Metalliferous Lode Deposits of Alaska

By HENRY C. BERG *and* EDWARD H. COBB

GEOLOGICAL SURVEY BULLETIN 1246

An inventory of the mines and prospects of Alaska and their geologic settings

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 67-279

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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ABSTRACT

An important factor in any rebirth of metal mining in Alaska will be a thorough appraisal of the metalliferous lodes already known in the State. Any such appraisal probably will depend, at least in part, on an inventory of these deposits and a knowledge of their geology.

This report summarizes from reports of Federal and State agencies published before August 31, 1965, the geology of Alaska's metal-bearing lodes, including their structural or stratigraphic control, host rock, mode of origin, kinds of minerals, grade, past production, and extent of exploration. In addition, the lists of mineral occurrences that accompany the 35 mineral-deposit location maps constitute an inventory of the State's known lodes. A total of 692 localities where metalliferous deposits have been found are shown on the maps. The localities include 1,739 mines, prospects, and reported occurrences, of which 821 are described individually or otherwise cited in the text.

INTRODUCTION

PURPOSE AND SCOPE OF REPORT

To help fill requests concerning the mineral resources of Alaska, the U.S. Geological Survey in 1961 published an index of the State's mineral deposits (Cobb and Kachadoorian, 1961). This index contains page references to data on mines, prospects, and reported occurrences of metallic and nonmetallic deposits in Alaska, compiled from reports published before January 1, 1960, by Federal and State agencies. The index, together with eight mineral commodity maps prepared by the Geological Survey (Cobb, 1960a, b, c, d; 1962, 1964a, b, c), constitutes an important part of an up-to-date appraisal of the State's natural resources—an appraisal that probably will have an important bearing on Alaska's long-term development.

It is recognized, however, that most of the reports referred to by Cobb and Kachadoorian (1961) are out of print and no longer purchasable from any official source. Thus, it may often be difficult or even impossible for interested persons without access to large university or government libraries to obtain data on mineral deposits in Alaska.

The present report, which summarizes from all reports published before August 31, 1965, the economic geology of the metal-bearing lodes in Alaska, makes available once again an important part of these data. It is intended not only for those concerned with evaluating or exploiting the lodes that have already been discovered but also for those searching for new ore deposits, as a desirable preliminary to prospecting for metalliferous lodes is to acquire as much information as possible about the deposits that are already known. This report provides some of that information by describing, wherever known, the geologic setting of Alaska's lodes—their structural control, mode of origin, host rock, kinds of metallic minerals present, grade, past production, and the extent to which they have been explored.

It will be evident, however, even to the casual reader, that knowledge of Alaska's metalliferous lodes is far from complete, for by the time even the earliest geologists and engineers were able to examine the mines and prospects, many had lain idle for years and were caved or otherwise inaccessible. Moreover, most of the first scientists who came to Alaska had to study large areas in a relatively short time and could therefore conduct only cursory examinations of mineralized sites; their reports, although classic, nevertheless reflect the reconnaissance nature of their investigations. Thus, despite our efforts to summarize all that has been published on the geology of Alaska's lodes, in many instances only detailed on-site examinations will answer the questions of the prospector, geologist, mining engineer, or mineral economist.

ORGANIZATION AND METHOD OF PRESENTATION

This report is arranged by mining regions and mining districts, geographical subdivisions whose boundaries, defined by the U.S. Bureau of Mines (Ransome and Kerns, 1954), mostly follow major drainage divides (pl. 1). We adopted this classification, which is largely independent of geology, chiefly for convenience and simplicity, but it also minimizes the tendency to sort our data by metallogenic provinces or to speculate on regional geologic controls that have governed the formation of certain mineral deposits—subjects that are beyond the scope of this report.

The 14 mining regions and the 67 districts included in them are arranged in alphabetical order and are accompanied by maps showing the locations of all known mines, prospects, and reported mineral occurrences. To conserve space, adjoining districts that are small or contain only a few lode mineral localities, are combined on single maps. Each locality has been given a number that corresponds to a citation in the text. The descriptions of the lode deposits of each mining region or each district (in the case of the Yukon River region) are prefaced by brief summaries of the physiography and general geology of the area. For convenience, these summaries are supplemented by maps (pl. 1) that show the physiographic provinces of Alaska and the distribution of the major rock units in the State.

The principal method by which we have undertaken to meet the two-fold objective of this report—to make an inventory of Alaska's lodes and to describe their geology—is to describe briefly the productive lodes, most of the more thoroughly explored nonproductive lodes, and all unusual mineral occurrences, whether productive or not. In addition, every mine, prospect, and reported occurrence known in Alaska is accounted for in the lists of localities that accompany figures 1–35.

Not every listed occurrence, however, is described individually in the text. To do so would make the report unnecessarily long and repetitive, for most groups of neighboring occurrences have similar geologic settings, and, for the purposes of this report, descriptions of one or two typical occurrences serve for all. For example, on figure 7, which shows the locations of lodes in the Valdez Creek district, locality 4 includes six listed occurrences, of which the four best known are described individually in the text, whereas the others, whose geologic setting is similar, are referred to only in a general way. Similarly, if several numbered localities are headed by the name of a geographic area, as, for example, on figures 7 and 8, a description of the general geology of the lodes in the area is followed by individual descriptions of the best known or most productive deposits and those that are geologically atypical.

Each occurrence cited in the text is accompanied by a number in parentheses that corresponds to a locality on one of the maps. To save space, the figure number of the map is given only once in each section—with the first occurrence. All succeeding locality numbers in the section are on the same figure.

Despite our efforts to make this report as complete as possible, certain occurrences are omitted because the discoverer or owner did not wish information on his claim to be made public; the discoverer failed to stake a claim or otherwise make his discovery known; or the report of the occurrence is entirely unsubstantiated. In addition, among Alaska's thousands of lode deposits, many of which were prospected and abandoned before 1900, it is inevitable that a few have been "lost" or have inadvertently been overlooked in our inventory.

Because of Alaska's great size, the maps used in this report are of comparatively small scale and consequently do not show many of the geographic features that must be referred to in giving the locations of some of the mineral deposits or geologic features. Wherever possible, we have tried to relate these locations to a physical feature large enough to appear on the map, but in some cases this was not possible. All geographic names cited in this report, however, do appear on 1:250,000-scale (1 inch=approx. 4 miles) or larger scale topographic maps published by the U.S. Geological Survey; the reader who is interested in locating a deposit or geologic feature precisely is urged to consult the appropriate topographic map. (All map sheets referred to herein are 1:250,000-scale topographic maps published by the U.S. Geological Survey. Indexes to these maps and copies of the topographic sheets may be obtained from the Geological Survey in Fairbanks, Alaska; Denver, Colo.; or Washington, D.C.)

DIVISION OF RESPONSIBILITY

In preparing the report, Cobb assembled most of the data for the sections on the Kuskokwim River, northern Alaska, northwestern Alaska, and southeastern Alaska regions. Berg prepared the rest of the material from the original sources and revised Cobb's sections to make them compatible in format, style, and detailed content with the rest of the text. Cobb prepared figures 1–35 and the list of selected references.

DOLLAR VALUES

Much of the gold recovered from lodes in Alaska was produced before 1934, the year the price of the metal was raised from $20.67 to $35 a fine ounce. Similarly, most of the gold assays were made in the early 1900's, when the lower price prevailed. Consequently, except where otherwise indicated—either by a post-1934 production figure or by a specific date of assay—all dollar values for gold production and gold assays cited reflect a price of $20.67 an ounce.

SOURCES OF INFORMATION AND ACKNOWLEDGMENTS

Most of the data in this report are taken from previously published reports of the U.S. Geological Survey. Other important sources are publications of the U.S. Bureau of Mines, State of Alaska Division of Mines and Minerals and its predecessor agency, the Alaska Territorial Department of Mines, and unpublished documents in the files of the Geological Survey. In general, the coverage of published reports coincides with the references to metalliferous lode deposits cited by Cobb and Kachadoorian (1961, p. 345–363), but it also includes all pertinent reports published before August 31, 1965.

Although most of the material is from published sources, we are indebted to many of our colleagues in the Geological Survey for generously providing unpublished data on lode deposits in the parts of Alaska in which they have worked. Special credit is due E. M. MacKevett, Jr., who wrote parts of the descriptions of the Yukon River and Kuskokwim River regions, and to C. L. Sainsbury, who contributed useful data on the lode deposits of the Seward Peninsula.

ALASKA PENINSULA REGION

The Alaska Peninsula region (pl. 1; fig. 1) is the area drained by the Ugashik River, Dago Creek, and all streams flowing into the Pacific Ocean south of Cape Kekurnoi. The region also includes Unimak and Sanak Islands and is classified as a single mining district.

The dominant feature (pl. 1) is the Aleutian Range—glaciated east-trending ridges 1,000–4,000 feet high surmounted locally by volcanoes 4,500–8,500 feet high. Northward the range merges with a low sand- and gravel-mantled plain that has local relief of 50–250 feet.

The geologic units of the Alaska Peninsula region (pl. 1) form two main belts, each of which strikes approximately parallel to the Peninsula. The northern belt, in places as much as 25 miles wide, consists predominantly of unconsolidated sand, silt, and gravel of Quaternary age. The southern belt is made up of Permian to Quaternary sedimentary and volcanic rocks intruded and metamorphosed by granitic plutons. It contains numerous volcanoes, some of which have been active in historic time.

Lodes containing gold, silver, copper, lead, and zinc occur in the Alaska Peninsula region. The most important are on Unga Island (7, see fig. 1) where about $2 million, chiefly in gold and silver, was produced between 1891 and 1904, mainly from the Apollo mine (7). The Apollo ore body, a reticulate network of mineralized fractures in intensely altered (propylitized) andesite and dacite of Tertiary age, consisted of free gold, pyrite, galena, sphalerite, chalcopyrite, and native copper in a gangue of quartz and subordinate calcite and feldspar. Comb structure and crystal druses indicate that the minerals were deposited in open spaces at relatively shallow depths. The main ore body, which averaged about 0.4 ounce of gold per ton, was a northward-plunging shoot 5–40 feet wide and several hundred feet long. Workings consisted of shafts and extensive tunnels, one of which was more than 6,000 feet long. Major operations at the Apollo mine ended before World War I, but sporadic small-scale mining continued until World War II.

In 1908, lode claims were staked on Popof Island (6), where gold was discovered in intensely altered Tertiary andesite. The deposit, similar in many respects to the ones on Unga Island, is 5–10 feet thick and contains as much as an ounce of free gold per ton. A short adit and several shafts were driven, but there is no record of production.

Gold claims were also staked early in the century at Mallard Duck Bay (2) and at the head of Port Moller (4). The Mallard Duck Bay deposit is in andesite and consists of breccia zones contain-

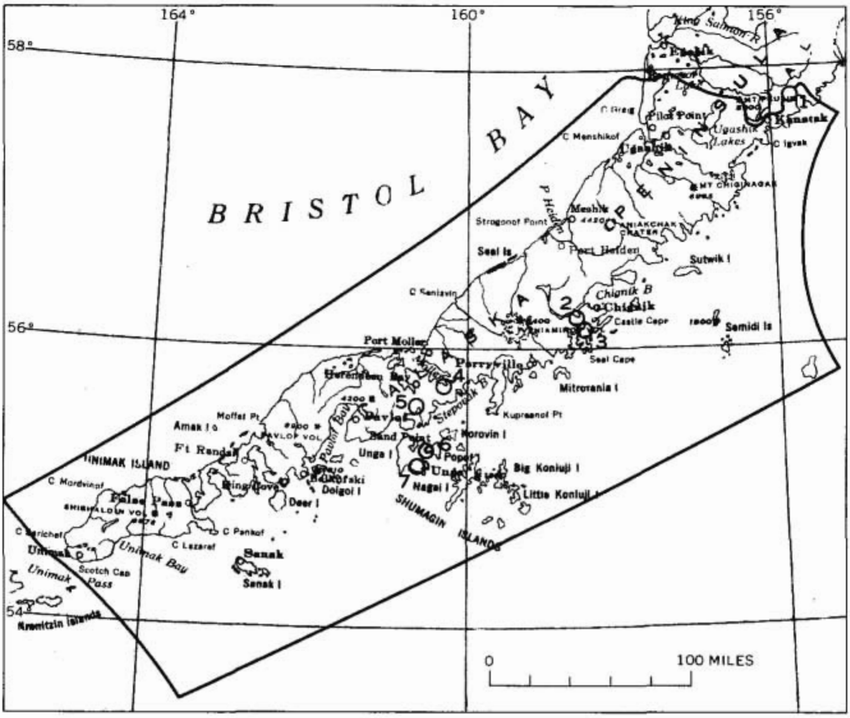

FIGURE 1.—Metalliferous lode deposits in the Alaska Peninsula region.

LOCALITIES

1. *Puale (Cold) Bay
2. *Mallard Duck Bay
3. *Prospect (Warner) Bay
4. *Port Moller
5. *Balboa Bay
6. *Popof Island

Unga Island area

7. *Apollo
   Shumagin
   Sitka

*Cited individually in the text.

ing galena, sphalerite, pyrite, and quartz; the andesite wallrock carries abundant pyrite. The richest zone is 4–6 feet thick and at least 100 feet long. The Port Moller deposit is similar to the one at Mallard Duck Bay but is in basalt. There is no record of production from either deposit.

There are several copper lodes at Prospect Bay (3) and on the east shore of Balboa Bay (5). The deposit at Prospect Bay consists of pyrite-, sphalerite-, and galena-bearing quartz veins in brecciated lava flows of probable Tertiary age. The metallic minerals occur in vugs, mainly in a zone 50 feet wide. The deposit at Balboa Bay consists chiefly of chalcopyrite in a shear zone in Tertiary volcanic rock.

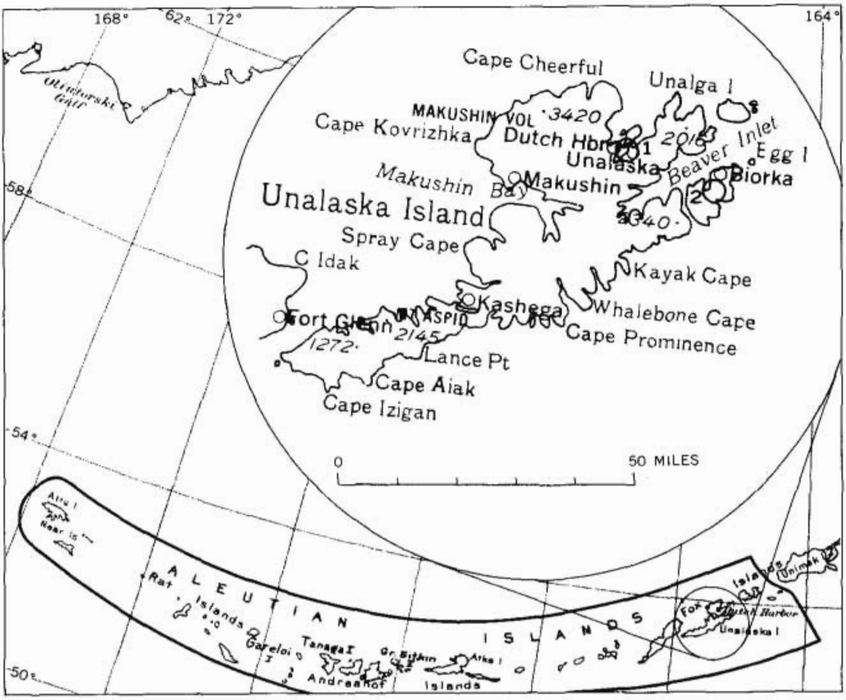

FIGURE 2.—Metalliferous lode deposits in the Aleutian Islands region.

LOCALITIES

1. Amaknak Island
   Pyramid Peak (Captain's Bay)
2. Sedanka Island

The properties were explored in the early 1900's by a few short adits, but no ore bodies were discovered and the claims were abandoned.

In 1920, samples of copper ore reportedly were taken from the mountains near the head of Puale Bay (1), where a lode said to consist of lenses of chalcopyrite reportedly was traced for a mile. Two samples from this lode assayed up to 0.31 ounce of gold and 8.1 ounces of silver per ton and 24.4 percent copper.

Additional information on this region is given in the following reference: Atwood (1911).

ALEUTIAN ISLANDS REGION

The Aleutian Islands region (pl. 1; fig. 2), which includes the islands west of Unimak, consists of an archipelago 1,400 miles long and 20–60 miles wide marked by an arcuate line of 57 volcanoes, 27 of which are still active. The volcanoes rise 12,000 feet from the surrounding sea floor and 2,000–9,000 feet above sea level. Other landforms in the region include wave-cut platforms as much as 600 feet in altitude and glaciated mountainous islands 600–3,000 feet high (pl. 1).

The oldest rocks in the region are Mesozoic and possibly late Paleozoic lava flows, tuff, and clastic beds that are exposed on Adak, Unalaska, and the Near Islands. About two-thirds of the region is underlain by Tertiary and Quaternary basalt and andesite lava flows and tuff that locally are cut by mafic to felsic dikes, sills, and stocks (pl. 1).

Deposits that contain zinc, gold, copper, and lead occur in the Aleutian Islands region, but with the possible exception of a single gold lode on Unalaska Island, none has been productive.

Among several relatively low-grade gold lodes on Unalaska Island, the most noteworthy are near Pyramid Peak (1, see fig. 2). There, eastward-striking vertical quartz fissure veins as much as 7 feet thick cut andesite and contain abundant limonite and sparse gold-bearing sulfides, chiefly pyrite and chalcopyrite. Early prospectors, who drove several adits and built a three-stamp mill about 1900, may have recovered some gold, but no production was recorded.

Pyrite and subordinate chalcopyrite also occur elsewhere on Unalaska Island. Some of the mineralization is in andesite dikes, and some in a granodiorite batholith; all the deposits, however, are small and low grade.

Auriferous quartz veins in altered volcanic rocks have been reported on Amaknak Island (1), possibly near a granodiorite contact. Metalliferous quartz veins also have been reported by prospectors on several of the islands west of Unalaska.

A deposit on Sedanka Island (2), potentially valuable for zinc, consists of quartz and ankerite veins containing sphalerite, abundant pyrite, subordinate chalcopyrite and galena, and small amounts of gold, silver, and cadmium. The veins are in vertical southeast-striking fractures in diorite that forms the hanging wall of a fault which strikes approximately N. 80° E. and dips 55° S. The richest mineralization is near the fault. The footwall is barren fine-grained greenstone. In 1946, the U.S. Bureau of Mines explored the deposit by surface stripping and channel sampling. The average zinc content of 29 samples of a narrow mineralized zone 240 feet long was 6.8 percent; of these, 19 consecutive samples average 9.1 percent zinc, 0.24 percent lead, 0.45 percent copper, and 0.04 ounce of gold and 1.4 ounces of silver per ton.

Additional information on this region is given in the following references: Drewes, Fraser, Snyder, and Barnett (1961); Webber, Moss, and Rutledge (1946).

BERING SEA REGION

The Bering Sea region (pl. 1; fig. 3) includes St. Lawrence, St. Matthew, and the Pribilof Islands. The entire region is considered as one district.

Most of the islands of the Bering Sea region are rolling uplands a few hundred to 1,000 feet high bordered by wave-cut cliffs. St. Lawrence Island, the largest, is chiefly a plain less than 100 feet above sea level surmounted by isolated mountain groups rising to altitudes of 1,000–1,500 feet (pl. 1).

St. Matthew and the Pribilof Islands are almost entirely underlain by late Tertiary and Quaternary basaltic and andesitic flows and associated pyroclastic rocks. The only known exception is a small area of pre-Pleistocene peridotite on St. George Island in the Pribilofs. St. Lawrence Island is underlain mostly by Paleozoic and Mesozoic sedimentary, metamorphic, and volcanic rocks cut by Mesozoic and Cenozoic granitic plutons. The north-central part of the island consists of Tertiary and Quaternary lava flows and tuff (pl. 1). Locally, bedrock is covered by small deposits of Tertiary gravel, sand, and clay.

There has been little prospecting for mineral deposits in the Bering Sea region, owing chiefly to the remoteness of the area and to governmental restrictions. The only lode so far reported is on St. Lawrence Island, where pyrite, chalcopyrite, galena, pyrrhotite, and sphalerite have been found at Cape Puguviliak (2, see fig. 3) and molybdenite, sparse chalcopyrite, and possibly galena near West Cape (1). The sulfide minerals at Cape Puguviliak occur in a calcite vein ½–2 inches thick in a small limestone outcrop; the molybdenite at West Cape is disseminated in a granitic pluton and occurs as thin films on joint planes. Samples from the zone of greatest molybdenite concentration assayed 0.17–0.77 percent MoS_2. Cassiterite has been reported near Boxer Bay, about halfway between West Cape and Cape Puguviliak, but it is not known whether it is in lode or placer deposits.

Additional information on this region is given in the following reference: Anderson (1947).

BRISTOL BAY REGION

The Bristol Bay region (pl. 1; fig. 4) includes the area drained by streams flowing into Bristol Bay from Cape Newenham on the west to and including Egegik Bay on the east, and into Shelikof Strait from Cape Douglas to Cape Kekurnoi. The region is considered as one district.

The region includes parts of two major physiographic provinces separated by a line trending northeastward approximately through the center of the Alaska Peninsula (pl. 1). Southeast of the line are

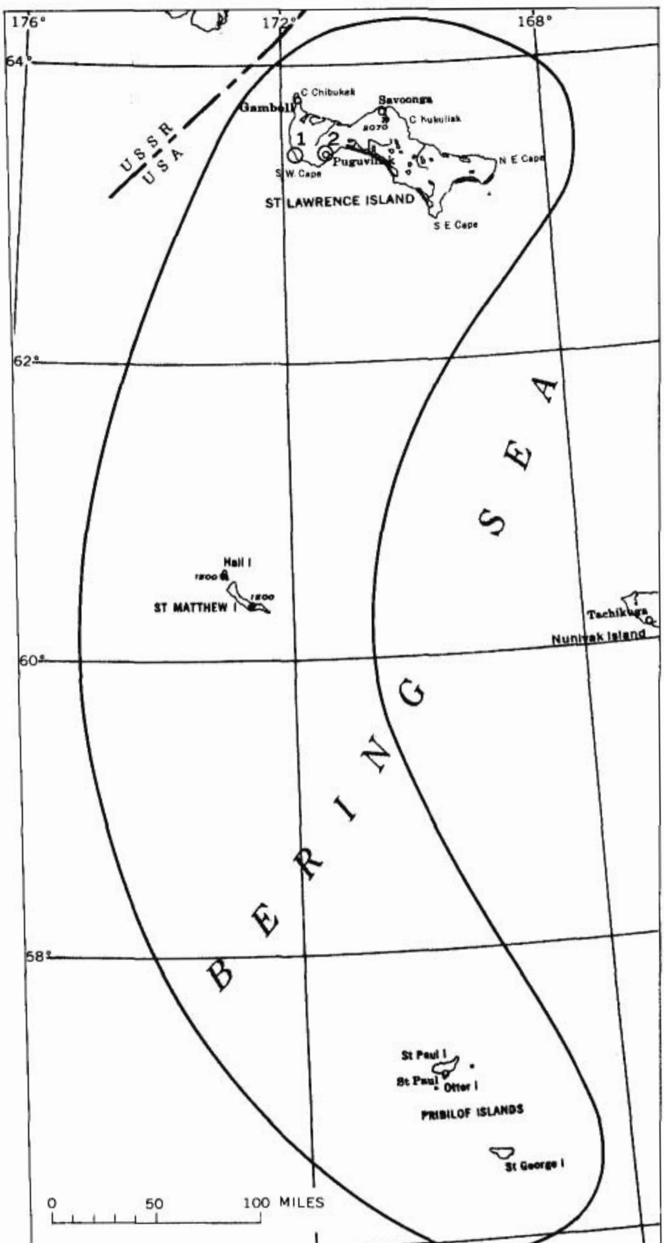

FIGURE 3.—Metalliferous lode deposits in the Bering Sea region.

LOCALITIES

1. *West Cape; Unnamed
2. *Cape Puguviliak (Powooiliak)

*Cited individually in the text.

the highlands and rugged mountains of the Pacific Mountain System; northwest of the line are the low mountains, plateaus, and plains of the Intermontane Plateaus. In many places the boundary is marked by a fault or by a line of granitic stocks and batholiths.

