a specific gravity of more than 2.8 (hereinafter referred to as the heavy-mineral fraction) which were separated from the lighter minerals with bromoform. Minerals found in the heavy fractions of concentrates from disintegrated bedrock are listed below in order of decreasing abundance:

Biotite.	Epidote.
Pyroxene (augite).	Magnetite.
	Olivine.
Amphibole (black and green hornblende).	Hematite.
	Spinel.
Ilmenite.	Pyrite.
Zircon.	Sphene(?).
Apatite.	Rutile.
Tourmaline.	

Facies in the monzonite.—The monzonite is composed of two main facies: one medium- to coarse-grained, dark-colored because of the predominance of biotite, augite, and hornblende; the other, fine- to coarse-grained, light-colored because of the paucity of these dark minerals (table 1). The light-colored facies has a relatively small heavy-mineral fraction which consists mostly of accessory minerals such as zircon, apatite, ilmenite, and so forth. It is the most radioactive monzonite facies. Tables 2 and 3 show statistically the differences between the two facies with regard to the heavy-mineral content of concentrates taken mostly from the disintegrated monzonite.

Sufficient information on these rocks is not available to determine the genetic relationship between the light and dark facies of the monzonite. Although rocks of intermediate composition occur, no evidence was found of any gradation between the two facies; in fact, several float specimens composed of both kinds of monzonite show a distinct line of contact between the two facies. Several small inclusions of fine-grained, dark-colored, schistose monzonite were found in the coarse-grained, light-colored facies.

Thus, the dark facies may represent an early stage of crystallization of the monzonite stock south and east of Flat; and the small mass on Cottonwood Creek may have been formed during this early stage as an offshoot of a zircon-poor, olivine-bearing facies from the main body of magma.

Although the heavy accessory minerals are scattered throughout all facies of the monzonite, they are not evenly distributed but appear to be relatively more abundant in the coarsest-grained phase of the light-colored facies; and within that facies concentrated within definable mineral zones. At the head of Flat Creek (fig. 3), in placer cuts on ground that has been stripped to bedrock, coarse-grained, light-colored monzonite is deeply disintegrated and is cut by small sharp V-shaped gullies. The exposures extend from near the valley floor almost to the saddle between Flat and Happy Creeks. Some of the concentrates from the monzonite at this locality were taken along a traverse of about 2,000 feet, parallel to the elongation of the placer cuts. The bedrock is of uniform texture and there are only slight variations in color; but there is considerable variation in the principal heavy accessory minerals in the concentrates of the rock (table 3). Sample 70-L contains 66 percent zircon; sample 58-L, 20 percent tourmaline; sample 63-L, 34 percent ilmenite; and sample 64-L, 18 percent apatite. The last three of these samples also contain a relatively higher percentage of common rock-forming minerals which accounts for the somewhat darker color of the rocks from which the samples were obtained. Probably these samples represent accessory-mineral zones in the monzonite, the nature and outline of which have not been determined, but which may be lenses or less regularly defined zones that go into the over-all makeup of the main rock body. Definite contacts were seen between the ilmenite zone (sample 63-L), the tourmaline zone (sample 58-L), and the zone of apatite (sample 64-L). These zones, however, are surrounded by monzonite that contain radioactive zircon as its principal heavy accessory mineral.

RADIOACTIVITY STUDIES

Equipment

The radiometric equipment in the investigations at Flat and vicinity in 1947 consisted of a Victoreen Model 263 portable survey meter with a standard Eck and Kreb 6-inch beta-gamma tube, and a GS model portable survey meter with a small glass-walled gamma tube in a brass housing. The low sensitivity of these tubes restricted the coverage of the area to the actual sites where radiometric readings were made with a tube in direct contact with the rock, or where samples were taken and tested later in camp or the laboratory.

Discussion of data

Study of both field and laboratory radioactivity data from the Flat area indicates that the only radioactive material with an equivalent uranium content greater than the average of most rock types occurs in the monzonite and in concentrates of placers derived from the monzonite. The radioactivity of the various rock types and placer concentrates is discussed below.

Monzonite

Data on heavy-mineral concentrates from monzonite, veins, and dikes in the vicinity of Flat are presented in table 4. The coarse-grained light-colored facies of the monzonite appears to be the most radioactive material in the area, probably because it contains relatively higher concentrations of accessory minerals (tables 2 and 3). Laboratory studies showed that one of the accessory minerals, zircon, contains almost all of the radioactive material present in the monzonite, although apatite also is slightly radioactive. In addition, biotite, because of "minute" inclusions of radioactive minerals, also appears to be slightly radioactive. It is possible that the total amount of

