Summary of reconnaissance for radioactive deposits in Alaska, 1945-1954, and an appraisal of Alaskan uranium possibilities

By Helmuth Wedow, Jr.

CAUTION

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Trace Elements Investigations Report 577

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Geology and Mineralogy

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUMMARY OF RECONNAISSANCE FOR RADIOACTIVE DEPOSITS IN ALASKA, 1945-1954, AND AN APPRAISAL OF ALASKAN URANIUM POSSIBILITIES*

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March 1956

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

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GEOLOGY AND MINERAOLOGY

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By Helmuth Wedow, Jr.

ABSTRACT

In the period 1945-1954 over 100 investigations for radioactive source materials were made in Alaska. The nature of these investigations ranged from field examinations of individual prospects or the laboratory analysis of significantly radioactive samples submitted by prospectors to reconnaissance studies of large districts. In this period no deposits of uranium or thorium that would warrant commercial exploitation were discovered. The investigations, however, disclosed that radioactive materials occur in widely scattered areas of Alaska and in widely diverse environments.

Many igneous rocks throughout Alaska are weakly radioactive because of uranium-and thorium-bearing accessory minerals, such as allanite, apatite, monazite, sphene, xenotime, and zircon; more rarely the radioactivity of these rocks is due to thorianite or thorite and their uranoan varieties. The felsic rocks, for example, granites and syenites, are generally more radioactive than the mafic igneous rocks. Pegmatites, locally, have also proved to be radioactive, but they have little commercial significance. No primary uranium oxide minerals have been found yet in Alaskan vein deposits, except, perhaps, for a mineral tentatively identified as pitchblende in the Hyder district of southeastern Alaska. However, certain occurrences of secondary uranium minerals, chiefly those

of the uranite group, on the Seward Peninsula, in the Russian Mountains, and in the vicinity of Kodiak suggest that pitchblende-type ores may occur at depth beneath zones of alteration. Thorite-bearing veins have been discovered on Prince of Wales Island in southeastern Alaska.

Although no deposits of carnotite-type minerals have been found in Alaska, several samples containing such minerals have been submitted by Alaskan prospectors. Efforts to locate the deposits from which these minerals were obtained have been unsuccessful, but review of available geologic data suggests that several Alaskan areas are potentially favorable for carnotite-type deposits. The chief of these areas is the Alaska Peninsula-Cook Inlet area which encompasses most of the reported occurrences of the prospectors' carnotite-type samples.

Alaska is also potentially favorable for the occurrence of large bodies of the very low-grade uraniferous sedimentary rocks, such as phosphorites and black shales. This type of deposit, however, has not received much study because of the emphasis on the search for bonanza-type high-grade ores. Uraniferous phosphorites similar to those of Idaho, Montana, and Wyoming occur in northern Alaska on the north flank of the Brooks Range; black shales comparable to the uraniferous shales of the Chattanooga formation of southeastern United States have been noted along the Yukon River near the international boundary.

Placer deposits in Alaska have some small potential for the production of the radioactive elements as byproducts of gold- and tin-placer mining. The placer area believed to have the relatively greatest potential in Alaska lies in the Kahiltna River valley where concentrates are known to contain such commercial minerals as ilmenite, cassiterite, platinum, and gold in addition to uranothorianite and monazite.

The possibilities of the natural fluids--water and petroleum--have not yet been tested in Alaska to any great extent. Studies of fluids are in progress to determine whether they may be used to discover and define areas potentially favorable for the occurrence of uraniferous lodes.

INTRODUCTION

Since 1945 the Geological Survey has conducted reconnaissance for radioactive deposits in Alaska, first on behalf of the Manhattan Engineer District, U. S. War Department, later on behalf of the Division of Raw Materials, U. S. Atomic Energy Commission. The primary objective of this reconnaissance has been the search for high-grade uranium ores. Although this search has been largely unsuccessful to date, certain positive leads to high-grade ores occur, and it can by no means be concluded that such ores will not be discovered in Alaska.

The chief hindrance to the search for uranium in Alaska has been the general inaccessibility of much of the Territory, which has an areal extent of about one-fifth that of continental United States (or about the equivalent of the states of Arizona, New Mexico, Colorado, Utah, Idaho, and Wyoming), with the consequent slowness and high cost of transportation. Another deterent has been the lack of adequate detailed maps, both geologic and topographic. About one-half of Alaska, which has as complex a geologic framework and widespread occurrences of metallic minerals as much of western United States, has not been mapped geologically at a scale greater than 1:1,000,000; most of the remainder is known only from very general exploratory surveys, with less than 10 percent mapped geologically at a scale comparable to most of the mapping in the States.

In the years prior to World War II little was known about the occurrence of radioactive materials in Alaska. Carnotite had been identified in a sample submitted to the assay office at Fairbanks in 1918. This sample was supposedly found by a railroad construction worker in the vicinity of Healy on the Alaska Railroad, but the exact locality is unknown. Monazite was reported by Mertie (1925, p. 260) in concentrates from the gravels of Big Creek in the Chandalar district on the south flank of the Brooks Range. Milton (Ross, 1933b, p. 437) tentatively identified monazite in placer concentrates from Valdez Creek near Denali on the south flank of the Alaska Range. Eschynite, monazite, and xenotime were identified by Waters (Mertie and Waters, 1934, p. 229, 239-240) in concentrates from gold-tin placers of the Tofty tin belt of the Hot Springs district near the junction of the Yukon and Tanana Rivers. In 1932 Wacker (Anonymous, 1932, p. 7) is reported to have found a uranium deposit on Martin Arm of Boca de Quadra Inlet in southeastern Alaska. Henry Joesting (1946, personal communication to P. L. Killeen) of the Territorial Department of Mines found, about 1941, that some concentrates from placers in interior Alaska were radioactive; the sample showing the greatest radioactivity was from Grubstake Creek in the Nenana district on the north flank of the Alaska Range. It contained 1×10^{-9} grams radium per gram of sample.

In 1944 the Union Mines and Development Corporation prepared a report on the uranium possibilities of Alaska for the Manhattan Engineer District (Judd, 1944). Also in 1944, J. H. Skidmore of Union Mines collected numerous placer concentrates in Alaska in a search for radioactive materials and reported (Skidmore, 1944) that a number of concentrates were radioactive, especially one that was obtained from placer-mining operations on Sweepstakes Creek in eastern Seward Peninsula.

The Alaskan Trace Elements Program of the Geological Survey, initiated late in 1944 on behalf of the Manhattan Engineer District, began with the scanning for radioactivity of more than 600 placer concentrates in the Survey's Alaskan collections. The results of the study (Harder and Reed, 1945) indicated that placer gravels in several areas might have some promise as sources of radioactive materials. Consequently, in 1945, investigations were made in the Ear Mountain (Killeen and Ordway, 1955), Sweepstakes Creek (Gault and others, 1953, p. 1-10), and Candle Creek (Gault and others, 1953, p. 11-14) areas of the Seward Peninsula, and the Yentna district (Robinson and others, 1955) in southern Alaska; in addition, brief reconnaissance trips were made to the Kuskokwim region, the Cape Mountain area of the Seward Peninsula, and a number of placer-mining districts in the Yukon-Tanana region, largely to collect concentrates for additional study. However, at all the localities investigated, the placers were found to contain only small amounts of radioactive minerals, although a lode deposit containing one of the copper uranites and uraniferous hematite was discovered at Ear Mountain (Killeen and Ordway, 1955).

The primary conclusion of the field work of 1945 was that Alaskan placers, in general, should not be considered in the near future as important for reserves of radioactive materials, and that the general emphasis of the Alaskan program of reconnaissance for radioactive deposits should be directed toward the search for bedrock sources in areas where:

(1) Radioactive minerals were known or reported to be present.

(2) Lode mines and prospects contain minerals known to occur in radioactive deposits elsewhere in the world.

(3) Igneous rocks of certain ages and petrographic types might contain radioactive minerals.

(4) Black shales and other sedimentary rocks are possibly radioactive.

(5) Concentrates from creek gravels and placer operations are known to contain radioactive minerals.

As much of Alaska is of difficult access, one phase of the Alaskan reconnaissance program was directed toward obtaining information on accessible areas contiguous to the Alaskan highway, railway, and river systems, where no previous information on radioactivity was available. The selection of other areas for investigation was governed by the five criteria set out above.

Because the results of the Geological Survey's reconnaissance program through 1950 had not yet indicated much promise for the occurrence of high-grade uranium ore deposits in Alaska, field studies were curtailed pending a reappraisal of Alaska's uranium possibilities. This reappraisal culminated in a report (Wedow and others, 1951) reviewing the geology and mineral deposits of the several Alaskan regions in the light of their uranium possibilities, these possibilities being based on the known occurrences of radioactive materials and geologic criteria suggesting the presence of uranium. The geologic criteria included: occurrence of hydrothermal hematitic alteration; the presence of cobalt, nickel, bismuth, silver, and fluorite; and, as less surely indicative, the occurrences of such minerals as arsenopyrite, bornite, cassiterite, chalcopyrite, galena, hematite, molybdenite, pyrite, siderite, sphalerite, and tetrahedrite, and their alteration products. The selection of the criteria was based on a review of literature pertaining to known domestic and foreign uranium deposits. Of particular aid were, reports by Bain (1950), Lang (1949a, 1949b, 1950), George (1949), Hess (1934), and Bastin and Hill (1917), although much information was also gleaned from numerous unpublished reports of the Atomic Energy Commission and Geological Survey. Because few of Alaska's mineral deposits have been investigated in detail, many of the deposits are known only from brief reconnaissance studies by Geological Survey geologists and U. S. Bureau of Mines engineers, or from reports by prospectors and mining companies. Consequently, the absence of many of the uranium indicator metals or minerals from descriptions of the mineral deposits may be due to incomplete information rather than absence from the deposit. However, the conclusions reached by the 1950-1951 reappraisal of Alaska's uranium possibilities indicated that several Alaskan regions were favorable for the occurrence of uranium, and several parties made field appraisals of possible uraniferous areas during the summer of 1951 in the Alaska Railroad belt, the Gulf of Alaska region, southeastern Alaska, and the Seward Peninsula (White and others, 1952) and during the summer of 1952 in southeastern Alaska, eastern Alaska, and the lower Yukon-Kuskokwim region (Wedow and others, 1953). In 1953, reconnaissance of possibly favorable areas was continued by one field party (Matzko and Bates, 1955).

In 1954, one field party investigated areas from which prospectors had submitted radioactive samples (Matzko and Bates, report in preparation).

Since 1951 the Geological Survey, on behalf of the Atomic Energy Commission, has maintained a laboratory during the summer months on the campus of the University of Alaska at College near Fairbanks. The chief purpose of this laboratory is to make preliminary studies of the content and nature of the radioactive material in samples submitted by the public and Government agencies. This laboratory is operated in cooperation with the University of Alaska, which has made space and facilities available to the Survey. Anyone in Alaska interested in having samples tested for radioactivity may submit the material either directly to the Survey laboratory or through Survey field geologists or offices.

Various techniques have been used in the field in the search for uranium in Alaska. In small restricted drainage basins, where much of the bedrock is covered with shielding materials such as moss, muck, and tundra, the testing of concentrates from creek gravels for radioactivity has been found to be the most satisfactory method of testing for the presence of radioactive deposits in the basin. However, as most uranium minerals are both extremely friable and soluble and are likely to be destroyed readily by the erosive and corrosive action of streams, the testing of the concentrates should be augmented by the analysis for uranium in alluvial fines, vegetation, residual soils, and stream waters.

Where mines, prospects, road cuts, and natural outcrops afford access to lode deposits and bedrock, direct radioactivity tests have been made with portable detection equipment in the field and samples of interest taken for later laboratory examination. In recent years the improvement of portable equipment for measuring radioactivity, particularly the development of more rugged and more sensitive portable survey meters of various types, has enabled the field geologist engaged in the search for uranium to switch from the laborious hand-counting methods of recording radioactivity to methods of continuous traversing, using ground vehicles, boats, light fixed-wing aircraft, and helicopters, as well as the time honored back-packing method for foot-traverses (Wedow, 1951).

Thus, in the years succeeding the initial field radioactivity studies by the Geological Survey in Alaska during 1945, a number of different techniques have been used to test for the presence of radioactive materials. Although a great variety of materials and types of deposits in widely scattered areas have been so tested, much of Alaska remains unexamined. However, because of the economic factors involved, the primary objective of the search for uranium in Alaska must continue to be the discovery of high-grade deposits. The results of the reconnaissance program conducted by the Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission and its predecessor, the Manhattan Engineer District, are summarized by region in the body of this report. In addition, an appraisal of the uranium and thorium possibilities of Alaska by types of deposits is given.

For the purpose of this report Alaska has been divided into six regions (fig. 1) based on arbitrary groupings of quadrangles of the Alaska reconnaissance topographic series (scale 1:250,000). The quadrangles included in each region are listed in the appendix.

SUMMARY OF RECONNAISSANCE

Southeastern Alaska

The results of reconnaissance for radioactive deposits in southeastern Alaska are summarized in table 1; the sites of the localities examined are plotted on figure 2.

Reconnaissance for radioactive deposits in southeastern Alaska by the Geological Survey did not begin until 1949. Tests of shipping concentrates and mill tailings from the Alaska-Juneau gold mine at Juneau in 1947 showed a maximum equivalent-uranium content of only 0.002 percent and analyses of the few samples from southeastern Alaska in the Survey's Alaskan concentrate collection likewise showed little or no radioactivity. However, unverified reports or rumors placed occurrences of radioactive materials in a number of widely scattered areas of southeastern Alaska, including localities on the Whiting River, on the mainland east of Petersburg, in the vicinity of Chichagof, at Goddard Hot Springs (Colby, 1942, p. 175), and on Boca de Quadra Inlet (Anonymous, 1932, p. 7).

Because very little information was available on the distribution of radioactivity in southeastern Alaska and because the region is prominent for its metalliferous lode deposits, the objectives of the reconnaissance party in southeastern Alaska in 1949 were as follows:

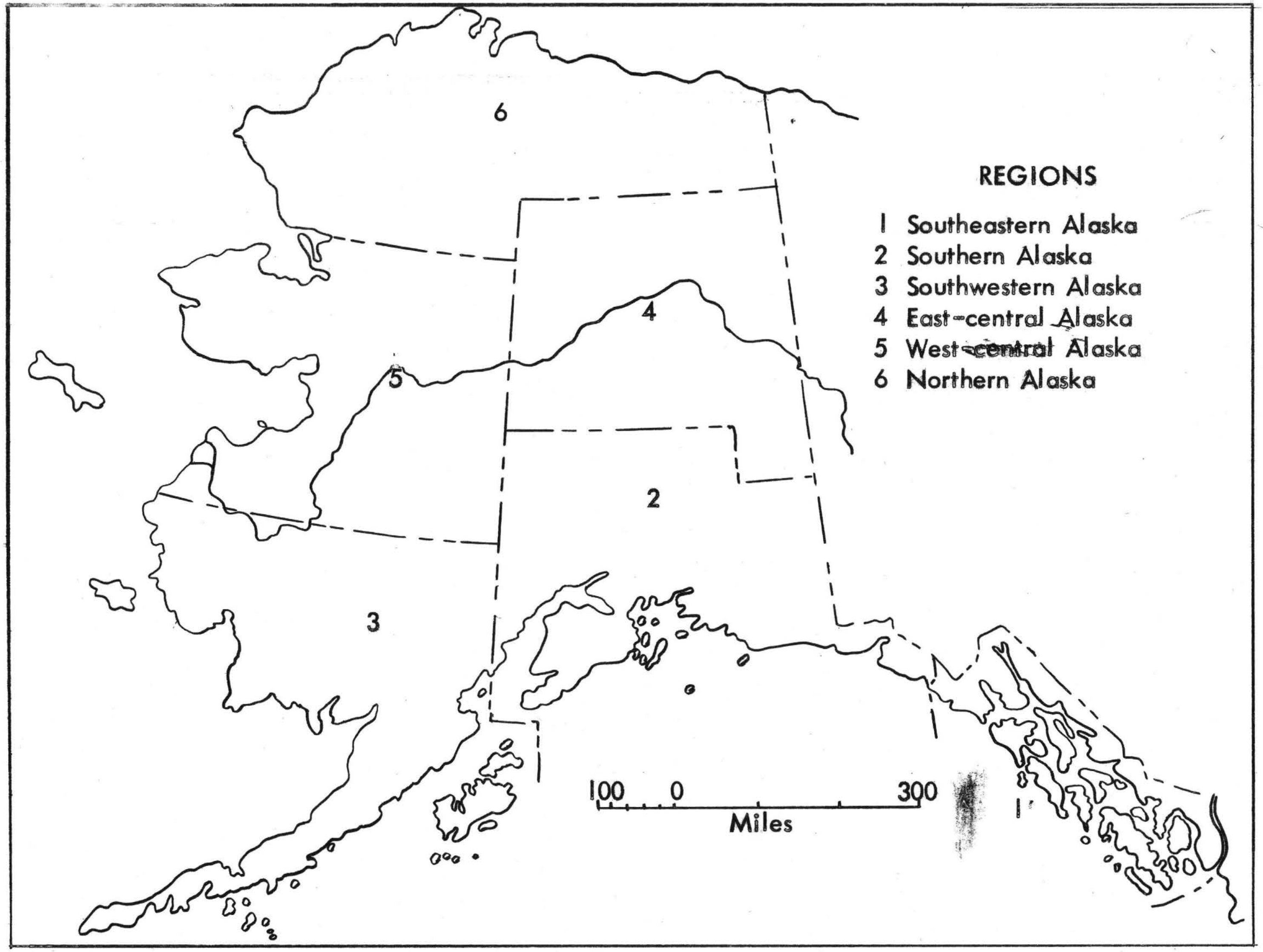

Figure 1.--Index map of Alaska showing regions

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Table 1.--Summary of reconnaissance for radioactive deposits in southeastern Alaska, 1945-1954

Location (Reference no. of fig. 2)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Ketchikan quadrangle		
Hyder district (1)	1949 1952	Silver-lead quartz fissure veins and mineralized shoots in zone along intrusive contact of Texas Creek granodiorite with metamorphic rocks of Hazelton group; examined chiefly on Mountain View property.	Maximum radioactivity of samples taken in 1949 is about 0.05 percent eU. Radioactivity is due to uranium in iron oxides, galena, sphalerite, pyrite, chalcopyrite, molybdenite, and scheelite. Tetrahedrite, freibergite, and fluorite are also present.	Samples collected by TDM1/ in 1950 from Canyon vein contain as much as 0.7 percent equivalent uranium; pitchblende is believed to be the radioactive mineral. USGS reconnaissance in 1952 failed to duplicate this sampling.	West and Benson, 1955 Wedow and others, 1951, p. 52-56 Wedow and others, 1953, p. 6, 12 Houston and others, 1954
George Inlet, Ketchikan district (2)	1951	Fissure veins and replacement zinc deposits in siliceous rocks close to granite contact containing chalcopyrite, galena, sphalerite, and pyrrhotite	<0.001 percent eU	---	White and others, 1952, p. 15
Ketchikan and vicinity (3)	1949	Bismuth-bearing gold-quartz veins	0.001 percent eU	---	West and Benson, 1955 Wedow and others, 1951, p. 60
Helm Bay (4)	1951	Bismuth(?)-bearing pyritic gold-quartz veins	<0.001 percent eU	---	Wedow and others, 1951, p. 60 White and others, 1952, p. 15
Gravina Island (southern end) (5)	1951	Hematite-copper sulfide replacement deposits	<0.001 percent eU, locally as much as 0.005 percent eU in felsic volcanic rocks	---	White and others, 1952, p. 15
			Craig quadrangle		
Union Bay area (6)	1951	Reconnaissance to find source of tyuyamunite-bearing coal sample submitted by prospector to Territorial Department of Mines	Sample estimated to contain more than 1 percent U; no radioactivity of significance found in area.	Geology of area not believed to be favorable for this type of uranium occurrence. Sample thought to have been "imported" as part of coal shipment to former cannery in area.	White and others, 1952, p. 13-15
Niblack Anchorage area (7)	1951	Hematite-copper sulfide replacement deposits with some galena(?), sphalerite, and jasper	<0.001 percent eU	---	White and others, 1952, p. 15
North Arm, Moira Sound (8)	1951	Silver-lead-zinc vein and replacement deposits	<0.001 percent eU	---	White and others, 1952, p. 16
Dolomi area (9)	1951	Gold-bearing breccia veins containing tetrahedrite and pyrite	<0.001 percent eU	---	White and others, 1952, p. 16
Cholmondeley Sound area (10)	1951	Gold-quartz veins	<0.001 percent eU	Contain traces of sulfides	White and others, 1952, p. 16
Green Monster Mountain (11)	1952	Contact metamorphic deposits containing magnetite and chalcopyrite, and small amounts of pyrite, pyrrhotite, molybdenite and hematite	<0.001 percent eU	---	Wedow and others, 1953, p. 11 Houston and others, 1953
Kasaan Peninsula (12)	1951	-----------------do-----------------	<0.001 percent eU	Metatorbernite and allanite reported from this area	White and others, 1952, p. 16 Wedow and others, 1951, p. 63
Lake Bay (13)	1952	Copper-bearing breccia vein containing pyrite, chalcopyrite, sphalerite, secondary copper minerals and iron oxides	0.001 percent eU	---	Wedow and others, 1953, p. 11 Houston and others, 1953
Baker Island molybdenite prospect (14)	1952	Silicified quartz diorite cut by narrow quartz veinlets containing molybdenite, pyrite, pyrrhotite, and iron oxides	0.001 percent eU	---	Wedow and others, 1951, p. 67 Wedow and others, 1953, p. 11 Houston and others, 1953