The Pacific Coast mountains consist of rocks ranging in age from Paleozoic to Quaternary. Paleozoic sandstone, shale, and limestone, Tertiary sandstone, conglomerate, and shale, and Quaternary lava flows occur locally, but the most abundant bedded rocks are Mesozoic sandstone, shale, and subordinate metamorphic units. The bedded rocks are cut by felsic and intermediate stocks and batholiths, probably mainly of Mesozoic age, and by felsic and ultramafic stocks and smaller plutons, probably mainly of Tertiary age. Mount Katmai, in the southeastern part of the region, is an active volcano.

About half of the part of the Bristol Bay region that is in the Intermontane Plateaus province is a lowland underlain by thick glacial and alluvial deposits. The lowland is bordered on the northwest by Paleozoic limestone and clastic beds, on the north by Mesozoic sandstone and shale, and on the northeast by Paleozoic to Tertiary metamorphic, plutonic, sedimentary, and volcanic rocks. Cretaceous and Tertiary felsic, mafic, and ultramafic stocks cut the bedded rocks in the northwestern part of the region. The geology of the northeastern part of the region is unmapped.

Lodes containing quicksilver, iron, gold, silver, copper, lead, zinc, molybdenum, antimony, and iron are known in the Bristol Bay region, but little ore has been produced from them.

MERCURY

One of the few Alaskan quicksilver deposits not in the Kuskokwim River region is at the Red Top mine on Marsh Mountain (2, see fig. 4) about 17 miles north of Dillingham. Cinnabar, the only ore mineral, is localized along a 100-foot-wide steeply dipping fault zone cutting folded graywacke and siltstone. The gangue minerals are secondary iron minerals, dolomite, and minor amounts of clay. About 60 flasks of mercury were recovered from the deposit between 1952 and 1955.

IRON

Considerable attention presently (1965) is being focused on iron deposits in the west-central and eastern parts of the region. A large buried low-grade iron deposit near Kemuk Mountain (3) was discovered by airborne geophysical exploration in 1959. According to information furnished by the discoverer, Humble Oil and Refining Co., exploratory diamond drilling disclosed several billion tons of material containing 10.5–12 percent magnetic iron and 15–17 percent total iron. The deposit consists of titaniferous magnetite disseminated in pyroxenite.

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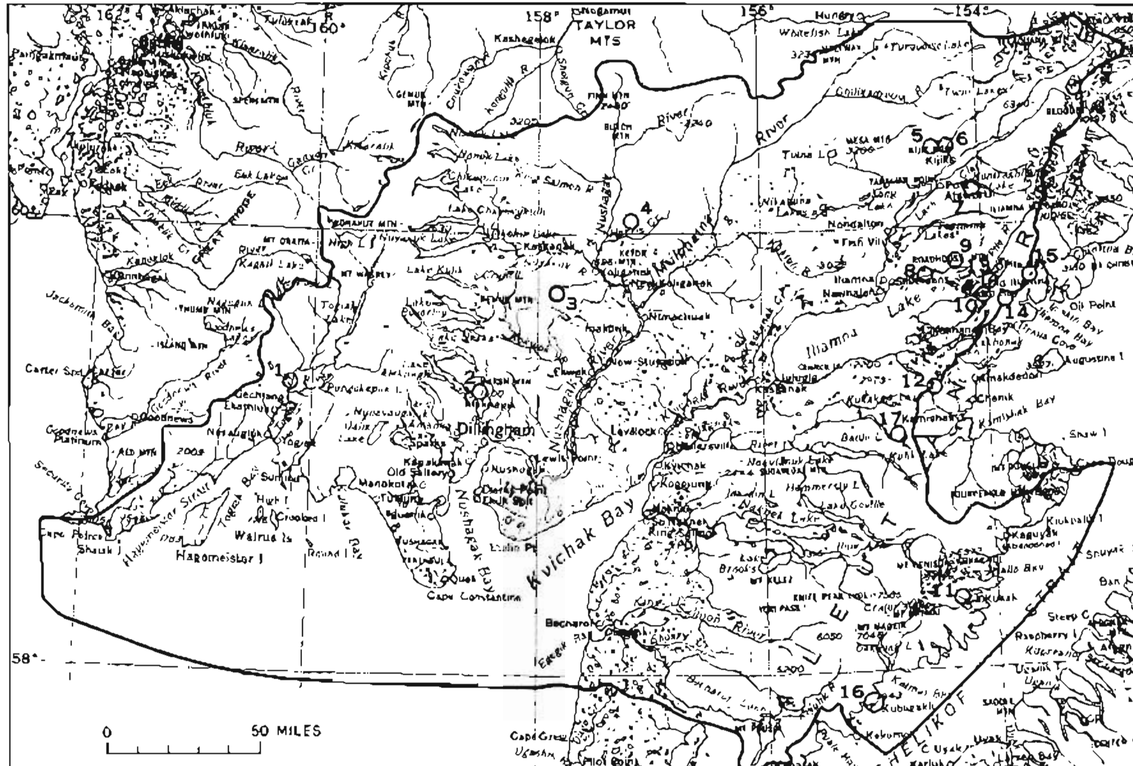

Figure 4.—Metalliferous lode deposits in the Bristol Bay region.

LOCALITIES

1. *Togiak River
2. *Marsh Mountain (Red Top)
3. *Kemuk Mountain
4. *Sleitat Mountain
5. *Thompson (Kijik Mountain)
6. *Thompson
7. *Kasna Creek
8. *Millet
9. *Knutson
10. *Durand

(10.) *Duryea
*Dutton
Pan American Petroleum Corp.

11. *Kukak Bay
12. Pan American Petroleum Corp.
13. Pan American Petroleum Corp.
14. Pan American Petroleum Corp.
15. Pan American Petroleum Corp.
16. *Cape Kubugakli
17. *Battle Lake

*Cited individually in text.

Several iron deposits have been staked east of the north end of Lake Iliamma (10, 12–15). Most are at or near contacts between intermediate to mafic intrusive rocks and metamorphosed volcanic and sedimentary rocks. The deposits are probably large but relatively low grade and consist of veinlets, disseminated grains, and lenses of magnetite in both the intrusive and the metamorphic rocks.

A lode containing appreciable hematite occurs on Kasna Creek (7), near Lake Kontrashibuna. This deposit has been prospected mainly for copper, however, and is described more fully in the following discussion on gold and copper.

GOLD AND COPPER

The metals traditionally sought in the Bristol Bay region have been gold and copper, mostly in deposits near Lake Iliamna. An exception is a gold lode discovered about 1930 near Sleitat Mountain (4), where about $200 in gold was recovered from small quartz veins near the periphery of a small granitic intrusive body. A little wolframite also occurs in a pegmatite vein in the same granitic body (J. M. Hoare, oral commun., 1965).

A lode discovered in 1964 about 2 miles north of Battle Lake (17) consists of a gold- and chalcopyrite-bearing quartz vein in Tertiary volcanic breccia interbedded with lava flows and cut by intermediate dikes. The vein also contains other sulfides and secondary copper minerals.

A low-grade lode that probably is the source of nearby gold placers occurs near Cape Kubugakli (16). It consists of numerous quartz stringers half an inch or less in width that cut fine-grained igneous country rock. Besides gold, some of the stringers carry small amounts of stibnite, molybdenite, galena, and tetrahedrite. The mineralization may be genetically related to dikes that crop out on nearby Mount Kubugakli.

Two silver-bearing deposits are known in the region. One of these, on the Thompson claims (6) about 7 miles northwest of Kijik, is in a shear zone in granitic rock and consists of arsenopyrite and small amounts of argentiferous galena, sphalerite, chalcopyrite, and pyrite; the gangue minerals are calcite and rhodochrosite. Thin veinlets carrying pyrite and a little chalcopyrite also occur along numerous parallel joints in a zone about 200 yards wide. Molybdenite-bearing granitic float has been found on other claims near the top of Kijik Mountain (5).

The other silver deposit is on the Duryea property (10), about 7 miles southwest of the village of Pile Bay. This lode is at the contact of limestone and greenstone and consists of pyrite and silver-bearing galena and sphalerite in fractures in brecciated limestone. The limestone, which is only slightly mineralized, is cut by numerous small andesite dikes. In 1909 the owners of these claims reported assays of 80–196 ounces of silver and up to $20 in gold per ton, 35–50 percent lead, and 15–20 percent zinc. Extensive surface and underground workings, now mostly caved, were developed early in the century, but no ore is known to have been shipped.

Several nonproductive deposits were prospected chiefly for copper. Of the best known properties, four—the Dutton, Millet, Durand, and Knutson—are near the northeastern end of Lake Iliamna, and one (Kasna Creek) is southeast of Lake Clark.

The Dutton claims (10), about 8 miles southwest of the village of Pile Bay, were discovered in 1901, and extensive development work was carried out from 1902 to 1905. The deposits are on the same limestone-greenstone contact as the Duryea lode, which is about a mile to the northeast. The limestone is largely converted to marble, and the greenstone is altered igneous rock originally of dioritic composition. Both limestone and greenstone are cut by numerous small porphyritic andesite dikes. The greenstone and the dikes contain a little pyrite and chalcopyrite, but the principal mineralization is in the limestone, where the largest lode averages 200 feet wide and is about 3,000 feet long. It consists of epidote-garnet-magnetite-calcite marble (skarn) laced with inch-thick veinlets of quartz, calcite, chalcopyrite, and pyrite. A little molybdenite and small masses of malachite are also present. Locally, lenses and layers of magnetite-rich rock occur in the marble, but they are not closely associated with the copper lodes.

The Millet copper prospect (8) consists of metalliferous calcite veins as much as a foot thick in brecciated limestone near its contact with dioritic intrusive rocks. The copper mineralization is associated with numerous dikes that cut the limestone. Metallic minerals consist of chalcopyrite, pyrite, and a little hematite; other minerals include epidote and garnet, which indicate that the mineralization is of contact-metamorphic origin. The mineralized breccia forms a zone 20 to 40 feet thick that has been traced on the surface for about 3,500 feet. The deposit was discovered about 1902, but little work was done until 1949–50, when the U.S. Bureau of Mines explored the property. The exploration program, which consisted of trenching, sampling, mapping, and diamond drilling, indicated two main and four subordinate lodes carrying 0.54 to 1.43 percent copper, a little silver, and a trace of gold.

The Durand prospect (10), about 2½ miles north-northwest of the Dutton claims, consists of a mineralized 10-foot vein in schistose greenstone. The vein, which strikes N. 80° E. and dips 45° N., contains scattered masses of chalcopyrite and pyrite, and small amounts of malachite and azurite. The hanging wall adjacent to the vein is impregnated with pyrite for a thickness of 4 feet. Possible extensions of this lode occur 2 miles to the south, where greenstone is cut by chalcopyrite- and pyrite-bearing quartz veins up to 40 inches thick.

The Knutson prospect (9) reportedly consists of a quartz vein 3–8 feet thick that cuts granite and contains sparse copper minerals and gold. A similar but thinner vein is said to parallel the Knutson vein about a quarter of a mile from the prospect.

The Kasna Creek prospect (7) is on the east side of Kasna Creek, about 2 miles from Kontrashibuna Lake. The deposit, reportedly of contact-metamorphic origin, is in limestone that is cut by dikes and sills of porphyritic basalt. It consists of several parallel zones as much as 250 feet wide and 1,050 feet long that contain specular hematite, subordinate chalcopyrite, and minor sphalerite, magnetite, and pyrite in a gangue of amphibole, chlorite or talc, calcite, and quartz. The limestone and included lodes strike northeast and dip northwest. The Kasna Creek prospect, discovered in 1906, was little known until 1948–49, when the U.S. Bureau of Mines sampled the lode, and conducted metallurgical tests. Their investigations indicated two main deposits averaging 0.69 and 1.14 percent copper, but by eliminating a lower grade part of one of the deposits, the Bureau obtained an average assay of 0.95 percent copper and 27.5 percent iron.

Some work was done on a copper deposit near Kukak Bay (11) about the time of World War I, but the grade, minerals, and geologic setting of this deposit are unknown.

A zinc lode on the west bank of the Togiak River (1) about 20 miles north of Togiak consists of a quartz vein 12–15 inches thick in altered pillow lava cut by diorite. The vein, which is exposed for 25 feet, contains sphalerite and minor amounts of pyrite and chalcopyrite. The sphalerite is coarsely crystalline and nearly black and constitutes about 30 percent of the vein.

Additional information on the region is given in the following references: Capps (1935); Hoare and Coonrad (1961b); Martin and Katz (1910, 1912); Mertie (1938b); Moxham and Nelson (1952); Sainsbury and MacKevett (1960, 1965); Smith (1915); Smith (1925); Warfield and Rutledge (1951).

COOK INLET–SUSITNA RIVER REGION

The Cook Inlet-Susitna River region is the area drained by streams flowing into Cook Inlet between Cape Douglas on the south and Portage at the eastern end of Turnagain Arm. It is divided into five districts: Anchorage, Redoubt, Valdez Creek, Willow Creek, and Yentna.

ANCHORAGE DISTRICT

The Anchorage district (pl. 1; fig. 5) is bounded on the south by Turnagain Arm, on the west and north by Knik Arm, and on the east by the divide between Cook Inlet and Prince William Sound.

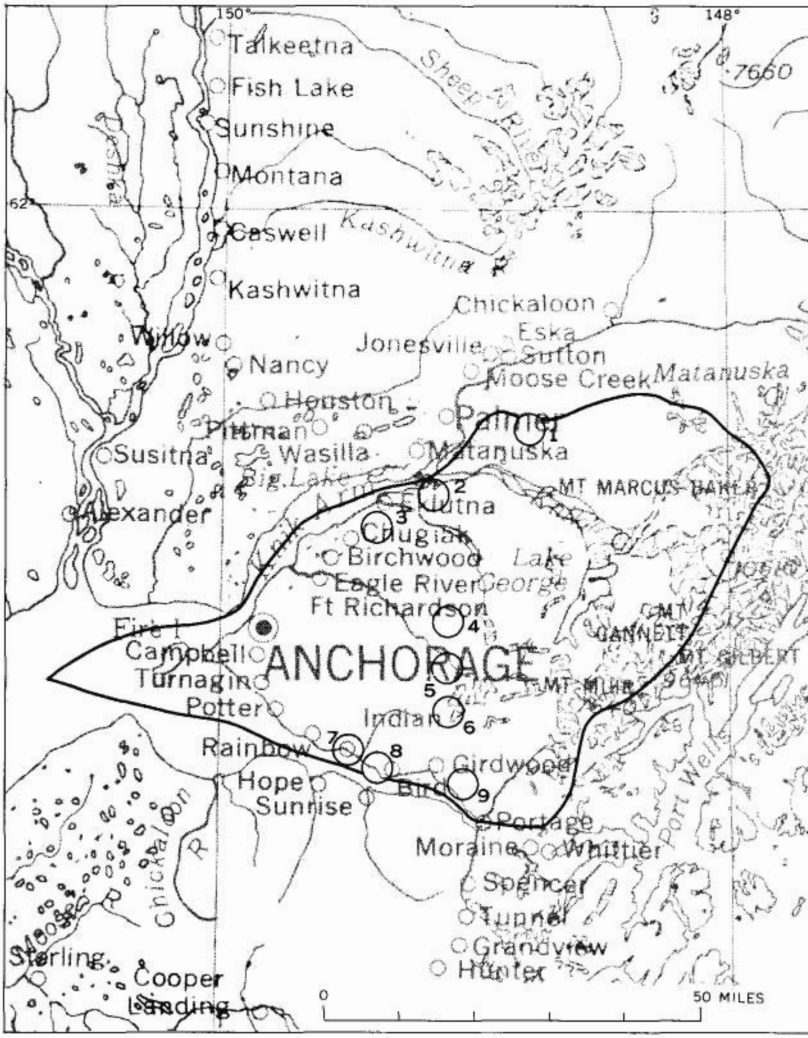

FIGURE 5.—Metalliferous lode deposits in the Anchorage district.

LOCALITIES

1. *Jim Creek
2. *Highway
   *Pioneer Creek
3. *Myers
4. *Peters Creek

Girdwood area

5. *Eagle River
   Unnamed
6. *Agostino

Girdwood area—Continued

(6.) Bahrenberg
   Brenner
   Gunnysack
   Monarch-Jewel

7. *Indian
   *Strong (Indian Creek)
8. *Bird Point
9. *Peterson Creek

*Cited individually in text.

With the exception of a narrow strip of lowland along its northwestern border, the Anchorage district lies within the Kenai–Chugach Mountain province of coastal Alaska (pl. 2). These little-explored rugged mountains are characterized by many peaks more than 5,000 feet in altitude and by extensive fields of perennial ice and snow.

The stratified rocks of the Anchorage district (pl. 1) consist chiefly of graywacke, slate or argillite, and intermediate to mafic volcanic rocks of Mesozoic age, and andesite and basalt lava flows and tuff of Tertiary and Quaternary age. The lowland in the northwestern part of the district is underlain mainly by Quaternary silt, sand, and gravel.

Lodes containing gold, silver, copper, lead, zinc, molybdenum, and chromite are present in the Anchorage district, but they have produced only a small tonnage of gold ore, mostly before World War II.

Several lodes north of Girdwood (5, 6, see fig. 5) were discovered about 1909 and prospected sporadically until about 1941. They consist of thin irregular auriferous quartz veins carrying arsenopyrite and minor amounts of chalcopyrite, argentiferous galena, sphalerite, pyrrhotite, molybdenite, pyrite, and magnetite. The gold commonly is alloyed with as much as 25 percent by weight of silver. The veins, in intensely silicified graywacke and slate, are grouped around small pipelike quartz diorite plutons that cut the bedded rocks. Some of the veins are oxidized to shallow depths and contain secondary iron, arsenic, copper, and lead minerals. A few of the oxidized veins were residually enriched in gold.

The most extensive development work in the Girdwood area was at the Agostino mine (6), where by 1936 about 1,100 feet of underground workings had been driven. The main veins averaged about a foot in thickness and were followed for several hundred feet along their strike. There is no record of the amount of gold recovered from this deposit, but it probably was not large.

Several other deposits in the Girdwood area, including one on Eagle River (5) about 6 miles north of the Agostino mine, were explored prior to World War II, but they were not productive.

Auriferous quartz veins were staked before World War I near the head of Peters Creek (4), about 30 miles east-northeast of Anchorage. They are as much as a foot thick, but average 2 inches or less, and contain sparse pyrite, galena, and chalcopyrite. Assays of the veins ranged from $12.60 to $38 per ton in gold. Several short tunnels were driven, but there is no record of the amount of ore, if any, that was shipped.

A copper deposit was discovered in 1906 near the head of Jim Creek (1), about 15 miles east-northeast of Matanuska. The deposit, at an altitude of 4,150 feet, is in Mesozoic greenstone a few miles south of its contact with a diorite pluton and consists of a massive sulfide vein about a foot thick. A gossan 4–8 feet wide marks the outcrop of the vein. The sulfide minerals consist of about 15 percent sphalerite and equal parts of chalcopyrite and pyrrhotite. About 5 percent of the vein is calcite. Assays of the vein showed 15.08 percent copper, 2.95 percent zinc, and 1.75 ounces of silver per ton and a trace of gold; assays of the greenstone country rock showed 0.41 ounce of silver per ton and 0.04 percent copper. The deposit was not productive.

The Myers prospect (3), a low-grade lead-zinc lode, is at an altitude of 1,500 feet about 2 miles southwest of Eklutna. The main deposit is a 3-foot-thick zone of disseminated crystals and small masses of arsenopyrite, pyrite, sphalerite, and galena in silicified greenstone. Nearby, a vein less than 2 inches thick contains calcite and scattered bits of sphalerite, galena, and chalcopyrite and is bordered by about 6 inches of slightly mineralized rusty gouge. There is no record of any production from this deposit.

About 1920 a little gold ore was shipped from the Strong mine (7), about half a mile east of Indian station on The Alaska Railroad. The lode, reportedly in or near a fine-grained felsic dike that cuts slate, graywacke, and greenstone, probably consists of quartz and calcite veins containing appreciable pyrite and iron oxide, and a little gold. Both dike and country rock are folded and faulted, and the dike has been disrupted into disconnected segments as much as 18 inches thick and 6 feet long. The graywacke near the dike contains disseminated pyrite.

Quartz veins containing small amounts of gold were discovered in 1911 just west of Bird Point (8). Since the veins crop out below extreme high-tide level, a 22-foot shaft and other workings were protected by artificial embankments, but during an unusually high tide, the workings were flooded, and the property was abandoned. The most promising deposit reportedly consists of a 2- to 16-inch vein that cuts slate and carries pyrite, chalcopyrite, galena, and copper carbonate in addition to gold. A mill test in 1912 is said to have yielded concentrates carrying $52.75 per ton in gold. Felsic dikes that may be genetically related to the lodes cut slate and graywacke in the mountains north of Bird Point. The sedimentary rocks near the dikes contain quartz veins, and both the dikes and the veins are said to carry gold.

Two little-known lodes, one of which was prospected for gold and the other for lead, are in the southern part of the Anchorage district. The gold lode, which was cursorily explored and abandoned by 1920, is in the upper Peterson Creek basin (9), about 5 miles southeast of

Girdwood. The lead-bearing lode (7), reported to be 12 feet wide, is about a quarter of a mile west of Indian station on The Alaska Railroad.

The Highway and Pioneer chromite deposits (2) are near the Anchorage-Palmer Highway about 30 miles northeast of Anchorage. They consist of stringers, disseminated grains, and discontinuous layers of chromite in dunite associated with pyroxenite, peridotite, and olivine gabbro. The ultramafic rocks reportedly contain little serpentine. The deposits, discovered around 1941, were explored in 1943 by the U.S. Bureau of Mines. The exploration, which consisted of trenching and diamond drilling, revealed that the chromite lodes are irregular in shape, decrease in grade with increasing altitude, and are cut by small faults with displacements of as much as 5 feet. It also indicated that the chromite is restricted to the dunite and does not occur in the other varieties of ultramafic rocks in the area. The average grade of the deposits ranges from 5.7 percent to 6.9 percent Cr_2O_3, the highest analysis showing 31.1 percent Cr_2O_3, and 11.1 percent Fe.

Additional information on this district is given in the following references: Bjorklund and Wright (1948); Capps (1916b); Landes (1927); Park (1933).

REDOUBT DISTRICT

The Redoubt district (pl. 1; fig. 6) is the area drained by the streams flowing into Cook Inlet from Cape Douglas on the south to, but excluding, the Susitna River on the north.

Three-fourths of the district lies within the Alaska Range and is characterized by rugged mountains with many summits that exceed 5,000 feet in altitude (pl. 1). The southern tip of the district is less rugged, and the northeastern part consists of plains and lowlands.

The oldest rocks in the district (pl. 1) are andesitic lava flows and tuff as old as Triassic. Next younger are Jurassic and Cretaceous sandstone and shale; the youngest are Tertiary coal-bearing sedimentary rocks and Tertiary and Quaternary lava flows and tuff. The Mesozoic bedded rocks are intruded and locally metamorphosed by intermediate and felsic batholiths. Augustine Island and Mount Redoubt are still active volcanoes. Unconsolidated deposits cover bedrock in most of the northeastern part of the district, and the geology of much of the central section is still unmapped.

Lodes that contain iron, gold, silver, and copper occur in the Redoubt district.

