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INTERIM REPORT ON AN APPRAISAL OF THE URANIUM POSSIBILITIES OF ALASKA*

By

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FOREWARD

This report presents in preliminary form the authors' opinions of the uranium possibilities of Alaska through March 1951, the date of the completion of the report. During the summer of 1951 some of the areas regarded as most favorable were appraised for their uranium possibilities in reconnaissance fashion by several Geological Survey field parties on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. A preliminary summary of the results of the investigations made during 1951 are presented in Geological Survey Circular 196, a copy of which is appended to this report.

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ABSTRACT

Summaries of the geology and mineral deposits, and appraisals of the uranium possibilities of the various regions of Alaska are presented in this report. A short statement on previous knowledge and investigation of radioactive materials in the Territory is also given. The review of data and appraisal for the Seward Peninsula-Kobuk, Lower Yukon-Kuskokwim, Upper Yukon, Alaska Railroad-Iliamna, and southeastern Alaska regions are essentially complete. Those of the Copper River, Gulf of Alaska, Aleutian and northern Alaska regions are not yet complete. A more detailed presentation of these latter regions will be made in the final report.

The appraisals are based on known occurrences of radioactive materials and geologic criteria that suggest the presence of uranium. Review of published and unpublished data to date shows that the Seward Peninsula-Kobuk region and southeastern Alaska followed by the Alaska Railroad, Gulf of Alaska and Lower Yukon-Kuskokwim regionsare perhaps the more promising regions of the Territory for the occurrence of high-grade uranium ores.

SUMMARY OF ALASKAN URANIUM POSSIBILITIES

The best uranium possibilities of Alaska are summarized by region as follows:

Seward Peninsula-Kobuk region. — The York tin district of the western Seward Peninsula is probably the most likely part of Alaska to contain high-grade uranium ores. The mineralization in this district roughly parallels the uranium-tin mineralization of Cornwall and the Erzgebirge. In addition to tin and uranium, the following elements known in the European districts have been recorded in the York district: antimony, arsenic, bismuth, boron, cerium, chlorine, cobalt, copper, fluorine, iron, lead, lithium, manganese, molybdenum, nickel, phosphorus, silver, thorium, and zinc. Of the mineralized areas within the York district the Lost River and Brooks Mountain areas contain the most important known uranium prospects, although metatorbernite and uraniferous hematite occur at Ear Mountain, and the mineralization at Cape and Potato Mountains also favors the presence of uranium. The prospects in the Lost River and Brooks Mountain areas contain moderate amounts of uranium in hematite, limonite, wolframite, molybdenite, pyrite, tetrahedrite, fluorite, and the hydrous copper carbonates. One of the most encouraging uranium finds is that reported by prospectors in the summer of 1950 in the central York Mountains, apparently in the vicinity of Brooks Mountain. Samples from this prospect contain from about 0.01 to 2.25 percent uranium. Zeunerite is the major uranium-bearing mineral in these samples; a lesser amount of uranium occurs as an impurity in fluorite, tourmaline, sericite, smoky quartz, siderite, hematite, arsenopyrite, and a secondary bismuth mineral. The gross petrology of these samples indicates that the prospect may be in a hydrothermally altered vein or dike.

The Nome and Koyuk districts on the Seward Peninsula are also favorable for the occurrence of uranium vein or lode deposits. In the Nome district, north of Nome and on the south side of the Kigluaik Mountains, a prominent mineralized belt contains prospects for iron, bismuth, copper, antimony, lead and silver. The Sinuk River limonite deposits at the western end of this belt are largely stockworks and veins in limestone. The association of hematite, pyrolusite, gold, galena, sphalerite, pyrite and purple fluorite with the limonite indicates that the deposits may be gossans overlying zones of hydrothermal alteration. In the Koyuk district of the eastern Seward Peninsula, uranothorianite and gummite associated with hematite, limonite, bornite, chalcopyrite, molybdenite, pyrite, bismuth, gold and silver, have been found in placer concentrates from gravels near an intrusive contact in the headwaters of the Peace River. The concentrates from these placers have an average equivalent uranium content of about 10 times that of the average uranothorianite-bearing concentrates obtained in the vicinity of other intrusive masses in the eastern Seward Peninsula.

Southeastern Alaska. -- The best uranium possibilities in southeastern Alaska are in hydrothermal deposits derived from solutions emanating from the Coast Range batholith. The Hyder district at the eastern edge of the batholith is considered to be one of the favorable areas of the region in which to prospect for uranium. To date investigations and prospecting in this district have found uranium in iron oxides and sulphides in veinlets on the Mountain View property. The uraniferous sulphides are galena, sphalerite, pyrite, chalcopyrite, and molybdenite;

the uraniferous iron oxides, hematite and limonite. These minerals occur with tetrahedrite, freibergite, fluorite, and scheelite in quartz fissure veins and mineralized shoots in a zone along an intrusive contact. Other radiation anomalies are reported elsewhere in the district. In general the mineral deposits of the Hyder district are of the intermediate temperature range and contain such typical minerals as argentiferous galena and tetrahedrite. These deposits are genetically related to the Texas Creek granodiorite and are found along and immediately adjacent to the contact of the granodiorite with the Hazelton group, which consists of metamorphosed sedimentary and volcanic rocks. The best uranium possibilities of the district probably follow the distribution of these intermediate temperature veins along the aforementioned igneous contact, although it is possible that lower-grade deposits containing sulphides and hematite, derived from the Hyder quartz monzonite, may also contain uraniferous material. Supporting data favoring the presence of uranium in the Hyder district are the occurrence of uraninite and uranium in complex association with ores of other metals southeastward from Hyder in the Hazelton area of British Columbia, and the occurrence of rich silver ores with a barite-jasper gangue in the Kitsault River district of British Columbia, also southeast of Hyder.

Although known mineral deposits are sparse within the core of the Coast Range batholith of southeastern Alaska, a silver deposit on Whiting River may warrant investigation for radioactive material. This deposit is a quartz fissure vein in a marble belt surrounded by quartz diorite. The metallic minerals in the vein are arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite, with arsenopyrite predominent. High assays for both gold and silver have been obtained on selected samples and moderate assays are common.

Several mineral deposits in a belt of metamorphic rocks and relatively small intrusive masses paralleling the main Coast Range batholith on the west are favorable for the presence of uranium on the basis of their contained mineral assemblages. These are as follows:

Location	Type of deposit
Annette Island near Crab (Kwain) Bay	Bismuth- and silver-bearing galena and tetrahedrite in veins and replacement bodies mostly in altered limestone.
Gravina Island in the vicinity of Dall Head	Hematitically altered copper ores containing jasper, in veins and replacement bodies.
Cleveland Peninsula, Helm Bay	Bismuth-bearing auriferous quartz veins.
Glacier and adjacent basins, east of Wrangell	Complex silver-lead-zinc deposits containing native silver and fluorite.
Thomas Bay	Sulphide-rich auriferous quartz stringers and mineralized zones with arsenopyrite and pyrite predominent.
Point Astley, Holkham Bay	Mineralized zones in schist containing bornite, chalcopyrite, galena, sphalerite, and native silver.

In addition, carnotite, associated with slate and coal, has been reported in southeastern Alaska, presumably from the north side of the Cleveland Peninsula.

A belt of mineral deposits genetically related to stocks and small batholiths satellitic to the main Coast Range batholith occurs in the western islands of southeastern Alaska. The larger part of these deposits are gold veins and contact copper deposits. Of all the deposits in this western belt, those whose mineral composition suggests the presence of uranium are as follows:

Location	Type of deposit
Prince of Wales Island, Niblack Anchorage	Hematitically altered copper ores in veins; may contain some jasper.
Prince of Wales Island, Dolomi area	Gold-bearing breccia veins containing tetrahedrite and pyrite as the predominent sulphides.
Prince of Wales Island, Kitkun Bay	Manganiferous(?) gold-bearing veins associated with mineralized zones containing hematite, magnetite, and chalcopyrite.
Prince of Wales Island, Dora Bay and South Arm of Cholmondeley Sound	Silver-lead-zinc and silver-lead veins with argentiferous galena predominent.
Prince of Wales Island, Twelvemile Arm	Vein gold deposits containing one or more of the common sulphides; a soft, black, sulphantimonide or bismuth mineral is reported at one prospect.
Prince of Wales Island, Kasaan Peninsula	Contact magnetite-chalcopyrite deposits containing hematite and molybdenite with fluorite reported in one prospect; a sample containing allanite and metatorbernite(?) may have come from one of these deposits. Quartz fissure veins (on Kasaan Mountain) containing silver and lead with tetrahedrite a prominent ore mineral.
Kosciusko Island, near Shakan	Molybdenite lode containing various other sulphides and iron oxides.
Dall Island	Silver-bearing tetrahedrite-chalcopyrite veins at Mount Vesta and argentiferous galena deposits near Sea Otter Harbor.

Coronation Island, Egg Harbor	Argentiferous galena-tetrahedrite ores.
Chichagof Island, Pinta Bay and Lisianski Inlet	Auriferous veins containing arsenopyrite as the predominent sulphide with subordinate pyrite, chalcopyrite, and sphalerite; with tetrahedrite and scheelite at the Lisianski Inlet lodes.
Glacier Bay district, Willoughby Island	Chalcopyrite, pyrite and tetrahedrite, all argentiferous, in pods along mineralized dikes.

Samples of uraniferous iron-stained (jaspery) rock, some of which are cut by veinlets of hematite(?) and pyrite contain from about 0.01 to 0.2 percent equivalent uranium, are reported from Prince of Wales Island, possibly from the vicinity of the hematitic copper ores of Niblack Anchorage.

Alaska Railroad-Iliamna region. -- Several of the districts of the Alaska Railroad-Iliamna region warrant investigation for uraniferous materials because mineral assemblages in certain of their lode deposits suggest the presence of uranium. Pertinent data on these lode deposits follow:

Location	Description of lodes
Kantishna district, Kantishna Hills	High-grade silver-lead ores; the deposits are metalliferous quartz veins emplaced along shear zones in schist; argentiferous galena and tetrahedrite, pyrargyrite, and gold-bearing sphalerite are the abundant ore minerals; also pyrite, marcasite and scheelite; heavy iron-staining is common.
Kantishna district, Mt. Eielson	Replacement bodies, derived from a granodiorite intrusive, occur in calcareous beds; sphalerite, galena, chalcopyrite and the copper carbonates are the chief ore minerals; the silver content of the ores is reportedly high.

Kantishna district, Slippery and Iron Creek area	Mineralized zones in sheared and brecciated sedimentary rocks; chalcopyrite is the main sulphide with secondary copper carbonates; sphalerite is also present in most prospects and minor amounts of native copper, cuprite, and sooty manganese(?) oxide are reported; hematite occurs at two prospects, and native mercury and cinnabar at one prospect.
Nenana district, Eva Creek area	Gold quartz lodes (chiefly Liberty Bell mine) wherein stringers of quartz and sulphides are emplaced along foliation in schist near granitic intrusives; ore minerals are auriferous arsenopyrite with lesser amounts of pyrite, chalcopyrite, native bismuth and bismuthinite.
Chulitna district, West Fork	A mineralized zone about 15 miles long and 2 miles wide; deposits are impregnated zones and veins; metallic minerals are arsenopyrite (predominent), chalcopyrite, galena and sphalerite.
Chulitna district, Portage Creek	Silver-rich ores at the Mint Mine in silicified breccia zones containing pyrargyrite, miargyrite, arsenopyrite, chalcopyrite, galena and tetrahedrite.
Talkeetna district, Iron Creek area	Copper lodes in veins along shear zones in lava flows; the primary metallic minerals are pyrite, chalcopyrite, arsenopyrite, specular hematite and a little gold; bornite and copper carbonates occur in a shallow oxidized zone.

In addition, the occurrence of uraninite(?) with cassiterite in placers of the upper Peters Creek drainage basin, Yentna district, also warrants investigation.

Lower Yukon-Kuskokwim region. — The only occurrence of uranium in the Lower-Yukon-Kuskokwim region that may be of some significance is in the Russian Mountains, a few miles east of Aniak in the Akiak district. Zeunerite occurs with chalcopyrite, arsenopyrite, and pyrite in quartz veins on Mission Creek. A similar deposit, but with no zeunerite reported, occurs on Cobalt Creek several miles to the north. Chemical analyses of other samples from this area show the presence of silver, gold and tin.

Upper Yukon region. — Previous reconnaissance for radioactive materials has already eliminated a number of leads in the Upper Yukon region. The only reasonably accessible mineral occurrence suggestive of uranium yet uninvestigated in the region is in the quartz-pyrite-fluorite veins attendant to a tourmaline granite intrusive on Hope Creek in the northeastern part of the Fairbanks district. In the northern part of the region radioactive minerals occur in concentrates from placers in the Koyukuk and Chandalar basins. A number of these concentrates also contain considerable hematite and traces of a variety of sulphides, both suggestive of a highly mineralized area. This part of the region, however, is probably both too remote and too little known to warrant investigation for radioactive ores at this time.

Copper River region. — The appraisal of the Copper River region is not yet complete. However, a preliminary check suggests at least four mineral deposits as worthy of radiometric examination. These are:

Location	Description
Kuskulana district, Kotsina River, Silver Star claims	Quartz veins in a shear zone, containing argentiferous tetrahedrite, galena, azurite, malachite, chalcopyrite, bismuthinite(?) and barite.

Kuskulana district, Roaring Creek, Skyscraper group	Stringer lodes containing chalcocite, covellite and specular hematite, the latter most abundant and considered to be of hydrothermal origin.
Nizina district, Rex Creek	Vein(?) fillings containing stibnite, pyrite, molybdenite and cinnabar.
Chisana district, Orange Hill mine	A gold lode containing minor amounts of molybdenite, native bismuth, chalcopyrite, pyrite and pyrrhotite.

Gulf of Alaska region. — The appraisal of the mineral deposits of the Gulf of Alaska region to determine areas favorable for the occurrence of uranium is not yet complete. A cursory survey of available data, however, suggests the following mineral lodes and occurrences as warranting attention.

Location	Description
Nuka district	Quartz fissure veins at Nuka Bay containing native silver, gold and copper, and arsenopyrite (predominent), pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, covellite and chalcocite.
Hope district, Bear Creek	Silver prospect in a mineralized sheeted-zone with argentiferous galena, pyrite, and arsenopyrite; native silver occurs in placers below lode.
Wells district	Reported occurrence of fluorite in auriferous quartz veins on Passage Canal; the veins also contain several of the more common metallic sulphides.
Cordova district	Hematite occurrences suggesting hydrothermal alteration on Hinchinbrook Island.

Aleutian region. — Review of data for the Aleutian region has not been completed. So far as is known the only metalliferous deposits are auriferous quartz veins, some of which contain sulphides, on several islands of the Aleutian Chain and on the Alaska Peninsula.

Northern Alaska. -- At present the only known occurrences of uranium in northern Alaska are the uraniferous phosphate rocks of Mississippian(?) age in the Brooks Range, and uranium-bearing biotite (associated with fluorite, hematite, molybdenite, pyrite, galena and scheelite) disseminated in pre-Cambrian(?) granite in the vicinity of Mount Michelson at the eastern end of the Brooks Range. No appraisal of the outlook for uranium in northern Alaska will be submitted until such data as are available are abstracted and reviewed. It is believed, however, that the occurrence of high-grade uranium deposits in northern Alaska is unlikely, unless it be associated with mineralization related to the intrusion of the pre-Cambrian(?) granite mentioned above.

INTRODUCTION

Alaska occupies a land area of about one-fifth the size of continental United States (inset, fig. 1) or about the equivalent of the states of Arizona, New Mexico, Colorado, Utah, Idaho and one-half of Montana. The geology of Alaska is even less known than that of the states mentioned above. More than half of the Territory has not been mapped geologically, and most of the remainder is known only from very general exploratory surveys with less than 5 percent mapped geologically at a scale comparable to most of the mapping in the states.

The purpose of this paper is to report on the data obtained to date on a current appraisal of the possibilities of finding high-grade deposits of uranium in Alaska. This appraisal is based on known occurrences of radioactive materials and geologic criteria that suggest the presence of uranium. These criteria include: 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, molybdenite, pyrite, sphalerite and tetrahedrite, and their oxidation products. The selection of criteria is based on a review of literature pertaining to known domestic and foreign uranium deposits. Of particular aid were reports by Lang (1949a, 1949b, 1950), George (1949), Bastin and Hill (1917), and Hess (1934), although much information was also gleaned from the numerous unpublished reports of the Atomic Energy Commission and the Geological Survey. To determine the Alaskan occurrences of the criteria mentioned above, a survey of all available data, both published and unpublished, on the mineral deposits of the Territory is now underway and will be completed about March 1951. Although a number of Alaskan mineral deposits have been studied in fair detail, many of the deposits are known only from hasty reconnaissance by Survey geologists or from reports by prospectors. 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 actual absence in the deposit.

To facilitate the review of the various Alaskan mineral deposits and the discussion of the uranium possibilities of the Territory, Alaska has been arbitrarily divided into nine major regions as shown on figure 1. These regions are merely a regrouping of the districts used by Smith (1939, pl. 3). A preliminary survey has shown that the Seward Peninsula-Kobuk region and southeastern Alaska are probably the most promising regions of the Territory for the occurrence of high-grade uranium ores, so that these two regions were the first to be appraised more completely and are therefore discussed first. The summary discussions of the other regions which follow, will be expanded in a final report.

PREVIOUS INVESTIGATIONS

In the years prior to World War II little was known about the occurrence of radioactive materials in Alaska. Carnotite was identified in a sample submitted to the assay office at Fairbanks in 1918. This sample was found by a railroad construction worker supposedly in the vicinity of Healy on the Alaska Railroad; but the exact locality is unknown.

Monazite was identified in concentrates from gravels of Big Creek in the Chandalar district on the south side of the Brooks Range (Mertie, 1925, p. 260), and eschynite, xenotime and monazite were identified in some gravels of the Hot Springs district near the junction of the Yukon and Tanana Rivers (Mertie and Waters, 1934, pp. 229, 239-240).

In 1932 Wacker (Mining Truth, 1932) reported the discovery of a uranium deposit on Martin Arm of Boca de Quadra Inlet in southeastern Alaska.

Henry Joesting of the Territorial Department of Mines in 1940 or 1941 found 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 and contained 1 x 10^{-9} grams radium/gram of sample (Joesting, 1946).