Table I.--Summary of reconnaissance for radioactive deposits in southeastern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 2)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Craig quadrangle--Continued		
Egg Harbor, Coronation Island (15)	1952	Replacement deposits in limestone; metallic minerals are galena, sphalerite, iron oxides, cerussite, smithsonite, hydrozincite and possibly tetrahedrite	<0.003 percent eU	---	Wedow and others, 1951, p. 67 Wedow and others, 1953, p. 11 Houston and others, 1953
			Petersburg quadrangle		
Groundhog and Glacier Basins and Lake claims (16)	1951	Replacement and fissure veins containing sphalerite, pyrrhotite, galena, pyrite, chalcopyrite, molybdenite, pyromorphite (?) and fluorite (?)	<0.001 percent eU	---	Wedow and others, 1951, p. 60 White and others, 1952, p. 17
Duncan Canal (17)	1951	Replacement deposit containing barite and traces of pyrite, sphalerite, galena and magnetite	<0.001 percent eU	---	White and others, 1952, p. 17
Woewodski Island (18)	1951	Gold-quartz vein, and replacement deposits containing pyrite, chalcopyrite, galena, and sphalerite	<0.001 percent eU	---	White and others, 1952, p. 17
Round Point, Zarembo Island (19)	1952	Granite intruding graywacke	0.004 percent eU	Radioactivity probably due to common accessory minerals in granite	Wedow and others, 1953, p. 10 Houston and others, 1953
Southwest coast, Zarembo Island (20)	1951	Colorless, white, green, and purple fluorite with fine-grained pyrite in veinlets cutting volcanic rocks	<0.001 percent eU, locally as much as 0.005 percent eU in felsic volcanic rocks	---	White and others, 1952, p. 16
Salmon Bay area, Prince of Wales Island (Exchange Cove to Point Colpoys) (21)	1951 1952	Narrow carbonate-hematite veins containing small amounts of thorite, monazite, sulfides, fluorite and rare-earth minerals	Maximum content is 0.095 percent eU; average is about 0.03 percent eU. As uranium content is 0.003 percent or less, radioactivity is due to thorium; average ThO_2 content is estimated to be about 0.1 percent	Veins range in thickness from less than 1 inch to as much as 2 feet. Country rock is graywacke which is hematitically altered adjacent to many of the veins. A prospector's sample of hematitically altered wall rock contains as much as 0.13 percent eU.	White and others, 1952, p. 13, 14, 16 Houston, 1952 Wedow and others, 1953, p. 6, 9, 10 Houston and others, 1953 Bates and Wedow, 1953, p. 3, 4, 8
North Shore of Prince of Wales Island (west of Red Bay) (22)	1952	Reconnaissance of Silurian(?) "graywacke" area for possible extension of thorium-bearing veins found in Salmon Bay area	0.001 percent eU	---	Wedow and others, 1953, p. 9, 10 Houston and others, 1953
El Capitan Passage and Shakan, Shipley, and Edna Bays, Prince of Wales and Kosciusko Islands (23)	1952	----------------do------------------	0.001 percent eU	---	Wedow and others, 1953, p. 9, 11 Houston and others, 1953
Shakan molybdenite deposit, Kosciusko Island (24)	1952	Breccia zone containing molybdenite, pyrite, pyrrhotite, chalcopyrite, sphalerite, molybdenite and iron oxides	0.004 percent eU	---	Wedow and others, 1953, p. 9, 10 Houston and others, 1953
Totem Bay, Kupreanof Island (25)	1952	Reconnaissance to locate possible northwestward extension of thorium-bearing veins found in Salmon Bay area; bedrock consists of Tertiary volcanic rocks	0.003 percent eU	---	Wedow and others, 1953, p. 11 Houston and others, 1953
Point St. Albans area, Kuiu Island (26)	1952	Quartz-carbonate veinlets containing sphalerite, galena, pyrite, pyrrhotite and iron oxides	0.001 percent eU	---	Wedow and others, 1953, p. 11 Houston and others, 1953
Thomas Bay (27)	1951	Fissure vein containing pyrite, arsenopyrite, chalcopyrite, pyrrhotite(?) and secondary metallic minerals	<0.001 percent eU	---	Wedow and others, 1951, p. 60 White and others, 1952, p. 17

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Table 1.--Summary of reconnaissance for radioactive deposits in southeastern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 2)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Port Alexander quadrangle		
Port Malmesbury pitchblende(?) prospect, Kuiu Island (28)	1953	Reconnaissance of possible pitchblende occurrence reported by D. E. MacDonald	Current information indicates no significant radioactivity	May also be location of hematitically altered samples, found in collections of the Territorial Department of Mines at the Ketchikan Assay Office, containing as much as 0.05 percent eU_3O_8 as determined by the New York Laboratory of AEC	Wedow and others, 1951, p. 63, 64 Velikanje, 1953, written communication Matzko and Bates, 1955 Also file data
Goddard Hot Springs area, Baranof Island (29)	1949	Reconnaissance for radioactive deposits in the vicinity of a reported radioactive Hot Spring; country rock chiefly granitic	Hot Spring waters not significantly radioactive. Heavy-mineral fractions of granitic rock contain as much as 0.016 percent eU; radioactivity is due chiefly to thorium in allanite and monazite	---	Wedow and others, 1951, p. 64 Bates and Wedow, 1953, p. 8 West and Benson, 1955
Saginaw Bay, Kuiu Island and Keku Islands (30)	1951	Chiefly barite, witherite and sphalerite in vein deposits	<0.001 percent eU, locally as much as 0.005 percent eU	Originally reported by Territorial Department of Mines as containing radioactivity anomaly of possible significance	White and others, 1952, p. 17
			Sumdum quadrangle		
Port Astley (31)	1952	Lenticular replacement veins in schist; contain pyrite, sphalerite, bornite, pyrrhotite, galena, and covellite(?). Also reported to contain native silver	0.006 percent eU (maximum)	---	Wedow and others, 1951, p. 60 Wedow and others, 1953, p. 6, 10
			Sitka quadrangle		
Chichagof and vicinity (32)	1949	Gold-quartz lodes in fault and shear zones; contain common metallic sulfides and gold	0.002 percent eU (maximum)	---	Wedow and others, 1951, p. 64
Baranof Exploration and Development Co. claims between Klag Bay and Lake Anna, Chichagof Island (33)	--	Analysis of samples of gold-quartz veins submitted by Jesse S. Moore, New York City, in February 1953	<0.001 percent eU	Samples submitted by Moore had been reported by Ledoux and Co. to contain 0.014 and 0.021 percent uranium oxide.	Wedow, 1953
			Taku River quadrangle		
Speel Arm, Port Snettisham (near Fannie Island) (34)	1952	Reconnaissance to locate possible occurrence of pitchblende(?) reported by U. S. Bureau of Mines	0.003 percent eU in quartz diorite country rock	---	Wedow and others, 1953, p. 6, 10 Houston and others, 1953
Limestone Inlet (35)	1952	------------------do------------------	<0.001 percent eU	---	Wedow and others, 1953, p. 6 Houston and others, 1953
			Juneau quadrangle		
Taku Harbor (36)	1952	------------------do------------------, breccia zone in schist contains pyrite and arsenopyrite	<0.001 percent eU	---	Wedow and others, 1953, p. 6, 10 Houston and others, 1953
Juneau and vicinity (37)	1949	Radioactivity traverses of roads in vicinity of Juneau and examination of mine dumps of several mines in Juneau gold belt	0.002 percent eU (maximum)	Uranothorianite reported in concentrates from Juneau airport dredging operations	West and Benson, 1955 Matzko, 1953, written communication
Admiralty-Alaska Gold Mining Co. claims, Funter Bay, Admiralty Island (38)	1949	Gold-quartz veins and a copper-nickel lode	0.001 percent eU	---	West and Benson, 1955

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Table 1.--Summary of reconnaissance for radioactive deposits in southeastern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 2)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Mt. Fairweather quadrangle		
Glacier Bay area (39)	1950	Radioactivity traversing by geologic mapping party	No significant radioactivity detected	---	Seitz, 1950, written communication
			Skagway quadrangle		
Haines-Skagway area (40)	1950	Radioactivity traversing by party investigating magnetite occurrences in vicinity of Klukwan	No significant radioactivity detected	Included about 55 miles of road traverses with jeep and about 10 miles of foot traverses. Also underground workings of Inspiration Mine near Summit on White Pass and Yukon RR.	Tolbert, 1950, written communication

1/ TDM sample collected by Howard M. Fowler, Engineer, Territorial Department of Mines, Alaska

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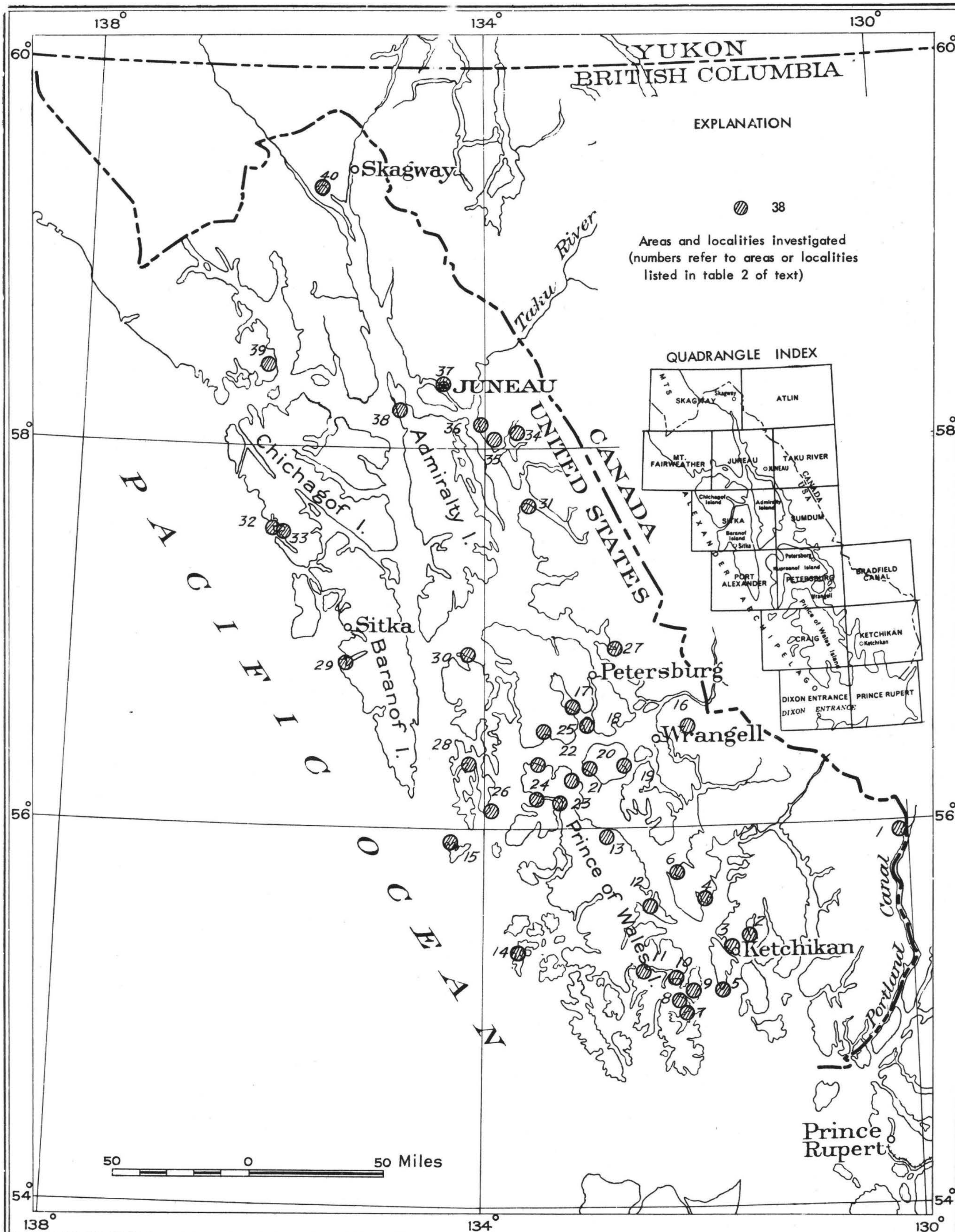


FIGURE 2.--MAP OF SOUTHEASTERN ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

(1) To examine a number of typical mineral deposits for radioactivity.

(2) To investigate such reported occurrences of radioactive materials or radioactivity anomalies as appeared to warrant study.

(3) To collect additional information on unverified rumors or occurrences of radioactive materials to determine whether field investigations were warranted.

Field investigations were therefore conducted in the summer of 1949 in the vicinities of silver-lead deposits near Hyder (locality 1), bismuth-bearing gold lodes near Ketchikan (locality 3), the reported radium-bearing hot spring at Goddard Hot Springs (locality 29), gold lodes at Chichagof and Juneau (localities 32 and 37), and gold and nickel deposits at Funter Bay (locality 38). The only samples of any significant activity were collected in the Hyder area. They contain 0.05 percent eU. The occurrence of uranium on Martin Arm of Boca de Quadra Inlet, east of Ketchikan reported by Wacker (Anonymous, 1932, p. 7) could not be located in a search by the Territorial Department of Mines in 1949 (Fowler, H. M., 1949, Oral communication to W. S. West) with directions from Wacker. However, Wacker subsequently claimed that the search was not conducted at the correct locality. As Wacker has no samples available for radioactivity tests, no further attempt has been made to examine this prospect.

Although no reconnaissance was made specifically for radioactive deposits in southeastern Alaska in 1950, radioactivity data were obtained incidental to geologic studies by regular Survey parties in the Haines-Skagway area (locality 40) and in the vicinity of Glacier Bay (locality 39).

The appraisal of the uranium possibilities of southeastern Alaska (Wedow and others, 1951, p. 49-67) in 1950-51 indicated that a number of lode deposits in southeastern Alaska contain mineral assemblages similar to those characteristic of high-grade radioactive deposits elsewhere in the world. Most of these deposits are related genetically to the Coast Range batholith. Consequently, in the summer of 1951, a Geological Survey party conducted radioactivity reconnaissance examinations of 47 lode mines, prospects, and other sites of favorable mineral assemblages in southeastern Alaska. The chief localities were: the hematitic copper ores on Gravina Island (locality 5) and at Niblack Anchorage (locality 7), silver-lead-zinc deposits on the North Arm of Moira Sound (locality 8), gold-tetrahedrite-pyrite breccia veins at Dolomi (locality 9), magnetite-chalcopyrite deposits on Kasaan Peninsula (locality 12), and the silver-lead-zinc ore in the vicinity of Groundhog Basin (locality 16). Also investigated in 1951 were a reported occurrence of tyuyamunite-bearing coal at Union Bay (locality 6) and thorium-bearing hematite-carbonate veins at Salmon Bay (locality 21). The only samples of significance were collected from the Salmon Bay area. They contain 0.095 percent equivalent uranium, and the radioactivity is due principally to thorium.

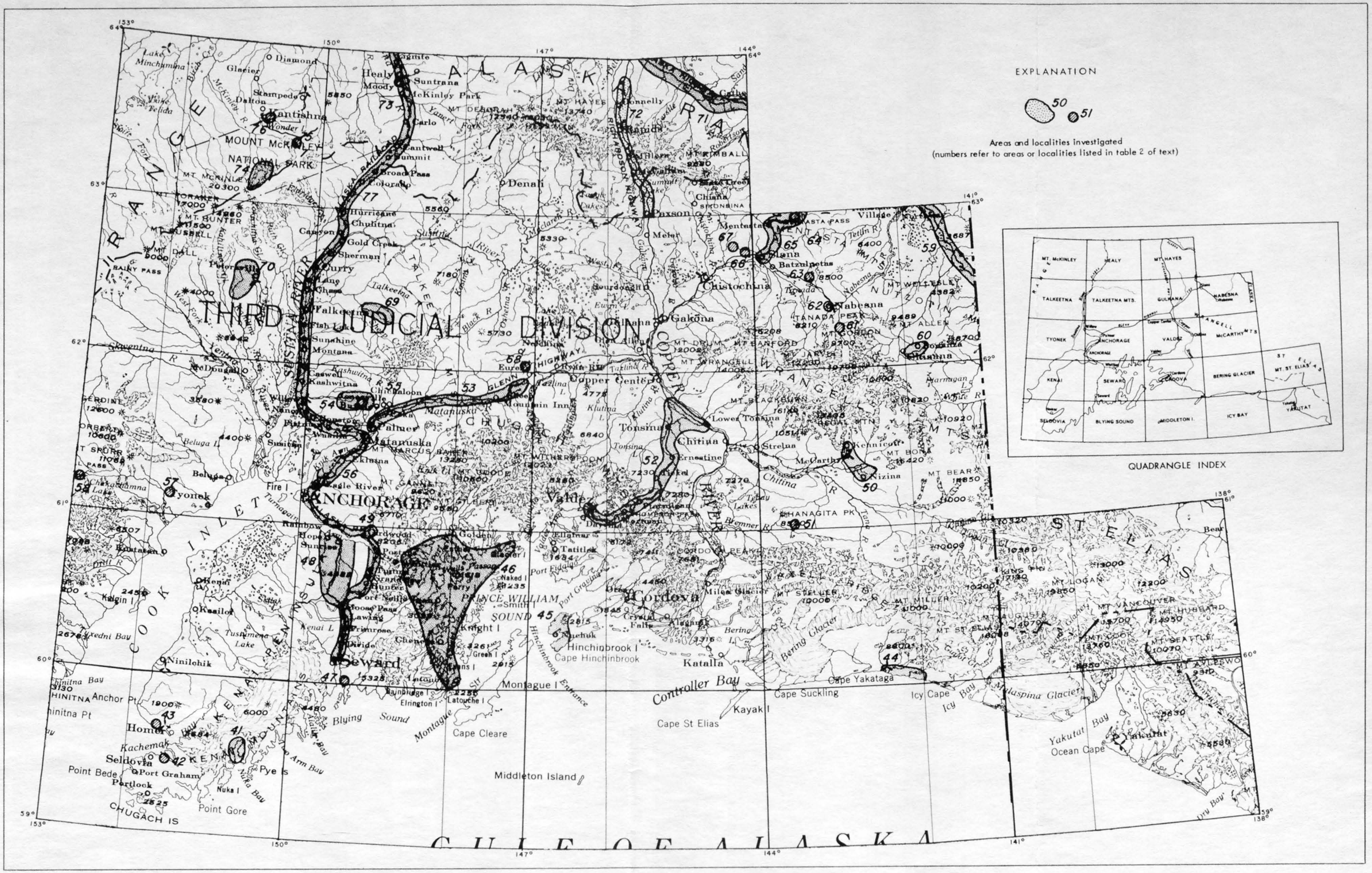
In the field season of 1952 the reconnaissance for radioactive deposits in southeastern Alaska was continued with the work centering chiefly on the study of the thorium deposits at Salmon Bay (locality 21) and the examination of geologically similar areas (localities 22, 23, and 25) elsewhere on the northern part of Prince of Wales Island and parts of adjacent islands. Other reconnaissance in 1952 included the examination of: molybdenite-bearing lodes on Baker Island (locality 14) and at Shakan (locality 24), lead deposits on Coronation Island (locality 15) and on the southern end of Kuiu Island (locality 26), copper ores at Green Monster Mountain (locality 11) and Lake Bay (locality 13), three occurrences of pitchblende(?) in the Taku Harbor-Port Snettisham area (localities 34-36) reported by the U. S. Bureau of Mines, a silver-copper lode at Point Astley (locality 31), and a pitchblende(?) occurrence on the Mountain View property in the Hyder district (locality 1) reported in 1950-51 by the Territorial Department of Mines. Significant radioactivity was found only at the Salmon Bay and Mountain View properties. The Salmon Bay examination did not reveal any samples higher in radioactivity than those collected the previous year. The reported occurrence of pitchblende on the Mountain View property was not found.

No major field studies were undertaken in the search for radioactive materials in southeastern Alaska during 1953. However, a brief, but unsuccessful, attempt was made to find a reported pitchblende occurrence in the vicinity of Port Malmesbury (locality 28) on Kuiu Island (Matzko and Bates, report in preparation).

Southern Alaska

The sites of localities studied in southern Alaska are shown on figure 3; the data are summarized in table 2.

Field investigation for radioactive deposits in southern Alaska began in 1945 when preliminary study (Harder and Reed, 1945) of placer concentrates in Alaskan collections showed that significant amounts of



Base from Alaska Map B, Edition of 1950

50 0 200 Miles

FIGURE 3.--MAP OF SOUTHERN ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

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Table 2.--Summary of reconnaissance for radioactive deposits in southern Alaska, 1945-1954

Location (Reference no. of fig. 3)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Seldovia quadrangle		
Nuka Bay area (41)	1951	Quartz fissure veins containing gold, silver, copper, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, covellite, tetrahedrite and chalcocite	0.002 percent eU or less	---	Wedow and others, 1951, p. 109 White and others, 1952, p. 10-12
Jakolof Bay area (42)	1949	Reconnaissance to locate reported radioactive ores	0.001 percent eU in unconcentrated rocks; as much as 0.007 percent in concentrates	Chromite stockpile may have been mistaken for pitchblende by prospectors	Moxham and Nelson, 1952b, p. 5
Homer coal field (43)	1950	Radioactivity traverse of Tertiary coal-bearing sequence in Homer coal field	No significant radioactivity detected	---	Cobb, 1950, written communication
			Bering Glacier quadrangle		
Yakataga Beach area (44)	---	Mineralogic study of radioactive concentrates from beach placers submitted to USGS in 1945-46	Concentrates contain as much as 0.32 percent eU; radioactivity due chiefly to three minerals of zircon group, two of which are thorium-bearing, the other uranium-bearing.	---	Moxham and Nelson, 1952a, p. 11-14 Matzko, 1953, written communication
	1954	Beach sands in Yakataga area	The unconcentrated beach sands contain 0.001 percent eU	Concentrates supposedly from this area were submitted to the USGS in 1952 and contain as much as 35 percent eU and 19 percent U; the chief radioactive mineral is uranothorianite	Matzko and Bates (Report in preparztion, 1956)
			Cordova quadrangle		
Hinchinbrook Island (45)	1952	Hematite deposits	0.003 percent eU	---	Wedow and others, 1951, p. 110 Wedow and others, 1953, p. 13
			Seward quadrangle		
Western Prince William Sound (46)	1952	Radioactivity reconnaissance of granitic rocks, adjacent contact metamorphic zones, and various types of metalliferous lode deposits	0.003 percent eU or less	---	Wedow and others, 1953, p. 13
Likes Creek area, Resurrection Peninsula (47)	1952 1953	Reconnaissance to locate source of carnotite-bearing sandstone sample submitted by prospector	Samples contain as much as 1.5 percent U; no significant radioactivity detected in the field	---	Wedow and others, 1952, p. 34, 35 Matzko and Bates, 1955
Moose Pass-Hope area (48)	1951	Quartz fissure veins and mineralized dikes containing gold, silver, arsenopyrite, pyrite, galena, sphalerite, chalcopyrite, pyrrhotite, and molybdenite	0.002 percent eU or less	---	White and others, 1952, p. 10-12
Girdwood area (49)	1951	Fissure veins similar to those in Moose Pass-Hope area	<0.002 percent eU	---	White and others, 1952, p. 10-12
			McCarthy quadrangle		
Nizina district (50)	1947	Radioactivity reconnaissance of various rocks and mineral deposits	0.002 percent eU or less	---	Moxham and Nelson, 1952a, p. 1, 3
Golconda Creek, Bremner district (51)	1947	Placer-gold deposit	0.004 percent eU in concentrate	---	Moxham and Nelson, 1952a, p. 3