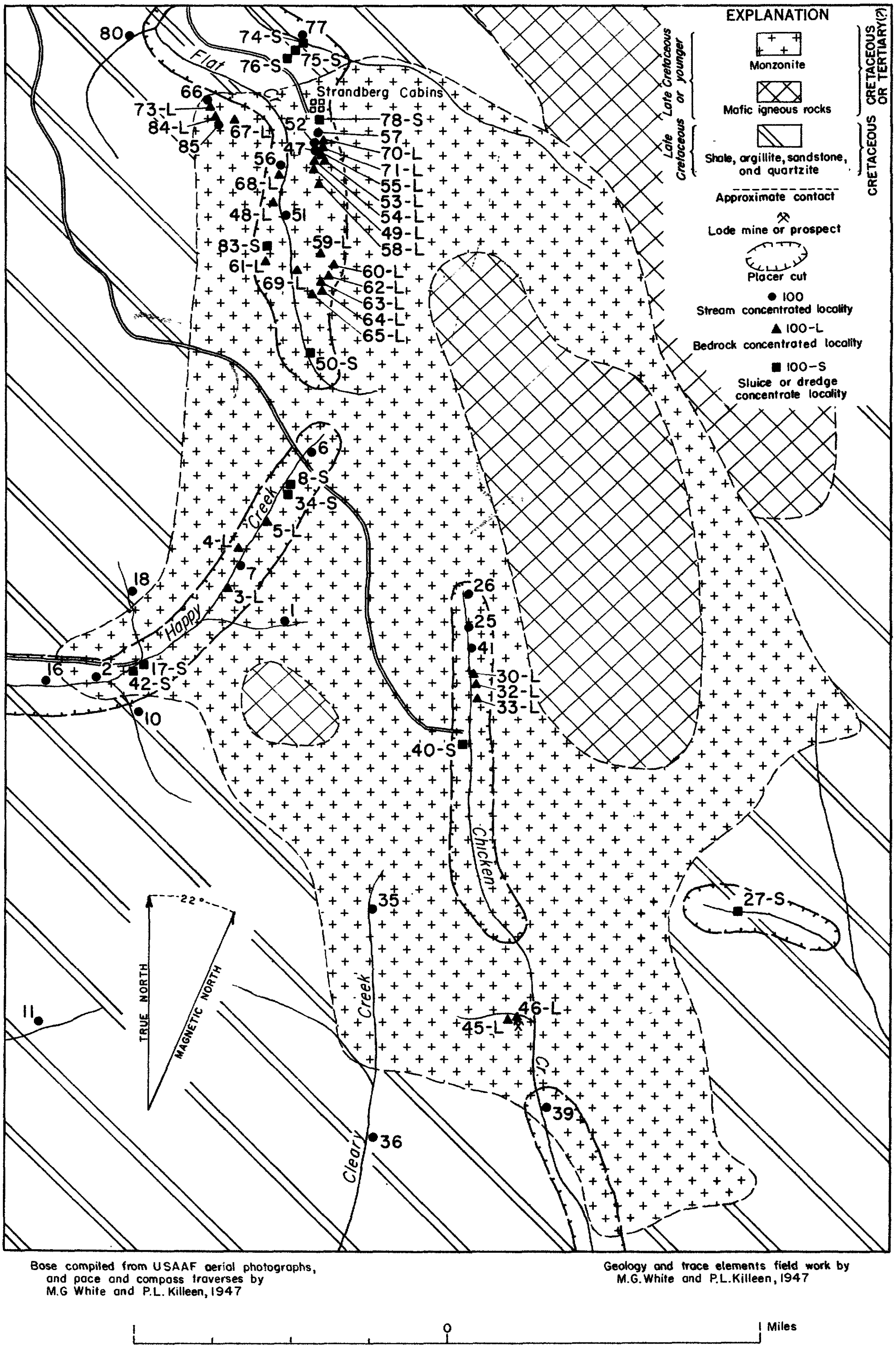

Figure 3. Geologic sketch map of the monzonite body at the head of Flat Creek, south of Flat, Alaska.