In 1944 the Union Mines and Development Corporation prepared a report on the uranium possibilities of Alaska for the Manhattan Engineer

Project (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 the concentrates were radioactive, especially one, which was obtained on Sweepstakes Creek in eastern Seward Peninsula.

The Alaskan trace elements program of the Geological Survey was initiated in 1944 with the radiometric scanning of over 600 placer concentrates in the Survey's Alaskan collections. As a result of this study several areas of placer gravels appeared to be promising sources of radioactive material (Harder and Reed, 1945), the field investigations of some of these areas were made in 1945 (Killeen and Ordway, 1946; Gault, Black and Lyons, 1946; Gault, 1949; Robinson, Wedow and Lyons, 1946). These stream pladers however were found to contain only small amounts of radioactive materials, although a lode deposit containing one of the copper uranites and uraniferous hematite was located on Ear Mountain in the York district of the Seward Peninsula during the investigations (Killeen and Ordway, 1946).

The main results of the 1945 field work indicated that placers in general could not be considered as important reserves of radioactive material, and the general emphasis of Alaskan trace elements reconnaissance was directed toward the search for bedrock sources in areas where: (1) Lode mines or prospects contained minerals known to occur elsewhere in radioactive deposits; (2) Igneous rocks of certain ages and petrographic types might contain radioactive accessory minerals; (3) Black shales and other sedimentary rocks possibly radioactive occurred; and (4) Concentrates from stream gravels and placer operations were 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 immediately contiguous to the highway system of the Territory where no previous information on radioactivity was available. Other operations were governed directly by the criteria setout immediately above. Thus, in the years succeeding the initial field work of the Geological Survey in 1945, a wide variety of materials in Alaska was examined for radioactivity. The primary objective, however, has been the search for lode and bedrock occurrences of radioactive materials.

Various field techniques have been used in the search. In small restricted drainage basins where much of the bedrock is covered with insulating materials such as moss, muck, tundra, etc., the radiometric testing of concentrates from stream gravels was deemed the most satisfactory method. In the future this method of investigating covered areas will be augmented by the testing of alluvial fines, vegetation and stream waters. Where mines, prospects, road cuts, and natural outcrops afford access to lode deposits and bedrock, direct radiometric tests are made in the field and samples of interest taken for laboratory examination. The improvement of radiometric equipment in the last several years with the development of more rugged counters and sensitive high-count gamma tubes has enabled field personnel to switch from laborious hand-counting methods to methods of continous traversing.

THE ALASKAN REGIONS AND THEIR URANIUM POSSIBILITIES

Seward Peninsula-Kobuk region

Uranium has been found in the York, Koyuk, and Fairhaven districts of the Seward Peninsula (fig. 3).

In the York district uranium is present in samples from lodes related to tin mineralization.

In the Koyuk district uranothorianite and gummite associated with copper sulphides, bismuth, silver, hematite, and limonite occur in placers at the head of the Peace River. Elsewhere in the Koyuk district and in the Fairhaven district uranothorianite is found in placers of streams eroding areas of granitic rocks.

The geology, mineral deposits, and uranium possibilities of the Seward Peninsula-Kobuk region are described by district below. The data on the geology and mineral deposits of the York district is summarized mainly from the works of Collier (1904), Hess (1906), Killeen and Ordway (1946), Knopf (1908), and Steidtmann and Cathcart (1922). The sources for the remainder of the region are largely in reports by Brooks (1907), Cathcart (1920), Collier, Smith, Hess and Brooks (1908), Eakin (1915), Gault (1949), Gault, Black and Lyons (1946), Harrington (1919), Killeen and White (1950), Mertie (1917), Moffit (1905; 1913), Moxham and West (1949), Smith (1908; 1909; 1910; 1911; 1912; 1913), Smith and Eakin (1911), West (in preparation), West and Matzko (1950; in preparation), and White (1949; 1950c). The Buckland, Selawik and Shaktolik districts have not been treated herein because they are largely unexplored, and little is known about their geology and mineral deposits.

York district

The oldest rocks of the York district (fig. 3) are Lower Paleozoic slates which have been intruded by sills, stocks, and dike-like masses of basalt and gabbro, now altered to greenstone. The Ordovician and Silurian Port Clarence limestone and the Mississippian(?) Cape Mountain limestone overlie the slates and greenstones.

At least two fault zones have been imposed on the older rocks of the district. One of these zones strikes N 20° W, the other N 70° E. Mesozoic(?) quartz-porphyry dikes and granite stocks were intruded into these fault zones, principally the one with the easterly trend. The quartz-porphyry dikes range in composition from dacite to rhyolite. The feldspar of the granite is orthoclase. The intrusion of the granite did not appreciably disturb the existing structure of the country rocks.

The dikes were intruded both before and after the emplacement of the granite and are not considered to be offshoots of the same magma from which the granite was derived, as is indicated by the fact that the mica in the dikes is muscovite, whereas that in the granite is biotite. The dikes and granite stocks are exposed at five places in the district; the Lost River area, Brooks Mountain, Cape Mountain, Ear Mountain and Black Mountain. In addition, the presence of a granite stock is inferred at Potato Mountain from the exposures of quartz-porphyry dikes.

After the invasion of the granites and some of the dikes associated with the granites, hot solutions containing tin, boron, fluorine and other elements invaded the border of the granites and adjoining limestones and dikes. They gave rise to highly mineralized replacement and vein deposits in granites, dikes and limestones. The granite stocks are believed to have come from a common deep-seated source, because of their similarity in mineral and chemical composition and because all the intrusives, with the possible exception of those at Black Mountain, were followed by tin-bearing solutions.

The youngest rock in the area, probably of Quaternary age, is amygdaloidal olivine basalt occurring in the form of dikes at Cape Mountain and as flows at Black Mountain and east of California River.

The mineralization of the York district is principally that produced by the intrusion of tin-bearing solutions containing boron, fluorine, and other elements. The mineralization occurs as vein and replacement deposits along and in the vicinity of the contact between granite and limestone and shale and in the quartz porphyry dikes that are associated with these rocks.

The vein deposits generally contain considerable quartz and occupy fractures in the granite, the dikes and the sedimentary rocks. The replacement deposits include contact-metamorphic deposits in limestone, and deposits formed by replacement in brecciated border phases of granite and quartz-porphyry dikes.

Cassiterite occurs as an irregular replacement of marble in the limestone contact metamorphic deposits and is associated therein with tourmaline, axinite, fluorite, pageite, hulsite, hornblende, pyroxene, vesuvianite, humite, serpentine, danburite, zinnwaldite, phlogopite, green mica, chondrodite, pyrrhotite, arsenopyrite, and pyrite.

Deposits in brecciated zones are found in the granite. In fact, occurrences of the tin mineralization in the granite are restricted almost entirely to fracture zones, where the cassiterite and associated minerals replace the feldspar in the granites. The suite of replacement minerals in addition to cassiterite includes quartz, sericite, tourmaline, topaz, fluorite, arsenopyrite and pyrite.

Replacements in the quartz-porphyry dikes are typified by some of the dikes on Cassiterite Creek in the Lost River area that are locally almost entirely replaced by sericite, fluorite and zinnwaldite, with scattered amounts of cassiterite, wolframite, tourmaline, topaz, humite, arsenopyrite and pyrite. Locally, quartz is a replacing mineral and is associated with cassiterite, sericite and wolframite.

The solutions that deposited the cassiterite and the other replacement minerals in the York district were hot solutions of deep-seated origin. This is inferred from the close association, both as to time and place, of such minerals as tourmaline, topaz, danburite, axinite and scapolite, with igneous activity. These minerals are not known to have been formed under surface conditions. The source of some of the elements that the solutions carried, such as fluorine, lithium, chlorine, sulphur, tin and tungsten, is probably igneous. The silicon, aluminum, iron, magnesium, sodium and potassium, however, may have been derived, partly or wholly from the limestones and dikes which the solutions traversed.

Some of the minerals were deposited from the hot solutions in cavities, fissures and other openings. Others replaced previously existing minerals. Some of them were probably formed by the interaction of the solutions with rock minerals. Quartz, fluorite, tourmaline, topaz, danburite, muscovite, zinnwaldite, wolframite, and plagioclase occur as minerals deposited directly from solutions in fissures. This same group of minerals and in addition, hornblende, magnetite, chondrodite, serpentine, phlogopite, arsenopyrite, pyrite and stannite are known to replace previously existing rock materials. It is probable that considerable amounts of the fluorite found in the tin-bearing limestone were formed by the interaction of the solutions with the original constituents of the limestone.

Lost River area. -- The principal known tin deposits in the Lost River area are restricted to the valley of Cassiterite Creek, and the headwaters of Tin Creek (fig. 3). On Cassiterite Creek quartz-porphyry dikes and limestone were mineralized, whereas on Tin Creek the mineralized rock appears to be restricted to limestone near a granite contact. The major mineralized quartz-porphyry dikes on Cassiterite Creek are known as the Cassiterite dike, the Greenstone lode, the Ida Belle dike and the Dolcoath dike. The chief change in the dikes effected by the hydrothermal solutions was the alteration of the feldspar phenocrysts and the groundmass to fine-grained sericite. In the most altered rock the feldspars and the groundmass have been replaced by yellowish-green fluorite. Cassiterite and wolframite have been introduced in minor quantities as replacement minerals, though they are not everywhere closely associated. These two minerals are also found in quartz fissure veins. Quartz rather than fluorite is the common associate of cassiterite and wolframite. Topaz is common in the silicified portions of the dikes, but tourmaline is rare. Locally the dike material is almost completely replaced by irregular grains of gray humite.

The alteration and mineralization of the limestone in the Lost River area took place adjacent to the quartz-porphyry dikes and away from the dikes where intense alteration parallels fissure and replacement veins. The limestone appears to have undergone two stages of alteration. In the first stage the changes involved consisted of the loss of carbon dioxide and the introduction of silica, alumina, iron, magnesium, sodium, potassium, lithium, fluorine, sulphur, arsenic and tin with the formation mostly of a variety of metamorphic minerals, but including pyrite, arsenopyrite and cassiterite. In the second stage of alteration the materials formed in the earlier stage were cut by fissure veins containing elements that are distinctive of deep-seated origin, i.e., fluorine, boron, lithium, tin, and tungsten. Traces of nickel and cobalt oxides are reported in an analysis of the tin ore on Cassiterite Creek made soon after the discovery of the ores (Collier, 1904, p. 22).

The granite on Tin Creek intrudes limestone, and both are cut by a quartz-porphyry dike. Preceeding the injection of the dike the limestone was altered to a white coarse-grained marble locally replaced by a mass of greenish minerals which are finely banded parallel to fissures, or concentrically forming circular and elliptical shaped bodies. The dark bands are composed chiefly of hornblende, the light bands chiefly of fluorite.

The various minerals that occur in the different rock types in the Lost River area are indicated in table 1.

The mineral occurrences at various mines and prospects in the Lost River area, are listed in table 1. Three adits have been driven into the Cassiterite dike on the east side of Cassiterite Creek. The Randt Extension tunnel is driven into the Cassiterite dike on the west side of

Cassiterite Creek. The Greenstone lode is a development on the east side of Cassiterite Creek just south of the Cassiterite dike. It occurs in an altered limestone that has been intruded by a narrow quartz-porphyry dike. The Ida Belle tunnel is in the dike of that name about 180 feet north of the Randt Extension tunnel. There is a small tunnel and shaft in the Dolcoath quartz-porphyry dike about one mile north of the adits on the Cassiterite dike.

At the Bessie and Maple claims one-half mile west of the mouth of Tin Creek, galena-bearing veins are found in a brecciated quartz-porphyry dike cutting limestone. A short distance from this occurrence is a kaolinized dike cut by stibnite-bearing veins.

The Yankee Girl prospect is located a short distance from the granite exposed on Tin Creek, in mineralized limestone. The mineralization is said to be in a yellow, soft, granular gossan.

The Wolframite-Topaz lode is located on the ridge west of Lost River opposite the mouth of Tin Creek. This mineralization is in a stringer lode in a fault zone cutting limestone.

The Alaska Chief claim is located about 4½ miles from Bering Sea on the north side of Rapid River. The mineralization is in limestone that has been faulted, brecciated, and intruded by a quartz-porphyry dike. At this locality there is a heavy porous body of red iron oxide containing galena.

The Idaho copper claim is several hundred yards below the mouth of Tin Creek on Lost River. Stringers of ore have been deposited in an irregularly shattered zone in the limestone.

No field investigations for radioactivity have been made in the Lost River area. However, recent radiometric scanning of rock and ore specimens revealed a few samples containing some radioactive material. Data on these samples are presented in summary form below.

1) Three samples from the Greenstone lode contain an average of 0.023 percent eU and 0.011 percent U; the uraniferous minerals are specular hematite, molybdenite, wolframite and pyrite.

2) A rhyolitic dike rock from the Cassiterite dike between Cassiterite Creek and Lost River contains 0.008 percent eU and 0.006 percent U; the uranium-bearing minerals are fluorite, galena, pyrite and magnetite coating smoky quartz.

3) A specimen of radioactive wolframite from the Randt Extension tunnel contains 0.008 percent eU and 0.004 percent U.

4) Three samples from an iron replacement zone exposed in a prospect pit on the spur west of Lost River opposite the mouth of Tin Creek contain an average of 0.061 percent eU and 0.049 percent U; the uraniferous minerals are limonite, hematite and minetite.

5) A sample of a rhyolite dike with uranium-bearing fluorite, pyrite and hematite from Curve Creek, a west tributary of Lost River below Tin Creek, contains 0.006 percent eU and 0.002 percent U.

<u>Brooks Mountain</u>. -- The rocks of Brooks Mountain (fig. 3) include an unknown thickness of black slate overlain by at least 1,000 feet of limestone both of which have been intruded by granite. After the emplacement of the granite, hydrothermal solutions were introduced along the limestone-granite contact and in fissures in the limestone. The solutions carried fluorine, boron, chlorine, lead, copper, zinc, sulphur, and tin into the limestone, but had little effect on the granite.

The various occurrences of the following minerals in the vicinity of Brooks Mountain are listed in table 2. Descriptions of the deposits follow:

1) The Luther prospect is situated in limestone about 20 feet from a granite contact, about due south of the main peak of Brooks Mountain. The limestone has been converted into a yellowish-green, hard mass, consisting chiefly of vesuvianite. Twenty feet beyond this point the limestone is a white granular marble, traversed by green silicate minerals. Small cubes of galena occur in vug-like openings in the green minerals.

2) The Read prospect is located about one-half mile south of the Luther prospect in essentially the same type of rock, with the same relation to the contact as the Luther prospect. The prospect is an ore vein approximately $3\frac{1}{2}$ feet thick, in limestone. The ore is primarily galena, mixed with black sphalerite. On the border of the ore is a belt of finely granular fluorite, several inches thick. Close by the Read prospect are several other prospects along the contact where lead, zinc, and tin minerals have been found.

Table 2. Distribution of minerals in the vicinity of Brooks Mountains, York district, Seward Peninsula

	1	2	3	4	5	6	7
Arsenopyrite . . .	-	-	-	-	-	M	-
Axinite	-	-	-	-	-	M	-
Bismuth	-	-	-	-	-	-	m
Cerrusite	-	-	-	-	-	-	m
Chondrodite . . .	m	-	-	m	-	-	-
Fluorite	M	-	m	-	-	M	-
Galena	m	m	M	M	-	m	M
Garnet	M	-	-	-	M	-	-
Hedenbergite . . .	M	-	-	-	-	-	-
Hulsite.	m	-	-	-	m	-	-
Limonite	-	-	-	-	-	-	M
Ludwigite.	m	-	-	m?	-	-	-
Magnetite.	-	-	-	m	M	-	-
Paigeite	m	-	-	m	-	-	-
Phlogopite	M	-	m	-	-	-	-
Pyroxene	M	-	-	-	-	M	-
Pyrrhotite	m	-	m	-	-	-	-
Scapolite.	m	-	-	-	-	-	-
Sphalerite	m	-	M	-	-	M	-
Spinel	-	-	-	m	-	-	-
Tourmaline	m	M	m	-	-	M	M
Vesuvianite . . .	Mb	M	m	-	M	-	-

M - major constituent
m - minor constituent
b - boron-bearing

1 - Limestone replacement near granite contact
2 - Luther prospect
3 - Read prospect
4 - Unnamed prospect near Read prospect
5 - do
6 - do
7 - Prospect on north side of Brooks Mountain

3) On the north side of Brooks Mountain galena occurs in a gossan in limestone. The skeleton of the gossan is composed of tourmaline. The iron oxide of the gossan contains bismuth and lead, the lead probably as a carbonate and the bismuth as an oxide.

No field investigations for radioactive material have been made by the Geological Survey in the Brooks Mountain area. Radiometric scanning of rock samples in Survey collection, indicates that some radioactive material is present in some ore material from the contact zone between limestone and granite a short distance north of the Read Prospect on Brooks Mountain. Three samples from this locality were studied. They average 0.019 percent eU and 0.017 percent U. The uraniferous minerals are azurite, biotite, purple fluorite, hematite, malachite and tetrahedrite.

During the summer of 1950 a number of samples containing radioactive material were sent to the Geological Survey by Mr. George Hellerich of Fairbanks, Alaska. The only information about the locality from which the samples were collected is that it is somewhere in the York Mountains. However, it is thought, from the appearance of the specimens and the mineral association therein, that they probably come from the vicinity of Brooks Mountain. According to Hellerich the samples were taken from a highly radioactive zone which was traceable over a distance of about 1,000 feet. The samples submitted are said to be representative of the various types of material in the zone and the adjacent country rock. Analyses of the equivalent uranium and uranium content of four samples from the radioactive zone are summarized as follows:

	Range	Average
Percent eU	0.018-2.144	0.585
Percent U	0.012-2.250	0.608

Zeunerite is the major uranium-bearing mineral in these samples; lesser, but still significant, amounts of uranium occur in purple fluorite, tourmaline, sericite, smoky quartz, siderite, limonite, hematite, malachite and arsenopyrite. It has been reported that these uranium claims have been leased to a prominent smelting company.

Potato Mountain. — The rocks of Potato Mountain (fig. 3) are sandy to calcareous, fine-textured slate, interbedded with a few strata of yellowish fine-grained sandstone, bluish clayey sandstone, and sandy limestone a few inches thick. Into this slate is intruded a quartz-porphyry dike, and ramifying quartz veins which range from a fraction of an inch to a few inches in width. The same mineralizing solutions that impregnated other areas in the York district were intruded at Potato Mountain at the time of the emplacement of the quartz veins. The presence of the quartz-porphyry dike and the minerals deposited from the solutions is evidence for the supposition that Potato Mountain is underlain at an undetermined depth by a granite mass of the same age and origin as that at Brooks Mountain, Cape Mountain and elsewhere in the district.