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Table 2.--Summary of reconnaissance for radioactive deposits in southern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 3)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Valdez quadrangle		
Valdez-Copper Center area (52)	1947	Radioactivity reconnaissance of verious types of bedrock and mineral deposits, chiefly gold lodes	0.005 percent eU or less	---	Moxham and Nelson, 1952a, p. 3, 4
			Anchorage quadrangle		
Matanuska Valley (53)	1947	Radioactivity reconnaissance of various types of bedrock and mineral deposits	0.002 percent eU or less	---	Moxham and Nelson, 1952a, p. 6
Willow Creek mining district (54)	1947	Gold-bearing quartz veins	0.004 percent eU or less	---	Moxham and Nelson, 1952a, p. 5
Fishhook Creek-Archangel Creek area, Willow Creek mining district (55)	1949	Radioactive pegmatites	Pegmatites average 0.004 percent eU; heavy-mineral fractions average 0.33 percent eU; radioactivity is due chiefly to one or more of the following: uraninite, thorite, cyrtolite, allanite	---	Moxham and Nelson, 1952a, p. 7-10
Anchorage-Kuik River area (56)	1947	Radioactivity reconnaissance of various types of bedrock and placer deposits	0.002 percent eU or less	---	Moxham and Nelson, 1952a, p. 5
			Tyonek quadrangle		
Nikolai Creek area (57)	1952 1953	Reconnaissance to locate source of carnotite-bearing limestone samples submitted by prospector, Howard Fowler.	Sample submitted by prospector contains as much as 0.6 percent U_3O_8; no significant radioactivity detected in field	---	Wedow and others, 1952, p. 20-23 Matzko and Bates, 1955
Mt. Spurr area (58)	--	Study of concentrate and rock specimens submitted by prospector	Concentrates contain in 0.0X range percent eU; radioactive minerals are chiefly monazite and zircon	---	Bates and Wedow, 1953, p. 8
			Nabesna quadrangle		
Alaska Highway (59)	1946	Granite and schist bedrock	Granite contains as much as 0.004 percent eU; no significant radioactivity found in schist	---	Wedow, Killeen, and others, 1954, p. 13-16
Bonanza Creek area, Chisana district (60)	1952	Gold- and silver-bearing galena-pyrite veins and various types of associated bedrock	0.004 percent eU or less	---	Wedow and others, 1953, p. 6, 7 Nelson and others, 1954
Orange Hill (61)	1952	Airborne radioactivity reconnaissance of lode deposit containing chiefly copper, lead, zinc and molybdenum sulfides	No significant radioactivity detected	---	Wedow and others, 1953, p. 6, 7 Nelson and others, 1954
Nabesna mine (62)	1952	Chiefly a gold lode but also containing various common sulfide minerals.	<0.001 percent eU	---	Wedow and others, 1953, p. 6, 7 Nelson and others, 1954
Rock Creek area (63)	1952	Molybdenite-bearing pegmatite	0.004 percent eU or less	---	Wedow and others, 1953, p. 6, 7 Nelson and others, 1954
Mineral Point area (64)	1952	Altered shear zone containing copper, gold, silver, and traces of nickel(?)	<0.001 percent eU	---	Wedow and others, 1953, p. 6,8 Nelson and others, 1954
Glenn Highway between Slana and Mineral Lake (65)	1946	Tests of concentrates from gravels of streams crossing highway	0.003 percent eU or less	---	Wedow, Killeen, and others, 1954, p. 16-18

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Table 2.--Summary of reconnaissance for radioactive deposits in southern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 3)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
Gulkana quadrangle					
Silver Creek area (66)	1946 1952	Quartz veins, containing silver-bearing galena and tetrahedrite with some gold, cutting diorite	Veins contain <0.001 percent eU; diorite contains as much as 0.005 percent eU	---	Wedow, Killeen, and others, 1954, p. 16-18 Wedow and others, 1953, p. 6, 8 Nelson and others, 1954
Indian group (67)	1952	Quartz veins containing silver-bearing galena and tetrahedrite, chalcopyrite, malachite, and azurite	0.004 percent eU or less	---	Wedow and others, 1953, p. 6, 7 Nelson and others, 1954
Talkeetna Mountains quadrangle					
Nelchina area (68)	1947 1952	Tests of concentrates from Nelchina placer-mining district and radioactivity traversing of various types of bedrock in the course of geologic mapping	No significant radioactivity detected	---	Moxham and Nelson, 1952a, p. 3,4 Wedow and others, 1953, p. 13
Iron Creek area (69)	1951	Chiefly replacement deposits containing chalcopyrite, pyrite, hematite, and other copper and iron oxides	0.002 percent eU or less	---	White and others, 1952, p. 7-9
Talkeetna quadrangle					
Cache Creek-Peters Creek area (70)	1945	Investigation of gold-placer deposits containing radioactive minerals	Heavy-mineral fractions of concentrates with uranothorianite, monazite and zircon are in the 0.0X range of percent eU	Bedrock source of radioactive minerals not found, but believed to lie in the Alaska Range north of the area; uranothorianite also occurs in placers of Kahiltna River below Cache Creek	Robinson and others, 1946 Harder and Reed, 1945
Mt. Hayes quadrangle					
Alaska Highway (71)	1946	Radioactivity tests of bedrock and placers adjacent to highway	Heavy-mineral fractions of concentrates from placers of streams draining areas of granitic rocks contain as much as 0.014 percent eU; radioactivity probably due to zircon	---	Wedow, Killeen, and others, 1954, p. 13-16
Richardson Highway between Donnelly Dome and Paxson (72)	1946	Test of concentrates from placers of streams adjacent to highway	0.004 percent eU or less except for those of Ober Creek which range from 0.003 to 0.001 percent eU; radioactivity due to traces of monazite	Ober Creek concentrates also contain traces of fluorite	Wedow, Killeen, and others, 1954, p. 18
Healy quadrangle					
Drazenovich uranium claims along Alaska Railroad 4 miles south of Healy (73)	1950	Radioactivity examination	No significant radioactivity detected	---	Moxham and West, 1953b, p. 3,7
Mt. McKinley quadrangle					
Mt. McKinley (74)	---	Radioactivity tests of 50 rock specimens collected by the 1947 Bradford Washburn Mt. McKinley Expedition	A specimen of manganiferous vein quartz contains as much as 0.009 percent eU; granitic rock types contain as much as 0.004 percent eU; remaining specimens are essentially nonradioactive	---	Matzko, 1951

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Table 2.--Summary of reconnaissance for radioactive deposits in southern Alaska, 1945-1954--Continued

Location (Reference no. on fig. 3)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
		Mt. McKinley quadrangle--Continued			
Mt. Eielson area (75)	1951	Replacement deposits containing chalcopyrite, sphalerite, galena, pyrite, and arsenopyrite; the galena and sphalerite are silver-bearing	$<$0.001 percent eU	---	White and others, 1952, p. 7-9
Kantishna Hills area (76)	1951	Quartz fissure veins containing silver-bearing galena and tetrahedrite, pyrite, arsenopyrite, sphalerite, chalcopyrite, and secondary copper and iron minerals	0.001 percent eU or less	---	White and others, 1952, p. 7-9
		Seward, Anchorage, Tyonek, Talkeetna, Talkeetna Mountains, and Healy quadrangles			
Alaska Railroad right-of-way (77)	1950	Radioactivity traverse	No significant radioactivity detected	---	Moxham and West, 1953b

radioactive material occur in the Yentna district. The study by Robinson and others (1955) in the Cache Creek-upper Peters Creek area (locality 70) disclosed that the placers did not contain sufficient amounts of radioactive minerals to be considered as an immediate source of uranium. The bedrock source of the radioactive minerals was not found.

Investigations in southern Alaska were continued in 1946 with examinations along parts of the Alaska Highway (localities 59 and 71), along part of the "Tok Cutoff", now designated as the eastern section of the Glenn Highway (locality 65), and in the Donnelly Dome-Paxson area (locality 72) on the Richardson Highway. No radioactive deposits of significance were found.

In 1947 study of areas contiguous to the highway system of Alaska was continued with the extension of reconnaissance to the "southern highway belt." The studies included selected localities in the Nizina district, Bremner district, Valdez-Copper Center area, Matanuska valley, Willow Creek mining district, and Anchorage-Knik River area (localities 50-54, and 56 respectively). Again, no significantly radioactive deposits were discovered.

No field investigations were made in southern Alaska during 1948, but laboratory studies disclosed the presence of radioactive minerals in prospectors' samples of beach placers at Yakataga (locality 44) and traces of radioactivity in specimens of vein quartz and granitic rocks collected on Mount McKinley by the 1947 Washburn Expedition (locality 74).

Radioactive pegmatites in the Willow Creek mining district (locality 55), found in 1948 by a Survey field party studying the gold lodes of the district, were examined in 1949. The pegmatites, however, did not contain commercial amounts of uranium or thorium, although the slight radioactivity present was found to be due chiefly to trace amounts of uraninite, thorite, and allanite. Also investigated in 1949 was a reported occurrence of pitchblende in the Jakolof Bay area (locality 42) on the Kenai Peninsula. No radioactivity of significance was detected in this area, and it is thought that the report originated when prospectors may have mistaken chromite for pitchblende in a stockpile on the shore of Jakolof Bay.

The only field studies made in southern Alaska during 1950 were limited to a radioactivity traverse along the right-of-way of the Alaska Railroad (locality 77) and an examination of claims staked for uranium near Healy (locality 73). No anomalous radiation was detected.

The reappraisal of the uranium possibilities of Alaska (Wedow and others, 1951) in 1950-51 indicated that certain metalliferous lodes in southern Alaska contain mineral assemblages associated with uranium elsewhere and hence were favorable for reconnaissance. Field appraisal of some of these favorable deposits was conducted in 1951 and included localities in the Nuka Bay, Moose Pass-Hope, and Girdwood areas (localities 41, 48, and 49 respectively) on the Kenai Peninsula; in the Iron Creek area (locality 69) of the Talkeetna Mountains; and in the Mount Eielson and Kantishna Hills areas (localities 75 and 76 respectively) on the north flank of the Alaska Range. No radioactive deposits warranting additional study were disclosed.

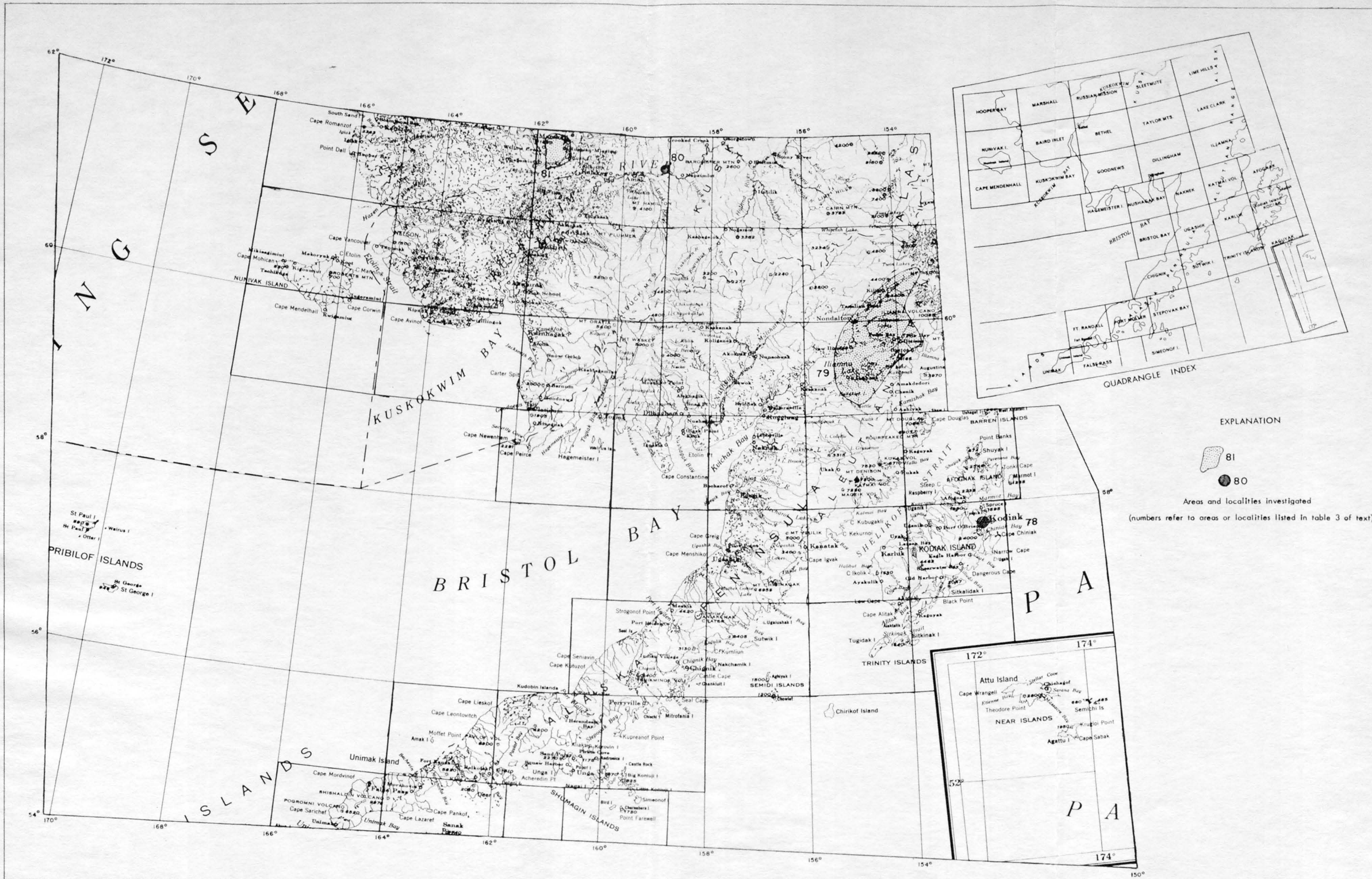
The reconnaissance examination of favorable lode deposits in southern Alaska was extended in 1952 to include selected localities (nos. 60-64, 66, and 67) in the eastern Alaska Range. In addition to investigations conducted to search specifically for uraniferous deposits, other Geological Survey parties made radioactivity tests in the Nelchina area (locality 68) and in the Prince William Sound region (localities 45 and 46) incidental to geologic studies.

In 1954, samples were collected from the beach sands in the Yakataga area (locality 44) to determine the extent and concentration of radioactive minerals known to occur in the sands. Preliminary results on samples obtained at a maximum depth of eight feet indicate that under present conditions, the beach sands are too low in radioactive black minerals to be a source of uranium, even as a byproduct material (Matzko and Bates, report in preparation).

Southwestern Alaska

Southwestern Alaska, which in this report includes most of the lower Yukon-Kuskokwim region, the Alaska Peninsula and the Aleutian Islands, has not been investigated for radioactive deposits in the same degree as several of the other main regions of the Territory, primarily because of its remoteness, general inaccessibility, and general dearth of geologic information on which to base an appraisal of its favorability or lack of favorability for uranium ores. The summary data on the limited amount of reconnaissance conducted in southwestern Alaska are given in table 3 and the locations of the areas investigated are shown on figure 4.

The first known occurrence of a uranium mineral in southwestern Alaska was discovered in 1947-48 (Moxham, 1950) when metazeunerite was identified in a concentrate from a copper deposit at the Konechney



Base from Alaska Map E, Edition of 1946.

50 0 50 100 150 MILES

FIGURE 4 --- MAP OF SOUTHWESTERN ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

Table 3.--Summary of reconnaissance for radioactive deposits in southwestern Alaska, 1945-1954

Location (Reference no. on fig. 4)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Kodiak quadrangle		
Kodiak and vicinity (78)	1954	Study of uraniferous sample submitted by prospectors in 1953	Commercial assays show a content of over 1 percent U; radioactivity due to meta-autunite and metatyuyamunite	Field investigations did not reveal any significant radioactivity and the uranium-rich samples submitted by the prospectors were not duplicated.	Matzko, 1953, oral communication Matzko, 1955, USGS-PRR no. A-1,741
			Iliamna and Lake Clark quadrangle		
Iliamna Lake-Lake Clark region (79)	1949	Chiefly silver-lead and copper deposits; also tested were various types of bedrock and concentrates of gravels from streams draining the more inaccessible areas	Maximum radioactivity of rocks and ores tested did not exceed 0.002 percent eU; maximum radioactivity of gravel concentrates was 0.007 percent eU; traces of radioactivity believed due chiefly to common accessory minerals of granitic rocks	Re-examination of the concentrates in 1953 disclosed that the radioactivity (0.007 percent eU) in a concentrate from the east shore of Lake Clark may be due to traces of a sooty black uranium mineral	Moxham and Nelson, 1952b, p. 1-4
			Russian Mission quadrangle		
Russian Mountains area (80)	1952	Copper prospects	A concentrate collected in 1944 from the workings on the copper lode of the Konechney prospect contains 0.017 percent eU due primarily to metazeunerite. Field examinations in 1952 found only 0.004 percent eU in quartz monzonite country rock and 0.002 percent eU or less in ore samples, although a trace of metazeunerite was found in one sample from the dump of the Konechney prospect	In 1952 all underground workings were inaccessible	Moxham, 1950 Wedow and others, 1953, p. 2, 4 West, 1953, p. 5-7
			Marshall quadrangle		
Marshall area (81)	1952	Vein deposits containing molybdenum, copper, and lead minerals and gold; also associated igneous and sedimentary rocks	0.001 percent eU or less	---	Wedow and others, 1953, p. 2, 4 West, 1953, p. 8-9

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prospect in the Russian Mountains (locality 80). The sample had been collected in 1944 by a Geological Survey party conducting mineral resource investigations in the central Kuskokwim region. The problems of accessibility and logistics, and the scheduling of other work elsewhere in Alaska prevented the examination of the Russian Mountains area until 1952, when helicopter-support was available from the 30th Engineer Topographic Battalion, U. S. Army. Unfortunately most of the surface and underground workings at the Konechney prospect was then inaccessible so that direct examination of the metazeunerite-bearing vein could not be made and only traces of metazeunerite were found in highly disintegrated material on the mine dumps.

The earliest field investigations in southwestern Alaska specifically for radioactive deposits were made in 1949 by Moxham and Nelson (1952b, p. 1-4), in the Iliamna Lake-Lake Clark region (locality 79). The investigation included the examination of silver-lead and copper lode deposits, one of which had been reported earlier to contain uranium. Also tested were most of the rock types in the more accessible parts of the region as well as numerous concentrates from creeks draining the more inaccessible areas. Only traces of radioactivity were detected and it was concluded that the region held little promise for the occurrence of uranium minerals. However, re-examination in 1953 of several of the concentrates taken along the shore of Lake Clark disclosed that the slight radioactivity of a concentrate from a beach deposit on the east shore of the lake in the vicinity of Currant Creek is due to traces of a highly radioactive mineral believed to be sooty pitchblende(?) rather than concentrations of one of the more refractory accessory minerals of granitic rocks as had been supposed.

An investigation was made in southwestern Alaska of vein deposits containing molybdenum, lead, gold, and copper minerals in the Marshall area (locality 81). These metalliferous lodes had been indicated as favorable for the presence of uranium in the 1950-51 appraisal of Alaskan uranium possibilities (Wedow and others, 1951, p. 83, 91), but when examined in 1952 were found to be essentially nonradioactive.

In 1953 a prospector from Kodiak submitted a sample containing about 1 percent uranium to the Geological Survey (locality 78). Mineralogic analysis of the sample indicated that the chief uraniferous minerals are metatyuyamunite and meta-autunite. The site from which the sample was taken was reported by the prospectors as just outside the city limits of Kodiak. A field examination of the sample locality and surrounding area in 1954, however, did not locate any significantly radioactive material (Matzko and Bates, report in preparation).

East-central Alaska

The data on the reconnaissance investigations for radioactive deposits in east-central Alaska are summarized in table 4; the areas covered by these investigations are shown on figure 5.

Although no field tests for radioactivity were made in east-central Alaska in the initial year (1945) of the Alaskan reconnaissance program, concentrates from various placer mining districts in the Yukon-Tanana region were collected by R. R. Coats of the Geological Survey specifically

Table 4.--Summary of reconnaissance for radioactive deposits in east-central Alaska, 1945-1954

Location (Reference no. on fig. 5)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Tanacross quadrangle		
Alaska Highway (82)	1946	Radioactivity reconnaissance of rocks adjacent to highway	Most radioactive rocks are granites which contain as much as 0.005 percent eU which is due chiefly to zircon and allanite	---	Wedow, Killeen, and others, 1954, p. 13-16
Glenn (Slana-Tok) Highway from Mineral Lake to Tok Junction (83)	1946	Radioactivity reconnaissance of rocks and placer deposits adjacent to highway	No significant radioactivity detected; maximum radioactivity of placer concentrates 0.003 percent eU	---	Wedow, Killeen, and others, 1954, p. 16-18
Taylor (Fortymile) Highway from Fortymile Junction to Chicken (84)	1950	Radioactivity reconnaissance of rocks adjacent to highway	No significant radioactivity detected, except in vicinity of Mt. Fairplay where granitic rock contains as much as about 0.018 percent eU; radioactivity due chiefly to zircon	---	White, Nelson, and Matzko (manuscript in preparation) Matzko, written communication, 1954
			Eagle quadrangle		
Chicken area (85)	1949	Radioactivity reconnaissance and tests of samples donated by prospectors	Granitic rocks and conglomeratic arkose(?) near Chicken contain as much as 0.005 percent eU; placer concentrates from Atwater Bar on the South Fork of the Fortymile River contain 0.04 percent eU--radioactivity due to uranothorianite and monazite	---	Wedow, White, and others, 1954, p. 10-12, 20-21
Wilson Creek area (86)	1949	Radioactivity reconnaissance to locate pitchblende-bearing vein reported by Charles Fellyez	Pitchblende not found; maximum radioactivity detected is in granitic rocks that contain as much as 0.005 percent eU	---	Wedow, White, and others, 1954, p. 13-18
My Creek area (87)	1949	Radioactivity reconnaissance to locate occurrence of pitchblende reported by E. D. Manske	Pitchblende not found; maximum radioactivity is 0.003 percent eU in granitic rocks; quartz veins containing galena and hematite contain <0.001 percent eU	---	Wedow, White, and others, 1954, p. 18-19
Ben Creek area (88)	1949	Radioactivity reconnaissance to locate high-grade "yellowish uranium ore" reported by Wm. Ott	High grade uranium ore not found; maximum of 0.005 percent eU occurs in felsic igneous rocks; radioactivity probably due to accessory allanite and monazite, as these were identified in concentrates containing 0.0X percent eU from placers of creeks draining areas of felsic igneous rocks	---	Wedow, White, and others, 1954, p. 19-20
Copper Creek copper prospect (89)	1949	Radioactivity study of "contact" copper deposit in highly metamorphosed roof pendant in granite batholith	Chief anomalous radioactivity is in iron-stained rocks along fractures in lime-siliceous rocks, maximum radioactivity is about 0.03 percent eU--radioactivity due to uranium as impurity in copper minerals	---	Wedow, White, and others, 1954, p. 7-9

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Table 4.--Summary of reconnaissance for radioactive deposits in east-central Alaska, 1945-1954--Continued