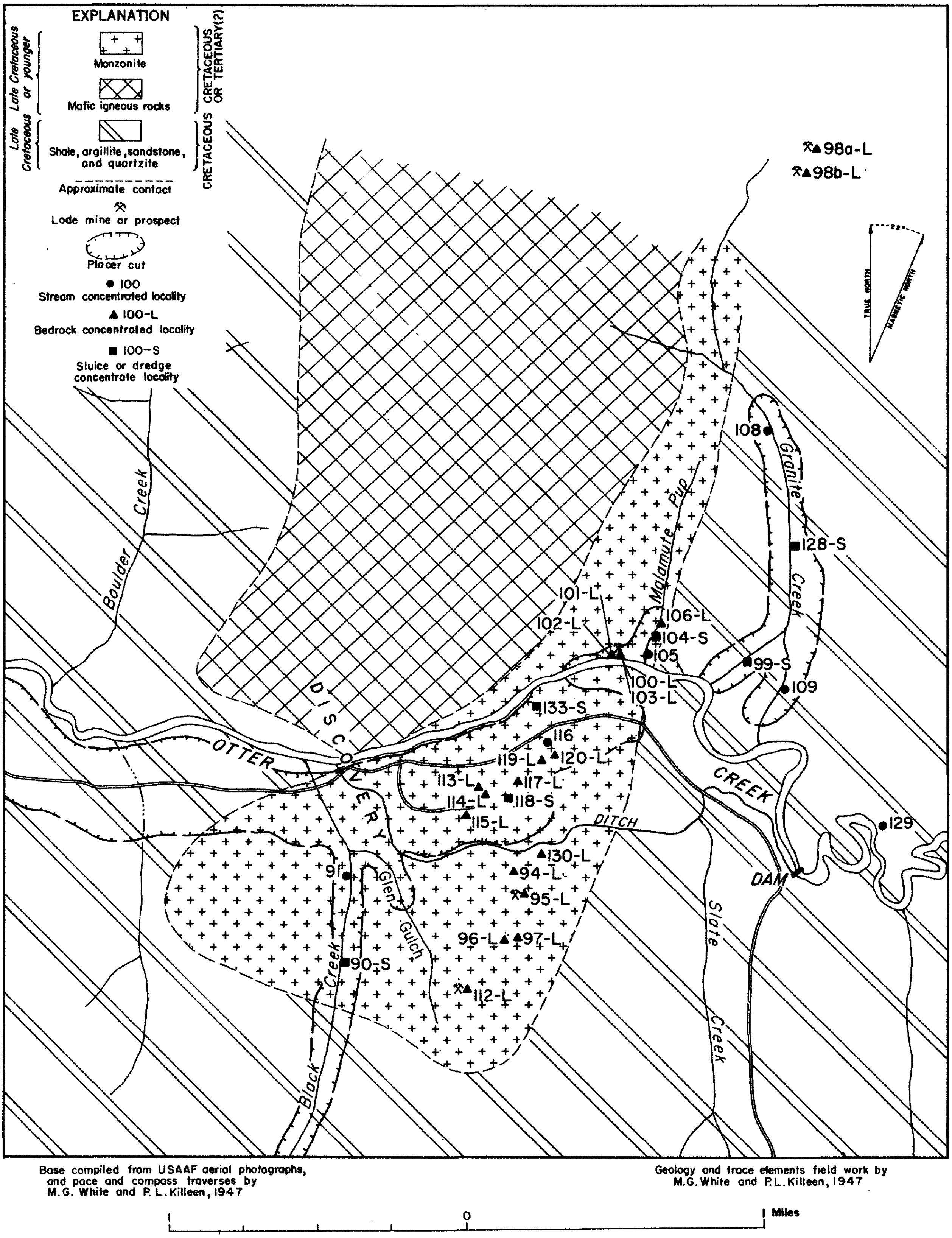

Figure 4. Geologic sketch map of the monzonite body in the vicinity of Discovery, near Flat, Alaska.

zircon present is constant for all facies of the monzonite, but the zircon recovery is relatively higher from concentrates of the light-colored monzonite compared to the dark-colored monzonite (tables 2 and 3). The radioactive accessory minerals of the monzonite are described below.

Zircon. —Details on the radioactivity and mineralogy of zircon were obtained by study of samples from exposures at the head of Flat Creek (fig. 3), where the zircon occurs in the greatest concentration.

Only a small percentage of the zircon crystals are equidimensional in cross-section, most of them being somewhat flattened parallel to the vertical axis which gives a tabular shape to a majority of the crystals and a thin lamellar shape to a small percentage of them.

Most of the crystals show some or all of the following faces: a, (100) or (010); m, (110); u, (331); p, (111); and x, (311). The crystals range from this complex association of faces to the simple elongated combination of tetragonal prism and bipyramid. The most complex combinations tend to be less flattened than those of intermediate complexity. Basal pinacoids, (001), were found on a very few crystals.

The zircon crystals, in general, are very small. Approximately 70 percent are between 60- and 100-mesh; about 10 percent are larger than 60-mesh; and 20 percent are smaller than 100-mesh.

Fluorescent techniques were of some aid in the mineralogic study of the radioactive zircon. Sandpaper strips were prepared from the heavy-mineral fractions of several of the concentrates for which the equivalent uranium content was known. By comparing the amount of zircon in the strips with the amount in samples of unknown equivalent uranium values under a mineralight, reasonably good estimates of the equivalent uranium content for the unknowns were obtained. These estimates were verified by subsequent radiometric determinations.

The equivalent uranium content of samples of 98 percent pure zircon, from different localities in the vicinity of Flat, ranges from 0. 10 to 0. 14 percent and averages 0. 13 percent. (The percentages of minerals given in this report are based on estimates by volume.) Most of the radioactive material in the zircon probably occurs in inclusions, which are reddish-brown and occur as irregular masses within the crystals. A large part of many crystals is made up of this included material. Evidence of the radioactivity of the inclusions lies in the difference of equivalent uranium values in samples with different amounts of inclusions in the crystals. For example, the zircon fraction from sample 60-L (table 3) contains 0. 10 percent equivalent uranium, whereas that of sample 61-L contains 0. 14 percent equivalent uranium. The zircon of sample 61-L contains more inclusions than the zircon of sample 60-L. Thus, there appear to be two factors which govern the radioactivity of the samples: one, the number of zircon crystals containing inclusions; and, two, the amount of included material in each zircon crystal.

Chemical analysis, by the Geological Survey's Trace Elements Section Washington Laboratory, of a zircon fraction (sample 47, table 5) with an equivalent uranium content of 0. 14 percent showed 0. 12 percent uranium and 0. 03 percent thoria, and, in addition, 1. 56 percent phosphorus pentoxide and 0. 40 percent rare-earth oxides. This chemical determination of uranium and thorium is conformable with the limits of error in the determination of the equivalent uranium content of the zircon. As this zircon fraction appears to be representative of the zircon fractions of other samples of comparable radioactivity, it is thought that the results of the chemical analysis of the one sample reflect reasonably well the relative amounts of radioactive elements present in the zircon. Crystals containing inclusions and crystals relatively free of inclusions were spectrographed for comparative purposes, by the Geological Survey's Trace Elements Section Washington Laboratory. The trace elements are so small in amount that their spectrum lines do not appear on either spectrograms, and the only difference detected between the two types of zircon was the presence of a larger amount of iron in the inclusion-bearing crystals.

Apatite. —All zircon was removed from the apatite fractions of several samples and the fractions cleaned to a purity of about 95 percent apatite. The equivalent uranium content of these cleaned fractions ranges from 0. 008 to 0. 01 percent. The apatite occurs in long colorless lustrous prismatic hexagonal crystals, 65 percent of which are less than 100-mesh in size.

The apatite is disseminated throughout the monzonite masses in the vicinity of Flat, but is less abundant than zircon. Like the zircon, the greatest concentrations of apatite are at the head of Flat Creek, in zones within the coarse-grained, light-colored monzonite (table 3). However, near Discovery, on the north bank of Otter Creek, 100 feet below the mouth of Malamute Pup, one zone of the coarse light-colored monzonite yielded a heavy-mineral fraction (sample 103-L, table 3 and fig. 4). that contains 55 percent apatite.