Several iron deposits (6–9, see fig. 6) have been staked since 1964 in the area east of Lake Iliamna. Most are at or near contacts between intermediate to mafic plutons and metamorphosed volcanic and sedimentary rocks. The deposits are large but relatively low

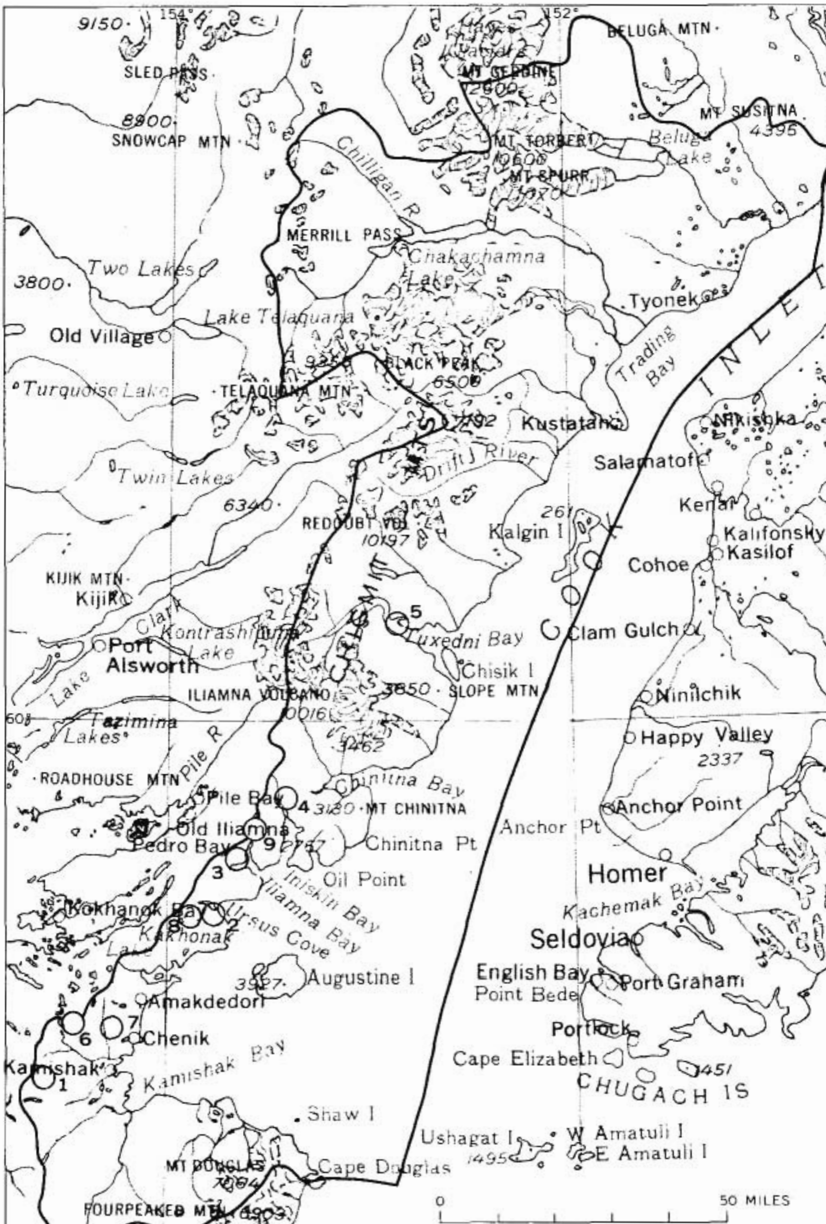

FIGURE 6.—Metalliferous lode deposits in the Redoubt district.

LOCALITIES

1. *McNeil (Crevice Creek)
   *Paint River
2. *Ursus Cove
3. *Diamond Point
   *Copper King
4. *Iniskin River

(4.) *Marsh Creek
5. *Tuxedni Bay
6. Pan American Petroleum Corp.
7. Pan American Petroleum Corp.
8. Pan American Petroleum Corp.
9. Pan American Petroleum Corp.

*Cited individually in text.

grade and consist of veinlets, layers, and disseminated grains of titaniferous magnetite in both the igneous and the metamorphic rocks.

Two magnetite deposits on a small island at the edge of a tidal marsh on the north shore of Tuxedni Bay (5) occur in northeast-striking faults in contact-metamorphosed volcanic and sedimentary rocks near the border of a quartz diorite batholith. An eastern deposit consists of magnetite disseminated in hornfels; a western deposit is a lens of massive magnetite and garnet with a marble hanging wall and a hornfels footwall. The western deposit, which may contain about 75 percent magnetite, is exposed for a width of 30–35 feet and can be followed for 55 feet along the strike. The eastern deposit, estimated to contain 10–20 percent magnetite, occurs in two parallel lodes, the exposed parts of which are 30 and 10 feet thick, separated by 20 feet of country rock. The western deposit was staked about 1916 and a short tunnel was driven; the eastern deposit apparently was not explored. There is no evidence that any ore was shipped from these deposits, which have been inferred to contain only a few thousand tons of magnetite-bearing material.

The only deposit in the region from which production has been recorded is the McNeil (Crevice Creek) gold-copper lode (1), 22 miles west-southwest of Kamishak. About 12 tons of ore, averaging $2.50 in gold and 15 ounces of silver per ton, and 17.55 percent copper, was shipped from the deposit early in the century, but high costs forced abandonment of the property by about 1926. Workings consisted of numerous pits and a tunnel 60 feet long. The lode is of contact-metamorphic origin and consists of veins and masses of chalcopyrite, minor pyrite and magnetite, and secondary copper minerals in actinolite-epidote-garnet-quartz-calcite rock (tactite). It is at the contact of calcareous sedimentary rocks and intermediate to mafic volcanic rocks, not far from exposures of intermediate intrusive rocks. The deposit was restaked in the mid–1950's and explored by several trenches, pits, and adits, but there was no recorded production.

A recent report by the State of Alaska Division of Mines and Minerals (Richter and Herreid, 1965) described several lodes similar to the McNeil deposit in the Paint River area (1). Most of them contain relatively sparse chalcopyrite and pyrite, and some contain conspicuous layers and lenses of magnetite-rich rock. The lodes have been explored by a few shallow trenches and pits, but no ore has been shipped.

The Copper King copper-iron lode (3) was discovered in 1905, but with the exception of a few surface pits, it was not developed and produced no ore. The lode occurs in marble inclusions (as much as 20 ft thick) in granite and consists of irregular masses of garnet and magnetite-bearing rock that locally contains disseminated chalcopyrite. The marble is also cut by quartz-epidote veins. Reportedly, some high-grade material has been found in bodies too small to mine.

Traces of copper and other metals have been found by U.S. Geological Survey geologists in sulfide-bearing bedrock near Ursus Cove (2), Diamond Point (3), the Iniskin River (4), and Marsh Creek (4).

Additional information on this district is given in the following references: Capps (1935); Detterman and Reed (1964); Grantz (1956); Mather (1925); Richter and Herreid (1965).

VALDEZ CREEK DISTRICT

The Valdez Creek district (pl. 1; fig. 7) is the area drained by the Susitna River above the mouth of the Talkeetna River and includes the Chulitna River basin.

Most of the district is in the high, rugged Alaska Range and in the somewhat less precipitous Talkeetna Mountains. Small parts lie in the Copper River Lowland on the east and in the Cook Inlet–Susitna Lowland on the west.

Bedded rocks in the district (fig. 1) include middle and upper Paleozoic limestone and clastic rocks; predominantly Mesozoic lava flows, greenstone, tuff, sandstone, and shale; Tertiary sandstone, conglomerate, and shale; and Tertiary and Quaternary lava flows. Locally, the Paleozoic and Mesozoic strata are intruded and metamorphosed by intermediate and felsic stocks and batholiths. Silt, sand, and gravel deposits are abundant in the lowlands.

Lodes in the Valdez Creek district have been prospected for gold and silver, and for copper, antimony, and molybdenum.

LODES PROSPECTED MAINLY FOR GOLD AND SILVER

CHULITNA AREA

A group of precious- and base-metal lodes near the West Fork of the Chulitna River (3–5, see fig. 7) were explored from about 1911 to 1942. Several tunnels and trenches were opened on the more promising lodes, and a small tonnage of gold and copper ore was shipped. The area is underlain by sedimentary and volcanic strata cut by thrust and normal faults and intruded by small stocks and dikes of quartz diorite and biotite quartz diorite porphyry. The lodes, which are genetically related to the porphyry, form three transitional types: disseminated deposits, mainly in the porphyry; bedded replacement deposits in calcareous rocks; and tabular and lenticular quartz-rich masses in faults and shear zones. Besides gold, the principal metallic minerals are arsenopyrite, pyrite, pyrrhotite, chalcopyrite, sphalerite, and argentiferous galena. A few of the lodes contain a little stibnite. Locally, shallow oxidation has produced secondary iron, copper, lead, and arsenic minerals.

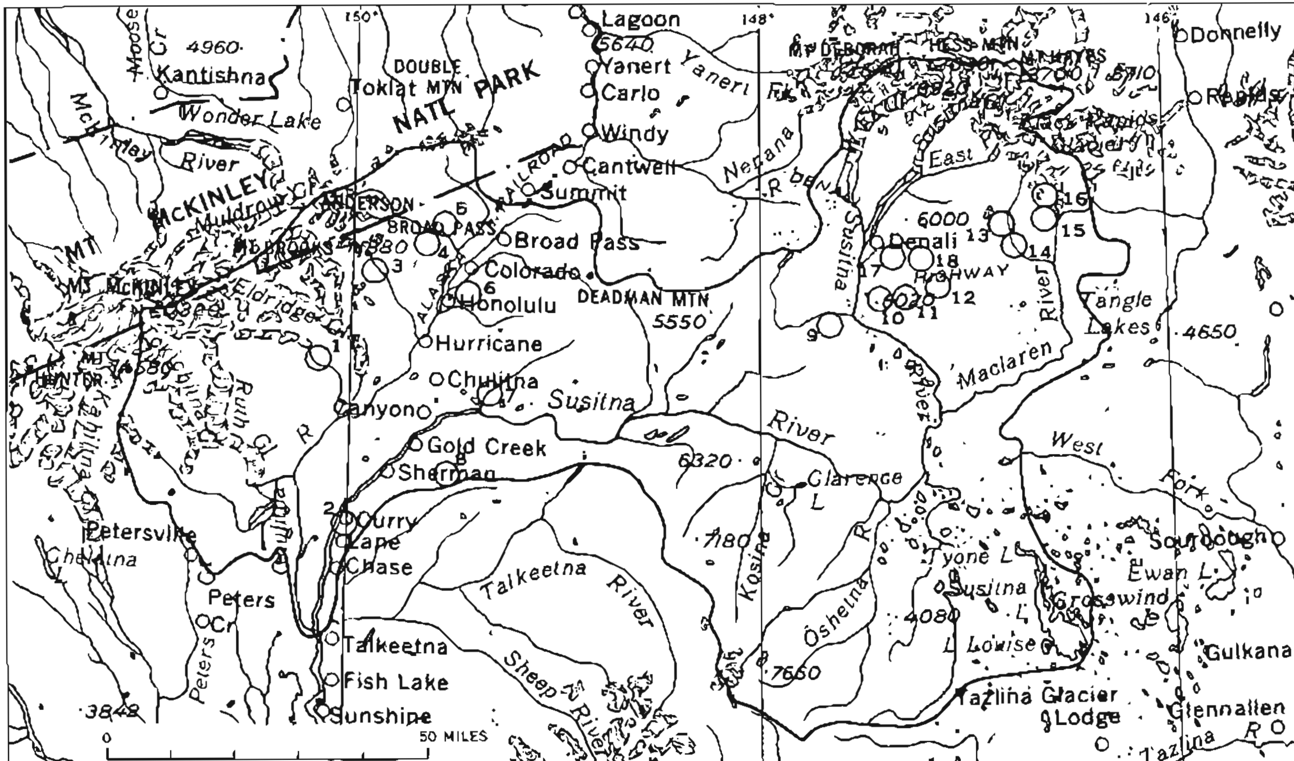

FIGURE 7.—Metalliferous lode deposits in the Valdez Creek district.

LOCALITIES

1. *Boedeker
2. *Curry

West Fork Chulitna River area

3. *Ready Cash
4. *Copper King
   Flaurier
   *Golden Zone
   Lindfors
   *Mayflower
   *Riverside
5. *Eagle (Northern Light)
   *Liberty
   Lucrata
   Silver King

6. *North Carolina
7. *Mint
   *Treasure Creek (3 occurrences)
8. *Gold Creek

Denali–MacLaren River area

9. *Butte Creek (3 occurrences)
   Unnamed (3 occurrences)

Denali–MacLaren River area—Con.

10. *Greathouse
    Windy Creek (3 occurrences)
11. Windy Creek (3 occurrences)
12. *Pass Creek
    Windy Creek
13. *Unnamed (2 occurrences)
14. Unnamed (3 occurrences)
15. Unnamed (3 occurrences)
16. *Kathleen-Margaret (K–M)
    Unnamed (2 occurrences)

Valdez Creek area

17. *Alaska Exploration and Mining Co.
    *Campbell and Boedeker
18. Accident
    *Lucky Top
    Wagner
    Yellowhorn

* Cited individually in text.

The most noteworthy disseminated deposit was at the Golden Zone mine (4), from which concentrates were shipped in 1941. The tonnage is unknown but probably was not large. Assays of Golden Zone ore made in 1925 and 1931 showed a trace to 2.52 ounces of gold, and 0.10–11.60 ounces of silver per ton.

The replacement lodes, consisting of silicified limestone beds partly replaced by sulfides, are represented by the Copper King (4), and, to a lesser extent, by the Riverside (4) and Liberty (5) prospects. At most of the prospects the sulfides occur as irregularly distributed aggregates, but at the Copper King, parts of certain beds have been replaced throughout, resulting in the formation of relatively massive sulfide material. A sample of this material from the Copper King deposit assayed 0.22 ounce of gold and 4.90 ounces of silver per ton, and 7.34 percent copper. Samples of other material from this and neighboring properties yielded lower assay values.

The Ready Cash (3), Mayflower (4), and Eagle (5) prospects, and the Little Lead claim on the Golden Zone property are on tabular or lenticular lodes consisting mainly of sheared altered country rock impregnated with quartz, carbonate, and sulfides. Individual masses of quartz are only a few tens of feet long and a few feet thick. They commonly are en echelon and locally are cut by postmineralization faults. Samples from several of these prospects contained a trace to 1.26 ounces of gold, and 0.70–8.60 ounces of silver per ton.

VALDEZ CREEK AREA

The Valdez Creek gold lodes (17, 18) are 3–7 miles east of Denali. They consist mainly of lenticular quartz veins containing pyrrhotite, subordinate pyrite, chalcopyrite, galena, sphalerite, and a little free gold. A few, however, consist of stringers and disseminated particles of the metallic minerals in the wallrock adjacent to the veins. The veins commonly are parallel to the foliation of metamorphosed sedimentary rocks or occur along shear zones in diorite. Individual quartz lenses are generally a few tens of feet long and less than 4 feet thick, but they lie in roughly parallel zones at least 1,000 feet long. Channel samples across several of the lodes contained a trace to 0.18 ounce of gold and a trace to 0.2 ounce of silver per ton; a sample of sulfide concentrates from the Campbell and Boedeker prospect (17) assayed 1.9 ounces of gold and 1.5 ounces of gold per ton. A piece of quartz about the size of a teacup found on the Lucky Top prospect (18) contained almost 2 ounces of free gold. The Valdez Creek lodes were discovered about 1906 and were prospected at intervals for 35 years. Development work consisted of trenches and pits, and short tunnels driven on a few of the richer lodes. Only a few tons of ore were milled, most of it from the

Alaska Exploration and Mining Company property (17) on Timberline Creek.

In 1929 the Boedeker claim (1) was staked on a low-grade gold lode at an altitude of 4,000 feet on the north side of the Chulitna River. The deposit consists of numerous quartz veins in slate, graywacke, and fine-grained schist. The largest vein, which contains sparse pyrite and arsenopyrite and traces of gold and silver, is as much as 12 feet thick and has been traced on the surface for about 800 feet. Several other veins, 2–10 inches thick and less than 100 feet long, contain disseminated pyrite, and a little galena and free gold. The lode was explored by several opencuts and a short tunnel, but there was no recorded production.

Many small veinlets carrying pyrite, pyrrhotite, chalcopyrite, and sphalerite have been found in metamorphosed sedimentary rocks near Eldridge Glacier, a few miles north of the Boedeker prospect.

In the 1920's a ruby-silver lode was worked at the Mint mine (7), about 9 miles east of Chulitna. The country rock at the mine is brecciated slate cut by at least one intensely altered andesite dike that evidently was intruded along a shear zone. The lode is about 25 feet wide and consists of quartz-sulfide veinlets in the breccia and dike and of stockworks on both sides of the dike. The sulfide minerals consist of about equal parts of pyrargyrite and arsenopyrite, lesser miargyrite and pyrite, and rare chalcopyrite, galena, and tennantite(?). A picked sample of ore assayed 117.9 ounces of silver per ton, but a series of channel samples showed only 1.20–32.2 ounces per ton. Development work consisted of two short tunnels and an opencut; an unknown but probably small amount of ore was shipped.

A silver-lead lode, discovered in 1950, is on a southern tributary of Gold Creek (8), about 7 miles east of Gold Creek station on The Alaska Railroad. The lode, which possibly is an altered dike, is described as a northward-striking vertical "ledge" that has been traced for a mile. It is composed chiefly of quartz and feldspar and is enclosed by black slate. Blebs of argentiferous galena up to half an inch in diameter are disseminated in quartz-filled fractures in the "ledge." Specimens reportedly from the same locality contain pyargyrite and pyrite.

LODES PROSPECTED MAINLY FOR COPPER

A copper lode, called the Kathleen-Margaret prospect (16), is at an altitude of about 4,000 feet, a mile or so west of the terminus of MacLaren Glacier. The lode, which has probably been known since 1918, was explored from 1953 to 1959 by underground workings totaling about 800 feet, by diamond drilling, and by shallow trenching. Approximately 2 tons of ore containing an estimated 1–2 per-

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cent copper was stockpiled at the prospect in 1960. The deposit consists of north-striking quartz veins that cut greenstone and contain bornite and chalcopyrite. The quartz veins are near an eastward-striking fault zone that probably is related to the genesis of the ore, for copper values in the largest and richest vein apparently diminish northward away from the fault-vein intersections. A narrow altered porphyry dike that may have been the source of mineralizing fluids is parallel to, and a few feet east of, the main copper-bearing vein. The tenor of the vein ranges from a few tenths of a percent to about 30 percent copper but commonly is between 1 and 5 percent. The vein also contains a little silver and traces of gold. The zone of richest material is about 60 feet long, 5 feet wide, and 100 feet deep; it extends northward from the fault and is adjacent to the west wall of the main vein. Several smaller copper-bearing veins at the prospect commonly are leaner and cannot be traced for more than 100 feet.

DENALI–MacLAREN RIVER AREA

Numerous copper- and molybdenum-bearing lodes in the Denali–MacLaren River area (9–16) have recently been investigated by the State of Alaska Division of Mines and Minerals (Kaufman, 1964), but only the better known deposits are described below.

At the Greathouse property (10), bornite and chalcocite, together with malachite-stained quartz, epidote, and calcite, occur in a shear zone in a basaltic lava flow cut by a thin quartz diorite dike. The maximum width of the lode is 3 feet, but this width persists for less than 100 feet. A chip sample across the 3-foot zone reportedly assayed about 11 percent copper. Mineralization in the remainder of the shear zone, which has been traced on the surface for several thousand feet, is erratic and generally of lower grade.

Copper minerals have been found in volcanic breccia at an altitude of about 4,650 feet near the head of the south fork of Pass Creek (12). The breccia, which consists of limestone fragments in an andesitic matrix, probably is interbedded with greenstone and is cut by irregular gabbro dikes. The lode contains limonite, malachite, azurite, and minor chalcopyrite that mostly replace limestone fragments and to a lesser extent fill fractures in the andesite. The deposit consists of two mineralized zones, measuring 33 feet and 2 feet wide, separated by 200 feet of barren rock. A chip sample across the 33-foot zone assayed 2.9 percent copper.

Small amounts of magnetite and secondary copper minerals have been found in the mountains south of Butte Creek (9), about 15 miles west of Denali. The magnetite occurs along the contact between amphibolite and interbedded argillite and limestone. The copper mineralization consists of sparse malachite and azurite in a few rust-colored carbonate veins in the amphibolite, which is also cut by mafic dikes. The zone of carbonate veins, which may mark a fault, has been traced for more than 100 feet, but assays show that it contains less than 0.1 percent copper. Float specimens of volcanic rocks carrying secondary copper minerals, quartz, and epidote have also been found in this area.

A copper-molybdenum lode occurs at an altitude of about 5,000 feet near the West Fork of the MacLaren River (13). The lode, marked by an iron-stained zone, consists of disseminated pyrite, chalcopyrite, and molybdenite in fine- to medium-grained felsic intrusive rock that cuts argillite. A random sample of the mineralized intrusive rock assayed about 0.2 percent molybdenum. A little molybdenite also occurs in quartz veins in this area.

LODES PROSPECTED MAINLY FOR ANTIMONY AND MOLYBDENUM

The North Carolina antimony prospect (6) is in the upper basin of Stibnite Creek, a small tributary of the East Fork of the Chulitna River. The lode probably consists of quartz-stibnite veins in slate and graywacke. Reportedly, the stibnite, which is said to carry some gold, occurs in short lenses as thick as 2 feet. The deposit was discovered early in the 1900's and was explored by two short tunnels and several opencuts, but there is no record of any production. A fault cutting altered shale and containing pyrite and a little gold occurs about a mile west of the antimony lode. Pyrite is also disseminated in limy beds near the fault.

Three deposits containing molybdenite and other sulfides have been found in or near a quartz monzonite stock intruding graywacke, slate, and conglomerate near Treasure Creek (7). Two of the deposits, discovered about 1939, were explored by trenches and short adits, but there has been little additional development and no production of ore.

One deposit, a poorly exposed lode on Treasure Creek a little more than a mile above its mouth, consists of arsenopyrite and subordinate molybdenite, sphalerite, chalcopyrite, fluorite, and epidote in a fault zone at the contact between quartz monzonite and sedimentary country rocks. Assays of the richest material showed 0.18 ounce of gold per ton, 0.1–0.5 percent molybdenum, 2–3 percent zinc, 0.1–0.5 percent copper, and traces of lead, cadmium, antimony, and bismuth. The quartz monzonite shows strong argillic alteration but little sulfide mineralization within 200–300 feet of the fault.

Another deposit (7), about a mile south-southwest of the Treasure Creek lode, contains what probably is the richest molybdenite mineralization known in the area. It consists of spotty but locally rich lenses, vugs, and masses of molybdenite, sphalerite, chalcopyrite, and pyrite in quartz-rich shear zones in argillized(?) quartz monzonite.

A channel sample across the widest (2.5 ft) and richest of these zones, however, assayed 0.1 percent or less molybdenum and zinc.

At the third locality (7), about three-quarters of a mile northeast of the Treasure Creek lode, molybdenite and chalcopyrite occur as scattered flakes and grains in a few fractures in brownish-gray siliceous hornfels. Locally the sulfides are accompanied by quartz. The deposit is about a third of a mile from the nearest outcrop of quartz monzonite.

Low-grade molybdenum mineralization occurs at Mile 247 on The Alaska Railroad, about 2 miles south of Curry (2). There, sparse molybdenite flakes are disseminated in small quartz veins and narrow aplite dikes cutting a 300- to 500-foot granitic dike. Molybdenite also coats the surfaces of a few small joints and fractures in the main dike.

Additional information on this district is given in the following references: Capps (1919d); Chapman and Saunders (1954); Kaufman (1964); MacKevett (1964b); Ross (1933a, b); Saunders (1961a); Tuck (1938).

WILLOW CREEK DISTRICT

The Willow Creek district (pl. 1; fig. 8) is the area drained by eastern tributaries of the Susitna River below Sunshine, by northern tributaries of Cook Inlet and Knik Arm east of the Susitna, and by the Matanuska River.

The eastern part of the district is characterized by rugged mountains, and the western part by plains and lowlands generally less than 1,000 feet in altitude (pl. 1).

The oldest and most widespread rocks in the Willow Creek district are lava flows, sandstone, and shale of Mesozoic age (pl. 1). In the northern part of the district they are cut by a batholith that probably is genetically related to the Willow Creek gold lodes. Tertiary coal-bearing sandstone, conglomerate, and shale, and Quaternary basalt, andesite, and tuff crop out locally, and the entire western quarter of the district is underlain by silt, sand, and gravel.

Lodes containing gold, silver, copper, lead, zinc, molybdenum, and iron are known in the Willow Creek district. Among these, only the precious-metal deposits have been productive, recovery from the Willow Creek mines totaling about 404,425 fine ounces, or about 5 percent of Alaska's lode gold output. Appreciable gold was produced from these mines every year from 1909 to the early 1950's, but most of the production was between 1932 and 1942. Since World War II, activity has been confined mainly to prospecting, and to assessment and development work, with little or no production of ore. About 204,000 fine ounces of gold, or 1 percent of the State's total placer gold production, has been recovered from placer mines in the Willow Creek district.