The placer gravels of Buck Creek, a stream draining the east side of Potato Mountain has been one of the principal producers of tin in the York district.

In the vicinity of the Red Fox claim, and the Alan Dale lode, at the head of Buck Creek about 8 or 9 prospect pits have been described in the literature. They are mostly stringers and veins of quartz, and one dacite porphyry dike about 10 inches wide that cut black shale. The minerals present are mainly pyrite and tourmaline, with a little stannite, and some serpentine.

At the Eureka claim on Little Potato Mountain black slate is cut by tourmaline and cassiterite-bearing quartz stringers.

At the Daisy claims near the top of Potato Mountain, slate is cut by a vein that is composed essentially of zoisite, hedenbergite, fluorite and calcite.

The slate at Potato Mountain is apparently not as mineralized as are the rocks at some of the other localities within the York district. It is possible that considerable mineralization is present in that part of the sedimentary rocks closer to the contact with the granite that probably underlies Potato Mountain. The state of knowledge of the deposits at Potato Mountain is not sufficient to corroborate any such supposition, but a careful investigation of the geology of the rocks at the mountain might indicate whether the mineral deposits at the present surface are an outer zone of mineralization that represents a residue from the hot solutions after most of the metals had been precipitated at depth, closer to the granite contact.

Ear Mountain. — The geology of Ear Mountain is not unlike that of other localities in the York district. The rocks are limestone, schist and slate. Partly metamorphosed gabbro dikes cut the schist. All these rocks are intruded by the Ear Mountain granite stock. Subsequent to the intrusion of the granite, basic mineralized dikes some of which are composite, i.e., basic at the edges, acidic towards the center, occupied fractures in both the granite and the country rock. Mineralizing solutions have affected the granite, and the limestone and dikes adjacent to the granite. The alteration in the granite and the dikes was limited to formation of black tourmaline near the contact. The limestone alteration took place for some hundreds of feet from the visible contact. At the Winfield shaft near the head of Tin Creek considerable replacement has taken place in the limestone. There the minerals include green pyroxene, grossularite, vesuvianite, fluorite, and microscopic crystals of scapolite, cassiterite, axinite, topaz, danburite, arsenopyrite, pyrite and chalcopyrite.

A search for radioactive mineral deposits at Ear Mountain was undertaken in 1945 by Killeen and Ordway (1946). They found that some of the tourmaline-quartz fissure veins in the granite, particularly those that contain red hematite and are associated with tourmalinized basic or fine-grained dikes, were radioactive. One of these radioactive zones crosses the top of Ear Mountain and extends to the northeast for about 5,000 feet. It is traceable mostly only by float. The radioactive dike or zone, where sampled at the point of greatest radioactivity, near the top of Ear Mountain, is about 8 feet wide. A channel sample across this 18-inch wide red, hematitic zone at the center of the dike contains 0.035 percent uranium. The red material appears to be an oxidized zone along close-spaced fractures. Fissure filling and replacement of the dike rock, the tourmaline-quartz vein, and the adjacent granite may be involved. The only uranium mineral identified is metatorbernite, occurring in vugs in both the granite wall rock and the tourmaline-quartz veins. None of it has been found in the red hematitic rock.

Cape Mountain. — At Cape Mountain (fig. 3) Mesozoic granite is intruded into mid-Paleozoic(?) limestone. Tin mineralization has been found principally at the junction of the granite with limestone, particularly where small apophyses from the granite cut the adjacent shattered limestone and formed channels for the intrusion of the mineralizing solutions. Some tin mineralization is found also in fissures and replacement veins in the granite itself.

The border zone of the granite is usually tourmalinized, and is usually quite barren of any other replacement minerals. Locally, however, cassiterite and pyrite have been formed, replacing some of the minerals in the granite. Subsequent oxidation of the pyrite has produced heavy red porous masses of hematite, containing cassiterite and tourmaline.

Contact with the granite has altered the limestone in a zone generally restricted to a few feet of rock adjacent to the intrusive and to fissures that cut the limestone in the vicinity of the granite. The alteration minerals in the limestone are mostly tourmaline and pyroxene. Minor constituents of the altered limestone are pyrite, pyrrhotite, fluorite, scapolite, sphalerite, quartz and cassiterite.

Cassiterite has been reported in vein quartz from Cape Mountain and locally cassiterite, accompanied by tourmaline, is found as an impregnation of granite adjacent to slips or fault planes.

Placer concentrates from several of the creeks draining Cape Mountain are radioactive and contain monazite and hematite, both of which give positive flux tests for uranium.

The following minerals have been reported from the stream gravels of Banner Creek, a tributary of the Anikovik River, about 14 miles east of Cape Mountain: cassiterite, magnetite, ilmenite, pyrite, fluorite, garnet and gold. (Brooks, 1901, p. 270).

Uranium possibilities of the York district. — On the basis of present knowledge the York tin district is probably the most likely part of Alaska to contain high-grade uranium ores. The mineralization in this district roughly parallels the tin-uranium mineralization of Cornwall and the Erzgebirge, for in addition to tin and uranium, the following elements known in the European districts have been recorded in the York district: antimony, arsenic, bismuth, boron, cerium, chlorine, cobalt, copper, fluorine, iron, lead, lithium, manganese, molybdenum, nickel, phosphorus, silver, thorium, and zinc. Of the mineralized areas within the York district, the Lost River and Brooks Mountain areas contain the most important uranium prospects, although metatorbernite and uraniferous hematite occur at Ear Mountain, and the mineralization at Cape and Potato Mountains also favors the presence of uranium.

Nome district

The Nome district lies in the southwestern part of the Seward Peninsula (fig. 3). The rocks consist of a sequence of Paleozoic metamorphic rocks, principally schist, limestone, quartzite and greenstone; Mesozoic granitic rocks, mostly in the Kigluaik Mountains and at Cape Nome; and Tertiary clastic sedimentary rocks.

The Nome district is noted mostly for placer-gold mining, but numerous lode prospects are scattered throughout the district, mainly as vein deposits and mineralized shear zone deposits. Both were probably formed in part prior to the metamorphism of the Paleozoic rocks, and in part during or after the intrusion of the Mesozoic granitic rocks. The vein deposits are mostly quartz with, some calcite and contain gold and very minor sulphides as the metalliferous constituents. Those mineralized shear zones primarily developed in schist are characterized by disseminated sulphides, principally arsenopyrite, pyrite and stibnite with the arsenopyrite predominent, whereas the mineralized shear zones along limestone-schist contacts and within limestone are characterized by the concentration of argentiferous galena and various copper sulphides.

Among the most prominent of the lode deposits are a number which lie in a belt on the south side of the Kigluaik Mountain about 25 miles north of Nome (fig. 3). The Sinuk River iron deposits at the western end of the belt (no. 17, fig. 3), described by Eakin (1915) and Mertie (1917, pp. 444-445), consist of stockworks and veins in limestone.

Limonite is the chief ore mineral at the surface but minor amounts of hematite, pyrolusite, galena, sphalerite, pyrite, gold, and purple fluorite have been reported. This mineral assemblage indicates that these iron deposits may be gossans overlying zones of hydrothermal alteration and thus may be comparable to some of the known radioactive lodes of the York district. Eastward from the Sinuk River iron deposits, this mineralized belt contains lodes of bismuth, copper, antimony, lead, zinc and silver. Elsewhere in the Nome district are various deposits containing molybdenum, tungsten, tin and mercury in addition to gold. The locations of these deposits are shown on figure 3, and their mineral assemblages indicated in table 3.

The lode deposits of the Nome district (listed in table 3), other than the Sinuk River iron deposits, are summarized by commodity as follows:

Antimony usually occurs as stibnite in quartz veins cutting schist. Kidneys of stibnite accompanied by very little quartz are found along shear zones in schist at several localities but the ore bodies are small.

Native bismuth and bismuthinite occur in quartz veins in schist on Charley Creek (no. 18, fig. 3), but the metal content of the veins are low. Platinum is reported to accompany the bismuth. In addition, bismuth nuggets have been reported in placers in the vicinity of Nome.

The copper minerals of the Nome district occur in replacement deposits along shear zones in limestone and schist. At a number of these deposits, hydrothermal alteration accompanying the deposition of the copper minerals has bleached and to some extent silicified the limestone. Quartz has been introduced along the shear zones in places. Where sulphides occur in these zones they are contemporaneous with the quartz. Chalcopyrite, bornite, pyrite and some galena are the usual sulphides present, but malachite and azurite are the most abundant ore minerals as most of the prospects are confined to surface workings.

Iron usually occurs as limonite which has formed by the oxidation of iron-bearing sulphides, and many of the vein and shear-zone deposits are thus heavily iron-stained. Hematite is much less common than limonite, and occurs in fractures in schist and greenstone on Slate Creek and with arsenopyrite, pyrite, stibnite, molybdenum and tungsten in quartz stringers in the California lode (no. 13, fig. 3) on Goldbottom Creek.

Galena, usually silver-bearing and associated with sphalerite, occurs in lenticular bodies along limestone-schist contacts. It is also found in small amounts with the copper minerals.

Cinnabar occurs in small amounts in placer gravels at many localities in the Nome district, and may be sparsely disseminated in quartz veins cutting schists.

The only occurrence of molybdenum in the district is in the California lode (no. 13, fig. 3) on Goldbottom Creek where presumably the sulphide of the metal occurs in small amounts with various other sulphides in quartz stringers.

Most of the silver of the Nome district occurs in solid solution with galena in lead deposits and small amounts are almost always alloyed with gold. No native silver has been reported.

Tin is reported in placer concentrates from Goldbottom Creek, a headwaters fork of the North Fork of the Snake River. The lode source of the tin is unknown.

Scheelite is found in most placer deposits of the Nome district. The lode sources are usually small quartz veins within mineralized shear zones in schist.

Sphalerite generally accompanies galena in the lead occurrences, and is associated with pyrite in quartz veins cutting schist.

As yet unverified reports of carnotite(?) in the vicinity of Nome have been obtained from mine operators' records filed with the Survey around 1915. Iron-stained schist along the ridge between Sunset Creek and Penny River, northwest of Nome is estimated to contain less than 0.003 percent eU on the basis of radiometric readings on the outcrop (West, 1946). A short reconnaissance investigation of the area in the vicinity of Teller in 1946 (White, 1949) failed to reveal any significant concentration of radioactive material. Reconnaissance of the Cape Nome granite in 1947 (West and Matzko, 1950) found that the small amount of radioactivity in the granite can be ascribed to accessory minerals, primarily zircon and sphene. No mineralized rock of any significance was discovered in the vicinity of the Cape Nome intrusive. Samples of the bismuth-bearing vein on Charley Creek mentioned above, recently submitted to the Geological Survey, gave negative results when tested radiometrically.

Uranium possibilities. — The occurrence of lode deposits containing various uranium indicator metals or minerals in the Nome district suggests that a mineralized belt on the south flank of the Kigluaik Mountains is favorable for the occurrence of radioactive materials. The Sinuk River limonite deposits at the western end of the belt contain oxides of iron and manganese in association with various sulphides and purple fluorite, an indication that the deposits may be largely gossans overlying zones of hydrothermal alteration and thus may be similar to the known radioactive lodes of the York district. Another favorable area is in the vicinity of Mount Distin where a hematitic gold-arsenopyrite lode occurs on Goldbottom Creek, a silver-lead-zinc deposit has been opened on Steep Creek and cassiterite pebbles have been found in the placers of Goldbottom Creek. The reports of deposits containing silver, lead, zinc, bismuth, antimony, molybdenum and tungsten elsewhere in the mineralized belt support the hypothesis that the Nome district may be favorable for the occurrence of uranium.

Council district

The rocks of the Council district (fig. 3) are much the same as those in the Nome district. In the central part of the Council district the country rock is composed of the schists and limestones of the mid-Paleozoic age, intruded by the mid-Paleozoic greenstones. The Bendeleben Mountains on the north side of the district and the Darby Mountains on the east side are composed of pre-Silurian metamorphic rocks, intruded by Mesozoic granite, which appears in scattered exposures throughout the central parts of the ranges.

The Darby Peninsula, between Golofnin (Golovin) Bay and Norton Bay, is composed of Mesozoic(?) intrusive and extrusive rocks. These rocks are intruded by later granites, which are apparently the same age as the granite intruding the rocks of the Darby, Bendeleben and Kigluaik Mountains.

Production of gold is the major mining interest in the district. Thus most of the prospects for other metals were found incidental to prospecting for gold. Reference material on the mineral deposits of the district therefore pertains primarily to the gold deposits, secondarily to other deposits. The mineralization in the district, as in the Nome district, lies primarily in mineralized limestone and schist. The mineralized rock is commonly iron-stained in varying degrees, mostly due to the oxidation of pyrite.

The principal prospects and mineralized localities (other than gold) in the Council district are summarized below:

1) Copper minerals in a mineralized contact between limestone and schist are reported: at Mt. Dixon; around the head of Moonlight Creek, a tributary of the Casadepaga River above Lower Willow Creek; and on Spruce Creek, a tributary of the Casadepaga River above Big Four Creek.

2) In schist on the east coast of the Darby Peninsula, about 3 miles north of Carson Creek, is a replacement copper prospect containing malachite and chalcocite.

3) A low grade copper ore, consisting mainly of chalcopyrite, is reported in mineralized schist at the head of the Niukluk River in the Bendeleben Mountains.

4) Near Bluff numerous oxidized gold-pyrite-arsenopyrite-bearing ores have been found in the schist and limestone. About 3 miles east of Bluff, adit exposes a one-foot wide zone of red ferruginous gouge-like material. The Bunker Hill lode, about 3 miles north of Bluff, contains chalcopyrite and copper carbonates in small quantities in addition to gold.

5) On the Fish River, a few miles above the mouth of the Niukluk River, a silver-lead prospect has been reported in schist and limestone. Cinnabar also occurs at this locality, presumably in quartz stringers.

6) At the Omalik (mispelled Omilak on figure 3) mine in the headwaters of the Fish River, argentiferous galena and stibnite, in separate contemporaneous(?) deposits are found in irregular pockets at the contact between a greenstone intrusive and limestone.

7) Chalcopyrite and bornite are fracture fillings in quartz veins cutting schist in the headwaters of the north headwaters fork of Kachauik Creek, a stream entering Golofnin (Golovin) Bay from the northeast. A malachite encrustation occurs on exposed portions of the vein.

In the summer of 1948, the Darby Peninsula and the drainage basin of the Kwiniuk River, in the southeast part of the district, were investigated for possible deposits of radioactive material (West, in preparation). In the concentrates from the stream gravels of a small stream on the west coast of the Darby Peninsula, about midway between Mission and Cheenik Creeks, a minor amount of an uranium-titanium niobate mineral has been found. The bedrock source of this mineral is not known, but may be from a mineralized zone near the contact between the younger granite and the older intrusives. The principal mineral in the concentrate is magnetite, with lesser amounts of sphene and topaz, minor amounts of hematite and allanite, and traces of scheelite. One concentrate taken near Cape Darby, on the contact between the younger granite and the older intrusives, in this case a metamorphosed granitic rock, consists of hematite and topaz. Traces of thorianite were found in a stream concentrate taken at the head of the Kwiniuk River. No information is available on the possible bedrock source of the mineral, except that it may be disseminated in granite.

Uranium possibilities. -- On the basis of favorable mineral associations, the silver-lead occurrences in the Fish River basin and the gold-pyrite-arsenopyrite ores in the vicinity of Bluff appear to warrant examination for the possible occurrence of uranium.

Fairhaven and Koyuk district. --- The geology of the Fairhaven and Koyuk districts (fig. 3) is mainly related to the rest of the Seward Peninsula to the west, but part of the rocks are related to those of the Yukon River valley to the east. Pre-Silurian schist and limestone with igneous rocks occur west of the Kiwalik and Koyuk Rivers. Rocks of middle and upper Paleozoic age, mostly limestone and dolomite with some black slate, outcrop south of the lower Koyuk River to Norton Bay, and in a narrow belt along the base of the Darby Peninsula. Post-Carboniferous greenstone is exposed along and just east of the Tubitulik River in the southwestern part of the Koyuk district. Metamorphosed granitic rocks on the east flank of the Darby Mountains and andesitic flows and tuffs on the Buckland-Kiwalik divide---all of Mesozoic, but probably pre-Cretaceous age---are intruded by younger granites, monzonites, syenites and diorites, which outcrop in scattered patches throughout both districts. Cretaceous sedimentary rocks, locally coal-bearing, are found east of the Tubitulik River and in small areas on the Kugruk and Peace Rivers. The youngest rocks of the districts are wide-spread Tertiary and Recent vescicular basaltic lavas.

Undoubtedly most of the Fairhaven and Koyuk districts has been investigated by prospectors since prospecting started in the early part of the century. However, as in most areas of Alaska, the primary interest in prospecting lay in discovery rich placer-gold deposits. Consequently, few lode deposits, particularly of base metals, have been reported. Mining for placer-gold centers largely around Candle, near the mouth of the Kiwalik River, and in the eastern parts of the districts in streams tributary to the West Fork of the Buckland River and the Peace River.

The major reported lode deposits of the two districts are summarized below:

1) An argentiferous lead deposit has been reported on the Kugruk River in the Fairhaven district near the mouth of Independence Creek. No information is available on the type of mineralization. Assays show a considerable amount of zinc, and traces of copper and gold, in addition to silver and lead.

2) Several small open cuts, known as the Beltz prospect, are found on Split Creek, a tributary of Bear Creek on the eastern edge of the Fairhaven district. The ore occurs in quartz veins cutting andesite and consists of chalcopyrite with some copper carbonate stain.

3) On the divide between the head of the Tubutulik River and Timber Creek, a tributary of the Koyuk River in the eastern part of the Koyuk district, malachite occurs in copper-stained greenstone, near the contact with limestone. Almost no sulphide mineralization is found at this locality and the copper carbonate occurs primarily in fractures and joints in the greenstone.

4) Platinum is recovered in many of the creeks of the eastern part of both the Fairhaven and Koyuk districts as a by-product of the placer mining for gold. The source of the platinum is considered to be the basic igneous rocks, perhaps the andesites, occurring throughout the mining area.

5) At the extreme head of Peace River, very coarse-grained granite contains copper sulphide minerals. The copper is apparently of no significance commercially, but as it appears to have been brought in contemporaneously with the granite it provides a clue to the source of some of the mineralization that is associated with the granitic intrusives.