Biotite. —The biotite fraction of concentrates from the coarse-grained, dark-colored facies of the monzonite is slightly radioactive. Examination of the plus 40-mesh flakes of biotite with the microscope revealed the presence of numerous very pronounced pleochroic halos around minute crystals of zircon, which are rarely fluorescent, and around a black monoclinic mineral tentatively identified as allanite. Radiometric tests of the biotite indicate a content of 0. 004 percent equivalent uranium.

In planning the field work for 1947 it was noted that the locations of the available samples with the highest equivalent uranium percentages trended in a northeasterly direction from Willow Creek through Happy Creek to the head of Flat Creek (fig. 3). The 1947 investigation showed a greater abundance of radioactive zircon in the heavy-mineral concentrates of the coarse-grained, light-colored monzonite from the heads of Happy and Flat Creeks than from elsewhere in the Flat area. As more of this facies of the monzonite is exposed at this locality than elsewhere in the area, it follows that the equivalent uranium content of concentrate samples from this northeast-trending belt would very likely be higher than elsewhere.

Vein and lode prospects

During the course of the investigation of the distribution of radioactive materials in the monzonite, radiometric tests were made on all prospects and exposures of sulfide-bearing, gold-bearing and other types of mineralized veins and lodes in the vicinity of Flat. These tests gave essentially negative results. A tabulation of the known veins and lodes of the area, all of which were tested for radioactivity, follows:

1. Gold-bearing quartz veins in the upper part of Granite Creek.

2. Quartz vein, carrying small amounts of gold and sulfides, on the north bank of Otter Creek, a short distance below the mouth of Malamute Pup.

3. Scheelite-bearing quartz veins in the bedrock of the Miscovich placer cut at Discovery.

4. Quartz vein containing gold, arsenopyrite, scheelite, and some stibnite; on Discovery Bench above the south valley wall of Otter Creek.

5. Cinnabar-bearing quartz vein; at the mouth of Glen Gulch.

6. Gold-bearing quartz veins; at the head of Glen Gulch.

7. Antimony prospect on Black Creek.

8. Gold-bearing quartz stringers cutting monzonite; at the head of Flat Creek.

9. Stibnite-bearing quartz at the head of Happy Creek.

10. Scheelite-bearing and cinnabar-bearing quartz-vein fragments in sluice concentrates from Happy Creek; bedrock location unknown.

11. Magnetite-pyroxene dike cutting black shale; at the foot of the west valley wall of upper Flat Creek.

Mafic igneous rocks

Radiometric scanning of the mafic igneous rocks at various exposures in the vicinity of Flat (fig. 2) showed that these rocks have no associated radioactive materials. Consequently no sampling or additional studies were made on these rocks.

Upper Cretaceous sedimentary rocks

The sedimentary rock sequence in the Flat area, comprising gray and black shales interbedded with sandy shale and sandstone, was tested radiometrically in the field but results were negative. Particular emphasis was placed on outcrop readings of black shales in an attempt to locate any bed that might contain a significant quantity of radioactive material. Samples from three different localities that gave the highest radiometric readings in the field contain only 0.002 percent equivalent uranium.

Creek placers

Panned concentrates.—The principal creeks that drain the monzonite south of Flat (Chicken, Happy, and Flat Creeks) have been extensively mined from mouth to head. The mining included not only the gravel along the principal drainage channels of the creeks but also the disintegrated monzonite bedrock, which contains considerable free gold derived from overlying gravels and from disintegrated gold-bearing quartz veins. As the bedrock is so highly disintegrated, it was mined as placer material, in some places to a depth of 25 to 30 feet. The average depth of bedrock mined is probably 15 to 20 feet.

Table 5 lists the data on panned concentrates from stream gravels that were of sufficient volume to permit laboratory work. As in the concentrates from the disintegrated monzonite, the radioactive material in the heavy-mineral fractions of panned concentrates from the stream gravels is contained in zircon.

Sluice-box and dredge concentrates.—Table 6 lists the sluice-box and dredge concentrates collected in the vicinity of Flat in 1947. The concentration ratio in these samples is not known but is undoubtedly extremely high.

Table 6 indicates that the definitely radioactive samples are restricted to the creeks draining the monzonite mass south of Flat. The degree of radioactivity and high content of zircon in some samples, for example, nos. 128-S and 133-S (0.035 percent and 0.033 percent equivalent uranium, respectively), may be attributed to the fact that they were panned relatively clean of rock-forming minerals and rock fragments at the mine, thus further concentrating the radioactive material. In most of the concentrates biotite, amphibole, pyroxene, and rock fragments are the predominant constituents.

SUMMARY AND CONCLUSIONS

Field investigations in the vicinity of Flat in 1947 show that previously reported radioactive materials in the area occur only in the monzonite intrusives and in the stream gravels derived from the erosion of these intrusives. The radioactive materials are localized almost entirely in zircon disseminated in the monzonite, particularly in a coarse-grained light-colored facies. Some samples of zircon contain as much as 0.14 percent equivalent uranium which is largely uranium (0.12 percent). The equivalent-uranium content of the zircon increases in proportion to an increase in the amount of an unknown substance occurring as inclusions in the zircon crystals.

Investigation of mafic igneous rocks, clastic sedimentary rocks including black shales, and vein and lode deposits containing gold and various other metals in the Flat area, revealed no significant concentrations of radioactive materials.

It is concluded from the present investigation that there is little likelihood of finding high-grade uranium lodes in the vicinity of Flat. However, as the radioactive material included in the accessory zircon of the monzonite is almost entirely uranium, other intrusives of the same age in the Lower Yukon-Kuskokwim region may likewise contain uraniferous material or actual uranium minerals either in the accessory minerals or in attendant contact-metamorphic or vein deposits. The occurrence of zeunerite in a copper lode in this same general belt of intrusives already has been noted (Moxham, 1950).