Location (Reference no. on fig. 5)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Eagle quadrangle-Continued		
Fortymile fluorite occurrences (90)	1952	Reconnaissance of two fluorite occurrences near Chicken	Maximum radioactivity 0.003 percent eU	Fluorite ranges from colorless through green to purple	Wedow and others, 1953, p. 13
Lower Mission Creek area (91)	1948	Reconnaissance of Mesozoic(?) granite and its Tertiary sedimentary derivatives	Granite averages 0.005 percent eU and arkose derived from the granite average 0.004 percent eU; biotite is the chief radioactive mineral in the granite and zircon and monazite contain the radioactive elements in the arkose rocks	Traces of uranothorianite reported in 1953 in placer concentrate from drainage of Seventymile River	Wedow, 1954 Matzko, 1953, written communication
			Eagle and Charley River quadrangles		
Yukon River between Eagle and Nation (92)	1948	Reconnaissance of sedimentary rocks of Precambrian to Triassic age	None of the sedimentary rocks contain more than 0.003 percent eU except for black shale beds in the Mississippian Calico Bluff formation; two black shale units each averaging about 6 feet thick contain 0.006 to 0.007 percent eU	Phosphatic pellets from one of the black shale beds contain as much as 0.022 percent eU, 0.019 percent U and about 15 percent P_2O_5	Wedow, 1954
			Big Delta quadrangle		
Richardson Highway in Harding Lake-Richardson area (93)	1946	Radioactivity reconnaissance of rocks adjacent to highway	Maximum radioactivity in area found in granitic rocks that contain about 0.005 percent eU; the chief radioactive minerals zircon and allanite(?)	---	Wedow, Killeen, and others, 1954, p. 11-13
			Circle quadrangle		
Miller House-Circle Hot Springs area (94)	1949 1952 1953	Reconnaissance for radioactive deposits associated with granitic rocks	Granitic rocks contain as much as 0.007 percent eU; concentrates from placers contain in 0.0X range percent eU; chief radioactive minerals are uranothorianite, allanite, sphene, purple fluorite, scheelite, malachite, zircon, and at one locality an unidentified yellow-green secondary uranium mineral	A water sample from Portage Creek contains as much as 40 parts per billion uranium	Wedow, White, and others, 1954, p. 4-6 Wedow and others, 1953, p. 3, 5, 6 Nelson and others, 1954 Matzko and Bates, 1955
Hope Creek area (95)	1952	Reconnaissance for radioactive deposits associated with granite and reported quartz-pyrite-fluorite veins	Granites contain as much as 0.004 percent eU; float fragment of limonite-hematite granitic breccia contains 0.055 percent eU	Review of the mineralogy indicated purple fluorite at the head of American and Sourdough Creeks	Wedow and others, 1953, p. 3, 5 Nelson and others, 1953, p. 25-29 Nelson, West, and Matzko, 1954
Steese Highway in upper Chatanika Valley (96)	1946	Radioactivity reconnaissance of rocks adjacent to highway	Granitic rocks contain as much as 0.005 percent eU, graphitic schist as much as 0.003 percent eU and other schist 0.002 percent eU or less; a dredge concentrate from placers on Nome Creek contains 0.012 percent eU probably due to thorium in traces of monazite	---	Wedow, Killeen, and others, 1954, p. 8

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Table 4.--Summary of reconnaissance for radioactive deposits in east-central Alaska, 1945-1954 --Continued

Location (Reference no. on fig. 5)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Fairbanks quadrangle		
Alaska Railroad right-of-way (97)	1950	Radioactivity traverse	No significant radioactivity detected	---	Moxham and West, 1953b
Liberty Bell mine (98)	1951	Gold-bearing quartz veins with arsenopyrite, pyrite, chalcopyrite, and bismuthinite	0.002 percent eU or less	---	White and others, 1952, p. 7-9
California Creek prospects (99)	1951	Two prospects: 1) quartz veins containing stibnite, pyrite, and chalcopyrite; and 2) quartz vein containing silver-bearing galena	0.002 percent or less	A 3-pan concentrate from Buzzard and Iron Creeks divide submitted by a prospector contains 0.015 percent eU with traces of platinum	White and others, 1952, p. 7-9 Matzko, 1953, written communication
			Fairbanks and Livengood quadrangle (Fairbanks district)		
Ester Dome area (100)	1946	Chiefly gold-lode prospects	Maximum radioactivity detected was 0.005 percent eU	---	Wedow, Killeen, and others, 1954, p. 3-8
Pedro Dome area (101)	1946	Chiefly gold, tungsten, and antimony lode prospects; granitic rocks, schist, and placer concentrates also tested	No significant radioactivity detected; maximum eU percent obtained in bedrock was 0.003 in granodiorite from Pedro Dome and in sulfide-enriched limestone on Seattle Pup	---	Wedow, Killeen, and others, 1954, p. 3-8
Melba Creek bismuth-bearing gold lode prospect (102)	1949	Gold-lode prospect reportedly containing bismuth minerals and considered to be a possible source of radioactive bismuth nuggets in placers of Fish Creek; deposit consists of quartz veins cutting a fine-grained biotite granite	0.002 percent eU or less	---	Wedow, White and others, 1954, p. 1-2
Tolovana mine on Willow Creek (103)	1949	Gold-bearing quartz veins containing minor amounts of arsenopyrite and stibnite	0.003 percent eU or less	---	Wedow, White, and others, 1954 p. 2
Cleary Hill mine (104)	1949	Gold-bearing quartz veins containing minor amounts of arsenopyrite and stibnite	0.003 percent eU or less	---	Wedow, White, and others, 1954, p. 2
Anderson prospect (105)	1951	Sheared quartz vein in granitic rock containing gold and several of the common sulfides	Maximum of 0.006 percent eU in granitic rock	---	White and others, 1952, p. 7, 9
Fox Creek silver-lead prospects (106)	1951 1952 1953	Silver-bearing galena in quartz-carbonate veins cutting highly weathered granitic rock	Samples of galena normally contain less than 0.01 percent eU, but locally contain as much as 0.03 percent eU in weathered pockets	Prospect staked in 1951 by Messrs. Lindgren and Fultz as a silver-uranium deposit; as DMEA application for Government aid was turned down the claims were allowed to lapse. U. S. Geological Survey work in 1952-53 consisted of applying geochemical prospecting techniques to the study of the prospects to determine whether such techniques could be used in the reconnaissance for uranium deposits in Alaska	White and others, 1952, p. 7, 9 Matzko, 1953 and 1954, written communication
			Livengood quadrangle		
Elliot Highway (Fox to Livengood) (107)	1949	Radioactivity traverse of Precambrian and Paleozoic rocks adjacent to highway	Samples collected contain a maximum of 0.003 percent eU, Birch Creek schist .004 percent eU, Middle Devonian and Carboniferous dark shale	---	Wedow, White, and others, 1954, p. 2

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Table 4.--Summary of reconnaissance for radioactive deposits in east-central Alaska, 1945-1954--Continued

Location (Reference no. on fig. 5)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Livengood quadrangle--Continued		
Livengood district (108)	1946 1949	Radioactivity reconnaissance of lode prospect, bedrock, and placer deposits with particular emphasis on source of euxenite-polycrase mineral found in placers on Goodluck Creek	Source of euxenite-polycrase mineral not found; maximum radioactivity detected in bedrock was 0.005 percent eU in granite on Livengood Ridge; traces of monazite found in placers of Ruth Creek	---	Wedow, Killeen, and others, 1954, p. 8-11 Wedow, White, and others, 1954, p. 2-3
			Tanana quadrangle		
Manley Hot Springs-Rampart district (109)	1948	Radioactivity reconnaissance of lode prospects and bedrock types of district with emphasis on cobalt-bearing silver-lead lode, and granitic rocks; also to locate source of ellsworthite, eschynite and columbite found in placers of Tofty tin belt	No significant bedrock source of radioactive minerals located; concentrates from placers generally contain 0.0X percent eU; granitic rocks contain as much as 0.004 percent eU; silver-lead lode material contains 0.00X percent eU.	---	Moxham, 1954
Grant Creek area (110)	1946	Reconnaissance to locate source of pitchblende reported by Walter Fischer	Source of pitchblende not located, no significant radioactivity detected in areal traverse.	---	Wedow, Killeen, and others, 1954 p. 33-36
			Tanana, Livengood, and Beaver quadrangles		
Yukon River traverse (111)	1949	Radioactivity traverse of rocks adjacent to river	No significant radioactivity detected except in a monzonitic rock from a locality about 30 miles below Rampart; it contains 0.008 percent eU	---	White, Stevens, and Matzko (report in preparation)
			Coleen quadrangle		
Porcupine and Coleen Rivers (112)	1948	Radioactivity traverse of sedimentary rocks adjacent to lower Coleen and upper Porcupine Rivers and reconnaissance of granitic rocks along International Boundary north of Rampart House	Silurian black shale contains a maximum of 0.005 percent eU, Carboniferous black shale - a maximum of 0.003 percent eU, Precambrian shales - a maximum of 0.005 percent eU; granitic rocks contain as much as 0.006 percent eU which appears to be due chiefly to traces of unidentified uranium minerals	---	White, 1952a
			Chandalar quadrangle		
Chandalar mining district (113)	1952	Radioactivity reconnaissance of metalliferous veins for possible uraniferous deposits; also attempt to locate source of monazite in placers	Vein deposits contain 0.001 percent or less eU; placer concentrates contain as much as 0.05 percent eU, due chiefly to thorium in monazite	---	White, 1952b Wedow and others, 1953, p. 3 Nelson and others, 1954
			Wiseman quadrangle		
Gold Bench area, South Fork of Koyukuk River (114)	1952 1953	Radioactivity reconnaissance to locate bedrock source of placer uranothorianite and associated sulfides	Bedrock source not found; gravel concentrates contain as much as 0.18 percent eU	---	White, 1952b Wedow and others, 1953, p. 3 Nelson and others, 1954 Matzko and Bates, 1955

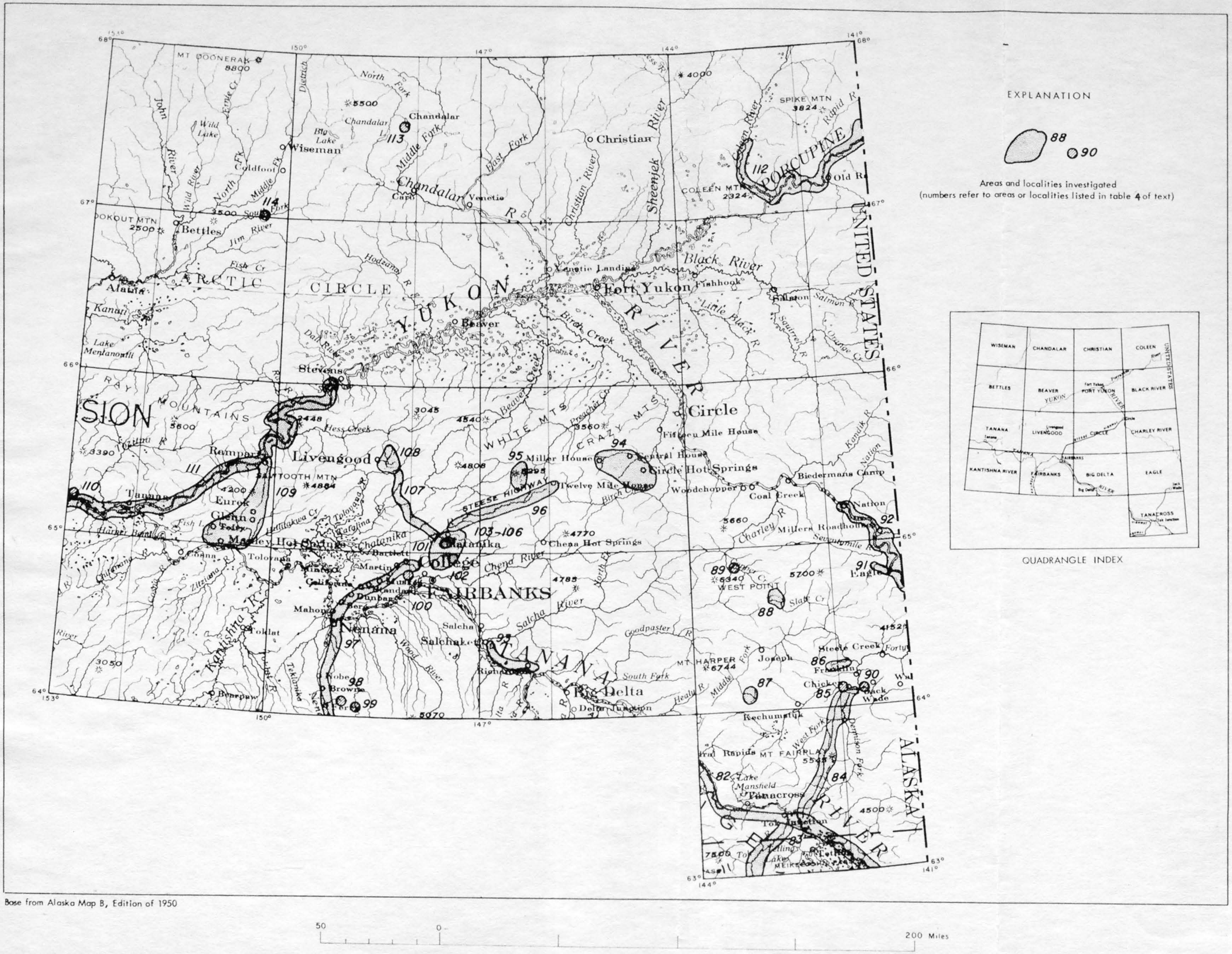

FIGURE 5.--MAP OF EAST-CENTRAL ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

for radioactivity tests. However, none of the concentrates collected in 1945 showed appreciable amounts of radioactivity, or new areas favorable for the occurrence of radioactive minerals, beyond those mentioned by Harder and Reed (1945).

In 1946 reconnaissance was directed toward the search for radioactive bedrock deposits in areas contiguous to the highway system of interior Alaska. In east-central Alaska the reconnaissance included the Fairbanks district (localities 100 and 101), along the Steese Highway (locality 96), the Livengood district (locality 108), along the Richardson Highway in the Harding Lake-Richardson area (locality 93), and along a part of the Alaska Highway (locality 82). Also investigated in 1946 was a reported pitchblende occurrence in the Grant Creek area (locality 110) north of the Yukon River west of Tanana. None of the 1946 investigations disclosed commercial deposits of radioactive materials, although minor amounts of uranium and thorium, occurring chiefly as impurities in accessory minerals of granitic rocks, were found to be widespread in the areas investigated.

No reconnaissance for radioactive deposits was made in east-central Alaska during 1947. In 1948, investigations were made in the Eagle-Nation area (localities 91 and 92), along the Porcupine and Coleen Rivers (locality 112) and in the Manley Hot Springs-Rampart district (locality 109). Sections of sedimentary rocks, chiefly of Precambrian and Paleozoic age, many thousands of feet in thickness were traversed for radioactivity along the Yukon River between Eagle and Nation (locality 92) and along the Porcupine and Coleen Rivers (locality 112). The major sedimentary rock types of interest in these areas were radioactive black shales of Paleozoic age similar to formations in the United States that contain large reserves of low-grade uraniferous material; and Precambrian red beds, which at one locality in northwestern Canada contain deposits with monazite and pitchblende or uraninite (Rabbitt, 1947; Lang, 1952, p. 63, 65). On the other hand, none of the Precambrian strata traversed contained radioactive materials similar to those found in beds of comparable age in Canada. Granitic rocks of Mesozoic(?) age in the lower Mission Creek area (locality 91) near Eagle contain minor amounts of the radioelements in such accessory minerals as biotite, zircon, and monazite, whereas in similar rocks along the international boundary north of the Porcupine River (locality 112), the radioactivity is due to trace amounts of unidentified uranium minerals.

The investigation in the Manley Hot Springs-Rampart district (locality 109) was primarily concerned with the examination of a cobalt-silver-lead lode deposit on Hot Springs Dome and the search for the bed-rock source of uraniferous minerals associated with cassiterite and gold in the placers of the Tofty tin belt. The cobalt-bearing lode proved to be essentially nonradioactive and the source of the uraniferous minerals in the placers could not be located.

Reconnaissance parties in the field during 1949 conducted studies at a number of widely scattered areas in east-central Alaska. These studies included: radioactivity traverses along the Yukon River (locality 29) and along the Elliott Highway (locality 107); the search for the bed-rock sources of uraniferous minerals identified in concentrates from placers in the Livengood area (locality 108) and in the Miller House-Circle Hot

Springs area (locality 94); the investigation of favorable metalliferous lodes in the Fairbanks district (localities 102-104) and on Copper Creek (locality 89) in the Eagle district; and the search for reported occurrences of high-grade uranium ores in the Fortymile district (localities 85-88). Although no deposits warranting exploration were discovered, minor amounts of the radioelements were found in most of the localities studied, chiefly in the accessory minerals of granitic rocks. The recognition of uraniferous fluorite in granitic rocks of the Miller House-Circle Hot Springs area was of specific note and the occurrence indicated the need for future study.

In 1950, reconnaissance in east-central Alaska was limited to radioactivity traverses along the right-of-way of the Alaska Railroad (locality 97) and along the southern half of the Taylor (Fortymile) Highway (locality 84). No significant radioactivity was detected along the railroad, but along the Taylor Highway granitic rocks were found to contain minor amounts of uranium, chiefly in accessory zircon.

Reconnaissance in 1951 consisted of the examination of several possibly favorable lode deposits in the Fairbanks region (localities 98, 99, 105, and 106). None of these deposits exhibited radioactivity of interest except for the silver-lead deposit at the head of Fox Creek northeast of Fairbanks (locality 106). However, the radioactivity at this prospect was not sufficient to grant a DMEA loan requested by the prospectors who noted the radioactive galena. At this locality the radioactivity of silver-bearing galena veins is due chiefly to minor amounts of uranium generally concentrated in weathered pockets in massive pieces of ore. Although not of commercial significance, the deposit is unique in that it was the first uraniferous vein deposit found in the Fairbanks district.

Search for radioactive deposits in east-central Alaska was continued in 1952 with the investigation of reported fluorite occurrences in the Hope Creek area (locality 95), Miller House-Circle Hot Springs area (locality 94), and in the Fortymile district (locality 90); the search for the bedrock source of placer monazite and the testing of metalliferous lodes in the Chandalar district (locality 113); and a brief search for the bedrock source of placer uranothorianite and associated sulfides at Gold Bench on the South Fork of the Koyukuk River (locality 114). In addition to the above, samples were taken at the Fox Creek silver-lead deposit (locality 106) for preliminary tests to determine whether geochemical techniques could be applied to the search for uranium in the deeply weathered tundra-covered terrain of interior Alaska. Again, no deposits worthy of exploitation were discovered. Of note, however, was the recognition of an unidentified secondary yellow-green uranium mineral in granite and uranothorianite in placers on Portage Creek in the Miller House-Circle Hot Springs area. The preliminary geochemical tests at the Fox Creek silver-lead deposit indicated that such techniques were feasible and that minor variations in uranium generally followed variations in the lead and zinc content of the residuum overlying the veins.

In 1953 brief additional studies were made in the vicinity of Gold Bench, at the Fox Creek silver-lead prospect, and in the Circle Hot Springs area (Matzko and Bates, 1955). The results of these studies emphasized the need and desirability of using water, soil, and plant sampling techniques in deeply weathered areas covered by muck, tundra, and vegetation.

West-central Alaska

Summaries of reconnaissance investigations for radioactive deposits in west-central Alaska are given in table 5. The locations of the area investigated are shown on figure 6.

The search for radioactive deposits in west-central Alaska was initiated in 1945 with the investigation of placers containing radioactive minerals. Investigations in the northeastern part of the Seward Peninsula were made in the Sweepstakes Creek area, of the Buckland-Kiwalik district (locality 135) and in the Candle Creek area (locality 137). Investigations in the western part of the peninsula were made at Ear Mountain (locality 139) and Cape Mountain (locality 141) in the York district. Also in 1945, R. E. Wallace of the Geological Survey collected additional concentrates in the Nixon Fork-McGrath area specifically for radioactivity studies.

Although the investigations in the Sweepstakes Creek area failed to locate the bedrock source of the chief radioactive mineral--uranothorianite--in the placers, the data obtained suggested that its source was probably in the granitic rocks underlying Granite Mountain in the northern part of the area. Similarly, the bedrock source of uranothorianite in the Candle Creek placers could not be located, but the source is believed to be in altered felsic rocks on one of the headwater tributaries of the creek.

Table 5.--Summary of reconnaissance for radioactive deposits in west-central Alaska, 1945-1954

Location (Reference no. on fig. 6)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			McGrath quadrangle		
Candle Creek (115)	1947	Placer concentrate	Maximum 0.003 percent eU; trace of monazite(?) reported	---	White and Killeen, 1953, p. 16, 18
			Iditarod quadrangle		
Vicinity of Flat (116)	1947	Reconnaissance to locate bedrock source of radioactive material previously found in placer concentrates	Radioactivity due chiefly to uraniferous zircon, an accessory mineral in monzonite that averages about 0.004 percent eU; concentrates may contain as much as 0.1 percent eU but generally only 0.0X percent eU	---	White and Killeen, 1953, p. 1-15
Julian Creek (117)	1947	Placer concentrate	Concentrate contains about 0.03 percent eU due chiefly to monazite	Source of monazite probably in porphyritic granite dikes that cut country rock in drainage basin of creek	White and Killeen, 1953, p. 16, 18
Moore Creek (118)	1947	Placer concentrate	Contains 0.001 percent eU	Concentrate consists chiefly of chromite with traces of cinnabar, scheelite, and pyrite	White and Killeen, 1953, p. 16, 18
			Medfra quadrangle		
Nixon Fork district (119)	1949	Reconnaissance to locate source of uranothorianite found in placers and examination of gold-copper lodes	Rocks from contact deposits contain as much as 0.05 percent eU, due chiefly to thorium in allanite and idocrase; source of uranothorianite not found although additional concentrates containing as much as 0.26 percent eU were collected	Parisite also occurs in the altered contact zone	White and Stevens, 1953, p. 10-19
			Ophir quadrangle		
Cripple Creek Mountains (120)	1947	Placer concentrates	Maximum 0.003 percent eU	---	White and Killeen, 1953, p. 16-18
			Unalakleet quadrangle		
McLeod molybdenite prospect (121)	1952	Molybdenite-bearing quartz vein	Vein contains maximum of 0.001 percent eU; wall-rock (rhyolite porphyry) contains 0.003 percent eU	---	West, 1954, p. 9-10
			Ruby quadrangle		
Poorman area (122)	1949	Search to locate source of uraniferous mineral of spinel group found in placer concentrates from upstream part of Solomon Creek	Source not found; placer concentrates contain as much as 0.056 percent eU	---	White and Stevens, 1953, p. 9
Long area (123)	1949	Search to locate source of uranothorite found in placers	Source of uranothorite found as accessory in granite on Birch, Straight, and Flint Creeks; granite contains as much as 0.008 percent eU; concentrates from placers contain as much as 1.6 percent eU	The uranothorite of one sample contains as much as 8.2 percent U	White and Stevens, 1953, p. 4-9