Five reconnaissances for radioactive materials have been made in the Fairhaven and Koyuk districts.

In 1945 an investigation of the Sweepstakes Creek area (the western headwaters fork of Peace River) was made (Gault, Black and Lyons, 1946) to determine the source of uranothorianite found in a heavy sand sample from this locality. Only minor amounts of the mineral were found in the creek gravels, and the bedrock source was not located. It probably is associated with the syenite intrusive mass at Granite Mountain in the headwaters of Sweepstakes Creek.

Also in 1945 a brief examination was made of the uranothorianite-bearing gold placers in the vicinity of Candle (Gault, 1949). No significant concentration of the mineral was found, nor was the bedrock source located.

In 1946 the reconnaissance of the uranothorianite-bearing gravels was extended to the north side of Granite Mountain (Killeen and White, 1950) into the headwaters of Quartz Creek, a tributary of the Kiwalik River, in an attempt to locate the bedrock source of this radioactive mineral. The brief examination revealed the presence of both uranothorianite and a uranium-bearing thorite high on the slopes of Granite

Mountain. Again, however, the bedrock source could not be located.

In 1947 an investigation was made of the area along the divide between the Kiwalik River and Buckland River northward from the headwaters of the Peace River (West and Matzko, in preparation). This area contains pre-Cretaceous granitic intrusives of the same age as the Granite Mountain syenite. Uranothorianite, thorite and a few secondary uranium minerals were found in the concentrates from streams draining areas that are underlain by the granitic intrusive, but no significant radioactive deposits were found. It was concluded that the radioactive minerals are probably disseminated in the granitic rocks. A significant lead, however, is the mineral assemblage of concentrates from gravels in small streams at the extreme head of the Peace River. These placers occur near an intrusive contact and the concentrates from them have an eU content of about ten times that of the average uranothorianite-bearing concentrates obtained elsewhere in the eastern Seward Peninsula. The heavy minerals in one of the concentrates, in addition to the normal rock-forming and accessory minerals, are: pyrite, chalcopyrite, hematite, ilmenite, uranothorianite, bismuth, bornite, gold, silver, chromite, thorite, and gummite. These minerals constitute about 10 percent of the heavy minerals. The gummite probably is an alteration product of the uranothorianite, although gummite usually is found as an alteration product of uraninite or pitchblende. The streams in which these gravels occur are short and run mostly over tundra. One of the samples was taken at the highest topographic occurrence of gravel in the drainage basin. The locations of the samples are such that the source area has a maximum size of about one-half square mile. This location at the head of Peace River is probably not far from the place where Smith and Eakin (1911, p. 135) discovered copper sulphide minerals in granite.

In 1948 an investigation was made of the Darby Peninsula and the Kwiniuk River in the Council district, and the Tubutulik River in the western Koyuk district (West, in preparation). In the headwaters of Clear Creek, the first tributary from the west above the mouth of the Tubutulik River, several stream concentrates from an area of granitic rock contain minor amounts of a uranium-niobate mineral. Topaz and traces of cassiterite in some of the concentrates indicate the possible presence of some tin mineralization in the area, but otherwise there is no indication of the source of the niobate mineral.

Uranium possibilities. — At present, the occurrence of uranium minerals with various copper sulphides, hematite, silver, bismuth, etc., in a placer concentrate at the head of the Peace River constitutes the only major lead to a uranium lode deposit in the eastern Seward Peninsula. It appears to be of sufficient significance to warrant the attention of the uranium prospector.

Kougarok and Espenberg districts

The geology of the Kougarok and Espenberg districts is much the same as that of the Nome and Council districts to the south. Most of the bedrock is early Paleozoic limestone and schist which is intruded by Devonian or Carboniferous basic rocks, now greenstones. Mesozoic granite is exposed at Hot Springs in the headwaters of the Serpentine River in the southern part of the Espenberg district. Rhyolitic dikes occur at Kougarok Mountain. Tertiary or Recent basalts form Devil Mountain in the northern part of the Espenberg district.

Almost all mining in the Kougarok and Espenberg districts has been limited to the exploitation of placer gold deposits---particularly those on the Kougarok River and its tributaries. The discovery of lode deposits has been incidental to the prospecting for placers. Brief descriptions of the few known lode deposits of the district follow:

1) The Ward copper prospect on the northwest side of Kougarok Mountain is a development consisting of several open cuts in an impregnated zone lying near a limestone-schist contact. The ore consists of malachite and azurite in about equal amounts. A little chalcopyrite is also reported. Blue fluorite occurs in float in the vicinity of the prospect.

2) Copper and other metallic sulphides are disseminated in metamorphosed limestone near the mouth of Taylor Creek on the upper Kougarok River.

3) A prospect showing malachite and azurite with a little galena is reported a few miles southeast of Kougarok Mountain. No details are available concerning this prospect.

4) Cassiterite, scheelite and cinnabar are reported in various placers of the districts, but no lode source for these minerals is known.

In 1946 Moxham and West (1949) investigated parts of the Kougarok and Espenberg districts to determine whether radioactive deposits, similar to the one at Ear Mountain to the west, were associated with a granitic stock in the Hot Springs area at the headwaters of the Serpentine River; and, in addition, to attempt to locate the bedrock source of placer concentrate containing 1.36 percent equivalent uranium from the south side of Harris Dome. No radioactive material was found in the Harris Dome area. In the Hot Springs area small amounts of radioactive accessory minerals are disseminated in granite, and several secondary minerals containing minor amounts of uranium occur in pegmatite dikes associated with the granite.

Uranium possibilities. — As so little information is available on the lode deposits of the Kougarok and Espenberg districts, it is almost impossible to predict their uranium possibilities. Further prospecting, however, does not appear to be warranted unless it be incidental to the search for other commercial mineral deposits.

Kobuk and Noatak districts

The Kobuk and Noatak districts (fig. 1) include the area drained by the Kobuk and Noatak Rivers in northwestern Alaska. Available geologic information on the districts is mostly restricted to areas immediately adjacent to the two main streams. The stratigraphy and structure are complex.

In general the country rock of the districts consists of the following:

1) Pre-Paleozoic to Eocene sedimentary rocks of many types including bedded volcanics; the older rocks are considerably metamorphosed.

2) Paleozoic basic igneous dikes and sills.

3) Upper Jurassic(?) basic intrusive rocks with some flows and tuffs.

4) Cretaceous(?) granite and diorite stocks and dikes.

5) Tertiary to Recent basaltic lava flows and volcanic ash deposits.

As in most areas in Alaska, prospecting in the Kobuk and Noatak districts has been for gold---primarily placer gold, and other mineral deposits were located only incidentally to this search. Such gold lodes as have been found occur at scattered localities in the Paleozoic schist and slate, but they have not proven of economic value and have not been found to contain sulphides or other mineralization of any significance.

Copper lodes have been reported from several places in the Kobuk-Noatak region, but the Survey has information on attempts to exploit only two prospects, both of which are in the Schwatka Mountains, north of the settlement of Kobuk, on the Kobuk River. One of these prospects is in the vicinity of Aurora Mountain where the copper mineralization is in limestone near the contact with early Paleozoic schist. The other is on Ruby Creek, a tributary of the Shungnak River, where sulphide mineralization has filled the interstices of a narrow zone of brecciated limestone. The ore is an iron oxide with chalcopyrite and bornite, and some galena, sphalerite and pyrite. Malachite and azurite are found in the surficial portion of the deposit. A spot examination for radioactivity was made at this latter locality in 1949 (White, 1950c) at the request of the Atomic Energy Commission. No samples collected at the deposit contain more than 0.007 percent equivalent uranium. The radioactivity is due to small amounts of uranium associated primarily with the sphalerite.

Galena was also found in a brecciated and recrystallized limestone on Wesley Creek, a stream entering the Kobuk River a short distance below Kobuk.

Magnetite, sometimes in relatively large masses has been reported from scattered localities in the highlands of the Noatak-Kobuk district. Some of this mineral from Dahl Creek, a stream paralleling Wesley Creek, and a short distance to the east was found to be a relatively low grade magnetic chromite, containing 40 to 45 percent chromic oxide.

Asbestos and jade deposits also occur in the Kobuk district.

Uranium possibilities. — Many mineralized localities probably exist in the rocks of the Noatak and Kobuk districts, but until more definite information is available about the geology and mineral deposits of the region, the possibility of finding high-grade uranium deposits therein appears remote.

Southeastern Alaska

At the present time uranium is known to occur at only one locality in southeastern Alaska. This occurrence is on the Mountain View property near Hyder where moderate amounts of radioactive material

(0.0X–0.X percent eU) have been found in iron oxides and various sulphides in quartz fissure veins along an intrusive contact, and a secondary uranium mineral, uraconite(?), occurs as films on fracture surfaces. In addition, a number of uranium occurrences have been reported by prospectors in southeastern Alaska, but no samples have as yet been submitted to verify these occurrences. Two moderately radioactive samples, the locations of which are not definitely known, may come from southeastern Alaska, possibly Prince of Wales Island. One of these samples was found by the radiometric scanning of material available in the Ketchikan Assay Office of the Territorial Department of Mines; the other, by scanning the Alaskan collections of the Geological Survey in Washington. Despite the fact that known occurrences of uranium in southeastern Alaska are very limited, this region of the Territory contains various types of hydrothermal deposits wherein the mineralization suggests the possible presence of uranium.

Information on the general geology of southeastern Alaska has been taken mainly from a paper by Buddington and Chapin (1929). The data on the mineral deposits has been abstracted mostly from reports by Brocks (1902), Buddington (1923; 1925; 1926; 1929), Eakin (1919), Knopf (1911; 1912), Mertie (1921), Overbeck (1919), Reed (1938), Reed and Coats (1942), Smith (1914), Spencer (1906), C. W. Wright (1908; 1909; 1915), and F. E. and C. W. Wright (1908).

Late Mesozoic intrusive rocks are the most prominent geologic feature of southeastern Alaska and the contiguous part of British Columbia. These rocks are part of a large composite batholith and its satellitic intrusions that form the backbone of the Coast Range from Vancouver to Skagway, both on the mainland and in the Alexander Archipelago. Other prominent features in the geology of southeastern Alaska (fig. 4) are:

1) A belt of highly metamorphosed rocks that lie adjacent to the Coast Range batholith on the west and consist largely of gneiss, highly schistose rocks and marble of Paleozoic and Mesozoic age.
2) Two belts of Mesozoic sedimentary and volcanic rocks, one extending northwestward from Gravina Island through Kupreanof Island to Juneau, and the other extending along the west coast of Chichagof and Baranof Islands.
3) A belt of Paleozoic sedimentary and volcanic rocks, locally metamorphosed, extending from Prince of Wales Island on the south to the Glacier Bay region on the north.
4) An area of Tertiary sediments and volcanics on Zarembo, Kupreanof, Kuiu and Admiralty Islands.
5) Recent lava flows on Kruzof Island.

The Coast Range batholith is the major factor controlling the structure and the localization of the mineralization in southeastern Alaska. The mineral deposits of the region, genetically associated with the batholith, are grouped into four northwest-trending belts (fig. 4) by their relationship to the main batholith or its subsidiary intrusives. The belts from east to west are the:

1) Eastern border belt

2) Central Coast Range batholith

3) Western border belt

4) Western satellitic intrusive belt

Eastern border belt

The eastern border belt of the Coast Range batholith lies entirely in British Columbia except for a small area in the vicinity of Hyder at the head of the Portland Canal (fig. 4).

In the Hyder area meta-sedimentary and volcanic rocks of the Hazelton group or "Bear River formation" are intruded by the Texas Creek granodiorite, the Hyder quartz monzonite and the Boundary granodiorite. The Texas Creek intrusive mass is thought to precede or be an early phase of the main Coast Range batholith which was later invaded by the Hyder and Boundary masses (Buddington, 1929, p. 14).

About 60 mines and prospects in the Hyder area are described by Buddington (1929, pp. 63-112). These deposits and the ones in the contiguous Salmon River district of British Columbia are classified by Buddington (1929, pp. 42-44) into five types. This classification, showing the relative abundance of ore and gangue minerals in the various types, is presented below.

Type of deposit	Major	Minor
Quartz fissure veins of the silver-lead-gold type	galena pyrite quartz	sphalerite chalcopyrite barite tetrahedrite pyrrhotite scheelite native gold native silver

Veins and vein-like replacement bodies of the silver-gold type (Premier type)	sphalerite quartz	pyrite chalcopyrite galena tetrahedrite silver-rich sulpho-salts native gold native silver
Veins of gold type	pyrite quartz	chalcopyrite sphalerite galena native gold
Disseminated and lenticular replacement deposits	pyrite galena sphalerite pyrrhotite calcite	chalcopyrite arsenopyrite tetrahedrite quartz barite native silver
Mineralized fissure zones	galena sphalerite quartz calcite	pyrite chalcopyrite pyrrhotite tetrahedrite arsenopyrite

In general the ore deposits in the Hyder area are located in the vicinity of the contact of the Texas Creek granodiorite with formations of the Hazelton group. At a few places the deposits are cut by dikes believed to be offshoots of the Hyder quartz monzonite and the Boundary granodiorite. It is thought, therefore, that the main period of mineralization in this area followed the emplacement of the Texas Creek batholith and preceeded the intrusion of the younger Coast Range igneous rocks, and that the deposits were formed from residual solutions released in the consolidation of the Texas Creek batholith. Some alteration and introduction of material, however, either accompanied or immediately followed the intrusion of the younger igneous rocks, as low-grade veins and disseminated deposits containing various sulphides and hematite are found in genetic association with these younger rocks.

In 1949 the Territorial Department of Mines reported (Fowler, 1949) the occurrence of radiation anomalies on the Mountain View property (no. 1, fig. 4) in the Hyder area. Brief investigation of this property in the same year (West and Benson, in preparation -a) revealed that moderate amounts of uranium are associated mostly with hematite and limonite; the sulphides---galena, sphalerite, pyrite, chalcopyrite and molybdenite; and scheelite. These minerals occur in quartz fissure veins and mineralized shoots in a zone along the intrusive contact of the Texas Creek granodiorite with rocks of the Hazelton Group. Other minerals of note in these veins are tetrahedrite, freibergite, and fluorite. A secondary uranium mineral, probably uraconite(?), occurring in films on fracture surfaces, has also been found on this property. Although the maximum eU content of the samples collected by the Geological Survey in 1949 is only about 0.05 percent, more recent sampling by the Territorial Department of Mines has revealed values up to about 0.3 percent (Saarela, 1950).

Radiation anomalies are also reported (Saarela, 1950) in the Texas Creek area (no. 2, fig. 4) some 8 to 10 miles northwest of the Mountain View property. These anomalies apparently occur, as at Mountain View, in the general vicinity of the contact of the Texas Creek intrusive with rocks of the Hazelton Group but their significance is not as yet known.

Uranium occurs in complex association with ores of other metals in the Hazelton area of British Columbia (Lang, 1949a, pp. 16-17) southeastward from Hyder and also in the eastern border belt of the Coast Range batholith.

Uranium possibilities. — The Hyder area is favorable for continued prospecting for uranium, for in addition to the above mentioned occurrence of uranium and radiation anomalies, the area contains other hydrothermal deposits in which minerals typical of the intermediate temperature range, such as silver-bearing tetrahedrite and galena, are predominent. The presence of fluorite, and uraniferous hematite and limonite in samples from the Mountain View property is noteworthy. Therefore, the occurrence of the iron oxides on other properties should be sought, as in some cases they may possibly be of hydrothermal origin, and thus be a valuable guide in further prospecting.

In general it is believed that the best uranium possibilities of the Hyder area follow the distribution of its other mineral deposits. Thus, prospecting for uranium, as well as for ores of other metals, is probably most favorable in the vicinity of the Texas Creek granodiorite-Hazelton group contact, although the low-grade deposits, containing sulphides and hematite, genetically related to the Hyder quartz monzonite and Boundary granodiorite should also be checked for radioactivity. These later deposits are exemplified by the quartz veins and disseminated deposits on Bear River Ridge north of Hyder and east of the Mountain View property, and on the Ebb Tide group (no. 3, fig. 4) on the Portland Canal about 3 miles south of Hyder.

Another favorable indication for uranium in the eastern border belt is the occurrence of a jasper-barite gangue with rich silver ores in the

Kitsault River district of British Columbia approximately 30 miles southeast of Hyder.

Central Coast Range batholith

The Upper Jurassic or Lower Cretaceous central Coast Range batholith with included Paleozoic and early Mesozoic metamorphic rocks straddles the international boundary in the latitude of southeastern Alaska (fig. 4). Buddington (Buddington and Chapin, 1929, pp. 358-359) generalizes about the batholith as follows:

> "The Coast Range batholith in southeastern Alaska and the adjoining part of British Columbia consists essentially of granodiorite, quartz monzonite, and quartz diorite, with a little associated diorite and more basic rocks and included belts of schist and injection gneiss. Few mineral deposits have been discovered within the core of the batholith. In the past this has been ascribed to an actual scarcity of metallization there; but it is now recognized that the exceeding ruggedness of the country and its inaccessibility, with consequent slight prospecting, may also be a contributing factor. Mineral deposits of economic importance occur in the belts of metamorphic rocks inclosed within the batholith, ... and there is no doubt that others will be found, but it will probably still be found to hold true that mineral deposits of commercial value are relatively sparse within the Coast Range batholith."

Examination of all available data also leads to the conclusion that the mineral deposits in the core of the Coast Range batholith are sparse. Lode deposits are known only on the Portland Canal, on the Chikamin, Unuk, Whiting and Taku Rivers, and in the area between the Chilkat and Chilkoot Rivers (fig. 4).

On Portland Canal about 14 miles southwest of Hyder is the Commonwealth group of prospects (no. 4, fig. 4) which, for the most part, are contact metamorphic deposits of pyrrhotite, molybdenite, sphalerite and chalcopyrite in a garnet-quartz-epidote gangue.

On Chickamin River an 8-foot quartz vein containing pyrite and molybdenite occurs about four miles upstream from the Behm Canal (no. 5, fig. 4). At the foot of Chickamin Glacier quartz veins from 2 inches to about 1 foot thick contain much pyrite and small amounts of pyrrhotite, chalcopyrite and galena (no. 6, fig. 4).

In addition to the deposits on Portland Canal and Chickamin River, Buddington (Buddington and Chapin, 1929, p. 381) mentions that quartz fissure veins with hematite or martite and pyrite are associated with quartz monzonite in the general area between the Portland Canal and Chickamin River (fig. 4).