WILLOW CREEK GOLD LODES

Gold-bearing quartz veins were discovered in 1906 in the Willow Creek area, along the southern border of the Talkeetna Mountains (1–6, see fig. 8).

All but one of the productive lodes were in the southern border of the Talkeetna batholith, a predominantly quartz diorite pluton of probable late Mesozoic age flanked on the southwest by mica schist and on the southeast by sedimentary rocks. Numerous lamprophyre, diabase, aplite, and pegmatite dikes cut the quartz diorite, and post-ore faults offset the gold-bearing veins as much as 600 feet horizontally. Most of the veins probably formed in open fractures and only a few by replacement of quartz diorite. Repeated movement parallel to the veins opened new cavities, and these were filled by successive generations of quartz.

The Willow Creek lodes may be divided into two groups of veins: an older, nonproductive group occupying southwest-dipping joints in the quartz diorite; and a younger, productive group occupying prominent shear zones in the pluton. In general, the productive veins strike north and northeast and dip to the west and northwest.

The nonproductive veins are small and consist of vuggy glassy quartz and sparse chalcopyrite, pyrite, arsenopyrite, molybdenite, stibnite, sphalerite, and gold. Locally, oxidation has produced secondary iron, copper, and molybdenum minerals.

The productive veins, some of which were 6 feet or more in thickness but most of which were 1–3 feet thick, consisted of bluish-gray to milky-white quartz, minor carbonate, and small amounts of pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, several telluride minerals, galena, stibnite (?), gold, and scheelite. The gold and associated minerals were deposited mainly at vein intersections, where the quartz was most susceptible to fracturing. Wallrock alteration, characterized chiefly by sericite and carbonate minerals, and less extensively by pyrite and chlorite, is intense within a few inches of the productive veins. Most of the veins pinch out along the strike, as well as down the dip, and pass into barren shear zones composed of altered quartz diorite fragments.

Among the more than 50 mines and prospects in the Willow Creek area, only the Thorpe mine (1) exploited a productive gold quartz vein in country rock other than quartz diorite. The vein, in mica schist nearly 2 miles south of the quartz diorite contact, was discovered sometime before 1930 and mined out by 1943. Several hundred feet of underground workings were driven on the vein, which report-

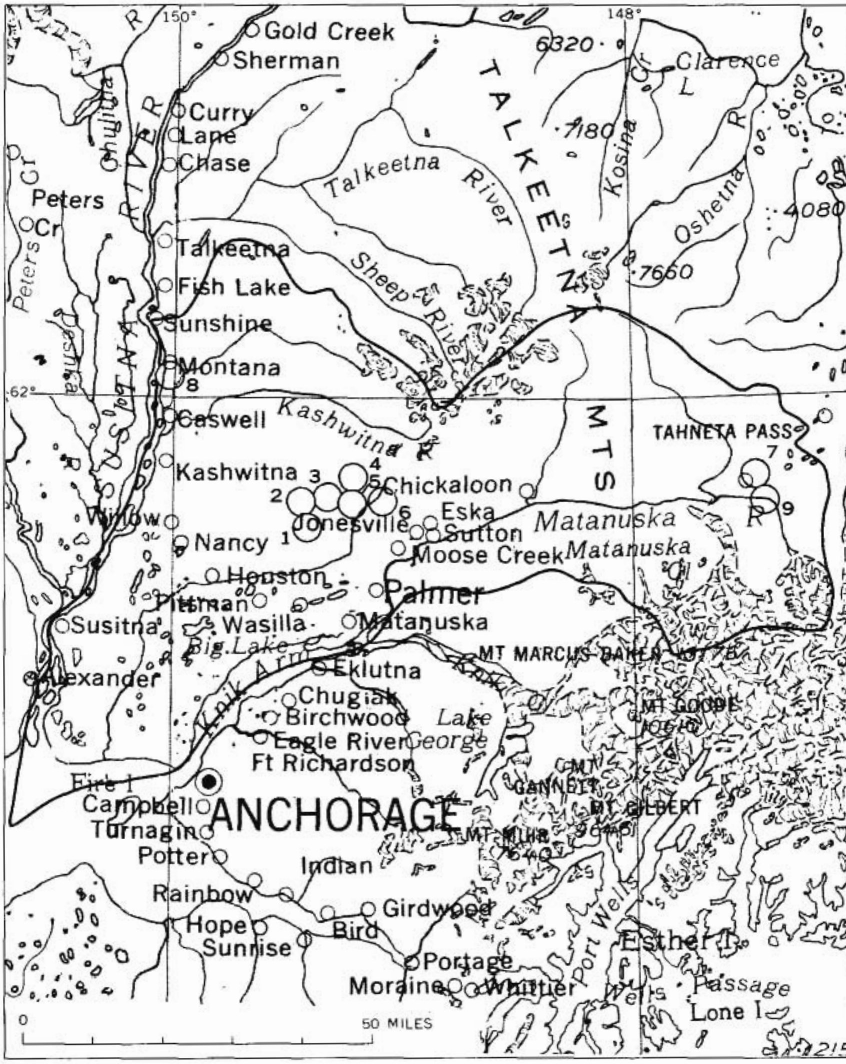

FIGURE 8.—Metalliferous lode deposits in the Willow Creek district. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 8

Willow Creek area

1. *Thorpe
   Wheeler, Betts, and Dimmick
2. Lucky Shot
   Panhandle
   War Baby
   Willow Creek Mines
   Wolverine
   Unnamed
3. Bronson and France
   *Gold Bullion
   Gold Cord
   Golden Light
   Gold King
   High Grade
   Independence
   Jap
   Kelly-Willow
   Kempf
   Leona
   Little Willie (Holland)
   Mammoth
   Marion Twin
   Martin
   Newman and Miller
   Schroff-O'Neil
   Smith
   Thorpe

Willow Creek area—Continued

4. Dixie
   Fern
   Galena-Gold
   Homebuilder
   Idamar
   Lane
   Little Gem
   Marmot
   Mary Ann
   Mogul
   Opal
   Snowbird
   Snow King
   Talkeetna
5. Arch
   LeRoi
   Mabel
   Mohawk
   Rae
   Rae-Wallace
   Stiles (Shough)
   Webfoot
6. *Lonesome (Gold Mint)
   Maverick
   *Moose Creek
   Northwestern

7. *Sheep Mountain
8. *Montana
9. *Rusaw Creek

* Cited individually in text.

edly was as much as 3 feet thick. The vein had a southeast strike and northeast dip—an attitude different from that of the productive veins in the quartz diorite—and cut the foliation of the schist at an angle of 60°.

The vein at the Lonesome mine (6), in the southeastern part of the Willow Creek area, is atypical in that in places it contains appreciable silver as well as gold. The vein, commonly less than 18 inches thick, strikes generally northwest and dips southwest. It pinches and swells, locally splits along the strike, and is cut by minor faults. The country rock is fractured fine-grained gabbro. Development work consisted of several hundred feet of underground workings on three levels and several surface trenches. Trenches in gabbro 0.6 mile east of the mine exposed oxidized vein material containing as much as 400 ounces of silver to the ton.

Another unusual occurrence is that of cinnabar in the Gold Bullion mine (3), where the mineral occurs in cracks in a productive quartz vein. The amount of cinnabar is small, but of interest, because it indicates late-stage relatively low-temperature mineralization in the district.

OTHER PROSPECTS

A copper lode was staked in 1914 on the west side of Moose Creek (6), about 10 miles north of Palmer. It is in quartz diorite and consists of masses, veins, and disseminated grains of sulfide minerals in a zone 30–100 feet wide that reportedly was traced on the surface for 7,000 feet. One massive sulfide body about 25 feet wide and at least 80 feet long was exposed in opencuts. The metallic minerals include pyrite, pyrrhotite, chalcopyrite, and sphalerite that carry small amounts of gold and silver. Assays of the mineralized rock showed 0.04–0.08 ounce of gold and 0.8–1.2 ounces of silver per ton, a trace to 5.6 percent copper, and, in one sample, 0.03 percent nickel. In addition to the opencuts, a short tunnel was driven on the lode, but there was no recorded production.

A copper deposit also was prospected early in the century at an altitude of about 4,200 feet on Sheep Mountain (7), on the north side of the Glenn Highway. The deposit is in shattered basic igneous rock (greenstone) and consists of small irregular quartz, calcite, and epidote veins containing chalcopyrite, malachite, azurite, and possibly bornite and chalcocite. Several square miles of the south flank of Sheep Mountain are stained dark red from the oxidation of disseminated pyrite in the greenstone. A sample of the pyritic greenstone assayed a trace of gold.

Deposits that probably are similar to those on Sheep Mountain have been reported near Rusaw Creek (9), in the upper Matanuska Valley.

A small "bog iron" deposit, consisting mainly of limonite and probably other hydrous iron minerals, is in the drainage basin of Goose Creek 1.3 miles southeast of Montana (8). A preliminary investigation by the U.S. Geological Survey indicated that the deposit, which is still forming, is 8 feet in maximum thickness and about 50 feet in diameter. It is rudely disc shaped, with the highest tenor material—containing 41.2 percent iron—in the upper central part. Although the occurrence, which is the only one known in Alaska, is too small to be of current economic interest, it calls attention to a relatively unprospected area that might contain similar, possibly larger, deposits.

Additional information on this district is given in the following references: Brooks (1925); Capps (1915, 1919b); Capps and Tuck (1935); Chapin (1921); Jasper (1962); Martin and Mertie (1914); Ray (1933); Ray (1954); Smith (1942); Stoll (1944); Thorne, Muir, Erickson, Thomas, Heide, and Wright (1948).

YENTNA DISTRICT

The Yentna district (pl. 1; fig. 9) includes the area drained by western tributaries of the Susitna River between Alexander and Sunshine and by its eastern tributaries between Sunshine and Talkeetna.

The district lies athwart three of Alaska's major physiographic subdivisions (pl. 1). The eastern third lies within the moderately rugged Talkeetna Mountains, the central third is in the Cook Inlet–Susitna River Lowland, and the western third is in the high, rugged mountains of the Alaska Range.

The oldest and most abundant consolidated rocks known in the Yentna district (pl. 1), are Mesozoic sandstone, shale, lava flows, and tuff. They are cut and locally metamorphosed by predominantly intermediate dikes, sills, and stocks. The youngest stratified rocks are Tertiary in age and consist of nonmarine sandstone, shale, mudstone, conglomerate, and, locally, coal. Most of the central third of the district is covered by Quaternary silt, sand, and gravel. The geology of the northwestern and southwestern corners of the district is incompletely mapped.

Lodes containing gold, copper, and molybdenum occur in the Yentna district.

Several gold-, copper-, and iron-bearing lodes were staked in the basin of Iron Creek (3, 4, see fig. 9) in 1910. Prospecting, mainly by opencuts, continued for about 10 years, but little or no ore was produced. The lodes are mainly mineralized faults and shear zones in andesitic lava flows and are a few inches to 30 feet or more wide. The lodes, which formed by replacement of sheared andesite, commonly consist of alternating layers of altered andesite carrying pyrite, arsenopyrite, chalcopyrite, hematite, and bornite and layers of relatively barren country rock. The sulfides also are disseminated

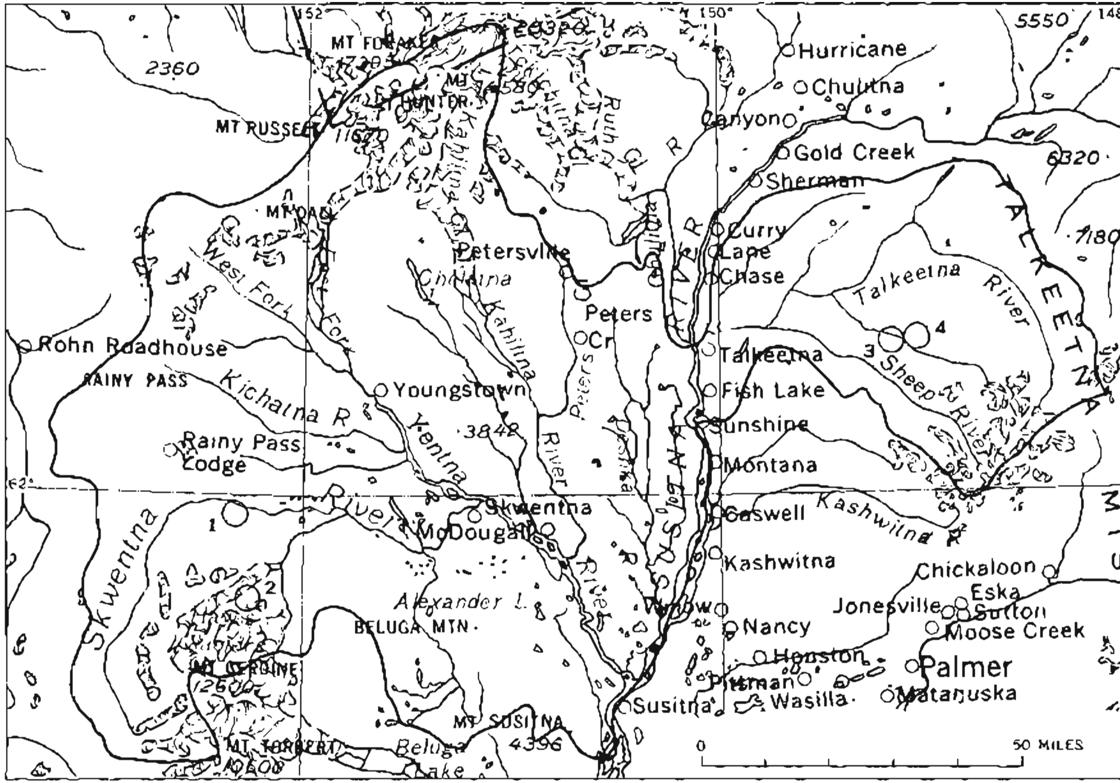

FIGURE 9.—Metalliferous lode deposits in the Yentna district.

1. *Skwentna River 2. *Hayes Glacier **Iron Creek area:** 3. Copper King; Copper Queen; Copper Wonder 4. Blue Lode; Eastview; Phoenix; *Talkeetna

*Cited individually in text.

in andesite horses in the shear zones and in the wallrock and extend for appreciable distances from the main lodes. The degree of replacement of sheared andesite by metallic minerals is variable; in the richer lodes sulfides and (or) hematite form nearly pure masses, assays of which show less than 1–8 percent copper and small amounts of gold and silver. Locally, malachite and azurite occur as a result of shallow oxidation. The largest lode is probably at the Talkeetna prospect (4), where trenches exposed a sulfide-rich zone at least 30 feet wide and several hundred feet long.

Lodes containing small amounts of copper, gold, silver, and lead occur in the Skwentna River area (1). They were discovered in the late 1890's but evidently were not developed and produced no ore. The main mineralization is near contacts between intermediate to felsic dikes and stratified basaltic volcanic rocks. The deposits consist of disseminated sulfides (chiefly pyrite and chalcopyrite) and narrow iron-stained quartz veins (which are mainly in the volcanic rocks and locally carry concentrations of pyrite, chalcopyrite, and galena). An assay of the disseminated material showed 0.05 ounce of gold and 0.15 ounce of silver per ton; a sample of one of the quartz veins assayed 0.1 ounce of gold and 0.25 ounce of silver per ton. Also present, but evidently not closely related to the contact zones, are small calcite veins in basalt; these contain chalcopyrite, bornite(?), and iron oxides. A few miles west of the Skwentna River area, quartz veins containing sparse pyrite, chalcopyrite, and galena occur in black slate intruded by granitic dikes.

Molybdenum-bearing lodes were discovered in 1959 east of the Hayes Glaciers (2). The deposits are said to consist of molybdenite and other sulfides disseminated in quartz lenses and stringers in a felsic stock 3–4 miles long and about a mile wide. Locally, the molybdenite may be sufficiently concentrated to be of potential economic interest, but the tonnage reportedly is small. The veins also contain gold, lead, iron, and arsenic.

Additional information on this district is given in the following references: Capps (1919c); Spurr (1900).

COPPER RIVER REGION

The Copper River region (pl. 1) includes the area drained by the Copper River and its tributaries, the area east of the divide between Prince William Sound and Cook Inlet-Knik Arm, and the area drained by streams flowing into the Gulf of Alaska west of the Canadian boundary. It is divided into five districts: Chistochina, Nelchina, Nizina, Prince William Sound, and Yakataga.

CHISTOCHINA DISTRICT

The Chistochina district (pl. 1; fig. 10) is the area drained by the Copper River and its tributaries above Gulkana; that part of the

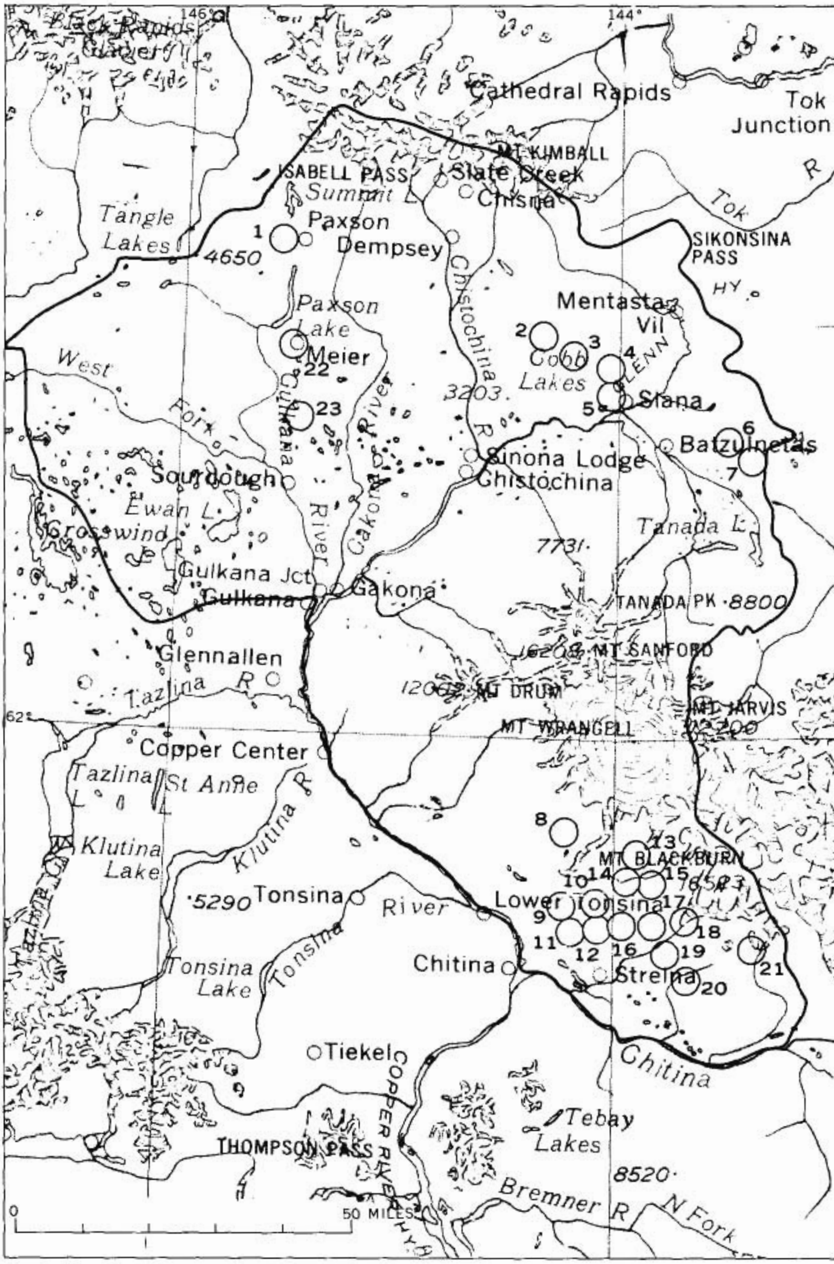

FIGURE 10.—Metalliferous lode deposits in the Chistochina district.

(Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 10

1. *Paxson Mountain

Slana area

- 2. *Burns
- 3. *Indian Creek
  - Neversweat
  - *The Dome
- 4. *Grubstake Creek
- 5. Bronnicke
  - *Silver Creek
  - Unnamed

6. *Unnamed
7. *Rock Creek
8. *Bear Creek
   *Mount Chitty

Kotsina-Kuskulana area

- 9. *Elliott Creek
- 10. Amman
  - Blue Bird
  - Bunker Hill
  - Cave
  - *Elliott Creek
  - Forget-me-not
  - Mountain Boy
  - Mountain Sheep
  - *Mullen
  - Peacock
- 11. *Benito Creek
- 12. Iron Mountain
- 13. Fall Creek
  - Goodenough
  - *Mineral Creek
- 14. *Larson

Kotsina-Kuskulana area—Continued

- (14.) *Lime Creek
  - *Lost Cabin
  - *Silver Star
  - *Warner
  - *Unnamed
- 15. *Amy Creek
  - Copper King
  - Keystone
  - Kotsina River
  - *Peacock Creek
  - *Roaring Creek
  - *Shower Gulch
  - Skyscraper
  - *Surprise Creek
- 16. Strelna Creek
- 17. *Clear Creek
  - Porcupine Creek
- 18. *Big Horn
  - Mayflower
  - *Nugget Creek
  - *Pierson
- 19. *Berg Creek (North Midas)
  - *Calcite
  - Copper Queen (Rarus)
  - London and Cape
  - *MacDougal Creek
  - *War Eagle

20. *Kinney-Golden
21. *Lakina River
22. *Meier Lake
23. *Hogan Hill

*Cited individually in the text.

Copper River basin bounded on the west by the Copper River between Gulkana and Chitina and on the south by the Chitina River between Chitina and the mouth of the Nizina River.

The Chistochina district contains parts of three of Alaska's major physiographic provinces (pl. 1); the plains and lowlands of the Copper River basin, the alpine snow-covered Wrangell Mountains, and the foothills and high rugged peaks of the Alaska Range.

The wide range of landforms in the Chistochina district is paralleled by the variety of geologic units within its boundaries (pl. 1). Bedrock as old as Paleozoic and as young as Quaternary is exposed in the district but is mostly confined to its periphery, for the entire central part, or about half of the district, is covered by a thick accumulation of gravel, sand, and silt.

The Paleozoic rocks are Carboniferous or Permian in age and comprise two main lithologic groups: one predominantly of greenstone, lava flows, and tuff and the other chiefly of limestone, sandstone, and shale. The Mesozoic strata, like the Paleozoic, can be divided into a volcanic group, mainly of intermediate to mafic lava flows and tuff, and a sedimentary group, mainly of limestone, sandstone, shale, and conglomerate. The Mesozoic rocks are economically important in the Chistochina district because they include the Nikolai Greenstone and overlying Chitistone Limestone, which, in the Kotsina-Kuskulana area, are host to numerous copper lodes. Tertiary and Quaternary lava flows, tuff, and detrital sedimentary rocks crop out in the district; the most prominent Cenozoic formation is the Wrangell Lava, which dominates the higher parts of the Wrangell Mountains. Mount Wrangell, one of the several prominent volcanoes in the district, still emits steam and ash. The bedded rocks are cut by plutons, mostly of Mesozoic(?) and Tertiary age. Some are mafic, but the most widespread and conspicuous are intermediate to felsic dikes, sills, and stocks.

Copper, gold, silver, and molybdenum lodes in the Chistochina district were prospected from about 1898 to 1940; the greatest exploration activity was prior to 1930. Iron, lead, zinc, and bismuth also occur in some of the lodes, but no attempt has been made to exploit these metals. Most of the prospects are between the Chitina River and the crest of the Wrangell Mountains in an area drained by the Kotsina and Kuskulana Rivers.

KOTSINA-KUSKULANA AREA

Most of the deposits in the Kotsina-Kuskulana area (9—19, see fig. 10) are in the Nikolai Greenstone and the overlying Chitistone Limestone, commonly near diorite, quartz diorite, and quartz latite intrusions. Some of the gold and silver lodes and all of the molybdenum deposits are in the dioritic rocks. The copper deposits consist of veins, stringer lodes, and disseminated copper minerals in intensely sheared, brecciated, or jointed rock. The copper minerals are chalcocite, bornite, enargite, chalcopyrite, covellite, malachite, and azurite, and the gangue minerals are quartz, calcite, and subordinate epidote, pyrite, limonite, and chlorite. No large deposits are known, and total shipments of copper ore from the area consisted of a few hundred tons of concentrates. Gold and silver production was also small, reportedly only a few ounces.