Location (Reference no. on fig. 6)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Ruby quadrangle--Continued		
Ruby area (124)	1949	Radioactivity traversing of roads and examinations of silver-lead lode on New York Creek	No significant radioactivity detected; maximum eU content of silver-lead lode is 0.003 percent	---	White and Stevens, 1953, p. 3,4
			Ruby and Melozitna quadrangles		
Yukon River traverse (125)	1949	Radioactivity traverse of rocks adjacent to river	No significant radioactivity detected	---	White and Stevens (manuscript in preparation)
			Norton Bay, Solomon, and Bendeleben quadrangles		
Darby Mountains (126)	1948	Radioactivity reconnaissance	Radioactivity in area appears to be related directly to areas of granitic rock; concentrates from placers of creeks draining areas of granitic rock contain 0.01 to 0.1 percent eU; radioactivity due chiefly to sphene, allanite, and zircon, locally to monazite, uranothorianite, and an unidentified uranium-titanium niobate mineral	Concentrates locally contain traces of cassiterite, topaz, fluorite, and various sulfides	West, 1953
			Solomon quadrangle		
Big Hurrah mine (127)	1951	Gold-bearing quartz vein containing chalcopyrite, pyrrhotite, and stibnite; intrude black slate of Paleozoic age	<0.001 percent eU	---	White and others, 1952, p. 4
Quiggley antimony prospect (128)	1951	Stibnite-bearing quartz veins	<0.001 percent eU	---	White and others, 1952, p. 4
			Solomon and Nome quadrangles		
Cape Nome area (129)	1947	Granitic rocks reported to contain allanite	Only traces of allanite found; heavy-mineral fractions of granitic rocks contain as much as 0.012 percent eU which is attributed to U and Th in sphene and zircon	---	White, West, and Matzko, 1953, p. 5-8
Nome-Council road (130)	1951	Radioactivity traverse of bedrock adjacent to road	No significant radioactivity detected beyond that previously noted in the Cape Nome area (see locality 129)	---	White and others, 1952, p. 4
			Nome quadrangle		
Hed and Strand mine (131)	1951	Quartz veins cutting schist of Paleozoic age; metallic minerals chiefly stibnite, pyrite, and arsenopyrite	0.001 percent eU	---	White and others, 1952, p. 4
Charley Creek bismuth prospect (132)	1951	Quartz veins and adjacent schist containing native bismuth, bismuthinite and iron sulfides	0.002 percent eU or less	---	White and others, 1952, p. 4
Snake River, Penny river, and Osborn roads (133)	1951	Radioactivity traverse of bedrock adjacent to roads	No significant radioactivity detected	---	White and others, 1952, p. 4

Table 5.--Summary of reconnaissance for radioactive deposits in west-central Alaska, 1945-1954--Continued

Location (Reference no. on fig. 6)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Nome quadrangle--Continued		
Sinuk River iron deposits (134)	1951	Veins and stockworks of limonite with hematite in limestone of early Paleozoic age; contain traces of magnetite, siderite, pyrolusite, galena, sphalerite, and gold; purple fluorite reported at one locality	<0.001 percent eU	---	Wedow and others, 1951, p. 33, 34 White and others, 1952, p. 4
			Candle quadrangle		
Buckland-Kiwalik district (135)	1945 1946 1947	Search for bedrock source of uranothorianite found originally in placers on Sweepstake Creek; search later extended to area along divide between Buckland and Kiwalik Rivers	Concentrates from systematic sampling of creek gravels in the Buckland-Kiwalik district generally contain 0.0X percent eU; locally eU content is 0.X percent and concentrates from various phases of placer-mining operations is XX.0 eU. Radioactivity is due chiefly to uranothorianite although uraniferous thorite, gummite, orangite, hydrothorite, allanite, sphene, and zircon also contain radio-elements and contribute to radioactivity of concentrates	Source of radioactive minerals not found, but is believed to be in the granitic rocks as the radioactive minerals are restricted to gravels of streams draining areas containing such rocks. Although the distribution of the uranothorianite is widespread, its concentration and association with metallic sulfides in placers at the head of the Peace River is a significant lead to a possible lode source. (See locality 136.)	Harder and Reed, 1945, p. 5, tables 1 and 2, appendix 1 Gault and others, 1953, p. 1-10, 15-27
Peace River area (136)	1951 1953	Search for bedrock source of uranothorianite associated with sulfides (see locality 135) found in placers on a head-water tributary of the Peace River	Concentrates contain as much as 0.8 percent eU or about 10 times the eU content of the average uranothorianite-bearing placers in the Buckland-Kiwalik district.	Brief reconnaissance in 1951 failed to locate bedrock source of uranothorianite although it disclosed that gummite, believed to be a decomposition product of the uranothorianite, occurs in intimate association with tetradymite, galena, and pyrite. Private prospecting in 1953 with a bulldozer did not locate a possible lode source for uranothorianite, gummite and sulfides; however the trenching program was not completed and the results are inconclusive	Gault and others, 1953, p. 28-31 Matzko and Bates, 1955
			Candle and Bendeleben quadrangles		
Candle Creek area (137)	1945	Investigation of uranothorianite-bearing placers	Bedrock source not found; radioactive concentrates generally contain 0.0X percent eU, although one contains 5.0 percent eU and 3.8 percent U	---	Harder and Reed, 1945, p. 14, tables 1 and 2, appendix 1 Gault and others, 1953, p. 11-14
	1954	Investigation of radioactivity anomaly found with airborne equipment	Granitic talus contains about 0.006 percent eU	---	Matzko, USGS-PRR: A-1,734
			Bendeleben and Teller quadrangles		
Serpentine-Kougarok area (138)	1946	Search for bedrock source of radioactive minerals found in placer concentrates and the investigation of a granitic intrusive for possible radioactive lode deposits	Radioactivity of placer concentrates and granite is due to zircon, sphene, allanite, hydrogoethite, and two unidentified radioactive secondary minerals. Radioactivity of granite chiefly in late-stage differentiates which average 0.008 percent eU	---	Moxham and West, 1953a

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Table 5.--Summary of reconnaissance for radioactive deposits in west-central Alaska, 1945-1954--Continued

Location (Reference no. on fig. 6)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Teller quadrangle		
Ear Mountain area (139)	1945	Investigation of placer deposits containing radioactive minerals and search for bedrock source of such minerals	Radioactivity of placer concentrates is as much as 0.X percent eU but is due chiefly to monazite and zircon; these minerals occur as accessories in granite. A uraniferous lode deposit traced over a distance of more than 5,000 feet from float was trenched at two places; the lode consists of a hematitic tourmalinized mafic dike. Channel samples across the lode in widths up to 8 feet contain 0.01 to about 0.05 percent eU. A copper uranite, possibly metazeunerite or metatorbernite has been identified in some samples	Tin-bearing lodes also occur associated with the granite stock at Ear Mountain; the minerals at these lodes and in the contact between the granite and limestone country rock include: vesuvianite, fluorite, topaz, cassiterite, tourmaline, arsenopyrite, pyrite, chalcopyrite, and pageite	Killeen and Ordway, 1955 Wedow and others, 1951, p. 29-31
Potato Mountain area (140)	1951	Search for radioactive deposits associated with fluorite-bearing tin deposits	0.001 percent eU	---	Wedow and others, 1951, p. 28-29 White and others, 1952, p. 3
Cape Mountain area (141)	1945	Search for bedrock source of radioactive minerals found in tin-bearing placers	Monazite and hematite are uraniferous; the monazite probably occurs as accessory mineral in granite, the hematite has formed by the oxidation of pyrite found in the contact zone; other thorium-bearing minerals probably also occur in the placers	Pyrite, cassiterite, sphalerite, and fluorite also occur in the tin deposits of the area	Wedow and others, 1951, p. 31-32 Killeen, 1945, oral communication
Brooks Mountain area (142)	1951	Metazeunerite occurrences in granite	Metazeunerite (previously identified as zeunerite) occurs with hematite in a lens-shaped body of altered coarse-grained granite at a granite-limestone contact. Although selected specimens of the deposit contain more than 2 percent U, the average content is between 0.1 and 0.2 percent. Metazeunerite also occurs as surface coatings of tourmaline veins cutting the granite and as traces in a base-metal lode also at the granite-limestone contact	The chief occurrences of metazeunerite (Foggy Day prospect) was explored by the U. S. Smelting, Refining, and Mining Co. with a 20-foot deep trench. The lens-shaped body was about 15 feet in diameter and 4-5 feet thick. Although the lens was removed during exploration radioactive hematitic stringers in the bottom of the trench indicate a possible downward extension of the uraniferous zone.	West and White, 1952 Wedow and others, 1951, p. 26-28
Lost River area (143)	1951	Search for uraniferous deposits possibly associated with tin deposits	No uranium deposits of commercial interest discovered; tin-bearing rhyolitic dikes contain as much as 0.01 percent eU; a pocket of iron oxides, not exceeding a few cubic yards in size, in limestone contains about 0.06 percent eU	The radioactive samples containing 0.0X percent eU from the Greenstone lode found in 1950 by scanning old collections could not be duplicated because workings on the lode had caved.	White and West, 1953 Wedow and others, 1951, p. 22-25
Teller and vicinity (144)	1946	Reconnaissance of placer-gold mining area	No significant radioactivity detected except minor amounts in granite boulders from gravels on Gold Run; a heavy-mineral fraction of one granite boulder contains 0.017 percent eU due chiefly to radio-elements in allanite and zircon	---	White, West, and Matzko, 1953, p. 1-4

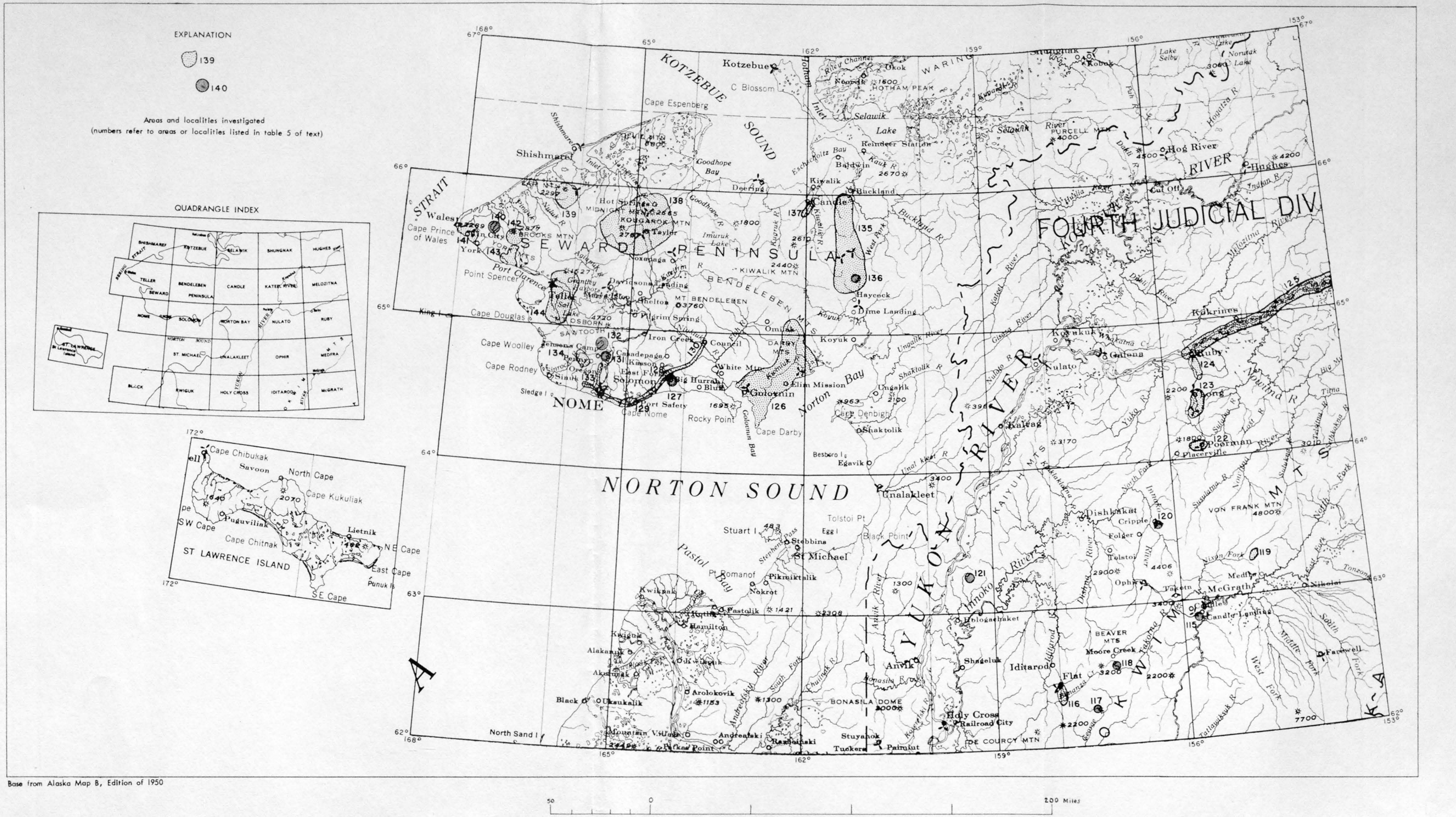

FIGURE 6 --MAP OF WEST - CENTRAL ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

The investigations at Ear Mountain disclosed that the radioactivity of the placers there is due chiefly to radioelements in monazite and zircon which occur as accessories in the granite stock forming the mountains. Although the radioactivity of the placers at Ear Mountain proved to have essentially no significance, the 1945 reconnaissance discovered the presence of uraniferous lodes consisting of hematitic tourmaline-quartz veins associated with tourmalinized mafic dikes. One of the radioactive vein-dike zones crosses the top of Ear Mountain with a northeasterly trend. It is traceable chiefly by float for over 5,000 feet. At one locality near the top of Ear Mountain it is 8 feet wide. A hematitic subzone about 18 inches wide in the central part of the 8-foot zone was the most radioactive part and contains 0.045 percent equivalent uranium and 0.035 percent uranium. Selected fragments of the radioactive rock contain as much as 0.18 percent equivalent uranium. The uranium occurs chiefly as copper uranite, probably metatorbernite or metazeunerite, and as an impurity in the hematite.

The brief investigations at Cape Mountain in 1945 and later mineralogic studies indicate that the radioactivity of the placers is due to uranium and thorium chiefly in monazite and zircon which were originally accessory constituents of the granite underlying the mountain. Hematite in the placers is also slightly uraniferous and was probably derived from the oxidation of masses of pyrite found in and near the contact of the granite with the limestone country rock.

The discovery of a uraniferous lode in association with granite at Ear Mountain in 1945 suggested that other, similar deposits may occur in the vicinity of other granitic bodies elsewhere on the Seward Peninsula.

Consequently, in 1946, an investigation was made in the Serpentine-Kougarok area (locality 138) centering chiefly around the granitic body at Serpentine Hot Springs. The chief radioactivity found in this area was that of the granite itself and placers derived by the natural concentration of the radioactive accessory minerals in the granite.

A brief reconnaissance conducted in the mining area in the vicinity of Teller (locality 144) disclosed no radioactive materials of commercial significance. Reconnaissance was continued in the Buckland-Kiwalik district (locality 135) with studies in the Quartz Creek area which lies to the north of the Sweepstakes Creek area investigated in 1945. Uranothorianite was again identified as the chief radioactive mineral in the placers and was traced from gravels into slope wash high on the north flank of Granite Mountain. Although the actual bedrock source was not found, it is believed to be concentrated in specific zones of segregation within the granitic rock.

In 1947 two major field investigations were conducted in west-central Alaska: (1) The examination of granitic bodies in the vicinity of Flat (locality 116) to determine the possibilities for bedrock concentrations of radioactive minerals previously known only in placers. The chief radioactive mineral proved to be uraniferous zircon which occurs as an accessory constituent of a quartz monzonite stock, and hence could not be considered as a commercial source of uranium. (2) The extension of reconnaissance in the Buckland-Kiwalik district (locality 135) to all as yet uninvestigated areas between Sweepstakes Creek on the south to Clem Mountain on the north. Because of the wide-spread cover of tundra and talus most of this investigation again had to be limited to the testing of placer concentrates rather than direct radioactivity traversing with portable survey meters. The reconnaissance showed that radioactive placers were limited to streams whose drainage areas were underlain at least in part by granitic rocks. Later, mineralogic studies revealed that uranothorianite, the most important uranium mineral found in the Buckland-Kiwalik district, is localized in placers on Sweepstakes Creek, Quartz Creek and Peace River on the slopes of Granite Mountain; in the Connolly Creek-Hunter Creek area; and on the south slope of Clem Mountain. The most important of these localized occurrences is believed to be one at the head of Peace River where uranothorianite and gummite are associated with copper sulfide and other metallic minerals in gravels of a restricted drainage basin near a syenite-andesite contact. Concentrates from these gravels contain as much as 0.8 percent equivalent uranium and are about 10 times more radioactive than similar concentrates from the average uranothorianite-bearing placers elsewhere in the district.

In addition to these investigations the party working near Flat collected samples for examination from Candle Creek, Julian Creek, Moose Creek, and the Cripple Creek Mountains (localities 115, 117, 118, and 120).

Field studies in 1948 were limited to a reconnaissance of the Darby Mountains (locality 126). As in the Buckland-Kiwalik district investigated in 1945-47, the chief source of radioactive minerals proved to be in the granitic rocks of the area. Although most of the radioactivity detected appears to be due largely to radioelements in such accessory minerals of granite as sphene, allanite, zircon and monazite, local concentrations of uranothorianite and uraniferous niobate minerals were found in placers of creeks draining areas of granitic rocks. The association of topaz, fluorite, and cassiterite with the uranium minerals suggests that the source might be related to possible tin-bearing lodes in or near contacts of the granitic intrusives with the country rock.

In 1949 field studies in west-central Alaska consisted of reconnaissance in the Nixon Fork and Ruby-Poorman districts (localities 119 and 122-124) and traversing along the Yukon River (locality 125). In the Nixon Fork district thorium-bearing minerals occur locally in altered rocks at a limestone-monzonite contact and may be related to gold-copper ores found along the same contact. The source of uranothorianite occurring in placers of streams crossing the contact was not found but is believed to be localized along the contact like the deposits of gold-copper ores and other thorium-bearing minerals.

In the Ruby-Poorman district the chief radioactive mineral found is uranothorianite which occurs as an accessory constituent of granite in the vicinity of Long. No significantly radioactive deposits were found in the reconnaissance traverse along the Yukon River.

No reconnaissance was made in west-central Alaska during 1950. However, scanning of old Survey collections and the receipt of uraniferous samples from a prospector pointed up the need for investigations in the Brooks Mountain-Lost River area (localities 142 and 143) on the Seward Peninsula (Wedow and others, 1951, p. 22-28, 32).

In 1951 radioactivity investigations in west-central Alaska were concentrated in the Brooks Mountain-Lost River area, although brief examinations were also made at several places in the Nome-Council area (localities 127, 128, 130-134) and at the headwaters of the Peace River (locality 136).

At Brooks Mountain prospectors had discovered a small body of metazeunerite-bearing altered granitic rock that contained between 0.1 and 0.2 percent uranium with selected specimens of ore containing over 2 percent uranium. Minor and trace amounts of metazeunerite were found at several other sites in the same general vicinity. Although no deposits of possible commercial interest were located in the Lost River area, it was found that tin-bearing dikes were slightly uraniferous.

None of the other localities examined on the Seward Peninsula in 1951 indicated sufficient amounts of radioactivity to be of further interest except at the head of the Peace River, where additional reconnaissance was made to find the source of uranothorianite, gummite and metallic sulfides known in placers. Again however, the source could not be located, but such information as could be obtained substantiates the belief that a copper-uranium lode may occur in that vicinity.

The McLeod molybdenite prospect (locality 121) was the only site tested for radioactivity in west-central Alaska during 1952. No significant radioactivity was detected at the prospect.

In the early part of the summer of 1953, a private party prospected at the head of Peace River (locality 136) for the uranium lode indicated by the previous investigations. No lode deposit was found by this prospecting, but as mechanical difficulties prevented completion of exploration such negative results as were obtained are far from conclusive.

An investigation was made in 1954 of a radioactivity anomaly near Candle (locality 137), located during an airplane traverse over the area. The source of the radioactivity was determined to be granitic float, which contains about 0.006 percent equivalent uranium, that occurs as an island in an otherwise tundra-covered area (Matzko and Bates, report in preparation).

Northern Alaska

Very few radioactivity investigations have been made in northern Alaska, primarily because of its remoteness and inaccessibility. What little information is available has been accumulated chiefly through the analysis and study of samples collected by geologists of the Navy Oil Unit of the Geological Survey in the course of the investigation of the resources of Naval Petroleum Reserve No. 4 and adjacent areas on the north flank of the Brooks Range. In addition, a spot examination was made in 1949, at the request of the Atomic Energy Commission, of a reported uranium occurrence in the vicinity of Shungnak on the Kobuk River. The results of these studies are given in table 6; the localities are shown on figure 7.

The "uranium deposit" in the vicinity of Shungnak, reported by A. G. Ferguson of Kotzebue to the Atomic Energy Commission in 1949, proved to be only slightly radioactive. The radioactivity was due to uranium occurring as an impurity in metallic minerals at an old copper prospect on Ruby Creek (locality 145).