Pyrite, pyrrhotite and chalcopyrite occur in a 2-foot vein on the Unuk River about 1 mile below the international boundary (no. 7, fig. 4).

At the Whiting River prospect (no. 8, fig. 4) a metallized quartz fissure vein occurs in a marble belt surrounded by quartz diorite. The metallic minerals in the veins are arsenopyrite, pyrite, galena, sphalerite and chalcopyrite. Arsenopyrite is predominant. High assays for both silver and gold have been obtained from selected samples and moderate assays are common.

Considerable quantities of sphalerite with pyrrhotite and minor amounts of pyrite, galena and chalcopyrite are reported on the Taku River about 1 mile from the international boundary (no. 9, fig. 4). The ore, however, gives only low assays for gold and silver.

Native gold, bornite, pyrite and hematite are reported in quartz veins at the northern end of the central Coast Range batholith in the area between the Chilkat and Chilkoot Rivers (no. 10, fig. 4).

Uranium possibilities. -- In 1948 two rumors of uranium finds in the area of the Coast Range batholith were received by the Geological Survey. One of these rumors placed the deposit on the Whiting River; the other, on the mainland east of Petersburg. No additional information or samples were obtainable with the consequence that neither were verified. Wacker (Mining Truth, 1932) reported a deposit of uranium on Martin Arm of the Boca de Quadra Inlet east of Ketchikan (no. 11, fig. 4). In 1949 a member of the Territorial Department of Mines made an unsuccessful attempt to locate this deposit (Fowler, 1949) with directions from Wacker. However, Wacker subsequently claimed that the search was not conducted at the correct locality. Wacker has no samples available for examination.

The possibilities for the occurrence of uranium in the central Coast Range batholith appear to be very slim, as most of the deposits apparently are either of the contact metamorphic or high temperature vein types. The Whiting River prospect may be similar to some of the properties east of the Coast Range batholith in the Hazelton district of British Columbia, where uraninite is associated with high-grade gold-arsenopyrite ores (Lang, 1950, p. 13). The fact that uranium has been found in association with molybdenite, at the Mountain View property in the Hyder area and at a number of properties in British Columbia (Lang, 1950, p. 14), would appear to warrant the checking of the known molybdenite occurrences in Alaska. As seen above, molybdenite occurs in two lode deposits in the core of the Coast Range batholith, viz., those on the Portland Canal and on the Chickamin River.

With regard to the possibility of uranium in the Boca de Quadra area, as reported by Wacker, the geological conditions there are not unfavorable for mineral deposits in general. According to Buddington and Chapin (1929, pl. 1) the Coast Range batholith in the area of Boca de Quadra includes a belt of metamorphosed sedimentary rocks. The conditions therefore are similar to other localities in the core of the batholith where known mineral deposits have been found.

Western border belt

The western border belt of the Coast Range batholith in southeastern Alaska extends from the western contact of the main batholith westward to a line through Clarence Strait, Kupreanof Island, Admiralty Island, and the mainland peninsula between Glacier Bay and Lynn Canal (fig. 4). This belt consists mainly of metamorphic rocks, probably of Paleozoic and early Mesozoic age; somewhat less metamorphosed Mesozoic sedimentary and volcanic rocks; and intrusive rocks subsidiary to the main Coast Range batholith.

The distribution of the more significant minerals in the major lode deposits of the western border belt is shown in table 4. These deposits (fig. 4) are of hydrothermal origin and include fissure veins, breccia veins, replacement veins, shear zone deposits, stringer lodes and stockworks. Contact metamorphism may also have been a contributing factor, particularly in the vicinity of the larger intrusive masses.

Uranium possibilities. -- The mineral assemblages of certain of the mineral deposits of the western border belt (see table 4) suggest the presence of uranium in that they contain fluorite, hematite, native silver, tetrahedrite, bismuth, cobalt and nickel. The following deposits would thus appear to warrant the first attentions of the uranium prospector.

1) The bismuth- and silver-bearing galena-tetrahedrite ores on Annette Island (no. 13, fig. 4).

2) The hematitically altered copper ores on Gravina Island in the vicinity of Dall Head (no. 14, fig. 4).

3) The bismuth-bearing gold quartz veins near Ketchikan[1/] and on Helm Bay (nos. 19 and 21, fig. 4).

4) The complex silver-lead-zinc deposits containing native silver and fluorite on the mainland east of Wrangell (no. 22, fig. 4).

5). The arsenopyrite-pyrite ores on Thomas Bay (no. 28, fig. 4).

6) The copper deposit containing native silver at Point Astley on Holkham Bay (no. 33, fig. 4).

1/ In 1949 West and Benson (in preparation -b) made a hasty search near Ketchikan in an attempt to locate the old workings on the bismuth-bearing gold-quartz vein of the Hoadley claim. The search was unsuccessful because of dense vegetation. Radiometric tests on the dumps of several old prospects in the general vicinity of the reported locations of the Hoadley prospects were negative.

A sample of carnotite, associated with slate and coal, has recently been submitted to Ketchikan Assay Office of the Territorial Department of Mines. According to reports it is from an unrecorded coal location on the north side of the Cleveland Peninsula. Buddington (Buddington and Chapin, 1929, p. 263) reports the occurrence of Tertiary clastic rocks on Union Bay on the north side of the peninsula which presumably could be coal-bearing.

The mineral deposits in the northern sector of the western border belt, particularly those of the Juneau gold belt and on Admiralty Island, do not appear to be favorable for the occurrence of uranium. The sulphide content of these deposits is almost invariably low, and there is very little indication of the hematitic alteration, which is frequently found to accompany certain types of high-grade uranium ore. Further, the fact that these northern sector deposits have been developed to a greater degree than those in the southern sector of the belt also reduces the possibilities for uranium therein, as even small amounts of radioactive minerals would have been long since recognized on the amalgamating or concentrating tables in the mills of such well known mines as the Alaska-Juneau and Treadwell. Two samples representative of the mill concentrates and tailings of the Alaska-Juneau mine for 1943 both contain less than 0.002 percent equivalent uranium.

The conclusion that the northern sector of the western border belt is unfavorable for the occurrence of uranium is supported by the negative results of short radiometric reconnaissance in the Juneau area and at Funter Bay (West and Benson, in preparation -b).

Western satellitic intrusive belt

The western satellitic intrusive belt of the Coast Range batholith lies west of the western border belt described above (fig. 4). Its main geographic elements are Prince of Wales, Kuiu, Baranof, and Chichagof Islands, and the part of the mainland in the vicinity of Glacier Bay. The geology of this belt is generally similar to that of the western border belt. Intrusive rocks, however, appear to occupy a less dominent position in areal distribution. Metamorphism of the sedimentary and volcanic rocks is not as pronounced as in the belts to the east, except near the intrusive rocks. These differences between the western satellitic intrusive belt and the more easterly belts are probably due to the westward plunge of the main Coast Range batholith beneath the intruded older rocks.

The distribution of the more significant minerals in the major lode deposits of the western satellitic intrusive belt of the Coast Range batholith is shown in table 5. The locations of these deposits are plotted on figure 4.

The most highly developed deposits of this belt are the copper ores of Kasaan Bay (no. 59, fig. 4), Kasaan Peninsula (no. 60) and the Copper Mountain area (no. 68) on Prince of Wales Island, and the gold-bearing veins of the Klag Bay-Kimshan Cove area (no. 88) on Chichagof Island. The remaining deposits, with a few exceptions, are but little developed prospects.

The types of deposits in the western satellitic intrusive belt include: high temperature vein and contact deposits; impregnated or veined shear zones; quartz fissure and breccia veins; mineralized dikes; and deposits probably derived by magmatic segregation. All of these types, except the possible magmatic segragates, are of hydrothermal origin, and with few exceptions were formed during the intrusion of the batholiths and stocks subsidiary to the main Coast Range batholith. A few of the deposits, notably the barite and zinc on Kuiu Island (nos. 80 and 81, fig. 4), and the fluorite on Zarembo Island (no. 24) in the western border belt, occur in Tertiary rocks, and hence must have formed later than those deposits related to the late Mesozoic intrusives.

Uranium possibilities. — Two moderately radioactive samples, both possibly from Prince of Wales Island, have been found by the radiometric scanning of material available in the collections of the Territorial Department of Mines and the Geological Survey. One of the samples may have been collected in the course of the Survey's investigation of the chalcopyrite-magnetite ores of Kasaan Peninsula in 1943-44. It contains approximately 0.1 percent eU, in part due to allanite and in part to one of the copper uranites, probably metatorbernite. The other sample, found in the scanning of rock collections by the Territorial Department of Mines in its Ketchikan Assay Office, contains 0.05 percent eU_3O_8, as determined by the Atomic Energy Commission (N. Y. Lab. no. 406K), who describe the sample as: "one hand specimen of altered iron-stained siliceous rock with veinlets of calcite, pyrite, and a dark red mineral, possibly hematite". Although the source of this sample is not known, its general appearance suggests a similarity to rocks in the vicinity of Niblack Anchorage or Dolomi on Prince of Wales Island. Portions of this sample seen by members of the Survey have a distinct "jaspery" appearance.

Samples of jaspery rock, recently submitted to the Ketchikan Assay Office, and also thought to be from Prince of Wales Island, contain from about 0.01 to 0.2 percent equivalent uranium.

The search for a reported occurrence of radioactive ore in the vicinity of Chichagof (Klag Bay-Kimshan Cove area, no. 88, fig. 4) was unsuccessful (West and Benson, in preparation -b). Radiometric tests of a variety of materials from many of the mines at Chichagof were negative. Colby's report (Colby, 1942, p. 175) of radium in the waters of Goddard Hot Springs appears to be unfounded (West and Benson, in preparation -b). Field radiometric tests on rocks in the vicinity of the hot springs were also negative.

The mineral assemblages in 17 deposits (table 5) in the western satellitic intrusive belt suggest the presence of uranium. These mineral deposits, located by number on figure 4, are:

1) Hematitically altered copper deposits in the vicinity of Niblack Anchorage (no. 45); the possible similarity of the jaspery radioactive material, mentioned above, to the descriptions of the ore material at Niblack Anchorage and at Dall Head on Gravina Island (no. 14) should be noted;

2) Gold-bearing breccia veins near Dolomi (no. 48) many of which contain tetrahedrite and pyrite as the dominent sulphides;

3) Gold quartz veins at Kitkun Bay (no. 50) some of which contain a black (manganese?) mineral, and with which are associated impregnated zones containing hematite, magnetite and chalcopyrite;

4) Silver-lead-zinc veins near Dora Bay (no. 51);

5) Silver-lead deposits on the South Arm of Cholmondeley Sound (no. 53) which are quartz fissure veins containing argentiferous galena as the predominent ore mineral in a gangue of quartz, siderite and calcite;

6) Tetrahedrite-bearing gold veins on the Dolly Varden group of claims at the head of Twelvemile Arm (no. 56);

7) Vein gold deposits near Hollis on Twelvemile Arm (no. 57) in which pyrite is the predominent sulphide, and in one of which is a soft, black, supposedly sulphantimonide or bismuth mineral;

8) Gold quartz veins near Granite Mountain on Twelvemile Arm (no. 58) which contain several of the more common sulphides, are deeply stained to a red-brown color, and contain quartz and calcite with some siderite as the gangue minerals;

9) Copper-palladium lode mine at the head of Kasaan Bay (no. 59) in which copper sulphides, chiefly bornite, are disseminated in a basic igneous rock; a hematitically altered zone about 20 feet wide off the 200-foot level was discovered by diamond drilling in 1943-44;

10) Chalcopyrite-magnetite ores of Kasaan Peninsula (no. 60) which are thought to be of contact origin; hematite and molybdenite are found in many of these deposits, and fluorite has been reported in one prospect; the radioactive sample containing allanite and one of the copper uranites, mentioned above, may be from one of these mines;

11) Tetrahedrite-bearing silver-lead quartz fissure veins on Kasaan Mountain, Kasaan Peninsula (no. 61);

12) Copper-iron deposits in the Copper Mountain area (no. 68) which are similar in origin and composition to those on Kasaan Peninsula;

13) Molybdenite lode at Shakan (no. 71) which contains---in addition to molybdenite---chalcopyrite, pyrite, pyrrhotite, sphalerite, hematite and limonite; with regard to the area in the vicinity of the Shakan igneous stock from which the molybdenite deposit was probably derived, Buddington (Buddington and Chapin, 1929, p. 367) states:

> "...the belt...deserves further prospecting. The Shakan stock is highly differentiated; evidences of metallization in it or in its vicinity were noted in several places and include arsenopyrite veinlets, galena, and specularite in local contact metamorphic pockets, the molybdenite lode at Shakan, and gold-bearing quartz veins. The country rock also is in part favorable for the formation of contact copper deposits."

14) Silver-bearing tetrahedrite-chalcopyrite veins on Mount Vesta, Dall Island (no. 73);

15) Argentiferous galena deposits on Sea Otter Harbor, Dall Island (no. 75);

16) Molybdenite deposit on Baker Island (no. 75);

17) Silver-bearing galena-tetrahedrite ores near Egg Harbor on Coronation Island (no. 79).

Except for the gold-bearing veins near Pinta Bay and Lisianski Inlet (nos. 90 and 91) on Chichagof Island and a few prospects in the Glacier Bay district (no. 97), the northern part of the western satellitic intrusive belt does not appear to be favorable for the occurrence of high-grade uranium deposits. At the deposits near Pinta Bay (no. 90) and Lisianski Inlet (no. 91) arsenopyrite is the predominent sulphide with subordinate pyrite, chalcopyrite and sphalerite. Tetrahedrite and scheelite also are found in the veins near Lisianski Inlet. Argentiferous sulphides (chalcopyrite, pyrite and tetrahedrite) occur in pods along mineralized dikes on Willoughby Island in the Glacier Bay district (no. 97).

Alaska Railroad-Iliamna region

The principal mineralized areas in the Alaska Railroad-Iliamna region are situated along the flanks and foot hills of the Alaska Range and in the peripheral area of the Talkeetna Mountains. Although gold production far exceeds that of any other metal in dollar value, ores of lead, silver, zinc, copper, and antimony have been produced in commercial quantity in the past. Only gold is being mined at present.

Uranium minerals are known to occur only in the Willow Creek and Yentna mining districts. In the Willow Creek gold lode-mining district (no. 13, fig. 5), 50 miles northeast of Anchorage, a few pegmatite dikes were found to contain very minor amounts of radioactive minerals. Uraninite and several thorium minerals have been identified, but no significant concentrations of the radioactive material have been found (Moxham, 1950a; Moxham and Nelson, in preparation -b). In the Yentna mining district (no. 10, fig. 5, uraninite has been identified in the gold-bearing placer gravels of Cache and Peters Creek, but the concentration of radioactive material in the gravel is too low to warrant its recovery as a by-product of gold mining (Robinson, Wedow and Lyons, 1946).

In 1918 a construction worker on the Alaska Railroad submitted a sample of carnotite to the Fairbanks Assay Office. The assayist appended a note to the report on the carnotite expressing some doubt on his part that the sample actually came from Alaska. Letters from the assay office to the worker requesting additional information on the locality were unanswered and the worker died in 1921. Subsequent efforts to obtain information from his acquaintances were unsuccessful.

In view of the possibility that the ore might have been found in the vicinity of the railroad, a radiometric traverse of the railroad right-of-way between Seward and Fairbanks was made in June 1950. No radioactivity of significance was detected (Moxham and West, in preparation).

Alaska Range

Kantishna district. -- The Kantishna district fig. 5) includes the north slope and foot hills of the Alaska Range, within the drainage of the upper Kantishna River.

From the foot hills southward to the crest of the mountains parallel belts of metamorphosed sediments and interbedded volcanics ranging from pre-Cambrian to Devonian are exposed. These units have been intruded by igneous rocks ranging from small dikes and sills to bodies of batholithic proportions, most of which are of Mesozoic age.

The lode deposits of the Kantishna district may be divided into four groups---lead-silver-zinc, antimony, copper,and gold

Lead-silver-zinc deposits have been found chiefly in the Kantishna Hills and on Mt. Eielson. The more important mines in the Kantishna Hills are located in the headwater basin of Moose Creek. Metalliferous quartz veins have been emplaced along shear zones in pre-Cambrian schist. Galena, pyrargyrite, tetrahedrite, and gold-bearing sphalerite are most abundant ore minerals, with lesser amounts of arsenopyrite, pyrite, marcasite, melanterite, free sulphur, scheelite, and scorodite. Some of the veins are heavily stained with iron oxides. Considerable development work has taken place, chiefly in the area between Friday and Eureka Creeks, where an estimated 1,500 tons of high-grade lead-silver ore has been shipped to the smelter(no. 1, fig. 5).

Mt. Eielson (no. 2, fig. 5) is composed primarily of granodiorite which has intruded Devonian argillite, limestone, slate, and schist.

Solutions emanating from the intrusive mass have replaced calcareous beds in an irregular zone about 4 miles in length along the north side of the granodiorite. Sphalerite, galena, chalcopyrite, malachite, and azurite, listed in order decreasing abundance, are the ore minerals definitely identified. Silver is carried in solid solution by the galena and sphalerite. Tetrahedrite has been reported from several prospects but never has been identified definitely. In most places the ore consists of bands of epidote minerals and sulphides, up to an inch in thickness, separated by barren zones. Development work consists only of trenches and pits. No ore has been shipped from this area (Reed, 1933).

Reports of significant quantities of silver in the Mt. Eielson ores would suggest that this area might well be investigated. It is accessible to the Alaska Railroad by the McKinley Park Road and could be readily included in the investigation of the Kantishna Hills, a short distance to the northwest.

Antimony lodes are found chiefly in the eastern portion of the Kantishna Hills in the headward basin of the Toklat River (no. 3, fig. 5).

The Kantishna Hills have been eroded from the pre-Cambrian Birch Creek schist which has been warped into broad, open folds striking and plunging in a northeasterly direction. Stibnite is found in veins and lenses in a shear zone in the schist. The low grade ore bodies consist of disseminated ore in quartz veins, where a high-grade ore is found in lenses and kidneys of the pure mineral. Minor amounts of pyrite, arsenopyrite and oxides of antimony are also associated with the stibnite.

Development work has been most extensive at the Stampede Mine, $2\frac{1}{2}$ miles above the mouth of Stampede Creek (White, 1942). About 68 tons of concentrates were shipped to the smelter in 1948.

Other antimony prospects have been located in adjacent parts of the Kantishna Hills, but no development has taken place.