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Table 2.—Percentages of minerals in heavy-mineral fractions[1] of concentrates derived from the dark-colored facies of monzonite in the vicinity of Flat

Field no. (47AWe)	Concentrate File no.	Location	Percent of heavy-mineral fraction					Concentration ratio	Percent eU[2] in heavy-mineral fraction
			Apatite	Zircon	Ilmenite	Tourmaline	Biotite, Pyroxene, Amphibole		
4-L[3]	1794	Happy Creek----	tr[4]	tr	tr	tr	98	2:1	0.002
32-L	1810	Chicken Creek--	2	6	1	2	89	500:1	.013
33-L	1809	---do----------	tr	tr	tr	tr	97	2:1	.004
45-L	1807	---do----------	tr	tr	tr	tr	98	270:1	.002
67-L	1887	Flat Creek-----	tr	tr	tr	tr	97	225:1	.000
117-L	1849	Discovery	3	3	tr	tr	94	700:1	.006
130-L	1852	---do----------	2	4	tr	tr	94	400:1	.009

[1] Greater than 2.8 specific gravity.
[2] eU - equivalent uranium.
[3] Crushed fresh bedrock.
[4] tr - trace.

Table 3.—Percentage of minerals in heavy-mineral fraction[1] of concentrates derived from the coarse-grained light-colored facies of monzonite in the vicinity of Flat

Field no. (47AWe)	Concentrate File no.	Location	Percent of heavy-mineral fraction					Concentration ratio	Percent eU[2] in heavy-mineral fraction
			Apatite	Zircon	Ilmenite	Tourmaline	Biotite, Pyroxene, Amphibole		
3-L	1791	Happy Creek----	17	15	tr[3]	tr	65	1,100:1	0.020
5-L	1793	----do----------	25	30	2	10	33	1,300:1	.020
48-L	1892	Flat Creek-----	15	75	tr	tr	10	10,000:1	.050
53-L	1911	----do----------	2	7	1	tr	90	135:1	.013
58-L	1897	----do----------	2	2	1	20	75	250:1	.003
60-L	1900	----do----------	11	77	tr	tr	12	4,500:1	.092
61-L	1895	----do----------	11	75	tr	tr	24	3,100:1	.100
63-L	1902	----do----------	8	15	34	tr	43	550:1	.018
64-L	1903	----do----------	18	10	3	1	68	350:1	.022
68-L	1889	----do----------	16	45	tr	tr	39	2,300:1	.062
70-L	1904	----do----------	16	66	tr	tr	18	2,300:1	.092
71-L	1909	----do----------	14	57	tr	tr	29	1,900:1	.097
103-L	1843	Discovery------	55	18	2	1	24	1,200:1	.022
106-L	1840	Malamute Pup---	5	15	2	10	68	2,300:1	.009

[1] Greater than 2.8 specific gravity.
[2] eU - equivalent uranium.
[3] tr - trace.

Table 4.—Data on concentrates from monzonite, veins, and dikes in the vicinity of Flat

Field no. (47AWe)	Concentrate File no.	Location and description	Concentration ratio	Percent eU in heavy-mineral fraction
3-L	1791	Head of Happy Creek about 1/2 mile downstream from crossing of road to Chicken Creek; coarse-grained light-colored monzonite.	1,100:1	0.020
4-L	1794	Head of Happy Creek about 1/8 mile upstream from sample 3-L; coarse-grained dark-colored monzonite.	2:1	.002
5-L	1793	Head of Happy Creek about 1/4 mile upstream from sample 3-L; medium-grained light-colored monzonite.	1,300:1	.020
30-L	1812	Placer cut near head of Chicken Creek; fine-grained monzonite.	(1)	(1)
32-L	1810	Same location as sample 30-L; coarse-grained dark-colored monzonite.	500:1	.013
33-L	1809	Same location as sample 30-L; coarse-grained dark-colored monzonite.	2:1	.004
45-L	1807	On right limit tributary of Chicken Creek at foot of steep headwater grade; coarse-grained dark-colored monzonite.	270:1	.002
46-L	1808	Same location as sample 45-L; oxidized quartz vein in monzonite.	(1)	(1)
48-L	1892	Head of Flat Creek about 3/8 mile southwest of Strandberg Cabins; oxidized zone in coarse-grained light-colored monzonite.	10,000:1	.050
49-L	1910	Head of Flat Creek about 1/4 mile south of Strandberg Cabins; quartz vein in coarse-grained light-colored monzonite.	10,000:1	.080
53-L	1911	Same location as sample 49-L; coarse-grained light-colored monzonite.	135:1	.013
54-L	1912	Same location as sample 49-L; black dike in monzonite.	(1)	(1)
55a-L	1905	Same location as sample 49-L; pegmatite lens-----	475:1	.027
55b-L	1906	Same as 55a-L, but sample consists of fresh rock crushed.	13:1	.007
58-L	1897	Head of Flat Creek in gullies about 3/8 mile south of Strandberg Cabins; coarse-grained light-colored monzonite.	250:1	.003
59-L	1898	Head of Flat Creek in wide placer cut about 1/2 mile south of Strandberg Cabins; dark-colored dike in monzonite.	150:1	.012
60-L	1900	Head of Flat Creek on east side of wide placer cut about 1/2 mile south of Strandberg Cabins; medium- to coarse-grained light-colored monzonite.	4,500:1	.092
61-L	1895	Head of Flat Creek about 1/4 mile west of sample 60-L; medium- to coarse-grained light-colored monzonite.	3,100:1	.100
62-L	1901	Same location as sample 60-L; medium- to coarse-grained light-colored monzonite.	?	.019
63-L	1902	Same location as sample 60-L; coarse-grained light-colored monzonite.	550:1	.018
64-L	1903	Same location as sample 60-L; coarse-grained light-colored monzonite.	350:1	.022
65-L	1899	Same as sample 64-L-----------------------------	3,400:1	.140
67-L	8887	Left limit of Flat Creek at break in slope about 1/4 mile west of Strandberg Cabins; coarse-grained dark-colored monzonite.	225:1	.000
68-L	1889	Head of Flat Creek in gullies about 1/4 mile southwest of Strandberg Cabins; coarse-grained light-colored monzonite.	2,300:1	.062
69-L	1896	Head of Flat Creek in middle of wide placer cut about 1/2 mile south of Strandberg Cabins; coarse-grained light-colored monzonite.	3,400:1	.110

See footnote at end of table.