After the recognition of phosphate in rock samples from the Anaktuvuk River area by A. E. Glover of the Territorial Department of Mines in 1948,

Table 6.--Summary of reconnaissance for radioactive deposits in northern Alaska, 1945-1954

Location (Reference no. on fig. 7)	Year of field work	Types of deposits examined or nature of investigation	Radioactivity	Remarks	References
			Ambler River quadrangle		
Ruby Creek copper prospect (145)	1949	Copper prospect reported to contain uranium; deposit consists of sulfides, oxides and carbonates filling fractures in a narrow zone cutting brecciated limestone	Maximum radioactivity of average ore is 0.007 percent eU; radioactivity is due to uranium in sphalerite, iron oxides and copper carbonates; the sphalerite is the chief radioactive mineral and contains 0.013 percent U	Samples contain as much as 10 percent copper	White, 1950
			Chandler Lake quadrangle		
Brooks Range phosphate (146)	1953	Uraniferous phosphate rock interbedded with organic shale and limestone of the Mississippian Lisburne group. Investigations made by members of the Navy Oil Unit of the Survey coincidental with other work	On Kiruktagiak and Tiglukpuk Rivers a zone of oolitic phosphatic shale and limestone is about 40 feet thick. Random samples taken at this locality in 1949 average 0.015 percent eU, 0.013 percent U, 31.95 percent P_2O_5 and 0.11 percent V_2O_5. The highest U content, 0.21 percent, is in a bed 1/2-foot thick at the base of the zone. The phosphate beds at this and other localities were sampled in detail in 1953.	The phosphatic facies of the Lisburne limestone extend over a wide area in the central part of northern Alaska; preliminary data from field work in 1953 indicates that the beds are not likely to be sufficiently thick for commercial interest. The occurrence of phosphate rock in northern Alaska was first recognized by A. E. Glover of the Territorial Department of Mines in a sample submitted for assay by an Eskimo from the Anaktuvuk River	Wedow and others, 1951, p. 113 Patton and Matzko, (manuscript in preparation)
			Mount Michelson quadrangle		
Mount Michelson area (147)	---	Examination of granite and placer samples collected in 1948 by Navy Oil personnel of the Survey	Gneissic granite contains up to 0.008 percent eU; the heavy-mineral fractions of several samples average 0.052 percent eU and 0.03 percent U with an average concentration ratio of about 30:1; the uraniferous mineral is biotite	Fluorite, molybdenite, pyrite, and hematite occur as accessories in the granite; these minerals as well as traces of galena and scheelite have been identified in concentrates from placers of streams draining areas underlain by the gneissic granite	White, 1952b, p. 1-7

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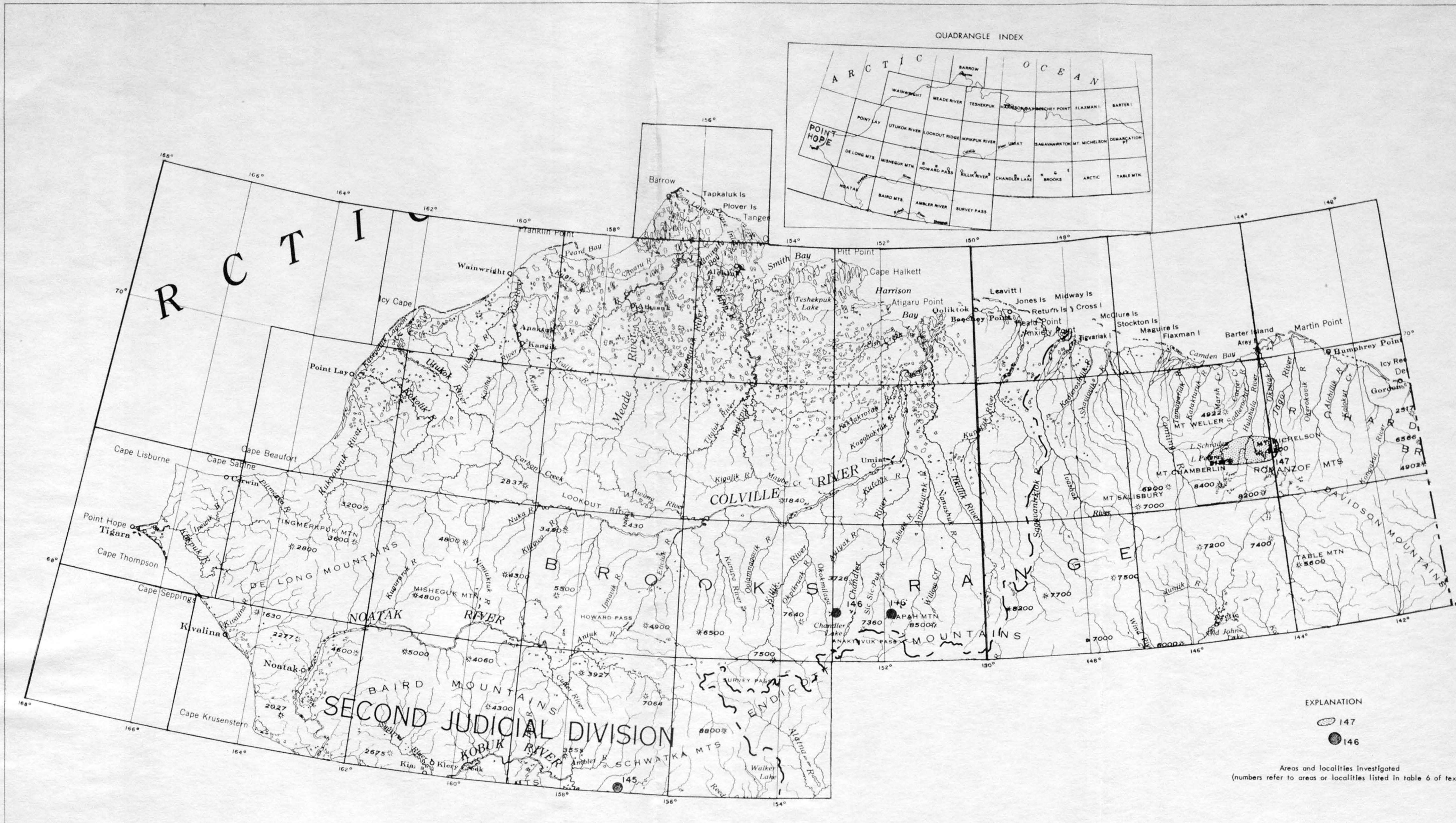

Base from Alaska Map B, Edition of 1950

50 0 200 Miles

FIGURE 7 — MAP OF NORTHERN ALASKA SHOWING AREAS AND LOCALITIES INVESTIGATED

studies by geologists of the Navy Oil Unit showed that the phosphate rock extends over a wide area along the north flank of the central part of the Brooks Range (locality 146) and north of the Brooks Range. The deposits are Mississippian in age and are comparable to the Permian phosphorites of the northwestern United States lithologically and in their content of phosphorous, vanadium, and uranium. Not enough work has been done to determine if there is a large enough tonnage of phosphate rock in northern Alaska to be of potential commercial value. The phosphate rock would have to contain at least 24 percent P_2O_5, the minimum grade minable in the northwest phosphate fields (in 1956).

Study of specimens of granitic gneiss collected in 1948 near Mount Michelson (locality 147) indicated that the radioactivity of this rock is due chiefly to uraniferous biotite associated with fluorite, hematite, and sulfide minerals.

POSSIBILITIES FOR URANIUM AND THORIUM IN ALASKA

Types of radioactive deposits

Uranium and thorium occur in many rocks of widely diverse origins, and almost all types of geologic processes involved in the emplacement, deposition, alteration, and disintegration of rocks have played a part in the formation of concentrations of these elements. Many attempts have been made to classify radioactive deposits. The general order of classification of radioactive deposits depends largely upon the local emphasis placed on the importance of one or a few types of deposits. Thus, in Canada a classification group containing pitchblende-bearing veins is of greater importance than one containing carnotite-bearing sandstones; whereas the reverse is currently true in the United States. Thus, also, discussions of radioactive deposits in Brazil and Ceylon, for example, might well treat thorium-bearing placers as having greater significance than other types of deposits containing the radioelements.

In general, most of the classifications in use today are mainly related either to the genesis or to the geologic environment of the deposits. Commonly, the most acceptable, and usable classification is somewhat arbitrary and uses either the genesis or environment, (whichever is more significant), or both. The interrelationship of genesis and environment and the problems of classification are well demonstrated by the five recent classifications of other writers shown in table 7. For the purpose of this report the author follows the classification used by Butler but with minor modifications. (See table 7.) Many of the more significant deposits containing uranium and thorium in Alaska are discussed by type of deposit and, in some cases, are compared to deposits in continental United States to enhance the discussion.

Igneous rocks, pegmatites, veins and related deposits

Igneous rocks

Most igneous rocks are weakly radioactive because of trace amounts of uranium or thorium or both, that occur chiefly as impurities in the common accessory minerals, such as allanite, apatite, monazite, sphene, xenotime, and zircon. The granitic rocks, that is, the felsic types, are generally more radioactive than the mafic types.

Table 7.--Classifications of radioactive deposits

George (1949, p. 10-18)	Bain (1950, p. 289)	Lang (1952, p. 13)	Kaiser and others (1952, p. 1)	Butler (1952, p. 9)	Wedow (this report)
1) Pegmatites a) Microlite-pyrochlore pegmatites b) Uraninite pegmatites c) Rare earth pegmatites	1) Primary deposits (Pegmatites (High temperature fissure veins (Mesothermal fissure veins	1) Granitic deposits	1) Deposits with structural control a) Veins, breccias, and pipes b) Disseminated deposits associated with fractures c) Pyrometasomatic deposits d) Pegmatites	1) Igneous rocks, pegmatites, veins and related deposits	1) Igneous rocks, pegmatites, veins and related deposits
2) Hydrothermal veins a) Chiefly pitchblende deposits of four types depending on associations with various types of metallic and gangue minerals b) Uraninite deposits (Katanga)	2) Sedimentary deposits (Bituminous and phosphatic shales (Alluvial or placer deposits (Carnotite-bearing sandstones	2) Pegmatite deposits a) Granite pegmatites b) Pegmatitic schist deposits, migmatites, etc. c) Diorite pegmatite, etc. d) Calcite and calcite-fluorite pegmatites	2) Deposits with stratigraphic control a) Phosphates b) Black shales c) Limestones and dolomites d) Lignites e) Deposits in sandstones f) Surficial or caliche deposits	2) Deposits in sandstone of carnotite, copper-uranium, and other minerals	2) Carnotite-type ores in sandstone and limestone
3) Disseminated deposits a) Granitic rocks and metamorphosed equivalents	3) Oxidized deposits (Precipitated almost in situ (Precipitated by an alkaline rock or soil (Precipitated in playa or playa-like deposits	3) Hydrothermal deposits a) Uraninite-bearing veins b) Pitchblende-bearing veins, stringer-systems, etc., with simple or complex mineral associations c) Disseminated or replacement deposits		3) Other consolidated sedimentary rocks	3) Carbonaceous rocks, phosphorites, and other consolidated sedimentary rocks
4) Sedimentary deposits a) With uranium minerals as cementing constituent (typified by carnotite deposits in sandstone) b) Placers c) Phosphate rock and black shales		4) Sedimentary deposits		4) Placers	4) Placers
5) Carbonaceous deposits a) Petroleum, oil shales, asphaltite, and other carbonaceous materials		5) Secondary deposits		5) Natural fluids	5) Natural fluids
		6) Placer deposits			

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Butler (1952, p. 12) reports that the Geological Survey has tested at least 100 bodies of igneous rocks in continental United States. He states that a few igneous rocks, particularly the late-stage magmatic differentiates, contain as much as 0.008 to 0.015 percent uranium and that numerous granitic rocks contain as much as 0.005 to 0.01 uranium. He further states that many granites and related rock types are more radioactive than previously reported in the literature.

Tests of numerous igneous rocks of Alaska have shown that most granitic rocks in the Territory contain 0.002 to 0.008 percent equivalent uranium. This radioactivity is due generally to one or more of the common accessory minerals mentioned above. Locally, however, the radioactivity is or is believed to be caused by minor amounts of uranothorianite, thorianite, uranothorite, thorite, gummite, clarkite(?), uraniferous biotite, uraniferous fluorite, and unidentified secondary uranium minerals. The work of Moxham and West (1953a) during 1946 in the Serpentine Hot Springs area of the Seward Peninsula lends support to the hypothesis (Phair, 1952) that uranium and thorium tend to concentrate locally in the late-stage magmatic differentiates of granitic rocks. At Serpentine Hot Springs fine-grained felsic dikes and pegmatitic veins cut the normal facies of their parent granitic rock. The felsic dikes and pegmatitic veins locally contain as much as 0.015 percent equivalent uranium and 0.032 percent equivalent uranium respectively and both average about 0.009 percent equivalent uranium in contrast to an average of about 0.005 percent equivalent uranium for the normal granite.

The generally low radioactivity of granitic rocks, both in Alaska and elsewhere, indicates that they cannot be seriously considered as commercial sources of uranium and thorium, although they will likely be among the most frequently reported "discoveries" by prospectors because of their relatively large size and rather widespread occurrence. However, the local concentration of uranium and associated sulfide minerals in a granitic rock, might indicate alteration of the rock by hydrothermal solutions. Further search should be made in the vicinities of such occurrences to determine whether uraniferous vein and related deposits were also formed as a result of the passage of hydrothermal solutions. In addition, the possibility should not be overlooked for the discovery of large low-grade igneous bodies, perhaps averaging only a few hundredths of a percent uranium, from which the uranium mineral could be extracted by simple physical methods to obtain a high tenor concentrate. In such a case the uranium mineral would also have to be a type from which the uranium could be extracted by simple leaching methods.

Pegmatites

Although pegmatites in the United States, Canada, and other parts of the world commonly contain uranium and thorium minerals as accessory constituents, they rarely are sufficiently rich to mine for these elements alone. The only significant world production of uranium and thorium from pegmatites, as far as is known, has been in Madagascar, where the principal minerals are euxenite and betafite (Page, 1950; Lang, 1952, p. 14-16).

Weakly radioactive pegmatites have been reported at many localities in Alaska. At two localities, uranium and thorium minerals have been identified as at least part of the source of the radioactivity in pegmatites. Reconnaissance of the Serpentine-Kougarok area (Moxham and West, 1953a) in the western part of the Seward Peninsula disclosed that secondary uranium minerals are the cause of the radioactivity of pegmatites closely associated with other late-stage variants of the granite at Serpentine Hot Springs. The pegmatites contain as much as 0.032 percent equivalent uranium and were generally the most radioactive of all the rocks tested by Moxham and West (1953a) in the area. Investigation in 1949 of radioactive pegmatites in the Willow Creek gold-mining district (Moxham and Nelson, 1952a, p. 7-10) near Palmer north of Anchorage indicated that the radioactivity (0.002-0.007 percent equivalent uranium) of these pegmatites was due primarily to trace amounts of uraninite, thorite, cyrtolite (altered zircon), and allanite.

Further studies of pegmatites in Alaska will doubtless find additional deposits of this type containing traces of various uranium- and thorium-bearing minerals. It is likely, also, that the bedrock source of certain radioactive minerals in placers--for example, the eschynite, ellsworthite, and columbite in the tin placers at Tofty in the Manley Hot Springs-Rampart district (Moxham, 1954), the euxenite-polycrase mineral identified in a placer concentrate from Goodluck Creek in the Livengood district (Wedow, White, and others, 1954, p. 2-3), and the occurrence of a uraniferous niobate mineral in the stream gravels of Clear Creek in the Darby Mountains (West, 1953)---may prove to be pegmatites.

In general, the results of pegmatite investigation by the Geological Survey in continental United States (Page, 1950; Butler, 1952, p. 13) showed that the uranium content of pegmatites is similar to that of the closely allied granitic rocks. Butler (1952, p. 13) concludes: "Because they (uraniferous pegmatites) are relatively small bodies of low average grade, they would be only insignificant sources of uranium or thorium." Radioactive pegmatites found in northern Saskatchewan, Canada, are usually fine grained, rich in biotite and dark quartz, and contain molybdenite as a minor accessory. The mineralization may be concentrated along structural zones. Pegmatite bodies containing large tonnages of slightly below ore grade (0.08 percent U_3O_8) have been found in the Charlebois Lake area in Canada, and other areas of commercial importance are expected to be found as prospecting is intensified (Mawdsley, 1955, p. 53-56).

Veins and related deposits

Vein and related deposits of uranium and thorium are perhaps the most sought after deposits of these elements in Alaska because of the potentialities for high-grade, bonanza occurrences. The emphasis on the search for such high-grade ores in Alaska, perhaps almost to the exclusion of consideration for other types of deposits, is obviously necessary because of the inter-related economic considerations of mining and transportation costs, accessibility, and so forth.

The best known and perhaps most spectacular vein and related deposits of uranium in the world include the pitchblende deposits of the Great Bear Lake area in Canada, the Katanga region in the Belgian Congo, and the regions of Saxony and Czechoslovakia in Europe. Similar deposits, but much smaller in extent, are known in the United States, mostly in the Front Range mineral belt of Colorado, also in other western states (Kaiser and others, 1952). Studies by the Geological Survey and Atomic Energy Commission in recent years have gained much information on the origin, spatial relationships, and mineral associations in vein and related deposits. This information is summarized by Butler (1952, p. 14-16) as follows:

"The (vein and related) deposits include pitchblende-bearing gold-silver and base-metal veins in the Front Range, Colo.; copper and tin-bearing structures in the Majuba Hill mine, Nev.; veins of secondary uranium minerals in the White Signal district, N. Mex., and the Marysvale district, Utah; uranium-bearing silicified zones in the Boulder batholith in the Clancy district, Mont.; pitchblende in pyrometasomatic deposits in the Franklin limestone, Warren County, N. J.; uraniferous fluorite veins in the Jamestown district, Colo., and in the Thomas Range, Utah; thorium-bearing veins of rare-earth minerals in the Clark Mountain district, Calif. and thorite-bearing veins in Custer County, Colo. -- to name but a few.

"Pitchblende is the principal uranium mineral in many of the vein deposits studied by the Geological Survey. Brightly colored secondary uranium minerals, principally phosphates, silicates, vanadates, carbonates, and sulfates, are the principal uranium minerals in others.

"Pitchblende occurs in many veins as grains, nodules, or disseminated masses forming high-grade pods or shoots separated by larger masses of essentially barren vein material. Many of the uraniferous shoots in deposits of the Front Range, Colo., are only small parts of extensive fractures containing deposits of other metallic minerals, principally those of gold, silver, lead, and zinc for which the veins were originally mined. Assemblages of these minerals, and of cobalt- and nickel-bearing minerals, smoky quartz, and dark-purple fluorite occur with much of the pitchblende and are valuable guides to new occurrences of uranium.

"Many of the deposits of secondary uranium minerals are the result of weathering of deposits of primary uranium minerals. Their form and distribution are, therefore, analogous to those of the deposits of primary minerals from which they were derived. On the other hand, because the minerals are formed by supergene processes, their distribution is controlled in part by factors that were not present at the time of deposition of the primary minerals. As a result, the secondary minerals in some deposits represent an outward displacement of uranium into rocks surrounding the places where primary uranium oxide originally was deposited. Where such dispersal has occurred the deposits are showy but of lower-grade than the primary deposits from which they were derived. Some deposits of secondary minerals, therefore, are indicative of higher-grade deposits of primary uranium minerals beneath the zone of secondary minerals, or horizontally back from the outcrop of that zone in some of the sandstone-type deposits. Deposits of secondary minerals are known, however, in several places where primary uranium minerals have not yet been found, for example, the Yellow Canary claims, Daggett County, Utah, in the White Signal district, N. Mex., and at Majuba Hills, Nev."

Various criteria have been used in the selection of areas for reconnaissance. (See p. 11.) Because there were no vein occurrences of uranium minerals known in Alaska before 1945, except for rumors and unverified reports from prospector sources, reconnaissance for high-grade vein deposits centered chiefly on (1) areas where radioactive minerals and associated metalliferous minerals occurred in placer deposits and (2) metalliferous lodes that contained mineral assemblages similar to those of uranium deposits elsewhere in the world except for the uranium minerals themselves. With the exception of a highly radioactive, black, cubic uranium-bearing mineral (uraninite?) closely associated with rutile in a metalliferous vein in the Hyder district (West and Benson, 1955) of southeastern Alaska, no ores containing primary uranium minerals have been discovered in Alaska. However, possible primary minerals such as uraninite, uranothorianite, and thorianite have been identified in concentrates from placers in the northeastern part of the Seward Peninsula (Gault and others, 1953), on the South Fork of the Koyukuk River (Nelson and others, 1954; Matzko and Bates, 1955), and in the drainage basin of the Kahiltna River (Robinson and others, 1955). Relatively large quantities of uranothorianite have been identified in beach concentrates of the Yakataga district and traces of sooty pitchblende(?) have been recognized in a concentrate from a beach deposit on the southeast shore of Lake Clark (Matzko, 1953, oral communications). Because these oxide minerals are friable and soluble, they probably have not been transported any great distance, and, hence, have a nearby bedrock source. In addition, these uranium- and thorium-oxide minerals are generally closely associated in the concentrates with metallic minerals, chiefly base-metal sulfides, and thus may have originated in radioactive vein deposits.

Although little is known of the occurrence of primary uranium oxide deposits in Alaska, the application of the various criteria used in the search for vein deposits of uranium and thorium and the investigation of leads developed from samples submitted by prospectors have led to the discovery of several occurrences of secondary uranium minerals, chiefly copper uranites. The general nature of these secondary occurrences strongly suggest that primary uranium ores may be found at depth.

At Brooks Mountain (West and White, 1952) in the York tin district of the Seward Peninsula, metazeunerite occurs with hematite in a highly oxidized lens-shaped body of pegmatitic granite at the contact between a granite stock and limestone, and as surface coating on a few of the quartz-tourmaline veins that cut the granite. Specimens of the metazeunerite-bearing pegmatitic lens contain over 2 percent uranium, but the average grade of the lens is only between 0.1 and 0.2 percent uranium. The metazeunerite-bearing tourmaline veins contain only about 0.05 percent uranium. The spatial relationships and mineral content of the main pegmatitic metazeunerite-bearing lens strongly suggest that the deposit was formed from mineralizing solutions following a zone of structural weakness in pegmatitic granite along the granite-limestone contact. If the solutions carrying the uranium were of an ascending hydrothermal nature, then it is likely that other pockets or lenses of uranium ore, possibly containing primary minerals, will be found at greater depths along an ore shoot.

At Ear Mountain, also in the York tin district and approximately 35-40 miles northeast of Brooks Mountain, occurrences of metatorbernite were discovered in 1945 by Killeen and Ordway (1955) in a hematitically altered quartz vein-mafic dike zone. The float trace of this zone extends for over 5,000 feet across the granite stock at Ear Mountain. An 8-foot width of the zone, including portions of the granite wall rock, at one point contained 0.01 percent uranium; a 1.5-foot red oxidized zone within the lode at this same point contained 0.035 percent uranium. Further surface exploration followed by drilling or other subsurface exploration is necessary at Ear Mountain to determine whether the occurrence of minor amounts of secondary uranium minerals at the surface are indicative of higher grade uranium ores at depth.

Another occurrence of metazeunerite which may have significance as a lead to primary vein ores is at the Konechney copper prospect in the Russian Mountains of the Kuskokwim region. The metazeunerite was first identified in a sample from the prospect collected by the Geological Survey in 1944 (Moxham, 1950). However, when a field examination of the prospect was made in 1952 by West (1954), all openings at the prospect were inaccessible and study of the radioactivity at the prospect was restricted to dump material. Traces of metazeunerite were recognized in only one dump sample collected in 1952, and it is possible that highly soluble secondary uranium minerals originally in the mine dump may have been leached by the percolation of acidic ground water. Thus the possibilities for the occurrence of primary ores at the Konechney prospect are still undetermined.

As mentioned above, the only known lode occurrence of a primary uranium mineral in Alaska is in the Hyder district (West and Benson, 1955), on the east side of the Coast Range batholith, near the Alaska-British Columbia boundary. This occurrence is a highly radioactive, black cubic uranium mineral closely associated with rutile in a vein on the Mountain View property. The samples in which it was found contained approximately 0.05 percent equivalent uranium; other uranium-bearing minerals in these samples include molybdenite, pyrite, and pyrrhotite. The chief values of the ores in the Hyder district are gold, silver, and lead, with tungsten, zinc, and molybdenum locally abundant. The deposits in this district appear to be at least superficially similar to lodes occurring on the east side of the Coast Range batholith in British Columbia. They contain uraninite in association with metallic sulfides and gold and silver (Lang, 1952, p. 40-46). The occurrence of the black primary(?) uranium mineral on the Mountain View property, thus, lends support to the belief of the author that the Hyder district is favorable for the occurrence of primary uranium ores, although much more intensive prospecting in the district is necessary before any final conclusions on the potentialities of the district can be reached. The mineral deposits of most of the regions and districts of Alaska are generally as yet poorly known except for reports from prospectors or the brief reconnaissance studies by personnel of Government agencies. It is the general lack of detail on the mineral content, structure, and origin of many of the reported mineral deposits that prevents speculation as to precise localities at which to prospect for vein deposits of uranium. However, some generalities on the Seward Peninsula and other regions will be presented.