Several deposits of stibnite, reported to occur as thin veinlets and lenses in a decomposed sandy stratum (Moffit, 1933, p. 314), have been found near the head of Slippery Creek, south of McKinley Fork (no. 4, fig. 5). The country rocks are dark, banded shales, siliceou beds, and interbedded lava flows, cut by acid dikes.

In a few copper prospects, in the headwaters of Slippery and Iron Creeks (Moffit, 1933, pp. 319-324), solutions from intrusive granitic rocks have mineralized sheared, brecciated metamorphosed sedimentary rocks. The primary copper mineral is chalcopyrite. Sphalerite and secondary copper carbonates are present in most of the prospects. Minor amounts of native copper, cuprite, and manganese are also reported. Hematite was found at one prospect and iron-staining is reported to be noticeable at the others. Near the head of the west fork of Slippery Creek, cinnabar and native mercury were found with iron and copper sulfides and various oxidation products, particularly hematite (Moffit, 1933, p. 321).

The chief area of gold mineralization in the Kantishna Hills is the ridge between Glen and Spruce Creeks. The gold is in quartz veins cutting the Birch Creek schist. Many of these veins also contain minor amounts of zinc, lead, and iron sulphides (Moffit, 1933, pp. 333-334).

Nenana district. — The Nenana district embraces the north slopes and foothills of the Alaska Range drained by the Nenana River and its tributaries (fig. 5).

The principal formations of this district include the pre-Cambrian Birch Creek schist, the Paleozoic(?) Totatlanika schist, the Cretaceous(?) Cantwell formation of moderately metamorphosed clastic sediments, Tertiary coal measures and gravels, and Pleistocene deposits; and Mesozoic(?) granitic intrusives.

Lode mining in the Nenana district has been confined chiefly to gold production from the Liberty Bell mine on Eva Creek where stringers of quartz and sulphides are emplaced along foliation planes of the Totatlanika schist near granitic intrusives. Gold-bearing arsenopyrite is the principal ore mineral and is associated with pyrite, chalcopyrite, and bismuthinite (Moffit, 1933, pp. 340-345), (no. 5, fig. 5).

A number of other gold-quartz lodes have been staked in this district but no development work has been done (Capps, 1912, pp. 52-54).

A "few carloads" of lead-silver ore were reported as being produced from a lode on California Creek, but no information concerning the location of the property is available (Capps, 1940, p. 186), (no. 6, fig. 5).

Valdez Creek district. — The Valdez Creek district includes the drainage basin of Valdez Creek (no. 7, fig. 5). Bedrock includes Mesozoic greenstone, tuff, limestone and schist which have been intruded by dioritic stocks.

Several prospect lodes containing gold and minor amounts of other metals have been staked on the south side of Valdez Creek between Denali and Eldorado Creek. The lodes occur as fissure veins, disseminated deposits and mineralized shear zones in both the metamorphosed sedimentary rocks and the intrusive diorite (Ross, 1933b; Tuck, 1938). None of the prospects have been developed to the production stage.

Chulitna district. — The Chulitna district includes the upper basin of the Chulitna River (no. 8, fig. 5). Bedrock includes: Devonian(?) to Triassic metamorphosed sedimentary rocks and interbedded volcanics intruded by Tertiary(?) acidic bosses, dikes and sills, and Eocene(?) coal-bearing sediments.

Lode deposits in this district are generally valued for their gold content, although a few contain up to 10 percent copper in small quantities.

The mineralized area is about 2 miles wide and extends from Costello Creek to Long Creek, and appears again on Ohio Creek, 7 miles farther southwest (Capps, 1919b; Ross, 1933a).

Sulphides are irregularly distributed and seldom exceed 50 percent of the lode matter. Arsenopyrite is the most abundant ore mineral. Chalcopyrite, galena, and sphalerite also are found at nearly every prospect, although, with two possible exceptions, they do not occur in commercial quantities.

The Ready Cash claim on Ohio Creek (no. 8, fig. 5) contains more silver, galena and sphalerite than most of the other claims. Small quantities of argentite and a silver telluride are thought to be the source of the larger amount of silver (Ross, 1933a, pp. 318-320).

The Golden Zone Mine, located at the head of Bryn Mawr Creek no. 8, fig. 5 is the only property in the district which has been actively developed. Gold-bearing arsenopyrite, pyrite and minor amounts of sphalerite, chalcopyrite, galena, malachite, and stibnite(?) occur along a shear zone in a small quartz-diorite stock intruded into metamorphosed sedimentary rocks (Ross, 1933a, pp. 321-325).

A gold prospect and an antimony prospect have been staked on Antimony Creek, a short distance east of the railroad. Both are associated with intrusives which cut a series of metamorphosed argillites and graywackes (Capps, 1919b, p. 229), (no. 9, fig. 5).

Yentna district. — The Yentna district includes the area drained by the Yentna River and its northern tributaries (fig. 5). . . Bedrock in the district is predominantly Mesozoic slate and graywacke overlain in places by Tertiary coal measures. Mesozoic granitic intrusive masses and associated dikes cut the Mesozoic sedimentary rocks in many localities.

No metalliferous deposits are known to occur in the Yentna district other than a few gold-quartz veins which have been found in the basin of Cache Creek. The bedrock source of the placer gold is believed to be the quartz veins which cut the Mesozoic graywacke and slate in the vicinity of granitic intrusives (Capps, 1913). Cassiterite and platinum also occur in the placers of the district (Mertie, 1919).

An investigation of an occurrence of radioactive minerals in gold placer deposits in the Cache Creek-upper Peters Creek area was made in 1945 (Robinson, Wedow and Lyons, 1946) and disclosed that deposits on both creeks contain small amounts of uraninite(?) in addition to slightly radioactive accessory minerals. The concentration of radioactive material was found to be insufficient to constitute a feasible source of supply and no search for a possible bedrock source of the uraninite(?) was made.(no. 10, fig. 5).

Iliamna Lake-Lake Clark area. -- The Iliamna Lake-Lake Clark area arbitarily includes the portions of the Alaska and Aleutian Ranges and adjacent territory in the general vicinity of the above mentioned lakes (fig. 6). . . The bedrock includes Paleozoic gneiss, schist and limestone and somewhat less metamorphosed Mesozoic sedimentary rocks, all of which have been intruded by a granitic batholithic.

The majority of lode deposits in this area are valued for their copper and gold content, although silver and iron also occur in significant quantities.

Three properties, the Dutton, Duryea and Durand claims are located several miles southeast of Pile Bay (Capps, 1935, pp. 91-94). The Dutton and Duryea lodes are along the contact between a metamorphosed Triassic limestone and an older greenstone, both of which have been intruded by small andesite dikes. The Dutton ore body (location 1, fig. 6) is a zone 200 feet wide, located chiefly in the limestone. The ore consists of chalcopyrite and pyrite with very minor amounts of molybdenite. The Duryea claims (location 2, figure 6) are about 2 miles south of the Dutton prospect and contain fissure deposits of silver-bearing galena and sphalerite in the limestone. Small nodules and masses of black manganiferous iron oxide have been found locally at the surface. Assays are reported to go as high as 196 ounces of silver, $20 gold, 35 to 50 percent lead and 15 to 20 percent zinc per ton.

The Durand claims (location 3, figure 6) are situated about 2 miles northeast of the Dutton and Duryea claims on a shear zone in the greenstone, with chalcopyrite, pyrite, and copper carbonates being reported. No production has taken place at any of these properties although considerable development work has been done.

Two copper prospects have been located near the shores of Iliamna Lake. The Millet property (location 4, figure 6) is located 22 miles west of Iliamna village. The mineralized zone is along a limestone-diabase contact and is from 22 to 42 feet wide for 3,500 feet along the strike. Chalcopyrite, pyrite and copper carbonates are the chief ore minerals. Several trenches and shafts have been put down but no production has taken place (Capps, 1935, p. 92).

At the Knutson prospect (location 5, figure 7), 2 miles east of the entrance of Knutson Bay, a 3- to 8-foot quartz vein cuts the granite wall rock. The vein is reported to be slightly and irregularly mineralized with copper and gold (Martin and Katz, 1912, p. 123).

Several metalliferous deposits occur in the general vicinity of Lake Clark, including a silver-lead, a copper and two molybdenum prospects.

The Thompson silver-lead prospect (location , figure 6) is located on a tributary of the Kijik River, 7 miles northwest of Kijik (Moxham and Nelson, in preparation -a). Arsenopyrite, galena, chalcopyrite, and pyrite in a gangue of calcite and rhodochrosite have been deposited in a shear zone in the granite wall rock. Very little development work has been done. Thompson, the owner of the prospect, has also located molybdenite, apparently also in the granite. The site has not been visited by any Geological Survey parties.

On Kasna Creek (location 7, figure 6) east of Lake Clark limestone country rock has been replaced by several parallel mineralized zones. The predominent ore minerals are specular hematite and chalcopyrite with a very small amount of copper carbonates (Capps, 1935, p. 92). Development work is now being carried out to determine the extent and tenor of the ore body.

A molybdenum deposit has been reported 10 miles northeast of the north end of Lake Clark, on the upper Kijik River. Only fragmentary reports are available and indicate that the molybdenum occurs in a pegmatite cutting the granite country rock. No development work has been done (Smith, 1917, p. 153).

The McNeil copper prospect (location 8, figure 6) is located near the mouth of Crevice Creek, a tributary of Paint River. Ore occurs in pockets in metamorphosed limestone in close proximity to acid intrusives. Rich chalcopyrite ore has been reported and assays also show significant silver. The prospect is about 17 miles from the tidewater and was accessible in former years by trail and wagon road, now overgrown with brush. About 10 tons of ore have been shipped to the Tacoma smelter (Mather, 1925, p. 173).

All of the mining properties in the Iliamna Lake-Lake Clark area described above, except the Durand, Knutson and molybdenite prospects were investigated by the Geological Survey in 1949 for possible radioactive ores. Nothing of economic interest was found (Moxham and Nelson, in preparation -a).

Talkeetna Mountains

Chulftna district. -- A portion of the Chulitna district is included in the northwestern Talkeetna Mountains in the vicinity of the southward bend of the Susitna River. Several lode deposits are known in this area, the most important of which is the Mint Mine, a ruby-silver prospect located on Portage Creek 9 miles east of Chulitna Station no. 11, fig. 5).

At this site, a series of slates have been intensly brecciated and silicified by the intrusion of andesite dikes. Quartz and sulphides, including pyrargyrite, miargyrite, arsenopyrite, chalcopyrite, galena, and tetrahedrite, have been deposited in the brecciated zones. A 40 pound selected sample assayed about 118 ounces of silver per ton. Insufficient development work has been done to determine the size or tenor of the ore body (Capps and Short, 1926).

Three lead-silver claims have been staked in the valley of Portage Creek but no development work consequence has taken place and little is known of the mineral constituents (Waring , ms.).

Talkeetna district. — The Talkeetna district embraces roughly the area drained by the Talkeetna River (fig. 5).

A granodiorite batholith of Mesozoic age forms the core of the Talkeetna Mountains. In this district the batholith has intruded andesite flows of unknown age and Triassic sedimentary rocks, predominantly limestone, slate, and argillite.

Claims on several copper lodes have been staked in the basin of Iron Creek, about 30 miles above its mouth (no. 12, fig. 5). The prospects occur as vein fillings along shear zones in amygdaloidal lava flows. Many of the ore bodies show abundant copper carbonates and bornite in a shallow oxidized zone. The primary metallic minerals are pyrite, chalcopyrite, arsenopyrite, specular hematite and a little gold (Capps, 1919a). None of the prospects have been developed to the production stage.

On the basis of the considerable amount of hematite reported at nearly all of the Iron Creek prospects, it would be advisable to check these deposits for radioactivity.

Matanuska and Wasilla districts. — The western part of the Matanuska district and the eastern part of the Wasilla district are known as the Willow Creek mining district (no. 13, fig. 5). This district lies on the southwest flank of the Talkeetna Mountains where a granodiorite batholith is in contact on the south with the pre-Cambrian Birch Creek schist and Tertiary sedimentary units.

The district is notable for gold production, having been the second most productive lode district in Alaska before World War II.

The gold veins are found along the south periphery of the batholith and were formed by fissure filling and replacement of the wall rock along fractures. Minor amounts of tetrahedrite, galena, pyrite, sphalerite, chalcopyrite, and scheelite are associated with the gold, but only gold is found commercial quantity (Ray, 1933).

A copper-bearing pegmatite has been located at the head of Purches Creek (no. 14, figure 5) and copper lodes have been staked in the valleys of Montana Creek and Kashwitna River, but little development work has been carried out (Ray, 1933, p. 184).

A group of claims have been staked on a copper prospect in a gneissic phase of the granodiorite at the head of Moose Creek (no. 15, fig. 5). The ore body is reported to be conspicuous due to a red gossan. The ore minerals are pyrrhotite, pyrite, and chalcopyrite with minor amounts of sphalerite. Assays show gold, silver, and some nickel. No development work has been done (Capps, 1940, p. 178).

In 1947 an investigation was made for radioactivity in areas adjacent to the highways in south-central Alaska (Moxham, 1950a). All of the operating gold mines in the Willow Creek area were checked underground, and dump material was tested at other localities. The copper-bearing pegmatite at the head of Purches Creek was investigated and every major bedrock type was tested. The results of this work failed to disclose any radioactive material of interest. In 1949 a brief examination of the pegmatite dikes of the Willow Creek area has shown that although some dikes are slightly radioactive due to very minor amounts of uraninite, thorite and other thorium-bearing minerals disseminated in the dike material, none are of economic interest (Moxham and Nelson, in preparation -b).

Uranium possibilities of the Alaska Railroad-Iliamna region

Several of the districts of the Alaska Railroad-Iliamna region warrant investigation for uraniferous materials because some of the lode deposits contain mineral assemblages suggestive of the presence of uranium. These lodes are:

1) High-grade silver-lead veins in the Kantishna Hills in the Kantishna district.
2) Silver-lead-zinc ores at Mount Eielson in the Kantishna district.
3) Copper deposits in mineralized shear and breccia zones on Iron and Slippery Creeks, also in the Kantishna district.
4) Gold-arsenopyrite quartz veins containing bismuthinite at the Liberty Bell mine, Nenana district.
5) Complex gold-silver sulphide ores on the West Fork of the Chulitna River and a silver-prospect on Portage Creek, both in the Chulitna district.
6) Hematitic copper ores on Iron Creek in the Talkeetna district.

In addition, the occurrence of uraninite(?) with cassiterite in placers of the upper Peters Creek drainage basin, Yentna district, also warrants investigation.

Lower Yukon-Kuskokwim region

The only occurrence of uranium in the Lower Yukon-Kuskokwim region (fig. 7) of Alaska that might be of some significance is in the Russian Mountains, a few miles east of Aniak, north of the Kuskokwim River, in the Akiak district. At this locality zeunerite occurs in a copper deposit in quartz veins cutting granitic rock. Uranium has also been found in contact gold-copper deposits in the McGrath district; in zircon, an accessory mineral of monzonite, in the Iditarod district; and in thorite disseminated in granite in the Ruby district.

The geology of the Lower Yukon-Kuskokwim region is known mostly on a reconnaissance scale and the known lode deposits were discovered incidental to the search for placer gold which is almost the only commodity that can be mined economically in the region.

The occurrence and distribution of the mineral deposits, other than gold, in this region are described in the following discussions of the districts. Brief statements of known radioactive material are also included. Where geologic and physiographic similarities permit, districts have been combined and discussed as a unit.

The major portion of the data on the districts of the Lower Yukon-Kuskokwim region has been abstracted from papers by Brown (1926), Capps (1935), Eakin (1918), Harrington (1918), Maddren (1915), Mertie (1937a ; 1938, 1940), Mertie and Harrington (1924), Moxham (1950b), Smith (1917), White and Killeen (1950; in preparation), and White and Stevens (in preparation -a; -b).

Marshall and Anvik district

Bedrock in the Marshall and Anvik districts (fig. 7) is exposed along the right bank of the Yukon River and in the highlands adjacent and to the north of the river. The oldest rocks are Carboniferous greenstones, and include metamorphosed tuffs, flows, and intercalated sedimentary rocks, with some altered basic intrusives(?). The source of much of the placer gold in these districts is thought to be gold-bearing quartz veins and stringers that cut the greenstone in most of the placer mining localities. These rocks are overlain by Upper Cretaceous sedimentary rocks, which are primarily clastic in origin. The igneous rocks of the districts include late Mesozoic and some early Tertiary bodies of soda granite, quartz diorite, and diorite, and andesite and dacite flows. The intrusive rocks are thought to be the ultimate source of the gold-quartz mineralization found in the greenstone.

Lode deposits occur on the north side of the Yukon River a few miles upstream from Marshall (fig. 7). A development known as the Arnold Lode has been opened on quartz veins and stringers cutting greenstone country rock. Minerals that have been found in the veins include calcite, pyrite, galena, molybdenite, wulfenite, anglesite, limonite, and free gold. In one vein, chalcopyrite is found in association with much magnetite, and iron oxide and copper carbonate material. Antimony mineralization is reported from the hills south of the Yukon, near the Kuskokwim River.

The few concentrates available from placer mining operations contain little or no radioactive material. No rock samples or lode material from the districts have yet been tested for radioactivity.

Iditarod district

In the Iditarod district (fig. 7 Upper Cretaceous clastic sedimentary rocks have been intruded by Upper Cretaceous(?) basic igneous rocks and early Tertiary(?) monzonite.

Most of the mineralized rock in the district is found near Flat and is associated with two small stock-like monzonite intrusives.

Stibnite, cinnabar, gold and scheelite occur in quartz veins in the monzonite and along the contact of the monzonite with the Cretaceous sedimentary rocks. None of these minerals, however, have been found in sufficient quantity to be of any economic importance.

An investigation for radioactive material was conducted in the vicinity of Flat in 1947 but no deposit of significance was located. The only radioactive material found is in zircon and other minor accessory minerals disseminated in the monzonite. The zircon contains approximately 0.14 percent uranium (White and Killeen, in preparation).

Ophir district

Most of the Ophir district(fig. 7) is underlain by Upper Cretaceous and Eocene sedimentary rocks. Small areas of Tertiary igneous rocks are scattered throughout the district and include: basic intrusives ranging in composition from diorite to pyroxenite; andesite and basaltic flows and associated tuffs interbedded with some sandstone and shale; and some granitic rocks, mainly monzonite.