COPPER CREEK PROSPECTS

Copper deposits (10) that were extensively prospected but were nonproductive are on several forks of Copper Creek, 2½–4 miles from the Kotsina River. The deposits were explored by several thousand feet of underground workings and many opencuts, all of which were abandoned by about 1928. Most are in the Nikolai Greenstone and a few are in the Chitistone Limestone, but all the lodes are near the greenstone-limestone contact. The formations are extensively folded and faulted and are intruded by small altered diorite dikes.

A typical copper deposit in the Nikolai Greenstone in the Copper Creek area is in sheared or brecciated greenstone and consists of small irregular veinlets of quartz, calcite, and epidote, and subordinate bornite, chalcopyrite, chalcocite, enargite, malachite, azurite, pyrite, and limonite. It commonly is within a few hundred feet of the top of the greenstone.

The most thoroughly explored copper deposit on Copper Creek is the Mullen prospect (10), where the lode consists of veins of calcite, pyrite, bornite, chalcopyrite, covellite, limonite, malachite, and azurite in brecciated limestone. Samples of the two principal veins assayed 1.55–5.82 percent copper, a trace of gold, and as much as 0.28 ounce of silver per ton. Total indicated resources of the two veins is about 1,360 tons.

CLEAR–BERG–MacDOUGAL CREEKS PROSPECTS

Lodes containing copper, gold, and silver occur in the headwaters of Clear Creek (17) and in the drainage basins of Berg (19) and MacDougal (19) Creeks. The creeks are tributaries of the Kuskulana River.

The Clear Creek deposits (17) are in Nikolai Greenstone, which is cut by dikes and stringers of altered diorite intruded in turn by aplite dikelets. All the rocks are crossed by numerous faults. Locally pyrite and a little chalcopyrite are disseminated in the greenstone near the diorite and, to a lesser extent, in the diorite itself. Quartz, calcite, aragonite, and stilbite veinlets are in sheared greenstone near the diorite contact. Some of the quartz and calcite veinlets contain pyrite, a little chalcopyrite and magnetite, minor bornite, malachite, and azurite, and a few grains of galena. The principal development work on the Clear Creek prospects consisted of three adits totaling 5,700 feet in length driven prior to 1916. No minable ore body was found, and the workings were abandoned.

The prevalent rock at Berg Creek (19) is Chitistone Limestone intruded by fine-grained and porphyritic varieties of diorite. The limestone is faulted and locally altered to an aggregate of garnet and other silicate minerals. The lodes, which are in the diorite, consist chiefly of veins containing magnetite, pyrite, and chalcopyrite—locally with gold and silver. By 1916, about 2,600 feet of adits had been driven on the Berg Creek lodes, and a mill and other buildings constructed, but the only production was a few ounces of gold and silver.

The MacDougal Creek lodes (19) consist of veinlets and irregular masses of magnetite, pyrite, and chalcopyrite in greenstone and contact-metamorphosed limestone cut by diorite porphyry. In some places, the altered limestone is stained with limonite, malachite, and azurite. On the War Eagle claim (19), small masses of magnetite and diopside rock contain pyrite, pyrrhotite, chalcopyrite, epidote, chlorite, calcite, and quartz. A sample of this rock assayed 62.07 percent iron, but there is probably less than 10,000 tons of this grade material. On the Calcite claim (19), the Chitistone Limestone is cut by diorite and for about 100 feet from the pluton is converted to a bleached banded rock composed of magnesite, dolomite, calcite, serpentine, and sparse pyrite, chalcopyrite, and malachite. Elsewhere the contact-metamorphosed limestone contains abundant garnet and a little pyrite, chalcopyrite, and magnetite. The deposit was explored by adits and opencuts, but no ore was shipped.

Small epidote veins and limonite-stained pyritic zones are abundant throughout the valley of MacDougal Creek, but only a few specimens of malachite-stained diorite containing minute amounts of pyrite and chalcopyrite have been found.

PROSPECTS NEAR KUSKULANA GLACIER

Several lodes were prospected for copper, gold, and silver near Kuskulana Glacier (18). The most thoroughly explored copper deposits are on Nugget Creek (18), 2–2½ miles from the Kuskulana River, where development included more than 4,000 feet of underground workings and numerous opencuts. A few hundred tons of copper concentrates were shipped from the Nugget Creek lodes, but ore was not found on the lower levels, and the ground was abandoned by 1930. The Nugget Creek deposits are in amygdaloidal basaltic lava flows of the Nikolai Greenstone. The best copper mineralization is in or near a northeast-striking fault zone that dips steeply northwest. The lodes consist of veins, films, irregular masses, and disseminated particles of bornite, chalcopyrite, and pyrite, and a little chalcocite and covellite, accompanied by dolomite and calcite. Locally, chalcopyrite also fills vesicles in the flows.

The Big Horn copper prospects (18), which are in intensely faulted Nikolai Greenstone near the junction of the two lowermost branches of Kuskulana Glacier, were explored by several adits, some of which intersected fractures containing small lenses of quartz, chalcocite, and bornite.

The Pierson prospect (18), on the southeastern side of the Kuskulana River about half a mile below Kuskulana Glacier, was explored by a short adit along the sheared contact between a latite intrusive and the Nikolai Greenstone. The shear zone, which is about 3 feet wide, contains a little pyrite and chalcopyrite and is stained with limonite and malachite.

ELLIOTT CREEK PROSPECTS

Several copper deposits on Elliott Creek (9, 10), a tributary of the Kotsina River in the western part of the Kotsina-Kuskulana area, are in complexly faulted Nikolai Greenstone and consist of veins, films, and disseminated grains of pyrite, bornite, chalcopyrite, and chalcocite, together with quartz, calcite, and epidote. Some of the deposits also contain a little gold, silver, and native copper. The minerals fill cavities or replace parts of the greenstone, especially near faults. Malachite stains are abundant but commonly indicate only small lodes of little value. The Elliott Creek deposits were staked in 1899 and explored for about 17 years, but there is no record of any production.

KLUVESNA RIVER PROSPECTS

There are several lodes, including one prospected for silver, in an area drained mainly by the lower Kluvesna River (13, 14) 4–5 miles above its confluence with the Kotsina River.

The Silver Star silver prospect (14) is on the Kotsina side of the divide between the Kluvesna and Kotsina Rivers, but for convenience, is here included with prospects in the Kluvesna drainage. The deposit is in a shear zone in greenstone and basalt near the contact between the Nikolai Greenstone and the underlying volcanic rocks of the Strelna Formation. Dioritic intrusive rocks crop out about a third of a mile east of the prospect. The lode consists of quartz veins containing tetrahedrite, galena, azurite, and malachite. Samples of the veins reportedly assayed 25–700 ounces of silver per ton and 1–32 percent copper. A little bismuthinite is probably also present.

On Mineral Creek (13), a tributary of the Kluvesna River, quartz veins that carry pyrite and chalcopyrite, subordinate chalcocite and

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bornite, and small amounts of gold and silver occupy shear zones in chert, tuff, and lava of the Strelna Formation. The bedded rocks are cut by numerous faults and intruded by intermediate to mafic medium- and fine-grained dikes and sills. Some of the intrusives, especially the light-colored fine-grained dioritic rocks, contain abundant disseminated pyrite. Assays of the veins, some of which are as much as 4 feet thick, showed up to $9.75 in gold and 3 ounces of silver per ton. On one of the claims an 18-inch-thick quartz vein reportedly assayed $60 in gold per ton.

The other deposits in the Kluvesna River area were prospected mainly for copper. Most of them are in sheared amygdaloidal greenstone or other volcanic rocks of either the Nikolai Greenstone or the Strelna Formation and consist of chalcocite, bornite, and chalcopyrite, minor cuprite, malachite, and native copper, and quartz and calcite. The minerals fill fissures and amygdules or replace parts of the country rock.

The deposits in the Kluvesna River area were explored by numerous adits and trenches, but no ore was produced.

ROCK CREEK-LIME CREEK PROSPECTS

At the Warner prospect (14), on Rock Creek a few hundred feet from the Kotsina River, bornite and chalcopyrite are in a 3-foot malachite-stained calcite vein in sheared Nikolai Greenstone, near the contact of the Chitistone Limestone.

Copper minerals have also been found near the Nikolai-Chitistone contact on Lime Creek (14), an eastern tributary of Rock Creek. This deposit is in sheared greenstone and consists of veinlets, small lenses, and disseminated grains of bornite and subordinate chalcopyrite, commonly with quartz and epidote.

A third deposit near the greenstone-limestone contact is at the Lost Cabin prospect (14), about a mile northwest of the mouth of Rock Creek. It consists of chalcocite, bornite, and chalcopyrite, disseminated in the greenstone.

Tunnels and opencuts were dug on most of the lodes in the Rock Creek-Lime Creek area, but no ore was shipped.

ROARING CREEK-KOTSINA RIVER PROSPECTS

Several copper prospects, none of which was productive, are in the basins of Amy, Roaring, Peacock, and Surprise Creeks (15) and Shower Gulch (15). These prospects also include the Larson claim (14), at an altitude of 2,500 feet on the south side of the Kotsina River 2½ miles above Rock Creek, and unnamed prospects (14) on the north bank of the Kotsina River, 1½ miles above Rock Creek.

Most of the deposits are in intensely faulted Nikolai Greenstone, but some are in brecciated shale, chert, gabbro, and volcanic rocks of the underlying Strelna Formation. The bedded rocks near some of the prospects are intruded by intermediate porphyritic dikes. The lodes, which are in or near shear zones, consist of small lenses, veinlets, and disseminated grains of chalcocite, native copper, bornite, chalcopyrite, cuprite, malachite, and azurite. The metallic minerals occur in different combinations and proportions, and not all are likely to be in a single deposit. Gangue minerals are quartz, epidote, and subordinate calcite. Locally, native copper, quartz, and epidote fill vesicles in lava flows.

SLANA AREA

Several lodes near Slana have been explored, chiefly for silver and copper (2–5). The deposits, which were not productive, were discovered in 1898 and prospected sporadically for about 50 years. In 1945 the U.S. Bureau of Mines sampled several of the deposits (Thorne, 1946), and in 1963 and 1964 the State of Alaska Division of Mines and Minerals investigated their geology (Richter, 1963).

The best known deposit is on Silver Creek (5), where hornfels and diorite are cut by a fault zone at least 100 feet wide. The fault zone, which strikes northeast and dips steeply west, contains bleached and altered hornfels and many quartz-carbonate veins. The veins—some as much as 4 feet thick—carry sphalerite, pyrite, chalcopyrite, galena, and tetrahedrite and are stained by secondary iron and copper minerals. Assays of the veins showed up to 0.04 ounce of gold and 17.50 ounces of silver per ton, 0.66 percent lead, and 1.59 percent copper. The deposit was explored by an adit, two shallow shafts, and opencuts, but no minable ore body was disclosed.

A quartz-sulfide lode occurs on the west branch of Ahtell Creek, 9 miles north-northwest of Slana and about a mile and a half northeast of a mountainous landmark called The Dome (3). The lode, which was explored by two short adits, is in a shear zone that cuts altered much-fractured diorite. The shear zone is up to 8 feet wide and strikes northeast and dips steeply west and includes quartz veins as thick as 8 inches that contain galena, copper, and iron sulfides. Much of the country rock is stained by limonite and blue and green copper oxidation products. Assays by the Bureau of Mines showed that the veins contain traces of gold and silver, 1.48–6.58 percent lead, and 0.19–0.31 percent copper. On the northeast flank of The Dome, a little chalcopyrite and galena occur in quartz and calcite veins in hornfels near a quartz monzonite stock. A zone containing disseminated pyrite and minor chalcopyrite has been traced across the top of The Dome.

Other mineralized sites (4, 5) include small pyrite- and chalcopyrite-bearing quartz and calcite veins in chlorite- and hornblende-rich metamorphic rocks near Grubstake Creek (4), a tributary of

Ahtell Creek; quartz veins, some of which contain sparse argentiferous galena and a trace of gold, in tuff and mudstone 2½ miles south of Grubstake Creek (5); and brecciated, serpentinized mafic igneous rocks cut by gold- and silver-bearing quartz veins that also carry sparse sphalerite, chalcopyrite, galena, and pyrite, on lower Ahtell Creek.

Lodes containing silver, copper, and lead are on a ridge east of Indian Creek (3), where quartz veins cut fractured coarse-grained porphyritic diorite. The largest vein, which is milky white, massive, and apparently barren, ranges from 18 inches to 10 feet in thickness and crops out for several hundred feet. Several opencuts on smaller veins exposed iron- and copper-stained vuggy quartz containing galena, chalcopyrite, tetrahedrite, and probably pyrite. Galena is the most abundant sulfide and forms well-defined streaks and bunches in the quartz, but the overall ratio of metallic minerals to quartz is small. Assays of the sulfide-bearing quartz showed a trace to 0.04 ounce of gold and 0.38–15.56 ounces of silver per ton, 0.47–19.92 percent lead, and a trace to 1.44 percent copper. A similar but leaner mineralized quartz vein occurs at the Burns prospect (2), 3½ miles northwest of the Indian Creek occurrence.

OTHER AREAS

Quartz-epidote veins carrying chalcopyrite, bornite, and native copper probably occur in the Nikolai Greenstone near its contact with the Chitistone Limestone at Bear Creek and Mount Chitty in the upper Cheshnina River basin (8). Assays made in 1902 of the sulfide minerals showed a trace to 0.1 ounce of gold and 1.8–4.52 ounces of silver per ton, but no production was recorded.

Copper lodes in a shear zone in the Nikolai Greenstone have been prospected near the head of the Lakina River (21), about 24 miles east-northeast of Strelna. They consist of chalcocite and bornite, partly in calcite veinlets as much as 3 inches thick and partly as veins and disseminated particles without gangue minerals. Small veins and grains of native copper are in the greenstone near the prospects. At the Kinney-Golden prospect (20), about 10 miles to the southwest, chalcopyrite occurs in a thin fault sliver of Nikolai Greenstone and Chitistone Limestone. A 200-foot tunnel failed to disclose an ore body, and the ground was abandoned.

Recent investigations in the Paxson Mountain area (1) by the State of Alaska Division of Mines and Minerals (Rose and Saunders, 1965) disclosed several copper lodes that consist typically of chalcopyrite, bornite, chalcocite, epidote, and quartz in amygdules, veins, and pods in basaltic lava flows. Locally the sulfides are oxidized to malachite and chrysocolla. Prospect pits have been dug on a few of the deposits, and a chip sample across a 10-foot mineralized zone at one locality assayed 6.9 percent copper.

In 1913, prospectors discovered auriferous quartz veins in sheared and altered igneous and sedimentary rocks on Benito Creek (11), a small tributary of the Kotsina River 12 miles northeast of Chitina. The largest vein is 2–3 feet thick and consists of free gold, pyrite, chalcopyrite, arsenopyrite, and silver in a gangue of quartz and subordinate calcite. One specimen of this vein contained a single piece of gold valued at $50. The prospect was explored by sluicing the overburden from about 600 feet of the largest vein and then sinking a few pits in it and one of the smaller veins. No production was recorded.

An unnamed gold lode (6) about 10 miles east of Batzulnetas consists of a zone 6–12 inches wide made up mainly of thin quartz and calcite stringers containing pyrite, galena, and sphalerite. The deposit probably is in an 8-foot-wide trachyte dike near its contact with diorite gneiss. The dike strikes northwest and dips northeast. The deposit was explored by a short adit, but no ore was produced. West of the adit another trachyte dike contains sparse auriferous(?) pyrite near the contact with the gneiss.

A molybdenite prospect on Rock Creek (7) was explored about 1938 by opencuts and an adit 170 feet long, but the exploration did not disclose a workable ore body. The molybdenite occurs mainly in a pegmatite dike cutting gneiss. The dike strikes northwest and dips southwest and ranges from a few inches to 2 feet thick. It was traced on the surface for about 70 feet. Most of the molybdenite forms small flakes, blebs, and veinlets that are irregularly distributed in shattered parts of the dike and nearby country rock, but small flakes are also scattered through some of the less-fractured gneiss and schist near the adit.

Magnetite and a little chalcopyrite have been found in greenschist and sheared diorite about a quarter of a mile northwest of Meier Lake (22). The metallic minerals form irregular pods up to an inch thick and a few inches long.

At Hogan Hill (23), pyrite and traces of chalcopyrite occur in fractures in granodiorite, and a few small chalcopyrite-bearing quartz veins have been found that are parallel to the foliation of amphibolite.

Additional information on this district is given in the following references: Mendenhall and Schrader (1903b); Moffit (1910, 1918, 1921, 1954a); Moffit and Maddren (1908); Moffit and Mertie (1923); Richter (1963); Rose and Saunders (1965); Thorne (1946); Van Alstine and Black (1946a).

NELCHINA DISTRICT

The Nelchina district (pl. 1, fig. 11) is the area drained by east-flowing tributaries of the Copper River from Gulkana on the north to, but excluding, the Tasnuna River on the south.

The dominant physiographic feature of the Nelchina district (pl. 1) is the Chugach Range, high rugged mountains that make up most of the southern two-thirds of the district. The remaining third of the district consists of low hills and plains, except for a small area in the northwestern corner in the rolling uplands of the Talkeetna Mountains.

The oldest rocks exposed in the Nelchina district (pl. 1) are middle to late Paleozoic marine sandstone, shale, and limestone. Next younger, and most abundant, are Mesozoic sandstone and shale and subordinate lava flows and tuff. The sandstone and shale are mainly marine in origin and Cretaceous in age, and the volcanic rocks are at least partly Jurassic. The youngest stratified rocks are Tertiary coal-bearing sandstone, conglomerate, shale, and mudstone. Jurassic granitic stocks cut the bedded rocks in the east-central part of the district, and deposits of unconsolidated silt, sand, and gravel of Quaternary age predominate in the lowlands.

Lodes in the Nelchina district have been prospected for gold, silver, manganese, and chromite. The gold lodes, which also contain a little copper, lead, and zinc, are mainly in an area southeast of Tonsina Lake (6–10, see fig. 11), the site of considerable exploration early in the present century.

The lodes near Tonsina Lake are quartz veins along northward-striking joints or faults in sedimentary rocks near small plutons. One deposit, on the Eagle property (8), was rich enough to mine. It is in sheared graywacke and slate intruded by porphyry dikes up to 30 feet thick and consists of several partly oxidized gold-, arsenopyrite-, and galena-bearing quartz veins as much as 6 feet thick. The dikes and metalliferous quartz veins strike northwest and are vertical; the relatively barren veins are irregular in attitude. Some of the productive veins were very rich, probably owing to residual concentration of gold in the oxidized material. The sulfides are not abundant, but the iron-stained and cavernous appearance of the quartz suggests that they may have been more plentiful before oxidation. Development at the Eagle mine consisted of a tunnel and several opencuts, and although the exact gold production is unknown, it probably was between $10,000 and $20,000. The property has been idle since about 1930.

Gold lodes similar to the one at the Eagle mine occur on Hurtle (Quartz) Creek (6), a tributary of the Tonsina River, and on Stuart Creek (8), a tributary of the Tsina River.

The Hurtle Creek deposit consists of numerous small quartz veins in graywacke and slate about 500 feet west of an 8-foot-thick porphyry sill. Most of the prospecting centered on two parallel quartz veins about a foot thick separated by 30 feet of country rock. The veins, which strike about north and dip 60° E., are iron stained and cavernous and contain free gold, galena, sphalerite, arsenopyrite, and chalcopyrite. They were explored by a tunnel and several opencuts, and a small arrastre was built to recover the gold, but production was probably small.

The Stuart Creek (Knowles) deposit (8) consists of lenticular iron-stained white quartz veins up to 14 inches thick carrying free gold and a little pyrite and galena. The richest veins occupy north-striking nearly vertical faults(?) in graywacke and slate, but veins in fractures with other attitudes and irregular masses of quartz in shear zones are also present. One or more thin diorite dikes occur on the property. The deposit was explored by a number of small opencuts, but little, if any, gold was recovered.

Between 1898 and about 1932, other auriferous lodes were discovered south of Tonsina Lake, but with the exception of the Townsend and Holland prospect (10) near Mile 40 on the Richardson Highway, none received much attention. The country rock at the prospect consists of slate cut by numerous quartz veins, some of which are as much as 5 feet thick. Two of the veins were explored by two tunnels and several trenches, but although the quartz carries gold and probably sulfide minerals, there is no evidence that much gold was recovered.

A lode reportedly containing gold and silver occurs at an altitude of about 4,000 feet on Fivemile Creek (5), 4 miles west-northwest of Chitina. A specimen said to have come from this lode was rich in galena, a possible host for silver, but the geologic setting of the occurrence is unknown.

A manganese lode near Liberty Falls (4) was explored by a few shallow trenches in 1959. It is in chlorite schist and consists of quartz veinlets 3 inches in maximum thickness that contain a dark-brown to black mineral tentatively identified as manganite. Selected specimens of mineralized material assayed as much as 58.7 percent manganese, but the tonnage of manganese-rich rock evidently is small.

Layers, lenses, and disseminated grains of chromite occur in a northeast-trending dunite sill about 7 miles southeast of Tonsina. The sill crops out intermittently over an area 12 miles long and up to 1½ miles wide. To date, two areas containing relatively high concentrations of chromite have been discovered. At Bernard Mountain (Red Hill) (2), at the western end of the intrusive, layers as much

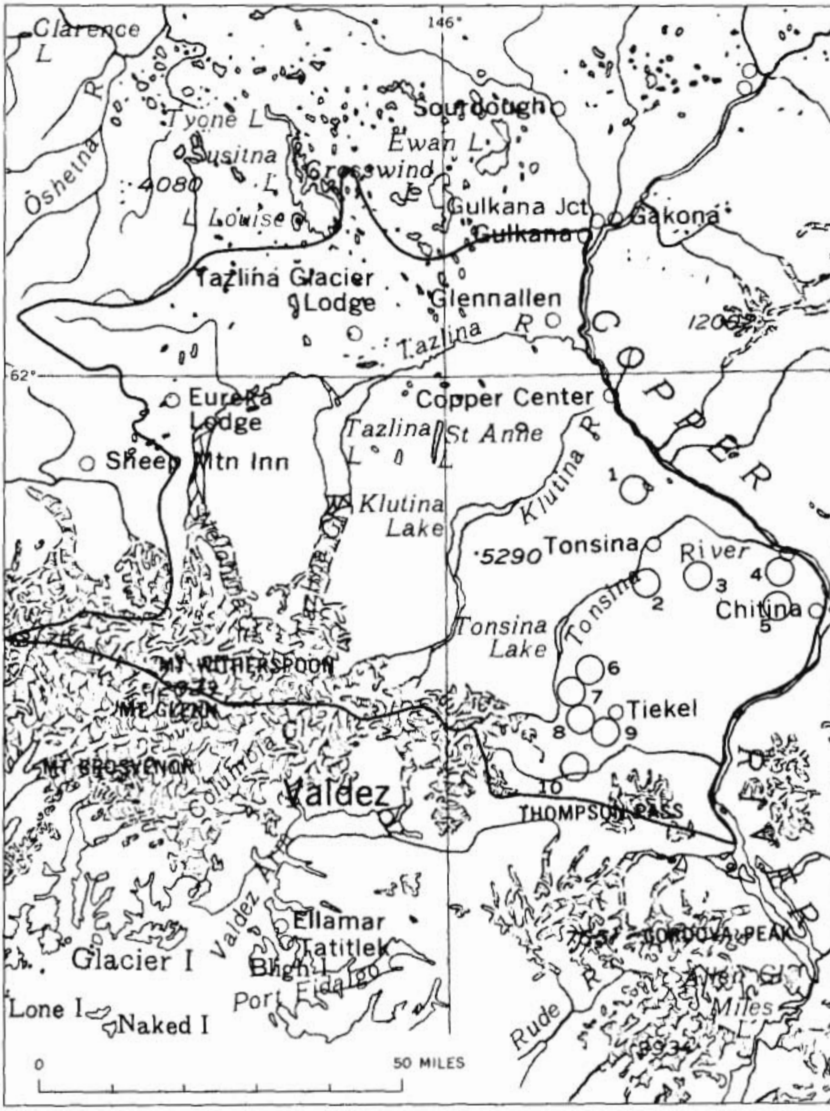

FIGURE 11.—Metalliferous lode deposits in the Nelchina district. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 11

1. *Willow Mountain
2. *Bernard Mountain
3. *Dust Mountain
4. *Liberty Falls
5. *Fivemile Creek

Tonsina Lake area

6. *Hurtle (Quartz) Creek
7. Telluride

(7.) Wetzler
8. *Eagle
   *Knowles (Stuart Creek)
   Ross
9. Portland
   Reis
10. *Townsend and Holland

*Cited individually in the text.

as several tens of feet thick contain up to 30 percent chromite. On Dust Mountain (3), at the northeastern end of the intrusive, a body of massive chromite as much as 10 feet thick is exposed for a distance of 75 feet. Samples of the richest material assay 36.0–57.7 percent chromite, with a chrome-iron ratio of 1.20–3.06. Assays also show traces of nickel and platinum. The most promising deposit thus far discovered is on the north side of Bernard Mountain.