Potentialities for vein and related deposits on Seward Peninsula.--The Seward Peninsula is probably one of the most likely regions of Alaska to contain vein deposits of uranium. The mineralization in the York tin district of the western part of the peninsula suggests a parallel with the uranium-tin mineralization of Cornwall, England, and in the Erzgebirge of Saxony and Czechoslovakia. The similarity of the occurrences of uranium, tin, and other metals in the York district to the occurrence of these metals at Majuba Hill, Nevada (Thurston and Trites, 1952) and of the secondary uranium deposits at Brooks and Ear Mountains to the occurrence of secondary uranium minerals overlying primary uranium oxide ores at Marysvale, Utah (Taylor and others, 1951) should also be noted. The metalliferous deposits in the York district are closely associated with stock-like intrusions of granite and genetically related mineralized dikes. In addition to uranium and tin, these deposits also contain many of the other base metals associated elsewhere with uranium deposits. It is quite conceivable, therefore, that more extensive prospecting followed by some physical exploration may reveal primary uranium oxide ores in the York district.

Elsewhere on the Seward Peninsula are many reported occurrences of metals that may be associated with uranium ores. An example is the east-west belt of various base metal prospects that lies a short distance north of Nome. Although brief studies with negative results were made in this belt in 1951 (White and others, 1952, p. 1-6), supplemental to investigations in the York tin district, it can yet be considered somewhat favorable on the basis of the widespread metallization. Examples of similar areas even more poorly known but believed to be favorable are in the vicinity of Bluff, where gold-pyrite-arsenopyrite ores in schist and limestone appear to have been hematitically altered, and in the area of the Bendeleben Mountains, where metallic deposits of all sorts have been rumored to occur but which is essentially unknown geologically.

Perhaps the most significant lead to a possible primary vein or related deposit in the northeastern part of the Seward Peninsula (Gault and others, 1953, p. 28-31) is the occurrence of uranothorianite and gummite with iron oxides and various metallic sulfides in placers at the head of the Peace River. These placers occur in the gravels of a small (1/2-square mile) drainage basin near a syenite-andesite contact. Concentrates from these placers contain as much as 0.8 percent equivalent uranium and are about 10 times more radioactive than uranothorianite-bearing concentrates obtained elsewhere in the eastern part of the Seward Peninsula. The gummite, normally a very friable, soluble mineral, is believed to be a decomposition product of the uranothorianite and occurs in intimate mineral aggregates with some of the metallic sulfides. The fact that the gummite and copper sulfides in the concentrates have not been found among the heavy-mineral accessories of the syenite suggests that their source is in a copper-uranium lode, possibly a vein, located somewhere in the 1/2-square mile area lying upstream from the topographically highest placer concentrate sample. Some private prospecting was attempted on the Peace River site during 1953 (Matzko and Bates, 1955), but the results were far from conclusive, and the potentialities of the headwaters of the Peace River remain to be determined.

In general, the whole of the Seward Peninsula can be considered as a possible uraniferous province, wherein the best potential is for vein and related deposits. In addition, however, low concentrations of uranium are scattered through many of the igneous rocks of the peninsula and could be the ultimate source of uranium in possible sandstone-type deposits in the clastic sedimentary rocks of the peninsula and contiguous regions.

Potentialities for vein and related deposits in other regions.--Other possible uraniferous vein provinces in Alaska are more poorly defined than the possible Seward Peninsula province. Next in order of importance, however, is that of the eastern border of the Coast Range batholith in southeastern Alaska, but only a small part of this potential province lies within Alaska where the eastern border of the batholith cuts across the Hyder district (loc. 1, fig. 2). Although the better potentialities for uraniferous veins in southeastern Alaska appear to lie in the Hyder district, the only significant lode deposits of thorium yet found in Alaska are on the western side of the Coast Range batholith in the vicinity of Salmon

Bay on Prince of Wales Island (Houston and others, 1954). There numerous steeply dipping, narrow, radioactive carbonate-hematite veins may represent an extremely late stage of the Coast Range intrusion or perhaps an even later stage of igneous activity. The thorium-bearing minerals in these veins are thorite and monazite and to a lesser extent hematite. The rare-earth minerals, bastnaesite and parisite, also occur in some of the Salmon Bay veins. In general the thorium-rare earth deposits at this locality appear to be too low in size and grade to warrant exploitation under present economic conditions.

The possible province of sandstone-type deposits in the Alaska Peninsula-Cook Inlet region, discussed later in this report, the occurrence of sooty pitchblende(?) in a beach placer concentrate in the Lake Clark area, and the reported occurrence of meta-autunite in the vicinity of Kodiak suggest that this region is also a general uraniferous province. Such reconnaissance of vein and lode deposits in the region as has been completed revealed little or no radioactivity at the sites of the deposits tested. On the other hand, the Alaska Peninsula-Cook Inlet region is a relatively large area, in which much of the geology is known only from broad scale reconnaissance studies. It would be unwise, therefore, to eliminate this region from serious consideration for additional prospecting and reconnaissance.

The Lower Yukon-Kuskokwim Highlands region is another potential uraniferous province as suggested by the occurrence of metazeunerite in the Russian Mountains, the minor amounts of uranium in the accessory zircon of monzonite in the vicinity of Flat, the uraninite and uranothorianite in the placers, the thorium-bearing minerals in the contact gold-copper deposits in the Nixon Fork area, and the presence of uranothorite in the Ruby-Poorman area. Whether or not significant radioactive deposits actually do occur in the belt occupied by the aforementioned scattered occurrences will, of course, only be determined by intensive prospecting. Perhaps one of the more likely sites in this belt at which to begin this prospecting is at its northeastern end in the Cosna-Nowitna region where granitic rocks are reported to intrude volcanic rocks, chiefly of rhyolitic composition. This area lies roughly mid-way between the Kuskokwim Mountains and Manley Hot Springs-Rampart sandstone-type provinces, which will be discussed later, on the same structural trend. Little is known of this region geologically except for a report by Eakin (1918).

In addition to the potential provinces suggested above, there are many other localities which have not yet been investigated and in which uranium might occur. The most significant of these is the Copper River region which was touched on briefly by Moxham (Moxham and Nelson, 1952a) in 1947. Many of the copper and other metallic deposits in this region are of difficult access but may warrant examination for radioactive minerals. Because of the ruggedness of the region as well as the difficulties of access, any ground studies there may well be preceded by scouting many of the mineral occurrences with scintillation-detection equipment mounted in light aircraft. Of specific interest in the Copper River region, for example, are argentiferous tetrahedrite-bearing quartz vein deposits on the Kotsina River in the Kuskulana district and vein(?) fillings of stibnite, pyrite, molybdenite, and cinnabar on Rex Creek in the Nizina district. (See Wedow and others, 1951, p. 107-108.)

Carnotite-type ores in sandstones and limestones

Carnotite-type deposits in sandstones have been the chief sources of uranium in the United States. The principal production has come from deposits of the well-known Colorado Plateaus but other deposits are known in Wyoming, Idaho, Nevada, Texas, Oklahoma, South Dakota, Pennsylvania and New Jersey. The carnotite-type deposits of the Colorado Plateaus occur chiefly in Triassic and Jurassic rocks, but elsewhere they are found in rocks ranging in age from Paleozoic to Tertiary (Fischer, 1950; Butler, 1952, p. 17, 18; Kaiser and others, 1952, p. 26-29). Carnotite in sandstone is also reported in Russia (Bain, 1950, p. 286).

Although carnotite is the principal mineral of these deposits, various copper-uranium and uranium-vanadium minerals, uranium oxide (pitchblende?), uraniferous asphaltite, and complex secondary uranium minerals are abundant locally. The deposits are found chiefly in lenticular beds of nonmarine sandstone, although some occur in mudstone. These deposits commonly contain about 0.1 to 0.5 percent uranium but are generally small and have an erratic distribution. Similar deposits in conglomerate and limestone are also known and are becoming more important as the search for uranium continues.

Little is known about the possibility for carnotite-type deposits in Alaska. It was thought originally that little likelihood existed for their occurrence in the Territory because of the scouring effect of the extensive glaciers that covered much of Alaska during Pleistocene time. However, as mentioned in the introduction of this report, a sample of carnotite ore, believed to have come from the vicinity of Healy on the Alaska Railroad, was analyzed in the assay office at Fairbanks in 1918. As yet unverified reports of carnotite(?) in the vicinity of Nome on the Seward Peninsula have been obtained from mine operators' records filed with the Survey around 1915. More recently, Tom Jones, a prospector at Seward, indicated that he and a partner had found a rich carnotite sandstone occurrence in Alaska but would not divulge its source nor submit samples for study (Wedow and others, 1952, p. 37-38), because he claimed it was near a rich gold-placer prospect which had not yet been staked.

In June 1951 a sample of "carnotite" was submitted by Mr. Libe of Ketchikan to the Assay Office of the Territorial Department of Mines at Ketchikan. The specimen consists of coaly material and a strongly radioactive yellow mineral, which was later identified as tyuyamunite in the Survey laboratory. The coaly material also contains considerable uranium. Although the sample was not analyzed quantitatively for uranium, a rough estimate from radiometric tests indicates a uranium content in excess of 1 percent. The sample had been found as "float" on the east shore of Union Bay, Cleveland Peninsula, southeastern Alaska near a former cannery site. Reconnaissance along the east shore of Union Bay to locate the source of the specimens was unsuccessful. In general, the geology of the Union Bay area does not appear to be favorable for the occurrence of carnotite-type ores, particularly where associated with coal. The rocks of the area are largely mafic and ultramafic rocks intrusive into highly metamorphosed sedimentary rocks. Tertiary clastic sediments crop out along the beach of Union Bay several miles north of the old cannery site and are reported to contain minor amounts of bituminous material. Field radioactivity tests of all rock types were consistently low. It is possible that the "carnotite" specimen had been "imported" from western United States or British Columbia in a shipment of coal to the old cannery (White and others, 1952, p. 14-16) or that it was transported to the site of discovery by glaciers from a source elsewhere in southeastern Alaska.

In 1951 samples of metatyuyamunite-bearing limestone containing 0.6 percent uranium oxide were submitted to the Survey by H. N. Fowler of Anchorage. Mineralogic studies of the samples show that the only uraniferous mineral they contain is metatyuyamunite which occurs both concentrated on the bedding surfaces of and disseminated through a thin-layered limestone. This occurrence of a carnotite-type mineral appears to be unique, although the specimens have some resemblance to the tyuyamunite-bearing limestone near Grants, N. Mex. (Rapaport, 1952). According to the Indian who collected Fowler's sample in 1949, the outcrop from which it was obtained is about 50 feet long and 10 feet high, and the "yellow rock" occurs in lenses as much as 3 inches thick between thin beds of limestone. In 1952 and 1953 brief but unsuccessful attempts were made to locate the site of this occurrence. Information obtained to date indicates that the Fowler prospect is on the north side of the valley of a small left-limit tributary of Nikolai Creek. This location is about 17 miles northwest of Tyonek and about 65 miles west of Anchorage. No bedrock was observed at this site as most of the area is covered by thick deposits of glacial debris and a dense growth of vegetation. However, several miles northwest of the reported site of the uraniferous limestone lies a thick sequence of Eocene clastic coal-bearing strata and bedded volcanic rocks, in which the Indians say are other occurrences of "yellow rock" similar to the samples submitted by Fowler (Wedow and others, 1952, p. 20-23; Matzko and Bates, 1955).

In 1952 two small specimens of "carnotite"-bearing sandstone were submitted to the Survey by Martin Goreson through Russell R. Norton, both of Seward. These specimens were reportedly found in 1949 by Goreson as "float" at the foot of Spoon Glacier in the valley of Likes Creek on the west side of Resurrection Peninsula about 10 miles southeast of Seward. Attempts in the fall of 1952 to locate the source of the "carnotite" or at least duplicate the float material failed because of adverse weather conditions. Chemical analysis of the least radioactive of the two specimens shows a content of 1.7 percent uranium. Mineralogic study indicates that the "carnotite" is actually metatyuyamunite and that other vanadium minerals are also present. (See Wedow and others, 1952, p. 34, 35.) In 1953 another attempt to find the source of the uraniferous sandstone was unsuccessful (Matzko and Bates, 1955). The alleged carnotite site is underlain by a sequence of lava flows now altered to greenstone (Martin, Johnson, and Grant, 1915, pl. 3). Clastic sedimentary rocks are reported to be interbedded with the greenstone in minor amounts, and nearby is a thick sequence of quartzite, slate, graywacke, and waterlaid tuff

(Martin, Johnson, and Grant, 1915, p. 217, 223-226).

Early in 1953 another carnotite occurrence on Resurrection Peninsula was reported to the Survey by Fred Richardson of Anchorage. The site of this occurrence was at the head of Likes Creek, but upon field examination proved to be iron-stained graywacke (Matzko and Bates, 1955).

In late 1953, Leo Mark Anthony, instructor, Mining Extension School, University of Alaska, submitted a radioactive sample given to him by prospectors from Kodiak (locality 78). The sample, reported to be from Pillar Mountain about 1 mile south of the town of Kodiak, contains up to 1 percent uranium. Metatyuyamunite and meta-autunite, the principal source of the radioactivity, occur in sandstone and along cleavage planes of feldspar (Matzko and Bates, report in preparation).

The general distribution of the foregoing reported occurrences of carnotite-type minerals, several of which are partially substantiated by samples, and the occurrence of sooty pitchblende(?) in a beach placer on Lake Clark suggest that a possible uraniferous province is present in southern and southwestern Alaska. Data are far too meager at present, however, to indicate that carnotite-type deposits have any commercial potential in Alaska. The locations of the reported occurrences must be sought, and, if found, the geologic settings must be studied in order to establish the criteria to be used in the search for similar deposits nearby, as well as elsewhere in the Territory. It is likely that after the physical aspects of several Alaskan "carnotite" occurrences are known, geologic guides to prospecting for such ore deposits can be established, in a fashion similar to the guides developed in the

Colorado Plateaus (McKay, 1955; Weir, 1952; Reinhardt, 1952a and 1952b). The list of guides suggested by Reinhardt (1952b, p. 7) are given below.

Guides attributed to sedimentation processes	Guides attributed to post-sedimentation processes
1. Presence of fossil stream channels	1. Proximity of ore
2. Thickening of sandstone lenses	2. Relation to mountain masses and large folds
3. Interfingering of mudstone and sandstone lenses	3. Bleaching of sandstone
4. Presence of carbonaceous material	4. Bleaching of mudstone adjacent to sandstone lenses
	5. Presence of yellow iron-oxide stains
	6. Presence of bleached mudstone pebbles in the sandstone lenses
	7. Etched and corroded sand grains

Meanwhile, in considering the statements of Kaiser and others (1952, p. 26-29) on the occurrence of uranium in sandstone and applying the guides suggested by Reinhardt for the occurrence of carnotite-type deposits on the Colorado Plateaus to the general geologic features of Alaska (Smith, 1939, pl. 1; Payne, 1953) certain areas in the Territory may ultimately prove to be uraniferous provinces of the sandstone-type. The more significant of these areas are discussed below.

Areas potentially favorable for carnotite-type ores

Alaska Peninsula-Cook Inlet area.--The belt of Jurassic-Cretaceous-Tertiary sedimentary rocks along the Alaska Peninsula and in the Cook Inlet region, parts of which have long been considered locally favorable for the occurrence of petroleum, consists chiefly of folded and faulted conglomerate, sandstone, and shale. The rocks are largely marine in origin and are probably the seaward extensions of large deltaic deposits, although some fresh-water or terrestrial deposits are also recognized. They are locally intruded by small masses of igneous rocks, chiefly of intermediate types such as quartz diorite and andesite. Some of these igneous rocks are Late Cretaceous or early Tertiary in age, others are late Tertiary or Quaternary and are closely related to the prominent volcanic activity characteristic of the Aleutian region. Many of the coarser clastic beds are lenticular and interfinger with the finer clastics. Local unconformities have been recognized. Carbonaceous material is prominent throughout the stratigraphic section, locally in sufficient quantity to form coal beds. Oil seepages and residue patches also occur in the vicinity of several of the anticlinal structures. (See Smith and Baker, 1924; Smith, W. R., 1925; Mather, 1925; Moffit, 1927; Capps, 1940.)

The possible province may be extended to include the graywacke-slate sequence of Mesozoic age that occurs in the Kenai Peninsula (Martin, Johnson, and Grant, 1915) and on the islands of the Kodiak group (Capps, 1937). The enlarged province thus includes the reported occurrences of carnotite-type minerals near Kodiak, Tyonek and Seward. The province consists primarily of the western parts of the Matanuska and Chugach Mountains geosynclines suggested by Payne (1953).

<u>Kuskokwim Mountains area</u>.--The belt of Upper Cretaceous sedimentary rocks in the Kuskokwim Mountains (Smith, P. S., 1939, pl. 1) consists of conglomerate, sandstone, and shale of both marine and fresh-water origin. Rocks of both origins contain abundant detrital

carbonaceous material. They overlie earlier Mesozoic(?) and Paleozoic rocks unconformably and are intruded by Late Cretaceous or early Tertiary stocks and dikes of a variety of granitic rock types. In some areas, particularly in the vicinity of the intrusives, the Cretaceous clastic strata are highly deformed and metamorphosed, but as a rule they are only openly folded (Mertie and Harrington, 1924). No carnotite-type minerals are known or have been reported in the area. However, a few intrusives, both in the area and around its periphery, have been studied and shown to contain minor amounts of radioactive minerals as accessories. At several localities the contact zones of the intrusives also contain radioactive minerals, and at one locality metazeunerite has been identified in a copper-bearing vein cutting a granitic stock (Moxham, 1950; White and Killeen, 1953; White and Stevens, 1953; West, 1954). This belt of Cretaceous clastics and its attendant intrusives coincides for the most part with the southwestern part of the Kuskokwim geosyncline of Payne (1953).

Manley Hot Springs-Rampart area.--Cretaceous clastic rocks are present in the Manley Hot Springs-Rampart area where they appear in the Tofty segment of the Kuskokwim geosyncline (Payne, 1953). They are intruded by granitic rocks in which radioelements occur, chiefly in such accessory minerals as zircon and monazite. In addition, placer deposits of the area locally contain columbite, ellsworthite, eschynite, and xenotime, all of which very likely had their bedrock source in deposits related to the intrusives. (See Eakin, 1913; Mertie and Waters, 1934; Moxham, 1954.)

Lower Yukon-Koyukuk area.--A sequence of about 8,000 feet of Upper Cretaceous rocks is one of the dominant features of the Koyukuk geosyncline (Payne, 1953). The sequence consists of both marine and fresh water conglomerates, sandstones, and shales. Almost all beds contain detrital plant material which locally in the fresh-water units is abundant enough to form coal beds. Most of the coarser clastic rocks are gray but locally are black where carbonaceous material is abundant. Other beds are reddish or reddish brown. The Cretaceous strata are intruded by Late Cretaceous or early Tertiary igneous rocks of felsic and intermediate types in the form of large dikes or sills and stock-like bodies. The rock types include soda granite, quartz diorite and diorite. Later Tertiary effusives are also common; these are generally basaltic in character, although dacites and andesites are reported in the southern part of the area. The Cretaceous rocks for the most part have been thrown into relatively broad open folds; some faulting is recognized. Stronger deformation with attendant metamorphic effects occur in the vicinity of the intrusives (Smith and Eakin, 1911; Smith, P. S., 1913; Harrington, 1918). No uranium minerals are known either in the clastic rocks or in the associated intrusives. However, uranium occurs around the periphery of the geosyncline in accessory minerals of granitic rocks, in the heavy sands of placers, and at one locality, in minor amount in a sulfide-bearing breccia vein (White, 1950; Gault and others, 1953, White and Stevens, 1953; West, 1954).

Cantwell area.--The Cretaceous Cantwell formation in the central part of the Alaska Range consists of massive conglomerate with interbedded sandstone, graywacke, argillite, shale, and slate. Carbonaceous material is common, particularly in the shale beds. The colors of the formation are commonly gray to drab but locally are bright red to brown. In some localities considerable thicknesses of volcanic tuffs and flows are interbedded with the clastic sediments. The lavas appear to be chiefly andesites although rhyolite and basalt also occur. The structure of the Cantwell formation is characterized for the most part by broad open folds with some faulting. Locally, however, it is highly disturbed and considerably metamorphosed. Large bodies of intrusive granitic rock are a prominent feature of the area. Some of these intrusives cut the Cantwell formation and are probably the parent magma from which smaller dikelike bodies of felsic rocks were formed (Moffit, 1915; Capps, 1940). No radioactive minerals are known in the Cantwell area, although the so-called Healy carnotite (p.30) may be from this area. The story of the Healy carnotite is best related in the Alaska Territorial Department of Mines monthly bulletin for February, 1954; it is given below.

"Since radioactive minerals became important, there has been a story circulating of a carnotite occurrence along the Alaska Railroad somewhere in the vicinity of Healy. The TDM has answered numerous inquiries, both verbal and by correspondence, on the subject. Many samples have been sent in from the area for radioactive testing and identification, and claims have been staked on the assumption that radioactives were present. Thus far, nothing significantly radioactive has been found in the district.

"The probable source of the story is contained in the old records of the College Assay Office, where it is revealed that George Gotto of Nenana, a railroad worker, sent in a very small sample of material in 1918 that was identified as carnotite by the assayer. The assayer added to his report that the sample was too small for positive tests and asked Gotto for more. Repeated requests for more of the same material and information on the location of its origin were never answered. Gotto died in 1921. It leaves the question unanswered as to whether the assayer might have been mistaken, or whether the sample might have been imported from somewhere else.

"Some of Gotto's former friends and many other people are still convinced the carnotite is there. One group was so insistent that samples brought from the area were carnotite that they refused to accept the TDM assayer's negative report and sent the samples on in to the AEC in Washington where they received the same results. Some people have been fooled by a variety of yellow alum that occurs in the district. Geological Survey men covered the railbelt with super-sensitive Geiger equipment, but found nothing of importance.

"In spite of all the above evidence to the contrary, the story may still be true. Carnotite could possibly exist in the Healy district. Perhaps an airborne scintillation survey such as those being widely performed in Canada would settle the question to everyone's satisfaction."

During the summer of 1951 a sample of metatyuyamunite-bearing limestone was submitted to the Fairbanks Radioactivity Testing Laboratory by H. N. Fowler of Anchorage. The sample contained 0.6 percent uranium oxide. As originally reported (Tolbert and Nelson, 1951, p. 6, 9) in 1951 the Fowler prospect was supposed to be located near the Yentna River north of the mouth of the Skwentna River. Information obtained during the following winter by Fowler, however, placed the location on the Deshka River, about 25 miles south-southwest of Talkeetna. The Deshka site was examined briefly in June 1952, by combined airborne and ground techniques. No uraniferous limestone was found, nor were any radioactivity anomalies discovered. However, late in the summer of 1952 additional inquiries by Fowler and his associates revealed that a native from Tyonek had found the sample in 1949 on a small tributary of Nikolai Creek (locality 17) (Wedow and others, 1952, p. 20-23). An attempt to visit this locality was made in October 1952, but was unsuccessful because of adverse weather conditions. The Nikolai Creek area was again visited briefly in June 1953. No uraniferous limestone was observed and no anomalous radioactivity noted. Because most of the area is concealed by glacial debris and dense vegetation, the few negative results in the reconnaissance of the Nikolai Creek area are not conclusive and further search is warranted.