The monzonite intrusives may be the source of the placer gold and the few lode deposits that have been found. These lode deposits occur as scattered quartz-stibnite-cinnabar-bearing veins, generally near the contact of the monzonite with the sedimentary rocks.

Placer concentrates from the gold-mining operations and some of the rocks have been tested for radioactivity with negative results. No radioactive mineral deposits were found during a brief spot examination of placer mining sites on the west slopes of the Cripple Creek Mountains in the eastern part of the district (White and Killeen, 1950).

Kaiyuh and Ruby districts

The Kaiyuh and Ruby districts are largely underlain by a middle Paleozoic metamorphic rock sequence. In the southern part of the Ruby district in the headwaters of the Nowitna River is a series of conglomerate, grit, sandstone and shale of Cretaceous and possibly Eocene age.

Pleistocene silt and gravel is found throughout both districts. In the gold producing areas of the Ruby district silt fills some valleys to a depth of 50 to 75 feet. Mesozoic(? granitic rocks occur as small stock-like masses in the districts. Eocene(?) soda-granite dikes in the vicinity of Poorman amd below Ruby on the left bank of the Yukon River are the youngest rocks of the area.

Placer gold has been the only material mined profitably in the Kaiyuh and Ruby districts. Cassiterite is abundant in some of the placer gravels but is not present in sufficient amount to be of economic importance. Bismuth has been reported from the placer gravels at two localities in the district. The lode source of the gold, tin, and bismuth has not been found.

A silver-lead prospect is located at the head of Beaver Creek about 15 miles south of Ruby. The deposit consists of highly oxidized galena-bearing veins cutting quartz-mica schist, but is not of sufficient size to be of economic importance. Another silver-lead lode is reported in the Kaiyuh Mountains, about 30 miles south of Galena.

Radioactivity studies were made in the Ruby district in the summer of 1949 (White and Stevens, in preparation -b). The only radioactivity detected in the district was that of two small granite intrusive masses located a short distance east of Long (fig. 7). These rocks contain approximately 0.005 percent eU. This radioactivity is due to a disseminated dark green, uranium-bearing thorium silicate minerals, probably thorite. This mineral contains, besides thorium, 8 percent uranium, and minor amounts of cobalt and bismuth. The silver-lead prospect at the head of Beaver Creek contains no radioactive material.

Cosna district

The oldest rocks of the Cosna district (fig. 7) include metamorphic, sedimentary, and igneous rocks of both intrusive and volcanic origin, mostly of Paleozoic age. Overlying these rocks is a series of sedimentary and volcanic rocks of late Paleozoic or early Mesozoic age.

There is but little additional geological information on the district and no information on possible mineral deposits.

No radioactivity investigations have been made in the district, and no radioactive mineral deposits have been reported.

Bethel and Akiak districts

The rocks of the Bethel and Akiak districts (fig. 7 include widespread sedimentary and associated volcanic rocks ranging in age from Mississippian(?) to mid-Tertiary or later. The volcanic rocks include a greenstone formation and the sedimentary rocks include graywacke, argillite, chert and limestone, and their metamorphic equivalents. The intrusive rocks include a pre-Upper Cretaceous gneiss and igneous rocks of Tertiary(?) age. The compositions of the intrusive rocks range from gabbro and diabase to granite.

Quartz-cinnabar-stibnite mineralized rock is found throughout the Georgetown district, northeast of the Akiak district, and extends into Bethel and Akiak districts. Small amounts of platinum are recovered from the gold dredging operations at Nyac, south of Aniak.

Minor amounts of copper are reported from scattered localities throughout the Bethel and Akiak districts. Two copper prospects, on Mission Creek and on Cobalt Creek, are located in the Russian Mountains, a few miles north of the Kuskokwim River and 15 miles east of Aniak (fig. 7 . These mountains consist of a quartz monzonite-granite stock intruded into Cretaceous sedimentary rocks. The copper is found in quartz veins cutting the granitic rock. The metallic sulphides are arsenopyrite, chalcopyrite, and pyrite. Chemical analyses of other samples from the area show the presence of minor amounts of gold, silver and tin.

No field investigation for radioactivity has been made at either of the above copper localities although samples of the oxidized ore from both localities have been studied in the laboratory. A sample from the prospect on Mission Creek contain minor amounts of zeunerite (Moxham,1950b). It is possible that a radiometric reconnaissance in the Russian Mountains might reveal the presence of significant deposits of uranium.

Georgetown district

Most of the bedrock of the Georgetown district (fig. 7 consists of upper Cretaceous and Eocene sandstone, shale, grit, and conglomerate, with some slate and quartzite, which is locally intruded by dikes and small stock-like bodies of granitic and basic intrusive rocks. A minor amount of quartz-cinnabar and quartz-cinnabar-stibnite mineralized rock occur in zones associated with the granitic or basic dikes in the sedimentary rocks. Arsenopyrite is locally common.

The few samples and localities of this mineralization that have been tested with counters were significantly radioactive. Cassiterite is present in the placer gravels of Julian Creek, a west fork of the George River, a tributary of the Kuskokwim River at Georgetown. A radioactivity investigation at this locality (White and Killeen, 1950) was conducted with negative results.

McGrath and Tonzona districts

The rocks in the McGrath and Tonzona districts (fig. 7) include a sequence of pre-Ordovician(?) metamorphosed sedimentary rocks overlain by sedimentary rocks of mid-Paleozoic, Permian, Upper Cretaceous and Eocene(?) age. The igneous rocks include lava flows of late Paleozoic or early Mesozoic age; basalt, andesite, rhyolite flows, and olivine diabase and gabbro dikes of Tertiary age; and Tertiary intrusive stocks of monzonite and granite---the latter being the source of many of the mineral deposits that have been found in the district.

Successful gold-mining operations have been conducted a few miles west of McGrath, at Candle Creek, a tributary near the mouth of the Takotna River; and 35 miles northeast of McGrath at the Nixon Fork mines, on the upper Nixon Fork of the Takotna River. Radiometric tests of samples from the placer mine on Candle Creek were negative (White and Killeen, 1950).

Radioactivity investigations were conducted in the vicinity of the Nixon Fork mines in 1949 (White and Stevens, in preparation -a). Both the placer and lode deposits were radioactive. The placer radioactivity is due primarily to traces of uranium-bearing thorianite, the source of which could not be located. Tin- and bismuth-bearing minerals also occur in the placer gravels. The radioactivity in the lode deposits is due to thorium and uranium associated with gold-copper ores in a contact zone between limestone and monzonite. The thorium is mainly in allanite, and minor amounts of uranium are found in carbonate and silicate minerals, such as parasite, vesuvianite and garnet.

Radiometric traverses were made at a gold placer and gold lode locality on Eagle Creek, a few miles south of the Nixon Fork mines (White and Stevens, in preparation -a). The heavy mineral concentrates from the placer gravels were found to be appreciable radioactive, due to minor amounts of thorianite, but no significant radioactivity was detected in any of the bedrock exposed in the stream valley, or at the placer and lode mining operations. Fluorite is also found in the concentrates.

Goodnews district

The Goodnews district (fig. 7 is the principal producer of platinum metals in United States territory.

In this district, late Paleozoic(?) sedimentary rocks, in part metamorphosed and associated volcanic rocks have been intruded by essentially unmineralized granitic rocks and ultrabasic rocks. The ultrabasic rock includes several varities of peridotite and perknite and is the source of the platinum mined from nearby placer gravels. Chemical examination of the ultrabasic rock shows the presence of chromium, nickel, and copper but none of these elements have been found in commercial quantity. Minor amounts of cobalt are associated with the platinum metals.

No data is available at this time on radioactivity in the rocks of the Goodnews district nor have there been any reports of radioactive mineral deposits. Some concentrates from platinum placer mining operations have been tested and found to be almost non-radioactive.

Tikchik, Nushagak, Mulchatna and Togiak districts

A large area of the Tikchik, Nushagak and Mulchatna districts (fig. 7) is covered by unconsolidated clastics gravel, sand, silt, and clay, mostly of Pleistocene to Recent age, but some of which may be as old as Pliocene or Miocene. Mississippian(?)-Permian and Cretaceous sedimentary rocks are exposed in the highlands around the Tikchik Lakes, and the hills surrounding the heads of the Nushagak and Mulchatna Rivers.

Tertiary granitic rocks intrude the Cretaceous sedimentary rocks near the Tikchik Lakes and the upper Mulchatna River. Little is known about the geology of the Togiak district.

Virtually no information is available on the radioactivity of the rocks of these districts. Radiometric tests on a few placer concentrates from the districts show no radioactivity.

Uranium possibilities of the Lower Yukon-Kuskokwim region

The occurrence of minor amounts of zeunerite, with an ore containing chalcopyrite, arsenopyrite and pyrite in the Russian Mountains suggests that high-grade uranium ores may be associated with the copper mineralization in this area.

The gold-galena-molybdenite mineralization in the Marshall district may also be worthy of investigation.

Upper Yukon region

No significant deposits of uranium have yet been found in the Upper Yukon region (fig. 8) of Alaska. Traces of uranium-bearing thorianite have been found in gold placers of the Fortymile district and the Wiseman district, and traces of a black mineral, probably of the euxenite-polycrase series, have been found in gold placers of the Tolovana district. Ellsworthite, eschynite, columbite and monazite occur in the tin placers in the Hot Springs district. The bedrock sources of these radioactive minerals, however, have not been located.

The geologic formations occurring in the region include rocks belong in age to practically all of the systems and many of the epochs from the pre-Cambrian to Recent. The sedimentary rocks show a wide range in lithologic composition, from the highly metamorphosed pre-Cambrian rocks to the slightly consolidated sand and gravel of the Quaternary. Igneous rocks of both extrusive and intrusive origin form notable components of the geologic sequence of rocks exposed in the region.

The mineral deposits that have been most developed in the Upper Yukon region are those in which the principal valuable mineral is gold, and primarily placer gold, but deposits containing other valuable metals such as tin, tungsten, antimony , and lead, have been found.

In the discussion of the districts of the Upper Yukon region that follows, none is included for the Melozi, Sheenjek, Black, Kandik, Preacher, Yukon Flats, Dall, and Goodpaster districts, because little or no information is available on them.

The information used in compiling the geological and mineralogical summaries of the districts of the Upper Yukon region were taken from both published and unpublished data of the Geological Survey. The principal published sources are: Chapin (1914), Eakin (1916), Hill (1933), Kindle (1908), Maddren (1912, 1913), Mertie (1917, 1925, 1930, 1931, 1933, 1937b), Mertie and Harrington (1924), and Prindle (1913).

Wiseman, Alatna, and Hughes districts

The Wiseman, Alatna and Hughes districts (fig. 8) include most of the territory drained by the Koyukuk River. Very little information, geological or otherwise, is available regarding the valley of the Koyukuk. What little is known about the rocks of the districts, indicates that the stratigraphic section includes locally metamorphosed sedimentary rocks, Pre-Cambrian to mid-Paleozoic and of Cretaceous age, and intrusive rocks of undetermined ages.

Lead, silver, copper and antimony are the only commercial metals, besides gold, that have been reported from the valley of the Koyukuk.

However, the only mineral deposits profitably mined in the Koyukuk River valley are placers located mainly in: (1) The Indian River-Hughes area, in the central part of the Koyukuk valley; (2) The Hogatza River area, in the Hughes district; and (3) The upper Koyukuk area, which includes that portion of the Koyukuk valley lying north and northeast of Bettles and the country near Wiseman. The larger part of the placer production from the region has come from the upper Koyukuk area. Three zones of sulphide mineralization have been located in the upper Koyukuk valley.

In the Alatna district near the headwaters of the Alatna River on the divide with the Noatak River is a pyritiferous, gold-bearing zone of Pre-Cambrian(?) schist. The zone is 6 to 7 miles wide, and the gold seems concentrated in six or more heavily mineralized beds, ranging in thickness from 10 to 75 feet, which also contain chalcopyrite, bornite, malachite, and stibnite.

In the Wiseman district about 40 miles above the mouth of John River, is a sulphide-bearing zone in the Birch Creek schist. The zone is several miles wide and trends northeast-southwest. It ranges from iron-stained schist to a highly altered, hematitic gossan deposit. The iron is apparently derived from the decomposition of sulphides, which are abundant in the schist.

Also in the Wiseman district, but to the east of the John River, just south of Anuktuvuk Pass, is a sulphide-bearing zone approximately 2 miles wide. The rocks in the zone are iron-stained and in places carry considerable purple hematitic capping. Most of the stain is apparently surficial, and is derived from the decomposition of the sulphides disseminated in the rock.

The two mineralized zones in the Wiseman district are related to formational boundaries, and both trend, in a general way, parallel to the major regional structure.

The only development work ever reported on a lode deposit in the Koyukuk valley is on the Silver King, located about 2½ miles above the mouth of Michigan Creek, an east tributary of the Wild River. At this locality argentiferous galena and quartz have been found in several exposures of dark phyllite or slate, but none are rich enough to mine. Galena has been found in the placer concentrates from several of the creeks in the upper valley of the Koyukuk and has been reported in rocks from various localities in the valley of the Bettles River and to the east of Wiseman. Silver has been reported in small amounts from the Bettles River valley in the northern part of the upper Koyukuk area.

Chalcopyrite, malachite, bornite and pyrite occur with vein quartz in hillside float and gravel in a number of the upper tributaries of the Koyukuk River. Native copper is associated with gold in placers on the Bettles River.

Antimony has been reported in quartz stringers in schist in the vicinity of Wiseman and in a mineralized zone on the divide between the Alatna and Noatak Rivers at the western edge of the Koyukuk valley.

No field investigations for radioactivity have been conducted by the Geological Survey in the Koyukuk River valley. The few specimens of mineralized bedrock that have been tested have proven to be non-radioactive, as have most of the few samples of heavy mineral concentrates available from gold placer mining operations. One of these concentrates, however, contains approximately 0.03 percent equivalent uranium and is from the Gold Bench mine on the South Fork of the Koyukuk River, about 30 miles south of Wiseman. The radioactivity is due to traces of thorianite. The concentrate consists primarily of magnetite, hematite, and garnet, but carries traces of galena, chalcopyrite, cinnabar, bismuthinite, and cassiterite. The bedrock source of the minerals is not known (White, in preparation -c).

Chandalar district

The Chandalar district comprises almost the entire drainage basin of the Chandalar River (fig. 3). Bedrock is exposed mainly in the area drained by the main forks of the upper Chandalar River. The sedimentary rocks include Pre-Cambrian rocks, probably the equivalent of the Birch Creek schist of the Circle and Fairbanks districts; Paleozoic sequences, largely metamorphosed; and Upper Cretaceous shale and conglomerate. The igneous rocks include Paleozoic granitic gneiss, basic intrusives and lava flows, generally altered to greenstone; Mesozoic granodiorite and related intrusives; and Tertiary basaltic lavas and intrusives.

The only mineral that has been mined profitably in the Chandalar district is placer gold. A few gold lode prospects are found in the central part of the district east of Chandalar Lake where gold and sulphides occur in quartz veins cutting early Paleozoic schist. The most abundant sulphide is arsenopyrite, but some stibnite, galena, and sphalerite are found. Pyrite, locally, is common, and siderite has been observed in some of the veins. The country rock adjacent to the quartz veins contains numerous oxidized pyrite crystals which has caused considerable iron-staining. Large amounts of hematite occur in concentrates from the gravels at various placer mines in the district.

There have been no field investigations for radioactive material in the Chandalar district. The only samples from the district that have been tested are the concentrates from the placer mines. Some of these are moderately radioactive, but the radioactivity is attributed to thorium in monazite (White, in preparation -c).

Tozi district

The Tozi district (fig. 8) on the north side of the Yukon River in the vicinity of the junction of the Yukon and Tanana Rivers and includes the Tozitna River basin, and the area drained by all streams entering the Yukon River directly south of the Tozitna basin.

The rocks of the district include a thick sequence pre-Cambrian(?) to Paleozoic metamorphic rocks that are largely of sedimentary origin.

The meta-igneous rocks include both greenstones and granitic rocks; the latter now altered to augen-gneiss and mica schist. This metamorphic sequence is intruded locally by Mesozoic(?) granite and monzonite with some diorite. The geology of much of the Tozi district is unknown, only the area adjacent to the Yukon has been investigated; and that by reconnaissance. At present placer gold is the only mineral that can be mined profitably in the Tozi district. The gravels at the headwaters of Tozimoran Creek, a west tributary of the Tozitna River, and Morelock Creek, a tributary of the Yukon River about 35 miles upstream from Tanana, carry an appreciable percentage of cassiterite. A radiometric examination of a number of concentrates from the gravels of both these localities have failed to show any significant radioactivity. Silver-lead ore has been found at two localities in the district. One is in the headwaters of Tozimoran Creek about 30 miles northwest of Tanana (Killeen and White, 1949) and the other is on Quartz Creek, a small tributary of the Yukon River about 3 miles below Morelock Creek (White and Stevens, in preparation -c). The galena is found in quartz and calcite stringers and veins cutting quartz-mica schist. Field investigations for radioactive materials were made at both of these localities with negative results.

In 1946 a counter traverse was made of the Grant Creek area, 30 miles below Tanana, to attempt to locate a reported occurrence of pitchblende. No radioactive minerals were found (Killeen and White, 1949). In 1949 an area of granitic rock cut by the Yukon River about 50 miles above Tanana was traversed radiometrically. No significant radioactivity was detected, nor was any significant mineralization found (White and Stevens, in preparation -c).

Porcupine district

The Porcupine district lies in the northeastern part of the Upper Yukon region (fig. 8). To date the only geological investigations in the district have been reconnaissance studies along the Porcupine River and the international boundary. Most of the rocks studied consist of thick sequences of pre-Cambrian and Paleozoic sedimentary rocks intruded by granite on the international boundary.

In 1948 reconnaissance for radioactive materials were undertaken on the Porcupine River (White, in preparation -a) and on the Coleen River (White, 1950b). These reconnaissances included radiometric traverses on sections of Silurian, Mississippian, and Devonian black shales, but none contained over 0.005 percent equivalent uranium. Rhyolitic dikes associated with a granite intrusive, along the international boundary, a few miles north of the Porcupine River contain a maximum of 0.006 percent equivalent uranium due to small amounts of disseminated radioactive minerals. No mineralization was found associated with this granite intrusive.

Occasional reports are received of lead and copper ores in the remote and virtually unexplored area of the headwaters of the Coleen River. The only authenticated mineral deposit in the Porcupine district is from a prospector who submitted a report of spectrographic analysis that showed the presence of 0.1 to 0.01 percent gallium in white, aluminum silicate rocks said to have come from a point on the Coleen River 50 miles above its mouth and from the Porcupine River immediately above the mouth of the Coleen River.