Table 4.—Data on concentrates from monzonite, veins, and dikes in the vicinity of Flat--Continued

Field no. (47AWe)	Concentrate File no.	Location and description	Concentration ratio	Percent eU in heavy-mineral fraction
70-L	1904	Head of Flat Creek in gullies about 1/8 mile south of Strandberg Cabins; coarse-grained light-colored monzonite.	2,300:1	0.092
71-L	1909	Same as sample 70-L------------------------------	1,900:1	.097
73-L	1888	Left limit of Flat Creek about 1/8 mile north-east of sample 67-L; medium-grained dark-colored monzonite.	225:1	.003
81-L	1876	Left limit of Flat Creek about 3/4 mile downstream from Strandberg Cabins; black dike in shale.	200:1	.000
84-L	1880	Same as sample 73-L------------------------------	160:1	.008
94-L	1855	About 1/4 mile south of ditch southeast of Discovery; tailings from gold-quartz lode mine.	1,400:1	.002
95-L	1856	Same location as sample 94-L; sample from ore bin of gold-quartz lode mine.	80:1	.000
96-L	1857	About 1/3 mile south of ditch southeast of Discovery; medium-grained dark-colored monzonite.	750:1	.001
97-L	1858	Same location as sample 96-L; medium-grained, very dark-colored monzonite.	700:1	.002
98a-L	1837	Head of Granite Creek; vein material from gold-quartz lode prospects.	(1)	(1)
98b-L	1836	-----do--	(1)	(1)
100-L	1841	Otter Creek about 1/8 mile below the mouth of Malamute Pup; sample from ore pile at lode mine.	1,900:1	.009
101-L	1842	Short distance downstream from sample 100-L; mineralized zone in monzonite.	2,300:1	.003
102-L	1844	Same location as sample 101-L; fine-grained light-colored monzonite.	1,800:1	.003
103-L	1843	Otter Creek about 75 feet upstream from mine entrance at sample 100-L; coarse-grained light-colored monzonite.	1,200:1	.022
106-L	1840	In placer cut on Malamute Pup; medium-grained light-colored monzonite.	2,300:1	.009
112-L	1860	Near head of Glen Gulch; oxidized decomposed medium-grained light-colored monzonite at gold-quartz lode prospect.	200:1	.002
113-L	1846	Placer cut on left limit of Otter Creek near Discovery; decomposed, very fine-grained, light-colored monzonite.	(1)	(1)
114-L	1847	Same location as sample 113-L; oxidized fine-grained dark-colored monzonite.	5,200:1	.002
115-L	1848	Same location as sample 113-L; medium-grained dark-colored monzonite.	(1)	(1)
117-L	1849	Same location as sample 113-L; very coarse-grained, dark-colored monzonite.	700:1	.006
119-L	1850	Same location as sample 113-L; medium-grained dark-colored monzonite.	2,300:1	.005
120-L	1851	Same location as sample 113-L; concentrate from quartz vein.	300:1	.000
130-L	1852	Southeast of Discovery on south side of ditch; coarse-grained dark-colored monzonite.	400:1	.009

[1] Too small for determination.