In 1952 while attempting to obtain additional information from a prospector at Seward on the location of a reported carnotite occurrence (Wedow and others, 1952, p. 37-38) the author was shown a sample of carnotite by another prospector and told that it had been found in the valley of Likes Creek (locality 7) on Resurrection Peninsula, southeast of Seward (Wedow and others, 1952, p. 34-35). Attempts to locate this site in September and October 1952 were hampered by adverse weather. Additional reconnaissance on Resurrection Peninsula in 1953 found no radioactive materials. It is now believed that the sample may not have come from Resurrection Peninsula, but that a yellowish epidote rock and iron-stained graywacke in the valley of Likes Creek were mistaken for carnotite. However, the origin of the uraniferous sandstone sample must be explained and the fact that the uranium mineral is chiefly metatyuyamunite, a relatively rare mineral and the same as in the uraniferous limestone reported to be from the Tyonek area mentioned above suggests that the sample may be from Alaska.

Other areas.--Many other areas in Alaska may have possibilities for the occurrence of carnotite-type minerals. However, until more information is available about the reported occurrences of carnotite and related minerals and the possibilities for local uranium source rocks, it is needless to speculate further as to where such minerals could be found in the Territory.

Carbonaceous rocks, phosphorites, and other sedimentary rocks

Uranium occurs in carbonaceous rocks, phosphorites, and other sedimentary rocks in relatively minor amounts in many parts of the world (McKelvey and Nelson, 1950; Bain, 1950). Studies in continental United States have indicated that black shales, lignites, and phosphorites commonly contain 0.005 to 0.05 percent uranium, but rarely as much as 0.1 percent uranium. The radioactive black shales are dominantly marine in origin, principally of Paleozoic age, and occur for the most part in eastern and central United States. (See Kaiser and others, 1952, p. 31-35.) Elsewhere in the world uraniferous carbonaceous rocks are known in Sweden and Russia (McKelvey and Nelson, 1950, p. 37-39; and Bain, 1950, p. 290-292, 310-313, 320). Uraniferous phosphorites range from Paleozoic to Cenozoic in age. The principal deposits in the United States occur in the Permian Phosphoria formation of the northern Rocky Mountains and the Pliocene Bone Valley formation of Florida. Similar phosphorites but of Cretaceous and Eocene age have been reported in Russia, Egypt, Tunisia, Algeria, and Morocco (McKelvey and Nelson, 1950, p. 40-42).

The most significant concentrations of uranium in coal appears to be in certain Tertiary lignites in the Dakotas, Montana, and Wyoming. The geologic relationships of the lignite suggest that its uranium may have been leached from nearby volcanic rocks and deposited in the lignite by surface waters (Kaiser and others, 1952, p. 31-35).

Inasmuch as the major objective of reconnaissance for uranium in Alaska has been the search for high-grade ores, little effort has been made to investigate the possibilities for uraniferous carbonaceous rocks, phosphorites, and coals, with the consequence that data on the radioactivity of these rock types are quite meager. In 1948, however, reconnaissance traverses through Precambrian and Paleozoic sections, thousands of feet thick, along the Porcupine River (White, 1952a) and in the Eagle-Nation area along the Yukon River (Wedow, 1954) in east-central Alaska revealed that certain beds of Mississippian black shales contain as much as 0.009 percent equivalent uranium and in general are comparable to similar deposits in continental United States. Other carbonaceous shales have been tested at random elsewhere in the Territory in connection with other investigations but do not contain more than 0.004 percent equivalent uranium as estimated from field observations.

The only known uraniferous phosphorite occurs in the Kiruktagiak-Chandler Lake area on the north flank of the Brooks Range in northern Alaska. It lies in the Mississippian Lisburne limestone and is almost identical in lithologic character with the Permian phosphorites of the Pacific Northwest. The uranium content is as much as about 0.02 percent, and in general the higher uranium values follow a high P_2O_5 content. (See Wedow and others, 1951, p. 113; Patton, 1955.) A small amount of uraniferous phosphatic material also occurs as nodules in the Mississippian black shales in the Eagle-Nation area (Wedow, 1954, p. 3-5).

Such coal deposits as have been tested in Alaska have shown no radioactivity comparable to that exhibited by the lignites of the

Dakotas, Montana, and Wyoming. The deposits tested include the bituminous and anthracite coals of Matanuska valley, the lignites of the Homer area, and scattered minor occurrences in east-central Alaska. The maximum radioactivity observed was 0.003 percent equivalent uranium in a coked coal near Chicken in the Fortymile district (Wedow, White, and others, 1954, p. 20-21).

It is essentially impossible to assess the potentialities of Alaska for significant deposits of uraniferous carbonaceous shales, phosphorites, and coals on the basis of the limited data now available. The occurrence of uraniferous black shale at two localities in east-central Alaska and phosphorite in northern Alaska, all in rocks of essentially the same part of the Mississippian system, suggests that sedimentary rocks of this system where exposed in intervening and adjoining areas of the northeastern part of the Territory are likely to be favorable sites for the occurrence of uraniferous organic deposits of marine origin. Such areas would include those mentioned by Mertie (1933, p. 423) along the international boundary north of the Yukon River, by Smith (1939, p. 30-32) in the Brooks Range from Cape Lisburne on the west to the Canning River region in the east, and by Moffit (1938, p. 22-29) in the Chitina valley.

Among the geologic guides suggested by Duncan (1954, p. 21, 22) in the search for uraniferous black shales are two that may well be applied to Alaska. These are as follows:

"6. Look for black shale zones that interfinger with or are overlain by slightly radioactive volcanics or their tuffs.

"7. Examine marine deposits containing black shales that appear to have been deposited during periods of extensive volcanism. Some fine-textured siliceous sediments such as cherts, radiolarites, novaculites, and diatomites interbedded with black shale perhaps were deposited where unusual amounts of siliceous volcanic material were supplied to ocean waters. Such deposits might contain unusual amounts of the uncommon metals, including uranium. Known uraniferous shale deposits associated with cherts include the Phosphoria formation, the Chattanooga shale, and shales in the Gardner formation."

Sedimentary deposits meeting the conditions set out in the guides quoted above are widespread in Alaska. Black shales associated with volcanics, at least in part silicic (rhyolitic or felsic), are known in almost every rock system of the Territory. A few examples are:

(1) Red and green volcanic breccias and tuffs interbedded with Devonian black slate and limestone on the southwest coast of Prince of Wales Island in southeastern Alaska (Buddington and Chapin, 1929, p. 96).

(2) Also in southeastern Alaska on the northern part of Kuiu Island Permian black shale and sandy limestone are intimately associated with sandstones and conglomerate containing cobbles and pebbles of various rock types including red rhyolite, white chert and red jasper; and with rhyolitic rocks of red, white, and green hues as well as with more mafic volcanics cut by many veinlets of bright red jasper. Carbonized plant remains are abundant in the sandstones (Buddington and Chapin, 1929, p. 119, 120).

(3) Black carbonaceous shales with associated cherts and cherty limestone of the Triassic McCarthy formation in the Copper River region (Moffit, 1938, p. 58, 59).

(4) Permian(?) and Triassic black argillites with associated volcanics and cherts in the Chulitna district of the Alaska Railroad region (Ross, 1933a, p. 294-302).

(5) Interbedded carbonaceous shales and volcanic tuffs and conglomerates of Tertiary age in the Aniakchak district in the Alaska Peninsula (Knappen, 1929, p. 195).

Placer deposits

In general only abrasion-resistant and insoluble minerals accumulate in placer deposits. Thus, most uranium minerals, because of their relatively high degree of solubility and friability, are not found in placers. The exceptions to this generalization include the occurrence of highly resistant or refractory minerals, such as zircon, which normally originate as accessories in igneous rocks and contain minor amounts of uranium and thorium. On the other hand, many thorium-bearing minerals are tough and resistant and hence relatively common in placers; in fact, most of the world production of thorium has been from monazite-bearing placers. In continental United States placer monazite has been mined extensively in Idaho, some production is reported in Florida, and significant quantities are known to occur in the Carolinas.

At the outset of the Alaskan Trace Elements Program of the Geological Survey in 1944 placer concentrates in the Survey's Alaskan collections were scanned for radioactivity as a means of rapidly finding possible leads to sources of fissionable materials, chiefly uranium. The results of the scanning (Harder and Reed, 1945) showed that some placers might be of some promise, but field investigations in 1945 indicated that Alaskan placers were not likely to serve as significant reserves of uranium. The general emphasis of the program was therefore directed chiefly to the search for high-grade uranium lode deposits. However, because one of the techniques used in the search for lode sources was the testing of the heavy-mineral concentrates of alluvial deposits, much data have been accumulated on the radioactivity and mineralogy of placer deposits in Alaska. Review of the data, collected over the years, shows that there are further exceptions to the generalization that uranium minerals are unlikely to accumulate as placers.

In general, the concentrates from most Alaskan placers and other alluvial deposits are either only weakly radioactive or essentially nonradioactive, that is, they contain from less than 0.001 to 0.009 percent equivalent uranium. Some concentrates, however, particularly those from several gold-placer operations, wherein the degree of concentration is extremely high contain as much as 80 percent equivalent uranium. Such amounts of radioactivity are, of course, extremely rare, but concentrates containing from several hundredths to several tenths of a percent equivalent uranium are relatively common in Alaska. The most significant areas from which such radioactive concentrates may be obtained are at Cape and Ear Mountains, at Serpentine Hot Springs, in the Darby Mountains, and on the Buckland-Kiwalik divide on the Seward Peninsula; at Flat, Nixon Fork, and in the vicinity of Long in the Lower Yukon-Kuskokwim region; on the Kahiltna River and some of its tributaries, and in the vicinity of Yakataga in southern Alaska; and on the South Fork of the Koyukuk River and in the Chandalar, Circle, Eagle, and Fortymile districts of east-central Alaska. The uranium and thorium in most of the radioactive placer concentrates occur chiefly as impurities in allanite, apatite, monazite, sphene, xenotime, and zircon. These minerals have been derived chiefly from the igneous rocks in which they occur as accessory minerals. Locally, however, the uranium and thorium in the placers occur in such minerals as uraninite, thorianite, uranothorianite, thorite, gummite, and other minerals not normally able to withstand the abrasive processes concommitant with the formation of placers. It is likely, therefore, in most cases, that the more friable and soluble uranium minerals found in placers have not been transported any great distance. Where these minerals, particularly the oxides, occur in placers in the headwater portions of streams, especially in association with other minerals commonly occurring in uranium lode deposits elsewhere, they strongly suggest that a significant bedrock source may be found in the drainage area upstream from the placer deposit.

It was formerly thought unlikely that significant quantities of uranium could be obtained from placers. A recent study of the "radioactive black" minerals occurring in the monazite placers of Idaho indicates a possibility that significant quantities of uranium might be obtained as a byproduct in the production of niobium and tantalum (Mackin and Schmidt, 1953). The radioactive black minerals are chiefly oxides of niobium, tantalum, and titanium with small amounts of uranium, thorium, and rare-earth elements, for example, samarskite, eschynite, and columbite. The presence of other possible commercial minerals such as monazite, cassiterite, ilmenite, gold, and platinum in the same placer as uraniferous minerals also enhances the value of the concentrates and may make the byproduct production of uranium possible.

With renewed interest in the possibility for production of uranium from placers, one naturally turns to Alaska because of its past and present prominence as a producer of placer gold. What then are the potentialities for uranium and thorium placers in Alaska?

A review of the known occurrences of thorium-bearing minerals in Alaska was made in 1952 (Bates and Wedow, 1953). This review pointed out that there was the possibility that thorium-bearing minerals might be produced as a byproduct of gold or tin mining in at least six widely scattered areas of the Territory. These areas are as follows:

Locality	Major thorium-bearing minerals
1. Tobin Creek-Big Creek area, Chandalar district, east-central Alaska	Monazite
2. Manley Hot Springs district, east-central Alaska	Columbite Ellsworthite Eschynite Monazite Xenotime
3. Long area, Ruby-Poorman district west-central Alaska	Thorite
4. Nixon Fork area, west-central Alaska	Uranothorianite
5. Buckland-Kiwalik district, west-central Alaska (Seward Peninsula)	Uranothorianite Thorite
6. Cape Mountain area, west-central Alaska (Seward Peninsula)	Monazite Xenotime

To the area listed above should be added the vicinity of Cape Yakataga on the Gulf of Alaska in southern Alaska where uranothorianite was identified as the chief radioactive mineral in a beach concentrate sample containing as much as 35 percent equivalent uranium (Matzko, 1953, personal communication); and, also, the Kahiltna River placers in the Yentna district of southern Alaska where a placer drill-hole sample from Red Hill Bar contains a suite of heavy minerals as follows (Robinson and others, 1955, appendix):

	Percent		Percent
Ilmenite	25	Garnet	5
Monazite	20	Cassiterite	3
Zircon	15	Sphene	1
Magnetite	15	Rutile	tr
Platinum	5	Hornblende	tr
Scheelite	5	Gold	tr
Uranothorianite	5	Biotite	tr

Evaluation of radioactive placer deposits (Kline, 1952) has been under study by the U. S. Bureau of Mines on behalf of the U. S. Atomic Energy Commission. Whether it will be economical to mine radioactive minerals from placers will be determined by such factors as:

(1) Tenor of the deposit (that is, pounds of "black sand" or marketable minerals per cubic yard of gravel)

(2) Total yardage of gravels to ensure a relatively long-term period of mining (that is, reserves)

(3) Water supply and accessibility

(4) Climatic conditions of the region, particularly as they affect the length of season during which mining operations can be conducted.

Whether or not Alaskan radioactive placers meet the necessary conditions for commercial production has yet to be determined. The subject is currently under review by the U. S. Bureau of Mines with the cooperation of the Geological Survey. The preliminary conclusions of the author at this time is that the Kahiltna River placers are perhaps the most likely, of all the known placer occurrences of uranium- and thorium-bearing minerals in Alaska, to meet most of the requirements governing commercial exploitation. Sufficient yardages of gravel and adequate water are available during the open season to support possible dredge operations. The tenor of the gravels is enhanced by a wide variety of such commercial minerals as ilmenite, cassiterite, platinum, and gold, in addition to the radioactive minerals--monazite and uranothorianite. The sites of the placers, which stretch along the Kahiltna from near its mouth on the Yentna River at least to the mouth of Cache Creek, are accessible by shallow-draft river boats from the Susitna and Yentna Rivers. The placers are also accessible by tractor from the "Petersville Road" which originates on the west bank of the Susitna River opposite the town of Talkeetna, a station on the Alaska Railroad, and extends to the Cache Creek placer-gold camp. However, much geological and mineralogical study of Kahiltna placers will be necessary before it can be determined whether these placers are sufficiently rich and economically feasible to mine.

Natural fluids

Some natural fluids such as water and petroleum locally are radioactive. Although it is generally believed that the radioactivity of the fluids is due primarily to radon and its daughter products, uranium also accounts for a slight amount of the radioactivity. Recent work by the Geological Survey on uranium in water (Fix, 1954) and in petroleum (Erickson, Myers, and Horr, 1954) shows that local, relatively large amounts of uranium in natural fluids and their residues may be of significance in the search for new uranium deposits if not as source materials themselves. According to Fix (1954, p. 11), most waters contain less than 1 part per billion uranium; hence, "...water containing 1.0 ppb U is considered anomalous and worthy of additional investigation to determine the cause."

Since 1952 the Geological Survey has been attempting to adapt the geochemical technique of analyzing water samples as another tool in prospecting for uranium in Alaska. Local conditions have limited studies to the Circle Hot Springs area where from one locality on Portage Creek samples were obtained which contain from 15 to approximately 40 parts per billion uranium. It is believed that this anomalous condition may be due to a nearby bedrock deposit of uranium. (See Nelson and others, 1954; Matzko and Bates, 1955.)

Considerably larger numbers of samples are needed for experimental purposes, both in the Circle Hot Springs area as well as in other areas of Alaska known to contain uranium minerals, before a satisfactory routine technique can be perfected that takes into consideration such peculiarities as permafrost and low volume ground water circulation.

The studies of Erickson, Myers, and Horr (1954) on samples of crude oils, natural asphalts, and petroliferous rocks showed that uranium and a wide variety of other metals commonly associated with uranium in lode deposits are consistently present, locally in relatively large concentrations, in these types of carbonaceous materials. The uranium content of the samples they studied was as much as 0.064 parts per million in crude oil, 62,500 parts per million in the asphalt, and

67 parts per million in oil extracted from petroliferous rocks. Analysis of the ash of these samples for uranium showed as much as 0.014 percent for the crude oil ash, 10 percent or more in the ash of the asphalts, and 0.48 percent in the ash of the oil of the petroliferous rocks. Erickson, Myers, and Horr concluded that the uranium and other metals "occur as metallo-organic compounds and are concentrated in the heavy asphaltic portion of the petroleum." They state further that the uranium and other metals very likely were concentrated during the formation of the oil and that natural asphalts and petroliferous rocks might be the source material of the uranium and other metals in some of the uranium deposits. They also point out "that many uranium deposits occur on the flanks of breached anticlinal structures which have served as traps for the accumulation of petroleum during geologic time."

As far as is known only one sample of petroliferous material from Alaska has been analyzed for uranium. In 1953 a sample of crude oil from a seep in the Yakataga district of the Gulf of Alaska region was obtained from Don J. Miller of the Geological Survey. The ash of this oil contained 0.014 percent uranium; however, more samples of oil from the Yakataga district must be collected for analysis before the significance of this one relatively high uranium oil sample can be fully evaluated. Meanwhile, attempts are being made to obtain other samples of oil from the Yakataga field as well as from other Alaskan petroleum fields, particularly along the Alaska Peninsula and in the Cook Inlet region, to analyze for uranium and other heavy metals. Particular attention should be paid to the crude oils and petroliferous rocks of the Iniskin Peninsula and in the Puale Bay-Wide Bay area of the Alaska Peninsula. If the petroliferous materials of these areas prove to be significantly uraniferous, such information will lend support to the hypothesis that the Alaska Peninsula-Cook Inlet region has potentialities for the occurrence of carnotite-type deposits (p. 81).

CONCLUSIONS

Although no primary deposits of high-grade uranium and thorium ores have been found in Alaska to date, many areas in the Territory are yet favorable for the occurrence of these ores. Although there is little likelihood that any occurrences of low-grade igneous bodies and the spotty pegmatitic deposits will ever be of commercial significance, nevertheless the potentialities of the low-grade igneous bodies with their extremely large tonnages should not be overlooked should the radioactivity of some such bodies be due to uranium in one of the primary oxide minerals easily concentrated by simple physical methods.

Vein and related deposits and deposits of the carnotite-type ores perhaps have the greatest potential insofar as possible Alaskan production is concerned. The Seward Peninsula, the Lower Yukon-Kuskokwim Highlands region, and southeastern Alaska are the most likely regions in which vein and related deposits might be found. In the first two of these regions secondary uranium minerals have been found closely associated with deposits of other metals, and it is possible that primary uraniferous ores occur at depth. In southeastern Alaska a mineral tentatively identified as pitchblende occurs in a metalliferous vein in the Hyder district and thorite and monazite have been found in carbonate-hematite veins on Prince of Wales Island, and, although most of the other mineral deposits tested show no evidence of significant radioactivity, much of this highly mineralized region has not been prospected.

Several samples submitted by Alaskan prospectors have contained carnotite-type minerals. Most of these are reported to be from the Alaska Peninsula-Cook Inlet region of southern and southwestern Alaska. These samples and the geologic setting of the region indicate that the Alaska Peninsula-Cook Inlet region is perhaps the most favorable in Alaska for the occurrence of carnotite-type deposits. Other belts of clastic sedimentary rocks, chiefly in southwestern and west-central Alaska, are also believed to be favorable for the occurrence of carnotite-type ores.

Uraniferous phosphorites and black shales have been noted at several localities in Alaska and other areas are believed to be favorable for this type of low-grade deposit. In general, however, present economic considerations would very likely prohibit development of such deposits.

Inasmuch as Alaska has produced considerable gold and some tin from placers, the Territory has a small potential for the production of uranium and thorium as a byproduct of the placer mining. The placer area believed to have the greatest potential is in the Kahiltna Valley region in southern Alaska; placer concentrates from this area contain such commercial minerals as ilmenite, cassiterite, platinum, and gold in addition to uranothorianite and monazite.

Water and petroleum--the natural fluids--show some promise in Alaska as indicators of possible uraniferous localities and possible uraniferous provinces, but much study on techniques of sampling as well as on interpretation of data will be necessary before routine methods can be developed for prospecting.

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APPENDIX

Reconnaissance topographic quadrangles of the Alaskan regions

Southeastern Alaska

Atlin
Bradfield Canal
Craig
Dixon Entrance
Juneau
Ketchikan
Mt. Fairweather
Petersburg
Port Alexander
Prince Rupert
Sitka

Southeastern Alaska--Continued

Skagway
Sumdum
Taku River

Southern Alaska

Anchorage
Bering Glacier
Blying Sound
Cordova
Gulkana

Southern Alaska--Continued

Healy
Icy Bay
Kenai
McCarthy
Middleton Island
Mt. Hayes
Mt. McKinley
Mt. St. Elias
Nabesna
Seldovia
Seward
Talkeetna
Talkeetna Mts.
Tyonek
Valdez
Yakutat

Southwestern Alaska

Adak
Afognak
Amukta
Atka
Attu
Baird Inlet
Bethel
Bristol Bay
Cape Mendenhall
Chignik
Dillingham
False Pass
Ft. Randall
Gareloi I.
Goodnews
Hagemeister I.
Hooper Bay
Iliamna
Kaguyak
Karluk
Katmai Vol.
Kiska
Kodiak
Kuskokwim Bay
Lake Clark
Lime Hills
Marshall
Naknek
Nunivak I.

Southwestern Alaska--Continued

Nushagak Bay
Port Moller
Pribilof I.
Rat Islands
Russian Mission
St. Matthew
Samalga I.
Seguam
Simeonof I.
Sleetmute
Stepovak Bay
Sutwik I.
Taylor Mts.
Trinity Islands
Ugashik
Umnak
Unalaska
Unimak

East-central Alaska

Beaver
Bettles
Big Delta
Black River
Chandalar
Charley River
Christian
Circle
Coleen
Eagle
Fairbanks
Fort Yukon
Kantishna River
Livengood
Tanacross
Tanana
Wiseman

West-central Alaska

Bendeleben
Black
Candle
Holy Cross
Hughes
Iditarod
Kateel River

West-central Alaska--Continued

- Kotzebue
- Kwiguk
- McGrath
- Medfra
- Melozitna
- Nome
- Norton Bay
- Nulato
- Ophir
- Ruby
- St. Lawrence
- St. Michael
- Selawik
- Shishmaref
- Shungnak
- Solomon
- Teller
- Unalakleet

Northern Alaska

- Ambler River
- Arctic
- Baird Mts.
- Barrow
- Barter Island
- Beechey Point
- Brooks
- Chandler Lake
- De Long Mts.
- Demarcation Point
- Flaxman Island
- Harrison Bay
- Howard Pass
- Ikpikpuk River
- Killik River
- Lookout Ridge
- Meade River
- Misheguk Mtn.
- Mt. Michelson
- Noatak
- Point Hope
- Point Lay
- Sagavanirktok
- Survey Pass
- Table Mtn.
- Teshekpuk

Northern Alaska--Continued

- Umiat
- Utukok River
- Wainwright