Rampart and Hot Springs districts

The districts of Rampart and Hot Springs (fig. 8) are located in the south-central portion of the Upper Yukon region, in the angle formed by the junction of the Yukon and Tanana Rivers.

Sedimentary rocks of Paleozoic, Mesozoic, and Cenozoic age and granitic rocks of Cenozoic age underlie the Rampart and Hot Springs districts. The sedimentary rocks adjacent to the granitic rocks are locally metamorphosed and mineralized.

Placer gold mining is the principal mineral industry in the Rampart and Hot Springs districts. A by-product of this mining is tin. The source of the tin has not been found.

Radioactivity investigations were made in the district during the summer of 1948 (Moxham, in preparation -a). Heavy mineral concentrates from the placers of many of the creeks were found to be moderately radioactive due to the presence of minor amounts of ellsworthite, eschynite, columbite, monazite, and zircon. A search throughout much of the district with traverse counters failed to reveal the bedrock source of these radioactive minerals.

Some development work has been done on a lode known as the Barret prospect about 5 miles northwest of Hot Springs. Although the initial development at this prospect was for gold, the commercial metals are silver and lead. The lode consists of veins in a shear zone in schist. Argentiferous galena is the chief sulphide, but small quantities of chalcopyrite, pyrrhotite, and pyrite are also present. Limonite is abundant and associated with it is some hematite and siderite. Erythrite (pink cobalt bloom) has been found both in quartz stringers and in crevices in the schist country rock. This deposit was not found to be significantly radioactive.

Tolovana district

The Tolovana district (fig. 8) lies to the northwest of the Fairbanks district. Much of the mining activity in the district is centered around the town of Livengood, about 82 miles by road northwest of Fairbanks.

The bedrock of the district consists primarily of two sedimentary sequences of Paleozoic rocks; one of Devonian age, and composed chiefly of clastic rocks; the other of Mississippian age, and composed chiefly of chert and silicified limestone. Both extrusive and intrusive Paleozoic basic igneous rocks are closely associated with the sedimentary rocks. In the central part of the district dikes and small stock-like masses of granitic rocks, thought to be of Tertiary age, intrude the sedimentary rocks. The granitic rocks may be the principal source of what mineralization has been found in the district.

Very few deposits containing sulphides have been reported in the Tolovana district. A few gold lode prospects have been located and partly developed in the headwaters of some of the creeks containing placer gold. These prospects are in gold-quartz stringers and veins cutting schist and contain arsenopyrite, and pyrite.

A search for radioactive materials in the district was made in the summer of 1946, but no significant radioactive deposits were found (Wedow and Matzko, 1947). Mississippian black shales in the district contain no more than 0.002 percent equivalent uranium. The source of a black pitchy mineral, probably one of the euxenite-polycrase series, found in a concentrate of placer gravels on a tributary of Livengood Creek, was not located (Wedow, Stevens, and Tolbert, in preparation).

A traverse made by car along the highway between Fairbanks and Livengood in 1949 discovered no significant radiation anomalies (Wedow, Stevens, and Tolbert, in preparation).

Fairbanks district

The Fairbanks district (fig. 8) is located north of the Tanana River in the south-central portion of the Upper Yukon region. Its placers and lode mines have produced more gold than any other district in Alaska.

The district is almost entirely underlain by the pre-Cambrian Birch Creek schist. This schist is predominantly of sedimentary origin and has a considerable range of composition. The chief rock types, however, are quartz-mica and quartzite schist. Minor amounts of augen-gneiss and crystalline limestone are also present. Numerous dikes and stock-like masses of granitic rock of Mesozoic(?) age intrude the

Birch Creek schist. These granitic rocks range in composition from a granite to a diorite and are thought to be the source of the sulphide and gold mineralization in the district.

The lodes of the Fairbanks district fall into two general categories--gold and tungsten.

The gold lodes of the district are mostly fissure veins or mineralized zones cutting the Birch Creek formation, usually fairly close to bodies of intrusive acidic rock. The mineralized zones are usually silicified schist with closely-spaced quartz veinlets. Although most of the gold lodes consit only of quartz with gold, a few of the deposits contain sulphides in economic amounts. The average sulphide content of the lodes, however, is only about 2 percent. The sulphide minerals that have been found in the lodes of the Fairbanks district are galena, stibnite, pyrite, arsenopyrite, sphalerite, bismuthinite, with isolated occurrences of argentite, chalcopyrite, and tetrahedrite. Only the stibnite and galena have been found in commercial quantity.

Tungsten in the Fairbanks district occurs as scheelite in ore shoots and mineralized zones, and calcareous schist. Minor amounts of scheelite have been extracted from gold-bearing quartz veins.

Fluorite is reported as abundant near the head of Hope Creek in the northeastern part of the district, where it occurs with pyrite in quartz veins cutting schist. The veins appear to be genetically related to a nearby tourmaline granite.

A preliminary investigation for radioactive mineral deposits was made in the Fairbanks district in the summer of 1946 (Wedow and Matzko, 1947). A majority of the placer mining localities, and gold, sulphide and tungsten lode mines and prospects were examined for radioactivity, but no significant amounts were detected. Since 1946 spot radiometric examinations have been made at several additional lode mines and prospects with negative results.

It is believed that the Fairbanks district holds no great promise for possible high-grade uranium deposits. It is suggested, however, that the occurrences of vein fluorite mentioned above be checked for radioactivity.

Circle district

The Circle district (fig. 8) lies on the southwest side of the Yukon River in the east-central portion of the Upper Yukon region. Most of the known bedrock underlying the district is the quartz-mica schist and quartzite schist of the pre-Cambrian Birch Creek Schist formation. Intruding this formation, particularly in the highlands of the eastern headwaters portion of Birch Creek are Mesozoic(?) granite intrusives. This granite is probably the primary source of what mineralization has been found in the district.

The Circle district has long been a prominent producer of placer gold, the only mineral commodity that has been produced in the district. A few lode prospects have been located, but have been of no economic importance. Wolframite and cassiterite are prominent constituents of the placer concentrates from Deadwood Creek located a few miles west of Circle-Hot Springs. Minor amounts of arsenopyrite and galena are also found.

In 1949 a brief radioactivity investigation was made in the district (White and Tolbert, in preparation). Radiometric traverses were made on the granite and the granite-schist contact around the headwaters of all of the streams where mineralized rock was indicated. Common accessory minerals associated with the granite were all that were radioactive. Only a small portion of the bedrock of the district was tested during this investigation.

Fortymile district

The Fortymile district (fig. 8) is located in the southeast corner of the Upper Yukon region. The bedrock of the district consists of various Pre-Cambrian and Paleozoic metamorphic rocks of both sedimentary and igneous origin. In the central and northern portions of the district these rocks are intruded by large bodies of Mesozoic(?) granitic rocks. In the southern part of the district late Mesozoic or early Tertiary volcanic rocks, principally rhyolite and dacite, cover extensive areas. Minor amounts of Tertiary volcanic rocks and coal-bearing sedimentary rocks are also found.

In 1949 radioactivity studies were made in the central part of the district in and on the borders of some of the granitic intrusive rocks where radioactive mineral deposits had been reported (Wedow and Tolbert, in preparation -a). No significant uraniferous deposits were found in any of the rocks examined during this investigation.

In 1950 the new Fortymile Highway was traversed with carborne counter equipment, from its junction with the Alaska Highway several miles east of Tok Junction to a point about 10 miles east of the village of Chicken (fig. 8). The only radiometric anomaly found on this traverse is in a highly weathered, altered granitic rock on the west slopes of Mount Fairplay. The anomaly is due to radioactive zircon (White and Nelson, in preparation).

Traces of uranium-bearing thorianite are found in two heavy mineral concentrates from a placer gold mine on Atwater Bar on the South Fork of the Fortymile River near Chicken. The source of the mineral is not known (White, 1950a).

Eagle district

The Eagle district (fig. 8) is located south of the Yukon River on the eastern edge of the Upper Yukon region.

Much of the district is relatively unknown geologically. Only the areas immediately adjacent to the Yukon River have been studied in any detail (Mertie, 1930). The known geologic section ranges from pre-Cambrian to Tertiary in age, and includes a great variety of rock types, sedimentary, volcanic and intrusive. Placer gold is the only metal that has been mined in the Eagle district. No significant lode deposit has ever been discovered. The primary source of the placer gold may be in the granitic rocks.

Radioactivity studies of the rocks in the Eagle district were made in 1948 (Wedow, in preparation -a). Mesozoic granitic rocks, Tertiary clastic rocks derived from the earlier granites, and adjacent gold placer gravels contain radioactive zircon and allanite. Near the base of the upper Mississippian Calico Bluff formation on the Yukon River black shale beds contain between 0.005 and 0.01 percent equivalent uranium. Pellets and nodules of phosphatic material scattered through some beds of these radioactive black shales contain up to 0.02 percent equivalent uranium.

Uranium possibilities of the Upper Yukon region

As previous reconnaissances for radioactive materials have already eliminated a number of leads in the Upper Yukon region, the only reasonably accessible mineral occurrence suggestive of uranium is in the quartz-pyrite-fluorite veins attendant to a tourmaline granite intrusive on Hope Creek in the northeastern part of the Fairbanks district. In the northern part of the region radioactive minerals occur in concentrates from placers in the Koyukuk and Chandalar basins. A number of these concentrates also contain considerable hematite and traces of a variety of sulphides, both suggestive of a highly mineralized area. This part of the region, however, is probably both too remote and too little known to warrant investigation for radioactive ores at this time.

Copper River region

The review of geologic literature for an appraisal of the uranium possibilities of the Copper River region in east-central Alaska (fig. 1) has not yet been completed, and the outlook for uranium in the region as presented in this report is not final.

The Copper River region is one of the most richly mineralized regions in Alaska. The gold and copper deposits have been the best developed.

Copper deposits are widespread in the region and are found as: (1) fissure veins and replacement deposits in the country rock, primarily limestone; (2) contact metamorphic deposits in limestone adjacent to granitic intrusives; and (3) in amygdules in lava flows. The fissure veins and replacement deposits are the most important and are best illustrated by the deposits of the Kennecott mine in the Chitina River valley in the central part of the region. At this mine thick Carboniferous or Triassic lava flows (called greenstones) are overlain by about 2,000 feet of Triassic dolomitic limestone. Most of the important copper mineralization is in the limestone, but the source of the copper is thought to be the greenstone. The ore consists of chalcocite with small amounts of bornite, covellite, enargite, galena, luzonite, pyrite, silver, sphalerite and tennantite.

Localities in the Copper River region that might be of interest from the standpoint of the uranium possibilities are:

1) On the Kotzina River in the Kuskulana district (fig. 1) quartz veins cut shale and contain argentiferous tetrahedrite, as the principal ore mineral, with lesser amounts of galena, chalcopyrite and bismuth. In the same vicinity there is abundant specular hematite in association with chalcocite ores of a type similar to those found at the Kennecott Mine.
2) On Rex Creek in the Nizina district (fig. 1) stibnite, pyrite, molybdenite and cinnabar occur as vein(?) fillings.
3) At the Orange Hill mine in the Chisana district (fig. 1) a gold lode contains minor amounts of molybdenite, native bismuth, chalcopyrite, pyrite and pyrrhotite.
4) At the Nabesna mine in the Chisana district a copper-gold deposits with chalcopyrite, copper carbonates, magnetite, limonite, pyrite, marcasite, pyrrhotite, galena and sphalerite occurs in well-mineralized fissure veins and replacement bodies in limestone.

Gulf of Alaska region

Review of geologic literature for an appraisal of the uranium possibilities of the Gulf of Alaska region is not yet complete. The partial data available, however, suggest that several districts in this region are favorable for the occurrence of uranium. The favorable data on these districts are summarized as follows:

1) In the Kodiak district gold quartz veins contain varying amounts of one or more of the minerals arsenopyrite, pyrite, chalcopyrite, galena and sphalerite (Capps, 1937, p. 174). Limonite and hematite(?) are also reported, mostly as products of surficial oxidation of the sulphides. These veins are probably genetically related to a granite mass that occupies the central axis of Kodiak Island. Uranium is rumored to occur in a lode deposit on Raspberry Island, in the northeastern part of the Kodiak group.

2) The mineral deposits at Nuka Bay (Capps, 1938, pp. 25-32) Nuka district, on the south coast of the Kenai Peninsula, contain gold, silver and copper in their native form, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, tetrahedrite, covellite, and chalcocite. Arsenopyrite is predominent. In 1936 the deepest mining had reached a depth of only about 200 feet. There is no evidence of secondary enrichment, but locally, the sulphides are considerably oxidized. Hematite occurs as a reddish jasperoidal material and in small veinlets in greenstone at the west end of Port Dick southwest of Nuka Bay (Martin, Johnson, and Grant, 1915, p. 237).

3) The Hope district on the Kenai Peninsula contains a number of auriferous quartz veins and mineralized dikes (Martin, Johnson and Grant, 1915, pp. 129-177). The sulphide content of these lode, however, is low. The principal metallic minerals are

arsenopyrite, galena, sphalerite and pyrite with subordinate amounts of chalcopyrite and pyrrhotite, and, locally, molybdenite. A silver prospect in a mineralized sheeted-zone occurs on Bear Creek (Martin, Johnson and Grant, 1915, p. 178-179) with galena, pyrite, and arsenopyrite as the ore minerals. No native silver has been found in the lode but nuggets of the native metals are reported in the placers of the Bear Creek and in Palmer Creek to the south.

4) Gold prospects in quartz veins and a mineralized dike occur on the north side of Passage Canal east of Whittier in the Wells district (Johnson, 1914, pp. 233-234). The veins are reported to contain gold, pyrrhotite, chalcopyrite, sphalerite and galena. The mineralized dike is highly altered and contains quartz, calcite, a cream-colored, brown-weathering carbonate, arsenopyrite and galena. According to Mendenhall (1900, p. 306) fluorite also occurs in the quartz veins on Passage Canal.

5) On Jackpot Bay west of Chenega in the Latouche district, a vein deposit contains an abundance of arsenopyrite, galena and sphalerite (Grant and Higgins, 1910, p. 76). Moderated gold and silver assays are reported.

6) Hematite is reported at two localities on Hinchinbrook Island (Grant and Higgins, 1910, p. 79) in the Cordova district. At one locality soft red hematite heavily stains the slate country rock and also occurs as small veinlets in fractures.

The hematite occurrence at the other locality is in a vein 2 feet wide.

Aleutian region

Relatively few mineral deposits of economic value have been found in the Aleutian region and none are in production at present. Mining has been confined almost exclusively to the production of gold from beach placer deposits. Several million dollars in gold was produced from one lode early in the century. No lodes are known to have been discovered in recent years and little information is available on known deposits. For this reason the data presented below has been restricted to a tabulation of the metalliferous deposits together with a brief description of the mineral association. The information has been compiled chiefly from a report by Atwood (1909).

District	Location	Description
Shumagin	Shumagin Mine, Unga Island	Quartz veins carrying low values in gold
Shumagin	Sitka Mine, Unga Island	Low-grade ore body in a dacite-andesite country rock. The ore consists of free gold, galena, sphalerite and pyrite.
Shumagin	Apollo Mine, Unga Island	Ore body in a fracture zone in andesite and dacite country rock. The ore minerals include free gold, pyrite, galena, sphalerite, chalcopyrite, and native copper. This mine produced several million dollars in gold, but the main ore shoot has been worked out.

Shumagin	Popof Island	Several gold claims have been staked on lodes in the hills immediately south of the beach placers on Popof Island. Gold occurs in a zone of oxidation which varies from 5 to 10 feet in thickness. Very little development work has been done and the property has been abandoned for many years.
Chignik	Prospect Bay	Several claims have been staked on a ore zone at the head of Prospect Bay. Pyrite, galena, sphalerite and chalcopyrite have been reported. No development work has been done.
Chignik	Mallard Duck Bay	Several claims have been staked on a mineralized zone in andesitic lavas. A zone from 4 to 6 feet wide and at least 100 feet long has been found. Galena, sphalerite, and pyrite have been reported. No development work has been done.
Aleutian	Unalaska Island	South of Dutch Harbor for several miles the rocks are cut by a system of vertical joint planes some of which carry auriferous quartz. The only lode known to have been worked is located on the shore of Captains Bay. The ore body proved to be low-grade. Assays show a small amount of gold and a trace of silver. No development work has been done here for many years.
Chignik	Prospect Bay	Claims have been staked on an ore zone in coarsely crystalline granite. Galena, sphalerite and chalcopyrite are the predominent ore minerals. No development work has been done.
Shumagin	Balboa Bay	Copper minerals have been reported from a shear zone on the east shore of Balboa Bay. Several prospects have been located but no development work has been done.

Northern Alaska

The data on the mineral deposits of northern Alaska has not yet been thoroughly reviewed in connection with this appraisal of Alaskan uranium possibilities. However, uranium is known to occur in small amounts in two different rock types of the region.

Uraniferous sedimentary phosphate rock occurs in the Mississippian Lisburne limestone on the north flank of the Brooks Range (Wedow, in preparation -b), and has been found at localities on the Anaktuvuk River, Chandler Lake, the Kiruktagiak River and the Etivluk River (fig. 2). In general the phosphate rock from Arctic Alaska is very similar in appearance and composition to the bedded phosphates of the Permian Phosphoria formation in northwestern United States. The best known exposures of the phosphatic beds are on the Kiruktagiak River, where a zone of oolitic phosphate, phosphatic shale and limestone is about 40 feet thick. Random samples taken at this locality average 31.95 percent P_2O_5, 0.11 percent V_2O_5, 0.015 percent equivalent uranium and 0.013 percent uranium. The highest uranium content, 0.021 percent U, was from a bed ½-foot thick at the base of the zone.

Samples of the Pre-Cambrian(?) "Okpilak" gneissic granite near Mount Michelson at the eastern end of the Brooks Range (fig. 2) contain up to 0.008 percent equivalent uranium (White, in preparation-b). The heavy mineral fractions from three of four samples (average concentration ratio 30:1) contain an average of 0.052 percent equivalent uranium and 0.03 percent uranium. Although most of the uranium appears to occur in biotite; fluorite, molybdenite, pyrite and hematite associated with uranium elsewhere, are also disseminated in the granite. Concentrates from the gravels of several streams draining the outcrop area of the granite contain traces of galena and scheelite in addition to the four minerals mentioned above.

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