Table 5.—Data on panned concentrates from stream gravels in the vicinity of Flat

Field no.[1] (47AWe)	Concentrate File no.	Location	Concentration ratio	Percent eU in bromoform heavy fraction
*1	1786	Happy Creek, east headwaters tributary----------	500:1	0.025
*2	1784	Happy Creek about 1 mile downstream from crossing of road to Chicken Creek.	300:1	.030
*6	1795	Happy Creek, 500 feet below upstream end of placer cut.	125:1	.002
*7	1792	Happy Creek, about 1/2 mile downstream from crossing of road to Chicken Creek.	1,000:1	.090
10	1785	Happy Creek, south headwaters tributary entering near site of sample 2.	1,000:1	.001
11	1799	Gold Creek, at break in slope near headwaters----	70:1	.001
*16	1783	Happy Creek, about 1/4 mile downstream from site of sample 2.	4,700:1	.052
*18	1790	Happy Creek, north headwaters tributary---------	150:1	.002
*19	1780	Happy Creek, 700 feet above mouth (concentrate from tailings).	390:1	.005
20	1781	Happy Creek, 1,000 feet above mouth (concentrate from tailings).	600:1	.001
*21	1779	Happy Creek, 500 feet above mouth----------------	1,600:1	.025
22	1778	Willow Creek, above mouth of Happy Creek---------	1,500:1	.018
23	1774	Willow Creek, left limit bench workings between Happy and Gold Creeks.	3,000:1	.023
24	1798	Gold Creek below bridge on Chicken Creek road---	(2)	(2)
25	1814	Chicken Creek, placer cut at head of Creek------	950:1	.013
26	1818	Same as sample 25 ------------------------------	900:1	.002
*35	1803	Cleary Creek, main headwaters-------------------	300:1	.022
*36	1802	Cleary Creek, below all headwater forks---------	1,100:1	.017
*37	1801	Cleary Creek, below bridge on lower Chicken Creek road.	1,700:1	.027
*39	1805	Chicken Creek, at head of lower placer cut-------	425:1	.010
41	1817	Chicken Creek, from small gully on east side of placer cut near head.	1,600:1	.004
43	1829	Slate Creek, head of east headwaters fork--------	3,000:1	.008
47	1907	Flat Creek, gully in monzonite 1/8 mile above Strandberg Cabins.	70:1	.100
*51	1891	Flat Creek, in main drainage, about 1/4 mile southwest of Strandberg Cabins.	300:1	.036
52	1908	Flat Creek, gully in monzonite south of Strandberg Cabins.	120:1	.140
56	1890	Flat Creek, gully in monzonite southwest of Strandberg Cabins.	225:1	.022
57	1913	Flat Creek, same as sample 52 ------------------	300:1	.072
*66	1886	Flat Creek, on left limit at break in slope about 1/2 mile west of Strandberg Cabins.	130:1	.023
77	1881	Flat Creek, north of Strandberg Cabins on east headwater fork.	1,100:1	.003
80	1878	Flat Creek, southwesternmost headwaters fork-----	1,300:1	.009
82	1877	Flat Creek, placer cuts on west side about 3/4 mile downstream from Strandberg Cabins.	35:1	.001
85	1879	Flat Creek, near sample 66 ----------------------	90:1	.005
*87	1872	Cottonwood Creek, at bridge on road to Iditarod Landing.	120:1	.001
*89	1873	Cottonwood Creek, gully in west side------------	90:1	.001
*91	1862	Black Creek, about 1/2 mile above mouth----------	4,500:1	.009
*93	1864	Black Creek, at head of placer cuts--------------	3,800:1	.001
*105	1839	Malamute Pup, near mouth-------------------------	550:1	.001
108	1834	Granite Creek, just below upper end of placer cut.	1,000:1	.002
*109	1832	Granite Creek, gravel from lower placer cut------	2,300:1	.007
110	1865	Black Creek, west tributary----------------------	650:1	.007
111	1866	Black Creek, west tributary----------------------	180:1	.026

See footnotes at end of table.

Table 5.—Data on panned concentrates from stream gravels in the vicinity of Flat--Continued

Field no.[1] (47AWe)	Concentrate File no.	Location	Concentration ratio	Percent eU in bromoform heavy fraction
*116	1854	Otter Creek, placer cut on left limit east of Discovery.	1,300:1	0.002
124	1823	Slate Creek, head of placer cuts on west fork----	(2)	(2)
126	1828	Slate Creek, head of placer cuts on east fork----	(2)	(2)
129	1830	Otter Creek on right limit about 3/8 mile east of dam.	(2)	(2)

[1] Samples considered most representative of the gravels now present in the streams bear an asterisk (*).
[2] Too small for determination.

Table 6.—Data on sluice-box and dredge concentrates from the vicinity of Flat collected during 1947

Field no. (47AWe)	Concentrate File no.	Location	Percent eU in bromoform heavy fraction	Percent zircon in bromoform-heavy fraction
8-S	1796	Happy Creek, placer cuts at head-----------------	0.020	30
13-S	1775	Willow Creek, Manley bench workings--------------	.010	16
14-S	1777	Willow Creek, Bauquier & Hatten operation--------	.013	18
17-S	1787	Happy Creek, Stuver mine-------------------------	.065	70
27-S	1819	Prince Creek, placer cut at headwaters-----------	.036	38
34-S	1797	Happy Creek, placer cuts at head-----------------	.028	30
38-S	1804	Chicken Creek, placer cuts near mouth, Awe mine.	.042	40
40a-S	1815	Chicken Creek, placer cuts at head---------------	.022	28
40b-S	1816	-----do--	.009	10
42-S	1788	Happy Creek, Stuver mine-------------------------	.072	75
50-S	1914	Flat Creek, highest placer cuts at head----------	.052	55
72-S	1815	Flat Creek, about 1-1/2 miles below Strandberg Cabins.	.013	15
74-S	1883	Flat Creek just below monzonite contact at Pat Savage mine.	.003	10
75-S	1884	-----do--	.004	10
76-S	1885	-----do--	.005	10
78-S	1893	Flat Creek head, Strandberg mine-----------------	.074	80
83-S	1894	Flat Creek, west of wide placer cut at head------	.038	33
88-S	1874	Flat Creek, mouth, North American dredge---------	.022	35
90-S	1861	Black Creek, lower placer operations-------------	.013	15
99-S	1833	Granite Creek, placer workings on bench at mouth.	.004	10
104-S	1838	Malamute Pup, placer cut at mouth of stream------	.014	13
118-S	1853	Discovery, Otter Creek, Miscovich mine-----------	.008	10
121-S	1822	Slate Creek, west fork, Ogriz mine---------------	.002	5
122-S	1821	-----do--	.006	10
123-S	1820	-----do--	.001	tr
125a-S	1825	Slate Creek, east fork---------------------------	.005	5
125b-S	1826	-----do--	.007	10
125c-S	1827	-----do--	.005	5
128-S	1831	Granite Creek, Salen mine------------------------	.035	31
133-S	1845	Otter Creek, below Malamute Pup------------------	.033	37
134a-S	1867	Otter Creek, Riley dredge------------------------	.005	8
134b-S	1868	-----do--	.005	8
134c-S	1869	-----do--	.005	8
134d-S	1870	-----do--	.005	8

CHAPTER B. —RADIOACTIVITY AND MINERALOGY OF CONCENTRATES FROM THE PLACERS OF JULIAN, MOORE, AND CANDLE CREEKS, AND THE CRIPPLE CREEK MOUNTAINS

ABSTRACT

Radiometric and mineralogic study of 10 concentrate samples from the placers of Julian, Moore, and Candle Creeks, and the Cripple Creek Mountains, Lower Yukon-Kuskokwim Highlands region, Alaska, failed to reveal any significant amounts of uranium. Only the sample from Julian Creek shows an appreciable amount of radioactivity (0.03 percent equivalent uranium), but this is attributed entirely to thorium in monazite.