Hydrozincite, a secondary hydrous carbonate of zinc, and a little chalcopyrite and malachite are sparsely but widely distributed in brecciated and hydrothermally altered limestone on the east side of Willow Mountain (1), about 7 miles north-northwest of Tonsina.

Additional information on the district is given in the following reference: Moffit (1918, 1935).

NIZINA DISTRICT

The Nizina district (pl. 1, fig. 12) is the area drained by eastern tributaries of the Copper River between Chitina and Miles Glacier, excluding the area drained by northern tributaries of the Chitina River below the Nizina.

The district is dominated in the south by the Chugach Mountains, in the northeast by the St. Elias Mountains, and in the northwest by the Wrangell Mountains (pl. 1). Within these regions of high relief and large fields of perennial ice and snow, the only large lowland area is the valley of the Chitina River.

The bedded rocks in the Nizina district (pl. 1) include upper Paleozoic limestone, sandstone, and shale; Mesozoic lava flows, tuff, limestone, sandstone, and shale; and Quaternary and Tertiary lava flows and pyroclastic and sedimentary units. From an economic standpoint, the most important Mesozoic formations are the Nikolai Greenstone and overlying Chitistone Limestone, which, in the McCarthy area, was host to the rich Kennecott copper deposits. The bedded rocks are cut by Mesozoic(?) and Tertiary intermediate and felsic stocks, dikes, and sills. In the Chitina River valley most of the bedrock is covered by sand, silt, and gravel. The geology of the northeastern corner of the district is unmapped.

Lodes containing copper, silver, gold, lead, zinc, molybdenum, and nickel occur in the Nizina district, but only the lodes bearing copper and precious metals have been the sources of substantial amounts of ore.

COPPER

Most of the following discussion is taken from reports by Miller (1946), Moffit (1938), and Bateman and McLaughlin (1920).

The period of greatest lode prospecting and mine development was from 1900 to 1938, when more than a billion pounds of copper was recovered, nearly all from the Kennecott mines (8, see fig. 12). Silver was recovered as a byproduct, but its total value was far less than that of the copper.

According to Miller (1946, p. 98):

The copper lodes in the Nizina district may be classified according to the nature of the host rock and the principal sulfide and gangue minerals. The Bonanza, Jumbo, Erie, Mother Lode, Green Butte, and Nelson deposits are in Chitistone limestone; chalcocite is the principal sulfide mineral, and calcite and dolomite are the only gangue minerals. The Westover and Radovan deposits also are in Chitistone limestone but differ in that bornite in the first and pyrite in the second are more abundant than chalcocite; in both quartz is a prominent gangue mineral. The Nikolai deposit and other deposits on Dan, Hidden, and Fourth of July Creeks are in Nikolai greenstone; in these deposits bornite and chalcopyrite are the principal sulfide minerals. In the Erickson deposit, which is also in Nikolai greenstone, the copper occurs chiefly as native copper and copper oxides. The nuggets of native copper found on Dan, Chititu, and Young Creeks and on some of their tributaries were derived from the greenstone.

The origin of the Kennecott copper deposits is still uncertain. Some geologists believe that the copper was derived from the Nikolai Greenstone, which everywhere contains a small amount of copper as an original constituent; others believe that the copper was deposited from hydrothermal solutions that emanated from a concealed granitic pluton in the Kennecott mine area. Evidence that supports a hydrothermal origin of the deposits has been discovered in recent investigations by the Geological Survey (E. M. MacKevett, Jr., oral commun., 1964). Whatever the original source of the copper, it probably was transported by aqueous solutions and deposited in chemically and structurally favorable sites in the greenstone and overlying limestone. The limestone, being more thoroughly fractured and easily replaced, became host to larger and richer deposits than the greenstone.

KENNECOTT MINES

The group of properties known as the Kennecott mines (8) includes the Bonanza, Jumbo, Erie, and Mother Lode mines, located at altitudes of 4,000–6,000 feet in the mountains about 7 miles north and north-northeast of McCarthy. The underground workings in the four mines were interconnected and totaled about 70 miles in length, the deepest workings reaching an altitude of about 2,800 feet. The mines exploited several ore bodies, the most important of which were the famous Bonanza and Jumbo veins—veins that were unique in that they constituted the largest masses of almost pure copper ore that have ever been discovered. The Kennecott mines were in almost continuous operation from 1911 to 1938, during which time they yielded most of the copper produced from Alaska. They were closed

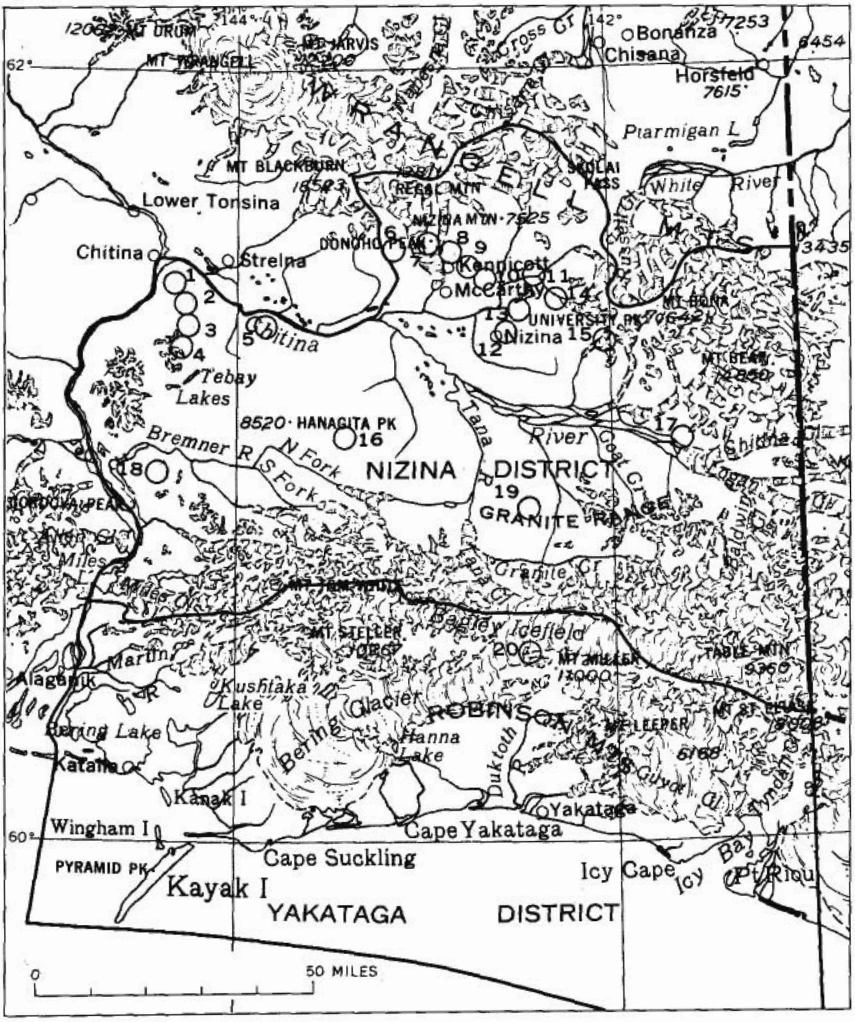

FIGURE 12.—Metalliferous lode deposits in the Nizina and Yakataga districts. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 12

Nizina district

1. *Blackney
2. *Surprise Creek
3. *Divide Creek
   *Falls Creek
4. *Spirit Mountain
5. *O'Hara
6. *Hidden Creek
   *Woodin and Herman
7. *Regal
8. Houghton Alaska
   *Kennecott
9. Donohoe
   *Green Butte
   *Tjosevig
10. *Nikolai
    *Unnamed
11. *Contact Gulch
    *Nelson
    *Peavine
12. *Rex Creek
13. *Bear Paw
    *Golden Eagle
    *Snowbird
    *Westover
    *Williams Peak
14. *Erickson
    *Radovan group
15. *Canyon Creek
16. *Golconda Creek
    Le Tendre
    Nelson
    Yellow Band
17. *Harrais
18. *Standard Mines Co.
19. *Unnamed

Yakataga district

20. *Unnamed

*Cited individually in text.

in 1938 after exploration by underground workings and diamond drilling failed to disclose new ore bodies. Since then relatively little copper has been produced from lodes in the Nizina district.

The Kennecott ore bodies were in Chitistone Limestone a little above the contact with the Nikolai Greenstone. The contact and the bedding strike northwest and dip about 25°–30° NE. The major ore bodies generally had the shape of upward-tapering elongate wedges whose keels were parallel to the dip of the limestone beds. The ore occurred as veins, irregular massive replacements, and stockworks, mostly in partly dolomitic beds in the lowest 300 feet of the Chitistone Limestone.

About three-fourths of the ore mined at Kennecott consisted of sulfide minerals, of which an estimated 95 percent was chalcocite. The remaining sulfides were chiefly covellite and sparse to trace amounts of enargite, bornite, chalcopyrite, luzonite, tennantite, pyrite, sphalerite, and galena. The remaining fourth of the Kennecott ore consisted of oxidized minerals, an unusual feature for a mineral deposit in Alaska, where glaciation commonly has stripped away this ordinarily shallow zone. At Kennecott, however, oxidation is not related to the surface, and oxidized minerals are as common at the deepest levels as at the shallowest. The oxidized ore consisted, in probable order of decreasing abundance, of malachite, limonite, covellite, antlerite, azurite, copper arsenates, chalcanthite, cuprite, and possibly brochantite.

Ore deposition was at least partly controlled by two sets of faults: one that cuts the bedding at a large angle and one that is parallel to the bedding. Bateman and McLaughlin (1920, p. 54–57) also showed that the Bonanza ore bodies were localized in the hinge of a minor syncline whose axis plunges parallel to the dip of the limestone. They related the faults and the fold by postulating that the fracture system was the result of stretching of the beds near the keel of the syncline. In brittle limestone, the tension would be relieved by the formation of upward-tapering wedge-shaped fissures that, when mineralized, would form Kennecott-type ore bodies.

GREEN BUTTE MINE

The Green Butte mine (9) is at an altitude of 4,000 feet on the east side of McCarthy Creek, about 6 miles northeast of McCarthy. The mine was most active from 1922 to 1925, when about 1,400 feet of underground workings were driven and some 1,500 tons of high-grade copper ore produced. The ore reportedly averaged about 1,200 pounds of copper and 10 ounces of silver per ton. Mining ceased in 1925, and little work has been done on the property since then.

The Green Butte lode is in Chitistone Limestone close to the contact with the underlying Nikolai Greenstone. Some of the workings extended a short way into the greenstone, but minable amounts of copper minerals were found only in the limestone. At the mine the formations strike slightly west of north, dip gently east, and, according to Miller (1946, p. 104), are separated by a gray shale bed a few inches to 3 feet thick.

The principal copper mineral mined at Green Butte was chalcocite, but bornite, malachite, azurite, and covellite constituted a small part of the ore. The minerals occur as veinlike replacement lodes and cavity fillings that, in the ore bodies, formed discontinuous masses of chalcocite as much as 4 feet thick. As at Kennecott, the major Green Butte ore bodies were formed at the intersections of steep dip faults and bedding-plane faults.

According to Miller (1946, p. 104)

> Significant quantities of copper may still be present on the Green Butte claims, but the deposits seen in the accessible working apparently are not large enough to justify the cost of establishing a means of transportation to the mine and reopening or extending the workings.

A group of claims, known as the Tjosevig prospect (9), adjoins the northern end of the Green Butte property. The prospect, which was not productive, was developed by a tunnel sometime before 1928, but little or no work has been done since then. The only copper minerals visible in the tunnel are malachite and azurite, which form thin films and veinlets along fractures in Chitistone Limestone.

REGAL MINE

The Regal mine (7) is on the southwest side of Donoho Peak, about 8 miles north-northwest of McCarthy. Between 1910 and 1925, two inclines, with one or more branching levels, and three adits were driven, but the amount of copper ore shipped, if any, is unknown. The mine is at the contact between Chitistone Limestone and Nikolai Greenstone and the workings extend into the lowest limestone beds and the upper part of the greenstone. The contact strikes about west, dips moderately north, and is cut by numerous steeply dipping, north- to northeast-striking faults. Displacements on the faults range from a few inches to about 20 feet.

The most noticeable copper mineralization consists of malachite that in some outcrops is evenly disseminated in the upper 3–5 feet of greenstone and in shaly beds near the base of the limestone. Other signs of mineralization are a few thin veinlets of malachite in the limestone and a few pieces of chalcocite-bearing float near the mine portals. Miller (1946, p. 102) stated that locally the upper 2 or 3 feet of greenstone is weathered to a spongy mass, but recent studies (E. M. MacKevett, Jr., oral commun., 1965) suggest that this zone may be the result of hydrothermal alteration rather than of weathering.

NIKOLAI MINE

The Nikolai mine (10) is at an altitude of 4,250 feet on Nikolai Creek, about 8 miles east-northeast of McCarthy. The deposit was staked in 1900 and developed until about 1911, but as far as is known, no ore was produced. Workings consisted of a shaft, a tunnel with two short drifts and a winze, and several prospect pits.

The rocks near the mine are Nikolai Greenstone and Chitistone Limestone; they strike N. 60° W., dip 30° N., and are cut by a prominent northeast-striking fault that dips steeply southeast. The fault does not contain copper minerals at the surface, but chalcopyrite, bornite, chalcocite, and malachite have been found in two shear zones in greenstone north of, and roughly parallel to, the fault. The copper minerals, together with calcite, quartz, and epidote, form replacement veins and cavity fillings and are disseminated in the greenstone in and near the shear zones. The richest lode is in the northern zone, where the workings explored a vein of copper and gangue minerals 1–4 feet thick and about 150 feet long. Prospect pits on the other zone disclosed a discontinuous copper-bearing vein at least 50 feet long and 6 inches in maximum thickness.

Miller (1946, p. 108) estimated that there is probably about 1,500 tons of material containing at least 25 percent copper in the vein above the tunnel level of the northern shear zone, but that the vein probably wedges out a short distance below the tunnel. There is no evidence that the southern shear zone contains much copper, nor do the prospect pits in the area near the exposed veins show significant mineralization.

Another nonproductive copper prospect (10) is about 1½ miles east-northeast of the Nikolai mine. The lode, which has been explored by two short adits, consists of chalcocite and minor azurite in fractured Chitistone Limestone, a little above the Nikolai Greenstone contact.

WESTOVER PROSPECT

The Westover copper prospect, which was staked about 1906 (13), is 1.6 miles north of the junction of Boulder and Dan Creeks. From 1911 to 1930 more than 1,400 feet of underground workings were driven, and an unknown, but probably small, amount of ore was shipped in 1917–18.

The prospect is in Chitistone Limestone at its contact with Nikolai Greenstone. The formations strike northward, dip gently eastward, and are cut by several steeply dipping northward-striking faults. Maximum apparent vertical displacement on the faults ranges from 20 feet near the tunnels to at least 250 feet several hundred feet south of the prospect. At least some of the displacement took place after the deposition of the copper minerals.

The Westover lode differs from most of the deposits in the Chitistone Limestone in that bornite, rather than chalcocite, is the chief copper mineral. Subordinate chalcocite apparently replaced part of the bornite, and both sulfides are partly oxidized to malachite. A little chalcopyrite is also present. The sulfide minerals, together with calcite and quartz, occur as lenses, veins, disseminated grains, and vugs in the lowermost 20 feet of the limestone. Most of the copper minerals are in specific limestone beds, which suggests that their deposition was controlled by bedding-plane faults or subtle chemical variations. Copper minerals also occur in some of the steeply dipping faults.

The ore that was mined was a wedge-shaped mass of bornite and chalcocite 35 feet long and as much as 10 feet deep, and several smaller veins and lenses. Miller (1946, p. 110) estimated that 100 tons of material containing about 30 percent copper, and an equal amount containing about 10 percent copper, was exposed in the workings in 1943, but he found no evidence to suggest the presence of larger lodes.

NELSON PROSPECT

The Nelson copper prospect (11) is on the south side of Glacier Creek, 1 mile from its junction with the Chitistone River. It was discovered in 1928 and explored in 1929–30 by about 1,100 feet of underground workings from which several tons of ore was recovered and shipped. In 1951, renewed interest in copper mining led to exploration of the deposit by diamond drilling, but as far as is known, no ore body was found.

The deposit is in the lowest limestone beds of a block of Chitistone Limestone and Nikolai Greenstone about a mile long and 2,000 feet wide that has been faulted down relative to correlative beds to the south (Miller, 1946, p. 111). The fault strikes northwest and dips 55°–60° SW., and the limestone and greenstone on the southwest side are thrust over the corresponding beds on the northeast side. The overthrust, whose stratigraphic throw near the prospect is approximately 5,000 feet (Sainsbury, 1952, p. 4), is one of the major faults in the Nizina district; it has been traced more than 12 miles to the northwest and probably extends southeastward along Glacier Creek. The fault block is cut by myriads of steeply dipping fractures of small displacement, most of which intersect the overthrust at a large angle. At the prospect the limestone strikes N. 5°–25° W., dips 10°–15° SW., and is separated from the greenstone by a 6-foot bed of shale and siltstone. Forty feet above the shale the Chitistone Limestone is marked by a thick zone of brecciated dolomite.

The Nelson lode consists of stringers; discontinuous veins and bunches; disseminated particles of chalcocite, subordinate covellite;

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and small amounts of enargite, bornite, malachite, chalcopyrite, native copper, and pyrite. The gangue minerals are calcite and dolomite. The lode is mainly along bedding planes and in steeply dipping faults in the limestone. Some of the steep faults, however, offset copper-bearing veins and are thus postmineralization in age. Seams of chalcocite that have been found in a filled solution cavity suggest that at least some of this mineral is of relatively recent supergene (secondary) origin (Sainsbury, 1952, p. 9).

Many other copper deposits in the Chitistone River-Glacier Creek area were explored, but no ore was shipped from any of them and all were abandoned by 1938. The most important are along the Nikolai-Chitistone contact in Contact Gulch (11) about a mile north-northwest of the mouth of Glacier Creek and at the Peavine prospect (11) 2 miles west-southwest of the mouth of Glacier Creek.

ERICKSON PROSPECT

The Erickson prospect (14), at an altitude of about 4,200 feet near the head of Glacier Creek, was explored by two tunnels and three levels of underground workings that totaled 300 feet in length. The lode was staked in 1906, and some ore was shipped in 1917, but the property has been inactive since about 1927.

The country rocks are faulted amygdaloidal lava flows, probably of the Nikolai Greenstone, that strike northwest and dip moderately southwest. Native copper and lesser chalcocite, malachite, and cuprite seemingly are restricted to one of the flows, a 6- to 8-foot bed that contains many black amygdules. The copper minerals, locally with quartz, occur as irregular masses, thin veins, and disseminated grains in the flow and in the amygdules. Miller (1946, p. 118) estimated that the copper content of the bed averages less than 5 percent but locally is as much as 10 percent. The mineralized zone, however, is difficult to follow and probably is discontinuous.

RADOVAN GROUP OF PROSPECTS

The Radovan group of copper prospects (14) is in Radovan Gulch on the southwest side of Glacier Creek, about 18 miles east-southeast of McCarthy. The group consists of three prospects: the Binocular claim, at an altitude of 6,340 feet on the west side of Radovan Gulch; the Low-Contact prospect, about 3,500 feet south-southeast of the Radovan prospect; and the Greenstone prospect, at an altitude of about 4,000 feet, 2.8 miles north-northeast of the Low-Contact prospect.

Work on the Binocular prospect, discovered about 1930, consisted of several shallow pits; the Low-Contact deposit, discovered about the same time, was explored by two tunnels. The Greenstone lode was staked in 1950 and was explored in 1951 by about 200 feet of underground workings. The deposits have continued to attract copper-mining interests, but no ore has been shipped from any of them.

Bedrock in Radovan Gulch is Nikolai Greenstone and Chitistone Limestone. Both formations are cut by several faults, the most prominent of which is a north-northeast-striking east-dipping normal fault that displaces the limestone-greenstone contact 1,000 feet. The Low-Contact and Greenstone prospects are on this fault.

The Binocular prospect is in a faulted lens of dolomitic limestone as much as 90 feet thick and several hundred feet long. The deposit is in the upper 20 feet of the dolomitic limestone and has been traced on the surface for about 200 feet. It consists of lenses, thin veins, vugs, and disseminated grains of pyrite, marcasite, chalcocite, bornite(?), and chalcopyrite. Oxidation has resulted in the formation of limonite and minor malachite, azurite, and cuprite (?). Gangue minerals are calcite, dolomite, and quartz. Samples of some of the sulfide-rich lenses reportedly assayed 0.03–12 percent copper; a few small pods were estimated to contain about 25 percent copper.

The Low-Contact prospect is in Chitistone Limestone about 150 feet above its base. It is on the downthrown side of the prominent fault described above, which at the prospect is represented by a breccia zone at least 100 feet wide. The zone also contains dikelike bodies that Miller (1946, p. 115) identified as igneous, but which Sainsbury (1952, p. 15) described as hydrothermally altered fault breccias. Parts of the zone contain copper sulfides, chiefly chalcocite and minor bornite(?), together with quartz, calcite, dolomite, and epidote. The best mineralization is a chalcocite(?) vein 1–6 inches thick exposed for 50 feet. Antimony minerals have been found in float but not in place.

The lode on the Greenstone prospect consists primarily of a vein in Nikolai Greenstone in the same fault zone as the Low-Contact prospect. The vein, which branches irregularly and carries inclusions of country rock and vein breccia, is 1–8 inches thick throughout a continuous exposure of 150 feet and contains chalcocite and small amounts of covellite, enargite, bornite, cuprite, malachite, and native copper. The southernmost 10–15 feet of the vein is 4 feet thick and contains about 80 percent chalcocite. A short distance south of this thick section, the vein disappears and the trace of the fault to the south is marked only by sporadic limonite stains. Sainsbury (1952, p. 13) estimated that the vein contains about 450 tons of chalcocite-rich material averaging 78 percent copper.

OTHER PROSPECTS

Several lodes containing bornite, chalcopyrite, and chalcocite are in Nikolai Greenstone on Fourth of July and Hidden Creeks (6), about

10 miles northwest of McCarthy. They were staked about 1906 and developed until about 1920; during this time a little copper ore was shipped from the Woodin and Herman claims (6) on Fourth of July Creek.

Bornite, chalcopyrite, chalcocite, and native copper have also been found in Nikolai Greenstone at many places on the north side of Dan Creek (13), about 14 miles east-southeast of McCarthy. The minerals are particularly common in a zone about 30 feet below the base of the Chitistone Limestone, but they have not been found in significant amounts in the limestone, except at the Westover prospect (p. 58). The better known deposits in the greenstone—on the Snow Bird, Bear Paw, and Golden Eagle claims—were explored in the early 1900's by short tunnels, but there is no record that any ore was shipped.

Lodes that contain copper occur in limestone and calcareous schist on the Harrais claims (17), near the terminus of Chitina Glacier. They were discovered in 1926 and developed by several short tunnels; no ore was found, and the claims have been virtually idle since 1932. The lodes consist of faults and shear zones containing small pods and aggregates of galena, sphalerite, chalcopyrite, bornite, pyrite, silver or a silver sulfide, and secondary iron and copper minerals. A sample of a sulfide-rich pod 10 inches in diameter and 1–4 inches thick assayed 4.78 percent copper, 6.53 percent lead, and 13.5 percent zinc. An assay of a sample of other material showed a little silver.