INTRODUCTION

In 1947 a reconnaissance party working in the vicinity of Flat (see Chapter A) in the Lower Yukon-Kuskokwim Highlands region, Alaska, collected samples of heavy sand—that is, sluice-box concentrates—from some nearby placer gold-mining operations. The localities from which the concentrates were obtained were among those on which the Geological Survey had little or no information and from which it had no samples for preliminary trace elements studies. The results of radiometric and mineralogic studies of the samples are given in table 7.

The localities, from which samples were collected, are as follows:

1. Julian Creek, a tributary of the Middle Fork of the George River, 25 miles southeast of Flat (no. 1, fig. 1).

2. Moore Creek, 30 miles east of Flat (no. 2, fig. 1).

3. Candle Creek, 5 miles southwest of McGrath (no. 3, fig. 1).

4. Cripple Creek Mountains, 35-40 miles northeast of Ophir (no. 4, fig. 1).

The radiometric data on the heavier-than-bromoform fractions of the placer concentrates shown in table 4 were obtained from laboratory beta counts made by the authors.

LOCALITIES SAMPLED

Julian Creek

Julian Creek is an eastward-flowing tributary of the upper Middle Fork of the George River, which flows from the north into the Kuskokwim River at Georgetown. The mining operation, half a mile upstream from the mouth of the creek, is owned by Harry Steen and operated by Harry Steen and Sture Stenberg in partnership.

The creek's bedrock is sandstone and slate cut by a few narrow porphyritic granite dikes—all presumed to be of Late Cretaceous age. Sandstone, slate, and porphyritic granite, therefore, make up the coarse material of the gravels. The sample, no. 1925, from this location is a representative one for all of the 1947 sluice-box cleanups.

Moore Creek

Moore Creek is a headwaters fork of the Takotna River, which enters the Kuskokwim River at McGrath. The mine in this locality is owned by Moore Creek Placers, a partnership operated by Elmer Keturi, one of the partners. The concentrate taken here, sample 1916, was from a pile of processed and discarded black sand that is representative of all the sluice-box cleanups at the mine. The gravel in the placer cut is comprised mainly of sandstone, shale, mafic igneous rocks, and some granitic rocks. The bedrock underneath the gravel is sandstone and shale of Cretaceous age.

Candle Creek

Candle Creek enters the Tatalina River a few miles southwest of McGrath. The placer mine, a dredging operation owned by Strandberg and Sons, is about 4 miles below the head of the creek in sandstone and shale of Cretaceous age, just downstream from the contact of these rocks with a small quartz-monzonite body. Gold-quartz veins associated with the intrusive rock are apparently the source of some of the placer gold. Three sluice-box concentrates, samples 1917, 1918, and 1919, presumably represent three different localities on Candle Creek. In 1947, dredging had not yet been resumed after suspension during the war.

Cripple Creek Mountains

On the west side of the Cripple Creek Mountains concentrates were obtained from Cripple and Bear Creeks, headwater forks of Graham Creek, a tributary of Colorado Creek, which flows from the east into the Innoko River about 40 miles north of Ophir.

The upper workings on Cripple Creek, owned and operated by Strandberg and Sons, are at the head of the creek in Fox Gulch.. Sample 1921 is representative of pre-1947 operations here, whereas sample 1922 is from the 1947 operations.

The lower workings on Cripple Creek and the Bear Creek workings are operated by Eric Hard. A sample was obtained from each of these two placer operations: sample 1920 from lower Cripple Creek;

sample 1924 from Bear Creek. In addition, sample 1923 was taken from Hard's workings on a high bench between Cripple and Bear Creeks.

The bedrock in the lower Cripple Creek workings is serpentinized greenstone, and in the upper workings it is sandstone and slate of presumed Late Cretaceous age. The coarse material of the creek gravels consists largely of chert, greenstone, andesite, and basalt porphyry. A smaller proportion of sandstone, slate, and granitic rocks is present also.

CONCLUSION

The information obtained during this investigation indicates that none of the placer deposits at the localities examined contain a significant amount of radioactive materials.

Table 7.—Data on concentrates from the placers of Julian, Moore, and Candle Creeks and the Cripple Creek Mountains

Location	Alaskan Concentrate File no.	Collector	Percent equivalent uranium in heavier-than-bromoform fraction	Mineralogy of heavier-than-bromoform fraction
Moore Creek----	1916	M. G. White----	0.001	80 percent chromite in octahedrons.* 3 percent zircon. 15 percent rock-forming minerals. Trace of cinnabar, scheelite, pyrite.
Candle Creek---	1917 and 1919	-----do---------	.003	90 percent spinel. 3 percent zircon. 2 percent cinnabar, sheelite, monazite(?). 5 percent rock-forming minerals.
	1918	----do----------	.001	65 percent rock-forming minerals. 30 percent garnet and spinel. 3 percent olivine. Trace of zircon.
Cripple Creek Mountains.	1920	P. L. Killeen---	.000	Mostly rock-forming minerals with large grains of zircon.
	1921		.002	
	1922		.001	
	1923		.001	
	1924		.001	
Julian Creek---	1925	----do----------	.03	80 percent pyrite. 10 percent rock-forming minerals. 5 percent garnet. 5 percent monazite.

*45 percent Cr_2O_3 by spectrographic analysis.

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