Several deposits (1–4) in the mountains east of the Copper River between the Chitina River and Canyon Creek[1] were prospected for copper in the early 1900's. No ore was produced, but several lodes showed sufficient mineralization to warrant underground development. All but one of the better known deposits are in shear zones in greenstone; the exception is an occurrence near Spirit Mountain (4) in which nickel and copper minerals are associated with ultramafic intrusive rocks. This occurrence is described on page 64.

One of the more thoroughly prospected lodes in the Chitina River–Canyon Creek area is on the Blackney property (1) near the head of Taral Creek. The sheared hydrothermally(?) altered greenstone at the prospect is probably intruded by the diorite that crops out nearby. Some of the shear zones contain parallel pyrite and chalcopyrite veins as much as 18 inches thick, which are separated by thin layers of greenstone. The largest metalliferous shear zone is 3 feet wide and crops out for 200 feet; it strikes N. 75° W., dips 45° S., and is cut off at its eastern end by a fault. Similar deposits on Sur-

[1] There are two Canyon Creeks in the Nizina district. This one is tributary to the Copper River, about 8 miles south of Chitina.

prise Creek (2) and near Falls and Divide Creeks (3) were explored by tunnels and opencuts.

OTHER METALS

GOLD AND SILVER

The only productive gold lodes in the Nizina district are in the headwaters of Golconda Creek (16), about 50 miles southeast of Chitina. They were worked until about 1942, when wartime restrictions followed by postwar increases in mining costs ended most mining. Several thousand feet of underground workings were driven on the three productive lodes, and opencuts and short adits were opened on several prospects. The amount of ore produced is not known, but the extent of the underground workings suggests that it was probably substantial. The lodes are iron-stained quartz and minor calcite veins in Paleozoic(?) slate and graywacke intruded by porphyritic diorite dikes. The veins, which contain free gold and sparse pyrite, galena, and molybdenite, are mainly in faults or shear zones in the bedded rocks and in some of the dikes.

During a traverse across the Chugach Mountains in 1959, U.S. Geological Survey geologists found quartz veins in rocks like those at Golconda Creek. One sample of a vein near an unnamed small lake (19) contained a little visible free gold; pyrite, hematite, and a little chalcopyrite were found elsewhere in the area.

Sometime before World War I the Standard Mines Company (18) explored a gold lode near the head of Eagle Creek. The lode is in schist and consists of a northward-striking eastward-dipping quartz vein as much as 13 inches thick containing free gold, pyrite, and galena. The vein reportedly assayed about $60 per ton in gold, but there is no evidence that any ore was shipped. Veins that crop out on nearby prospects contain a little chalcopyrite.

Early gold prospectors in the Nizina district also explored quartz veins that cut Cretaceous sedimentary rocks and contain pyrite, free gold, and, locally, molybdenite and stibnite. Moffit and Capps (1911, p. 99) described a lode on Rex Creek (12) that presumably is typical of these veins, as follows:

> A thin vein * * * in a porphyry dike on the upper part of Rex Creek * * * consisted of quartz with molybdenite and pyrite and assayed 0.18 ounce gold and 12.80 ounces silver to the ton. The dike rock near the vein, although seemingly little altered, contained pyrite and showed a trace of both gold and silver.

ANTIMONY

Several quartz veins prospected for antimony and gold occur in sheared hornfels and granodiorite on Williams Peak (13), about 12 miles southeast of McCarthy. The northward-striking nearly vertical veins are as much as a foot thick and contain finely granular to coarsely bladed stibnite, a little realgar, and possibly orpiment. Some of the veins have been explored by several short adits, but there have been no recorded ore shipments.

LEAD AND ZINC

A lead-zinc deposit at the O'Hara prospect (5), about 25 miles southeast of Chitina, is in marble and consists of sparse veins up to 8 inches thick of galena, sphalerite, pyrite, marcasite, and pyrrhotite. The marble also contains a few thin layers of mica schist and a little disseminated tourmaline, pyrite, pyrrhotite, and sphalerite. Three adits were driven about 1940, but they did not reveal a minable ore body.

MOLYBDENUM

A molybdenum-bearing lode (15), reportedly in granitic rocks near the head of Canyon Creek,[2] was described by the owner in 1940 as a quartz vein as much as 8 feet thick carrying scattered stringers and bunches of molybdenite. The greatest concentration of molybdenite was said to be in a foot-thick zone near one of the walls of the vein. The deposit is evidently unfavorably situated with respect to timber and water and has been only slightly prospected.

NICKEL AND COPPER

A nickel-copper deposit is at Spirit Mountain (4), near the head of the Canyon Creek south of Chitina. The copper content attracted interest first, and between 1907 and 1917 the lode was explored by test pits and two short tunnels. No ore was shipped, however, and the property was abandoned in 1917. The early assays also showed nickel, and the deposit was reexamined in 1942, when interest in this strategic metal was high.

The country rock at Spirit Mountain is a sequence of metamorphosed sedimentary and volcanic rocks intruded by sill-like bodies of sulfide-bearing peridotite and pyroxenite. Two of these bodies constitute the principal nickel-copper deposit, which consists of disseminated grains and massive lenses of pyrrhotite, chalcopyrite, the nickel minerals bravoite and pentlandite, and sphalerite, pyrite, magnetite, and limonite.

Kingston and Miller (1945, p. 49) estimated that the deposit contains about 6,500 tons of disseminated and massive sulfide material carrying, respectively, 0.22 percent nickel and 0.12 percent copper, and 7.61 percent nickel and 1.56 percent copper. They concluded that the deposit is too small and inaccessible to mine profitably, even at advanced nickel prices, and that any additional nickel-copper deposits found in the area are not likely to be larger or richer.

[2] This Canyon Creek is tributary to the Chitina River, about 31 miles southeast of McCarthy.

Additional information on this district is given in the following references: Bateman and McLaughlin (1920); Brabb and Miller (1962); Kingston and Miller (1945); Miller (1946); Moffit (1914, 1918, 1937, 1938); Moffit and Capps (1911); Sainsbury (1952); Seitz (1963a); Smith, P. S. (1942).

PRINCE WILLIAM SOUND DISTRICT

The Prince William Sound district (pl. 1; fig. 13) comprises the area drained by streams flowing into Prince William Sound and the Gulf of Alaska from Cape Junken on the west to the Glacier River on the east and the area drained by the western tributaries of the Copper River below and including the Tasnuna River. Middleton Island is also in the district.

The district is in the Kenai and Chugach Mountains (pl. 1) and, except for the lowlands of the Copper River delta and relatively low hills on some of the islands in Prince William Sound, is characterized by rugged mountains whose summits commonly exceed 5,000 feet in altitude.

The rocks of the district (pl. 1) are mainly Mesozoic and Cenozoic graywacke, slate, and subordinate greenstone intruded by numerous Late Cretaceous and Tertiary plutons. The plutons are mainly felsic or intermediate stocks, dikes, and sills, but they also include a few mafic and ultramafic bodies. Middleton Island is made up of Tertiary sandstone, shale, mudstone, and conglomerate; the Copper River delta, in the southeastern corner of the district, is Recent sand, silt, and gravel.

Most of the following description is summarized from a report by Moffit (1954b).

Copper and gold lodes have been worked successfully in the Prince William Sound district, and silver has been recovered as a byproduct of the refining of the gold and copper ores. Iron, arsenic, lead, zinc, antimony, and nickel also occur in the lodes but have not been recovered. Most of the copper deposits are in or near greenstone, which is probably genetically related to the lodes, but the largest and most productive were in the adjacent slate and graywacke. The gold lodes are chiefly in graywacke and slate. The same primary sulfide minerals occur in both the copper and the gold deposits, but the relative amounts in each type of deposit differ. Sulfides and a little quartz characterize most of the copper lodes, whereas the gold lodes are mostly free-milling gold quartz veins carrying sparse sulfides. The mineralogy of the gold lodes contrasts with that of the copper lodes as follows: Pyrite is the dominant iron sulfide in the gold lodes, whereas pyrrhotite dominates in the copper lodes; galena and arsenopyrite are more common in the gold lodes than in the copper lodes; and antimony, which has not been reported in the copper deposits, is found in several of the gold deposits.

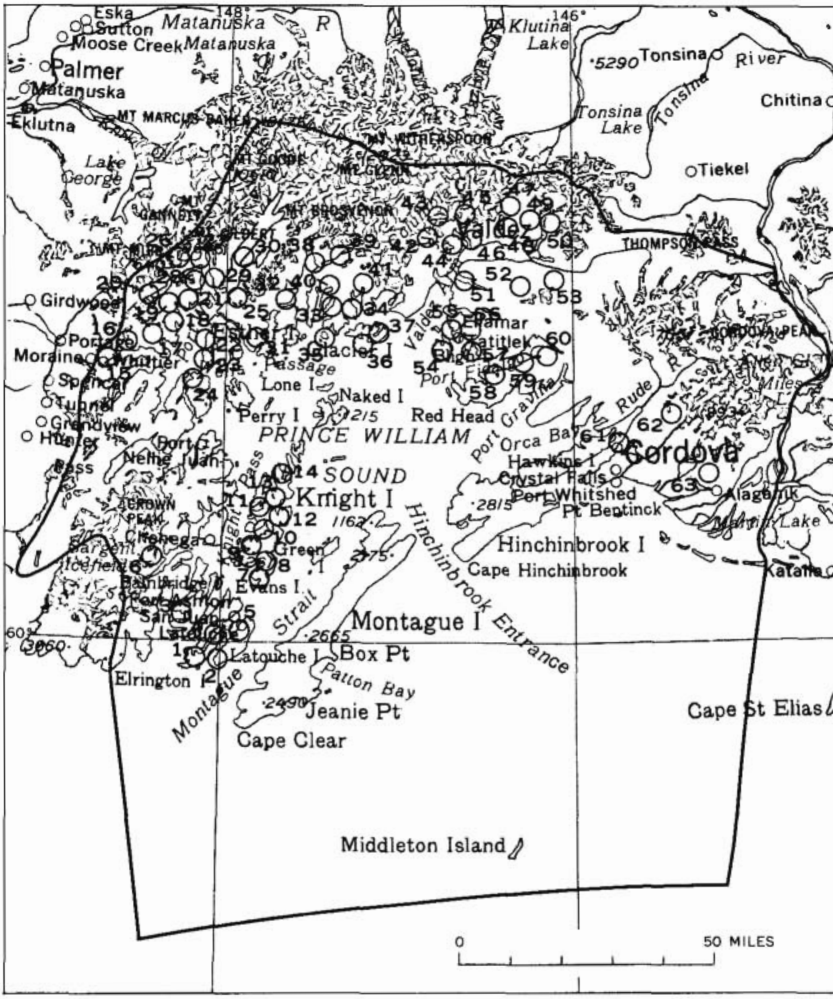

FIGURE 13.—Metalliferous lode deposits in the Prince William Sound district.

LOCALITIES

Latouche Island area

1. Elrington Island
2. *Latouche Consolidated Copper Co.
   Seattle-Alaska Copper Co.
3. Hogg Bay
4. Elrington Island
5. *Horseshoe Bay (RADCO)
   *Latouche
   Latouche Island Copper Mining Co.
   Wilson Bay
6. *Jackpot Bay

Knight Island area

7. Copper Queen
   Happy Jack
   Hogan, Hample, and Egan
   Wilcox
8. Graham and Harrison
   Harvey
   Home Camp
   Minnie
   Mummy Bay
   Snug Harbor
9. Cathead Bay
   Copper Bay

*See footnote at end of list.

LOCALITIES SHOWN ON FIGURE 13—continued

Knight Island area—Continued

(9.) Copper Coin
Hubbard and Elliott
Mallard
Moore
10. Jonesy
Knights Island Alaska Copper Co.
Knights Island Copper Co.
Monarch
Nellie
Twentieth Century Knight Island
Unnamed
11. *Copper Bullion (Rua Cove)
Marsha Bay
Pandora
South Arm
12. Lower Herring Bay
13. Big Passage
Crown Copper
Knights Island Mining and Development Co.
Unnamed

14. Disk Island
Louis Bay

Port Wells area

15. Hillside
16. Bullion
Golden Giant
Portage
17. Alaska Homestake
Dunklee and Reilly
Lansing
Tomboy
18. Banner
George and McFarland
Hummer
19. Hermann and Eaton
Sweepstake
Yakima
Unnamed
20. Skypilot
21. Anderson and Yannes
*Granite
Harris
Olsen and Viette
Reed, Gautier, and Cooper
22. Kavanaugh and Boon
23. Fish, Collins, and Stewart

*See footnote at end of list.

Port Wells area—Continued

24. Reagan
*Thomas-Culross
25. Arrowhead
Carter
Conley and McChesney
Consolidated
Frodenberg and Bloom
Golden Eagle
Golden Wonder No. 1
Golden Wonder No. 9
Griset
Lucky Swede
Mayflower
Morning Star
Mountain
North Star
Nugget
Sweepstake
Tolson & Stanton
26. Black & Hogan
27. Barry Arm
Capitol Hill
Reiter & Olson
28. Mitchell & Myers
29. Cameron
Griset & Benson
Last Chance No. 2
Paymaster
Simonton & Mills
Walters, Brasslin & Atkinson
30. Cann & Miner

Eaglek Bay-Unakwik Inlet-Glacier Island area

31. Eldorado
32. *Siwash Bay
33. Blackjack
*Cedar Bay
34. Gilnow
35. Byers
36. Chamberlain
37. Jensen
Jensen, Wallace, Kilbourn
Nelson & Rystrom
38. *Miners Bay
39. Four in One
Miners River
Norris Lead Zinc
40. *Wells Bay
41. *Long Bay (Globe)

Continued on following page.

LOCALITIES SHOWN ON FIGURE 13—continued

Port Valdez area

42. Bessie Williams
    Mayfield
    National
43. Cameron-Johnson
    Gold King
    Rough & Tough
44. Alice
    Big Four
    Bluebird
    Hecla
    I. X. L.
    Palmer
    Shoup Bay Mining Co.
    Silver Gem
    Spanish
    Whistler
45. Minnie
    Olson
    Rambler
46. Alaska Gold Hill
    Bunkerhill
    *Cliff
    Cube
    Gold Bluff
    Guthrie & Belloli
    Owl
    Seacoast
    Sealy-Davis
    Thompson-Ford
47. Big Four
    Chesna
    45
    Hercules.
    Millionaire
    Monte Carlo
    Mountain View
    Quitch
    Slide
    Sunshine
48. Alaskan
    Devenney & Dolan
    High Grade
49. Blue Ribbon
    Ethel (Williams-Gentzler)
    Ibex
    July
    Little Giant
    Mountain King
    Rose
    Rose Quartz
    Star

Port Valdez area—Continued

(49.) Valdez
    Valdez Bonanza
50. Pinochle
    *Ramsay-Rutherford
    Rose Johnson
51. Curley Kidney
    Jack Bay (2 occurrences)
52. Bay View
    *Midas (Solomon Gulch)
53. Addison Powell
    Sulfide Gulch

Ellamar-Port Fidalgo area

54. Bligh Island
    Cloudman Bay
55. *Ellamar
56. Fielder & Hemple
    *Galena Bay Mining Co.
    Mogul
    Reynolds-Alaska Development Co.
57. Alaska Commercial Co.
    Banzer
    Chisna Consolidated
    Falck
    Hemple
    Hoodoo
    *Landlock Bay Copper Miniug Co.
    Montezuma
    Reynolds-Alaska Development Co.
    Standard Copper Mines Co.
    Steinmetz
    *Threeman (1 mine, 2 prospects)
58. Dickey (Mason & Gleason)
    *Fidalgo-Alaska (Schlosser)
59. Fidalgo
60. Whalen & Nelson

Cordova area

61. Cordova Copper Co. (Fleming Spit)
    *Wilson Point
62. *Ibach

McKinley Lake area

63. Bear Creek Mining Co.
    Lucky Strike
    McKinley Lake Mining Co.

*Cited individually in the text.

COPPER

The copper deposits of Prince William Sound contain pyrite, pyrrhotite, and chalcopyrite, and subordinate arsenopyrite, galena, sphalerite, cubanite, and chalcocite(?). The sulfides occur as veins in fractures and as disseminated particles in the wallrock that locally coalesce into massive replacement lodes. The ore bodies were either lenticular or irregular, and the distinction between ore and waste was not sharp, owing to a gradual decrease in the disseminated-sulfide content with increasing distance from the main lodes. Locally, shallow oxidation has produced limonite, malachite, azurite, and a little native copper.

Copper minerals occur throughout the Prince William Sound area, but the major deposits are in the northeastern and southwestern parts of the district. The northeastern area includes deposits at Ellamar (55, see fig. 13), Landlocked Bay (57), Port Fidalgo (58), Galena Bay (56), and Solomon Gulch (52). The southwestern area includes the lodes on Latouche (2, 5) and Knight (7-14) Islands.

Sustained copper production in the Prince William Sound district began at Ellamar and Latouche in about 1897 and ended in 1930, when the mines at Latouche were worked out. From 1910 to 1930, almost 214 million pounds of copper were produced, of which more than 56 percent came from the Latouche and Ellamar deposits.

NORTHEASTERN AREA

The Ellamar mine (55) was by far the most productive in the northeastern area. It yielded not only copper ore but important amounts of gold and silver and was a source of pyrite for smelter use. The ore body consisted of a hanging-wall lens of solid pyrite and an underlying body made up of chalcopyrite, pyrrhotite, and sphalerite. The two parts were separated by a 2-foot layer of black slate. The ore body plunged steeply from its outcrop at sea level and reportedly pinched out at a depth of 530 feet. It was elliptical in horizontal cross section and at the 200 level was 90 feet wide and 240 feet long. Chalcopyrite was the main source of copper in the ore; sphalerite yielded most of the gold and silver. According to Moffit (1954b, p. 298):

> The Ellamar ore body is representative of the copper deposits on northeastern Prince William Sound, although it was much larger than any other known deposit and yielded a greater proportion of gold and silver than the other copper lodes of the district. This body, like that of most of the larger mines and prospects, was deposited in faulted sedimentary beds and had no evident connection with nearby greenstone lavas.
>
> Many other smaller mines and prospects in this part of the sound yielded copper ore. * * * Chief among them were the Midas mine [52] on Solomon Gulch, and operations of the Threeman Mining Company [57] on Landlocked Bay and at Fidalgo–Alaska Copper Company [58] * * * on Port Fidalgo. The

ore from Solomon Gulch and Port Fidalgo was from deposits in faulted sedimentary beds; that from Landlocked Bay was from an area of much faulting where greenstone and sedimentary rocks occur in intimate association. The principal copper mineral in these places was chalcopyrite, though chalcopyrite was supplemented in the Landlocked Bay area by a considerable quantity of chalmersite (cubanite).

SOUTHWESTERN AREA

The Latouche Island deposits (5), the most productive copper lodes in southwestern Prince William Sound, are similar in many respects to those in the northeastern part of the district. At Latouche, and at Horseshoe Bay (5) 2 miles south of Latouche, sulfide minerals occur in a fault zone in graywacke and slate. The Latouche deposits, which extend along the fault zone for about half a mile, yielded nearly all the copper mined on the island. The Beatson mine, on the southern part of the Latouche lode, was the principal producer.

The country rock at the Beatson mine consists of interbedded graywacke and slate that near the ore bodies is altered to greenish schist and a hard cherty rock with conchoidal fracture. The lode is closely related to the northeastward-striking Beatson fault, which separates graywacke and slate in the footwall on the east from black slate in the hanging wall on the west. Ore bodies formed where mineral-bearing solutions following the fault were trapped beneath the impermeable slate of the hanging wall. The richest ore bodies were lenses of solid sulfides, but most of the ore consisted of abundantly disseminated sulfides in the altered graywacke and slate. In places, shallow surficial oxidation has produced secondary iron and copper minerals. The ore that was mined comprised pyrrhotite, pyrite, and chalcopyrite, subordinate sphalerite, galena, and cubanite, minor gold and silver, and sparse quartz, siderite, ankerite, and chlorite(?). The Beatson lode was mined for a maximum length of about 1,000 feet and for a maximum width of about 400 feet, and the mining operations extended through a vertical distance of about 500 feet. The Girdwood mine, which is about 2,000 feet north of the Beatson, and the Chenega mine, halfway between them, exploited sulfide deposits that were practically continuous with the Beatson lode.

Two large sulfide deposits at Horseshoe Bay (5) have been explored for copper and as a possible source of sulfur. They consist of massive and disseminated replacement lodes in and near a fault zone and contain pyrite and pyrrhotite; subordinate chalcopyrite, cubanite, sphalerite, and galena; and minor gold and silver. The fault is parallel to the bedding of the enclosing graywacke and slate and may be an extension of the Beatson fault. Workings exposed lenses of massive sulfides as much as 122 feet thick and 500 feet long.

The copper deposits on Knight Island (7-14) differ from those at Ellamar and Latouche in that they are in greenstone rather than in slate and graywacke. They were extensively prospected, but none was productive.

A prospect at Rua Cove (11), explored by underground workings and numerous opencuts, typifies the Knight Island deposits. It is in the western part of a northward-striking nearly vertical shear zone and consists of a lens of sulfides as much as 100 feet wide and 400 feet long. The lens, which strikes N. 25° E. and dips 60° W., is made up mainly of pyrrhotite containing grains and veinlets of chalcopyrite, sphalerite, and cubanite. The gangue consists of subordinate quartz and greenstone. Sulfides also occur in the sheared greenstone east of the lens. The mineralization was probably mainly by replacement and is most abundant near the walls of the shear zone. There are many smaller deposits like the one at Rua Cove on Knight Island, especially near Drier Bay (9, 10).

OTHER AREAS

Copper lodes similar to those on Knight Island are on Glacier Island (36, 37) and near Cordova (61), and copper deposits in granitic country rock occur near Cedar Bay (33). The Glacier Island and Cordova deposits were explored prior to World War II, but they proved to be too small and low grade to mine profitably. At Cedar Bay, granitic rock is cut by a northward-striking vertical breccia zone 8–10 feet wide carrying quartz, pyrite, sphalerite, and a little chalcopyrite and covellite. The largest sulfide body discovered was a lens 8 inches thick and 3–4 feet long.

Other nonproductive lodes containing sulfides of copper and other metals occur in many places on the mainland between Long Bay and Port Wells. The most thoroughly explored include deposits on Long Bay (Globe) (41), Wells Bay (40), Siwash Bay (32), and two near Miners Bay (38, 39). The Miners Bay lodes also carry a little nickel.

The Ibach copper prospect (62), discovered early in the century, is near a contact of diorite and black slate about 14 miles northeast of Cordova.

GOLD

The following deposits in the Prince William Sound district are those in which gold was not the byproduct of copper mining but was the principal metal sought. Silver invariably was associated with, but was subordinate in amount to, the gold.

Auriferous lodes occur throughout the district but are most numerous in the Port Valdez (42–53), Port Wells (15–30), and McKinley Lake (63) areas. The lodes, which occur in slate and graywacke and in granitic intrusive rocks, consist mainly of quartz and calcite fissure veins containing small amounts of gold, silver, pyrite, galena, chalcopyrite, arsenopyrite, sphalerite, pyrrhotite, and stibnite. Some are marked by a thin oxidized zone.

Lode gold production from the Prince William Sound district, including gold recovered as a byproduct of copper mining, was at least 136,000 fine ounces, all produced before World War II. The Cliff mine was the most productive followed by the Ramsay-Rutherford, Granite, and several smaller mines.

The deposit at the Cliff mine (46), near Valdez, typifies the gold lodes of the district. It is in graywacke and slate and consists of several fissure veins of vuggy and banded bluish-white quartz and minor calcite, albite, chlorite, and brown-weathering carbonate. The veins range in thickness from less than an inch to 4½ feet and carry about 4 percent arsenopyrite, pyrite, sphalerite, galena, and free gold. In places, the adjacent wallrock contains abundant veinlets and disseminated grains of pyrite and arsenopyrite. Some of the gold-bearing veins are cut by faults that contain relatively barren quartz.

The lodes at the Ramsay-Rutherford mine (50), on the east side of Valdez Glacier, are in graywacke and argillite and consist of veins a few inches to several feet thick of quartz and subordinate calcite, siderite (?), and crushed country rock carrying small amounts of gold, silver, pyrrhotite, pyrite, chalcopyrite, sphalerite, and galena.

The gold deposits of the Granite mine (21), on the west side of Port Wells, differ from those of the Cliff mine in that they are associated with intrusive rocks. In the mine area, graywacke, slate, argillite, and altered granitic rock are cut by northwestward-striking northeastward-dipping faults that are the loci of the gold-bearing veins. Locally, the granitic rock forms the hanging wall of the productive veins, which consist of quartz, calcite, and crushed country rock, together with subordinate pyrite, sphalerite, stibnite, galena, arsenopyrite, chalcopyrite, and gold. Other stibnite-bearing auriferous veins, some of which have been prospected solely for antimony, occur near Port Wells.

Auriferous quartz veins were also prospected in the Port Wells area and on nearby Culross Island (24). Those on Culross Island are unique in that they are entirely in greenstone. The veins are chiefly quartz and carry, in addition to gold, the same sulfide minerals as the gold lodes of the Port Valdez area.

A little gold was recovered in the early 1900's from lodes near McKinley Lake (63), about 20 miles east-southeast of Cordova. The deposits are quartz veins as much as 20 feet thick in graywacke and slate, and quartz stringer lodes in brecciated graywacke. A few of the veins carry visible free gold, but the only metallic minerals ordinarily visible are pyrite and arsenopyrite. Locally, pyrite, arsenopyrite, and sparse free gold are disseminated in the country rock near the veins. Assays as high as $100 per ton in gold were obtained from some of the veins, and $1.85 per ton from the enclosing mineralized sedimentary rocks. The lodes were worked by several adits and probably other underground openings.

Unproductive quartz veins cutting graywacke and slate and carrying gold, silver, and sulfide minerals were also prospected near Jackpot Bay (6) and Wilson Point (61).

Additional information on this district is given in the following references: Brooks (1912); Capps and Johnson (1915); Chapin (1913); Condon and Cass (1958); Grant (1906); Grant and Higgins (1909, 1910); Johnson (1914, 1915a, b, 1916, 1918a, b, 1919a, b); Mihelich and Wells (1957); Moffit (1954b); Moffit and Fellows (1950); Richter (1965); Rose 1965b); Stefansson and Moxham (1946); Stejer (1956).

YAKATAGA DISTRICT

The Yakataga district (pl. 1; fig. 12) includes the area drained by the Martin River and its tributaries and by streams flowing into the Gulf of Alaska along the coast between the Copper River and the Canadian boundary. Its northern half is in the Chugach Range, and its southern half includes coastal plains and lowlands whose relief is generally less than 1,000 feet (pl. 1).

Except for a narrow northern strip underlain by Mesozoic sedimentary rocks, and for the Bering Glacier delta (made up of unconsolidated Quaternary deposits) the district is underlain by Tertiary sandstone, mudstone, shale, and conglomerate (pl. 1). The Tertiary rocks are locally coal bearing and petroliferous.

The remoteness and inaccessibility of the mountains in the northern half of the Yakataga district have discouraged systematic prospecting for lode deposits. The only lodes known are near the Bagley icefield (20, see fig. 12), where native copper, malachite, and azurite have been found in volcanic rocks. None of these deposits is of commercial value.

Additional information on this district is given in the following reference: Brabb and Miller (1962).

KENAI PENINSULA REGION

The Kenai Peninsula region (pl. 1; fig. 14) is the Kenai Peninsula south of Turnagain Arm and west of the divide between Cook Inlet and Prince William Sound. It is divided into the Homer, Hope, and Seward districts.

The region includes two dissimilar and clearly separate physiographic provinces—the Kenai Mountains and the Kenai lowland (pl. 1)—whose boundary trends north-northeastward from the head of Kachemak Bay to Turnagain Arm. The mountains average about 4,000 feet above sea level and trend northeastward, reflecting the

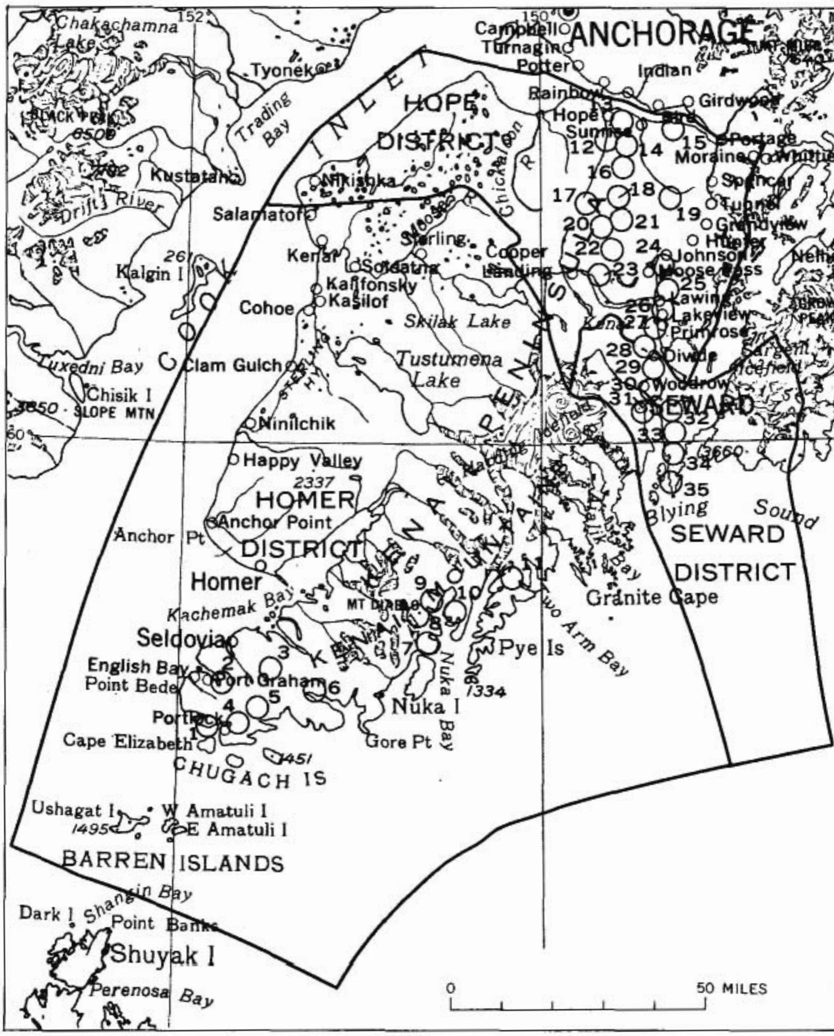

FIGURE 14.—Metalliferous lode deposits in the Kenai Peninsula region. (Localitie listed on next page.)

LOCALITIES SHOWN ON FIGURE 14

Homer district

1. *Claim Point
2. *Alley (Port Graham)
3. *Red Mountain
4. *Rock (Port Chatham)
   *Cone Mountain
5. *Mills and Trimble
6. *Port Dick (2 occurrences)

Nuka Bay area

7. Sather
8. Little Creek
   *Nukalaska Mining Co.
   *Skinner
9. *Alaska Hills
   Nuka Bay Mines Co.
   *Rosness and Larson
10. *Goyne
    Johnson and Degan
    *Sonny Fox
11. *Kusturin and Johanson (Two Arm Bay)

Hope district

12. Robinson and Bowman
13. Bear Creek
    Coon and Plowman
    Gold Stamp
    *Nearhouse and Smith
    Taylor
14. Downing
    Hirshey and Carlson
    *Kenai Star
    Robin Red Breast
    *Sunshine
15. *Sawmill Creek
    Slate Creek (2 prospects)
16. Donaldson Creek
    *Lucky Strike
    *Teddy Bear
17. *Johnson and Skeen
18. *Independence
    Iron Mask
    Mascot

Hope district—Continued

19. Brewster
    *Ready Bullion
    Seward Gold
20. Devils Creek
21. *Alaska Oracle
    *Colorado
    *Gilpatrick
    *McMillan
    *Ronan and James
    Slate Creek
    Swetman
22. *Quartz Creek
23. Lyengholm, Hargood, and Larson
24. *Case
25. *California-Alaska
    Crown Point
    *Kenai-Alaska
    *Skeen-Lechner
26. *Seward Bonanza
27. Brown Bear
    Porcupine
    *Primrose
28. Schoonover

Seward district

28. Mizpah
29. *Mile Seven
30. *Mile Four
31. *Northern Light
    *Resurrection Bay Mining Co.
32. Redman and Guyot
    Shaw, Deubruel, and Bouchaert
33. Copper Chief
    Iron Cap
    Real Thing
34. *Feather Bed
    *Peterson
    Reynolds-Alaska Development Co.
35. *Fairview
    *Iron Mask
    Lietzke

*Cited individually in the text.

regional strike of their constituent rocks. The lowland is an area of low relief and of altitudes less than 200 feet, above which the land occasionally rises to altitudes of as much as 2,000 feet. Two such highlands are the ridge on the north shore of Kachemak Bay, and the area between Tustumena and Skilak Lakes.

The geology of the mountain and lowland parts of the Kenai Peninsula region are markedly dissimilar (pl. 1). The mountains are composed of slightly metamorphosed but complexly faulted and folded stratified rocks, chiefly of Mesozoic age, that are locally intruded by dikes, sills, and stocks that range in composition from granite to peridotite. Most of the lowland is mantled by thick deposits of sand, gravel, and silt; bedrock exposures are sparse and consist of moderately indurated and gently folded Tertiary coal-bearing sandstone, shale, and conglomerate.

The main areas of outcrop of felsic and intermediate plutons are on the southern coast of the Kenai Peninsula between Nuka and Resurrection Bays; the most notable ultramafic bodies, important for their chromite content, are at Red Mountain and Claim Point, near the southwestern end of the peninsula.

HOMER DISTRICT

The Homer district (fig. 14) is the area drained by the Kenai River below and including Skilak Lake and by streams flowing into the Gulf of Alaska from Callisto Promontory (Bear Glacier) to the western end of the Kenai Peninsula. It also includes the Barren Islands.

Lodes in the Homer district have been worked for gold, silver, and a small amount of chromite. The lodes also contain minor amounts of copper, lead, zinc, and nickel.

GOLD AND SILVER

The district's productive precious-metal lodes are near Nuka Bay (7–11, see fig. 14) on the southern coast of the Kenai Peninsula. They were discovered about 1918 and from 1924 to 1942 produced about 5,500 fine ounces of gold. The amount of recovered silver, which probably is partly alloyed with the gold and partly in sulfide minerals, is unknown.

The lodes are in graywacke and slate, commonly near small quartz diorite plutons, and consist of quartz veins and stockworks carrying free gold, native silver and copper, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, tetrahedrite, covellite, and chalcocite. Gold is unusually abundant in some of the veins. One shipment of 5 tons of ore from the Sonny Fox mine (10) yielded a net return of $530 per ton, and a substantial amount of the ore milled at the Nukalaska mine (8) yielded an average of $100 per ton (probably based on a gold price of $35 an ounce). Oxidation of the Nuka Bay lodes is persistent to the deepest levels reached by mining (about 200 ft below the surface), but except for a little residual concentration of gold, no secondary enrichment has been reported. The presence of covellite, however, suggests that secondary (supergene) enrichment has taken place on a limited scale in at least some of the Nuka Bay deposits.

Most of the productive lodes were stockworks of veins averaging about a foot thick. The largest individual vein was on the Skinner property (8), where underground workings exposed 3–8 feet of quartz that was traced on the surface for 2,600 feet. The vein contains fairly abundant sulfides but was not productive.

Most of the Nuka Bay lodes were explored by underground workings and opencuts, but minable ore was found only in the deposits on the Nukalaska (8), Alaska Hills (9), Rosness and Larson (9), Goyne (10), and Sonny Fox (10) properties.

Gold lodes also occur near Two Arm Bay (11), Port Dick (6), Port Chatham (4), and Port Graham (2). They were discovered around 1900 and explored mostly before World War I, but none was productive.

The deposits near Two Arm Bay are in graywacke, slate, and granitic dikes and consist of quartz veins carrying sparse pyrite, chalcopyrite, and gold. The smaller veins form stringer lodes as much as 8 feet wide, whereas the larger veins tend to form isolated discrete lodes up to 6 feet thick. A sample taken across one of the vein-bearing dikes assayed $1.80 in gold. Little work was done on these prospects.

The Port Dick occurrences (6), which were explored by several tunnels between 1899 and 1907, consist of quartz veins in highly indurated graywacke and in crosscutting felsic dikes. The veins contain arsenopyrite, minor chalcopyrite, pyrite, pyrrhotite, and sphalerite, and very sparse gold. Individual veins range in thickness from 6 to 40 inches. The smaller veins locally form stringer lodes as much as 2 feet wide. Some of the veins, which locally contain a little calcite, have a layered appearance resulting from alternating bands of quartz and sulfides.

At the Rock prospects (4), about 2 miles east of the head of the northeast arm of Port Chatham, early prospectors explored clusters of quartz veinlets in brecciated and altered granitic dikes near graywacke contacts and discrete quartz veins as much as 44 inches thick in both the graywacke and the dikes. The larger veins contain arsenopyrite, chalcopyrite, pyrrhotite, and a little sphalerite. Some work was also done near Cone Mountain (4) on rusty-weathering zones consisting of fractured country rock cemented by quartz and calcite carrying sparse sulfides.

Gossans up to 15 feet wide that contain disseminated pyrite occur in tuff on the coast between Port Chatham and Port Graham; at the head of Port Graham, the Alley claims (2) were staked on iron-stained quartz veinlets that reportedly fill fractures in chert and contain as much as $6 per ton in gold.

The Mills and Trimble lode (5), about 2½ miles north of the western end of the west arm of Windy Bay, is marked by brown gossan and consists of foot-thick quartz veins that cut sedimentary rocks and felsic dikes and contain sparse arsenopyrite, chalcopyrite, and pyrite. Assays of the mineralized material reportedly showed gold, silver, copper, and nickel.

CHROMITE

Two groups of chromite deposits have been found near the southwestern tip of the Kenai Peninsula. One group is near sea level at Claim Point (1) and the other near the top of Red Mountain (3). Although the deposits have been known since the early 1900's, only a relatively small amount of ore has been shipped, and that mostly under the stimulus of high wartime prices. Approximately 2,000 tons of ore averaging about 45 percent Cr_2O_3 was mined in 1917-18, all from a single mine at Claim Point. Mining ceased with the decline in metal prices at the end of World War I and was not resumed until 1942–44, when a total of 6,619 tons averaging about 42 percent Cr_2O_3 was produced from deposits on Red Mountain. The most recent production was in 1954–57, at which time 21,435 tons of ore was mined from the Red Mountain deposits.

The chromite deposits are in two ultramafic plutons that intrude graywacke, slate, and chert. The main intrusive rock type is dunite; serpentinite (derived from the alteration of the dunite) and subordinate pyroxenite are also present. According to Guild (1942, p. 139):

> Chromite grains are distributed in small quantity throughout the dunite; the ore deposits are parts of the dunite and serpentine masses in which chromite has been concentrated by magmatic segregation. These deposits are tabular, strongly banded bodies, which range in size from stringers to bodies containing more than 50,000 tons, and in grade from a few percent to 50 percent of chromic oxide (Cr_2O_3). Analyses of the chromite alone, separated from the silicate gangue, show that it usually contains 54 to 59 percent of Cr_2O_3 and has a chrome-iron ratio of 3:1 or greater.

In 1942 and 1944, the U.S. Bureau of Mines sampled the deposits by trenching and core drilling. Their work indicated that the two major deposits at Red Mountain aggregate 80,800 long tons of material containing 25–43 percent Cr_2O_3, with a Cr:Fe ratio of about 3:1, and 16,000 long tons of lower grade material. The five other Red Mountain deposits sampled probably total less than 20,000 long tons of material whose Cr_2O_3 content ranges from about 11 to 49 percent.

Estimated chromite resources at Claim Point include 272,700 long tons of material containing 16–26 percent Cr_2O_3, with a Cr:Fe ratio of about 2.7:1.

Analysis by the Bureau of Mines of samples of olivine from Red Mountain also showed 0.25 percent nickel and 0.03 percent cobalt.

Additional information on this district is given in the following references: Guild (1942); Martin, Johnson, and Grant (1915); Rutledge (1946); Sanford and Cole (1949); Smith, P. S. (1938).

HOPE DISTRICT

The Hope district (fig. 14) comprises the area drained by streams flowing into Cook Inlet and Turnagain Arm from just north of Salamatof to Portage and the area drained by the Kenai River above Skilak Lake. The eastern boundary of the district is the divide between Cook Inlet–Turnagain Arm and Prince William Sound.

Lodes in the Hope district have been prospected for gold, silver, and copper, but only gold, alloyed with silver, has been mined profitably. The lodes also contain minor amounts of lead, zinc, molybdenum, and antimony.

Lode mining in the district began in 1898, when a little gold ore was milled on Sawmill Creek (15, see fig. 14) east of Sunrise. The period of greatest development and production was from 1911 to about 1942, after which the mines were closed by government order. Total production was about 13,500 fine ounces.

Two types of lodes are recognized in the district: fissure veins and mineralized dikes. The minerals in both types are the same, and it is likely that they had a common origin and were deposited at about the same time. The fissure veins were the source of nearly all the marketable ore; although many of the mineralized dikes were closely examined and some extensively explored by trenches and underground workings, they produced little gold.

FISSURE VEINS

A typical fissure vein has been described as a simple fissure filling of quartz, calcite and rare ankerite, rock fragments, and subordinate metallic minerals. So-called sheeted veins, those in which quartz layers alternate with thin laminae of country rock that may be rich in sulfides, have also been reported. It is possible that the sheeted veins, at least, were formed mainly by replacement rather than by simple cavity filling. The deposits are in slate and graywacke and range from stringer lodes to isolated, relatively persistent veins as much as 5 feet thick and several hundred feet long. Some of the veins were cut by postmineralization faults that crushed the quartz and caused it to pinch, swell, and, in some cases, lens out. The veins ordinarily transect the bedding and cleavage of the country rock and have diverse strikes and dips, but many of the richer and larger lodes strike approximately east and dip moderately to the north.

The chief metallic mineral in the veins is arsenopyrite; it generally is accompanied by smaller amounts of chalcopyrite, galena, sphalerite, and pyrite, and locally by molybdenite and pyrrhotite. Most of the veins carry sparse free gold, commonly associated with the galena and sphalerite, and a little silver, mostly alloyed with the gold but probably also in the galena. The veins are stained with secondary iron and arsenic minerals, chiefly limonite and scorodite.

Most of the fissure veins are in three areas: one drained by Porcupine and Falls Creeks (24–27), near the east end of Kenai Lake; another drained by Resurrection and Sixmile Creeks (13–14, 16), west and southwest of Sunrise; and a third drained by Quartz, Slate, and Summit Creeks (21–23), 7–13 miles northeast of the head of Kenai Lake. A few relatively isolated occurrences, including the only one in the district prospected mainly for copper—the Ready Bullion prospect (19)—are about 9 miles west-northwest of Tunnel on The Alaska Railroad (19), near the head of Resurrection Creek (17), about 8½ miles south-southwest of Hope (12), and along streams tributary to the south shore of Turnagain Arm (15).

In the three main areas, the best known occurrences, chiefly those that were productive or especially promising, are the Case (24), Kenai-Alaska (25), Skeen-Lechner (25), California-Alaska (25), Seward Bonanza (26), and Primrose (27) properties near the east end of Kenai Lake; the Nearhouse and Smith (13), Sunshine (14), and Lucky Strike (16) claims between Resurrection and Sixmile Creeks; and the Alaska Oracle, McMillan, and Ronan claims (21) in the Quartz–Slate–Summit Creeks basin.

MINERALIZED DIKES

The mineralized-dike deposits consist of sulfide-bearing quartz veins occupying fractures in light-colored fine-grained altered porphyritic dikes that probably were originally of intermediate composition. The veins are generally small, ranging in thickness from a fraction of an inch to 6 inches, but locally they constitute 30 percent of the dike rock. Most of them are randomly oriented, but locally the veins are roughly parallel to each other and perpendicular to the strike of the dike. The mineralogy of the dike veins is essentially identical to that of the fissure veins. Calcite is somewhat more abundant in the mineralized dikes, however, and stibnite, unreported in the fissure deposits, occurs in small amounts in a quartz vein in one of the dikes. In general, the mineralization is low grade and spotty, and many dikes are barren.

Most of the mineralized dikes strike approximately north and are nearly vertical, parallel to the regional bedding or cleavage of the enclosing slate and graywacke. Among several in the area south and south-southwest of Sunrise, the most prominent dike is remarkable in that it has been traced for 11 miles although it is only about 8 feet wide. Most of the mineralized-dike deposits in the district are in this dike.

Mineralized-dike lodes from which a little gold was recovered were on the Kenai Star (14) and Gilpatrick (21) properties; the most thoroughly explored nonproductive lodes were on the Teddy Bear (16), Independence (18), Colorado (21), and Johnson and Skeen (17) claims.

Additional information on this district is given in the following references: Johnson (1912); Martin, Johnson, and Grant (1915); Moffit (1906); Tuck (1933).

SEWARD DISTRICT

The Seward district (fig. 14) is the area drained by streams flowing into Resurrection Bay and Blying Sound from Callisto Promontory on the west to Cape Junken on the east.

The district contains lodes that have been prospected for gold and copper.

GOLD

The gold prospects (29–31, see fig. 14) are a southward continuation of the group of fissure veins near the east end of Kenai Lake (p. 79–80) and are identical with them in mineralogy and geologic setting. Gold lodes reportedly also occur on tributaries of the Resurrection River, 11–14 miles northwest of Seward, but nothing is known about them.

None of the gold lodes in the Seward district was productive; the ones explored by underground and surficial workings include deposits on the Resurrection Bay Mining Company (31), Northern Light (31), Mile 4 (30), and Mile 7 (29) properties.

COPPER

All the copper deposits known in the district are on the Resurrection Peninsula in a northward-trending belt that extends from a point near its southern tip to about the latitude of Seward (32–35). The lodes, mainly in iron-stained sheared and brecciated mafic lava flows and less commonly in gabbro or peridotite, consist of quartz, calcite, and epidote stringer lodes containing varying amounts of chalcopyrite, pyrite, pyrrhotite, magnetite, sphalerite, hematite, and marcasite. A little gold was reported in one of the deposits. Locally, oxidation of chalcopyrite has resulted in the formation of malachite and azurite. The metallic minerals constitute the bulk of some of the veins, but they are usually less abundant than the gangue minerals.

Some of the lodes, notably those on the Peterson (34), Fairview (35), and Iron Mask (35) claims, were explored by short tunnels, but little is known of their grade and size. Assays, probably of selected material, were made early in the 1900's and showed 1.1–9.8 percent copper. The lode on the Feather Bed (34) property reportedly included four stringers of nearly pure chalcopyrite as much as 7 inches thick that contained 14–19 percent copper. According to reports by early prospectors, some of the copper-bearing shear and breccia zones range in width from 5 to 12 feet and can be traced for distances of 100–4,500 feet.

No ore was shipped from the copper lodes in the Seward district, and the prospects were abandoned by 1920.

Additional information on this district is given in the following reference: Martin, Johnson, and Grant (1915).

KODIAK REGION

The Kodiak region (pl. 1; fig. 15) includes Kodiak, Afognak, and the Trinity Islands and the small islands nearby. The region, classified as a single district, is characterized principally by mountains with summits 2,000–4,000 feet in altitude and by gently rolling highlands (pl. 1).

The geologic units of the region (pl. 1) are distributed in northeast-trending belts in which most of the structural elements, including bedding, foliation, alined intrusive bodies, and faults, strike northeast. Several faults probably extend the full length of the region.

About three-fourths of the region is underlain by predominantly Cretaceous graywacke and slate intruded and locally metamorphosed by Tertiary plutons. The plutons are mainly dioritic, but small mafic and ultramafic bodies also occur, mostly on northwestern Kodiak Island. The largest pluton is a quartz diorite batholith about 5 miles wide and 60 miles long that strikes northeastward, parallel to the long axis of Kodiak Island. Numerous stocks, dikes, and sills that probably are satellitic to this batholith crop out throughout the region.

Other bedded rocks include lower Mesozoic sedimentary and volcanic units exposed on the northwestern side of the island group and Tertiary sandstone, shale, and conglomerate on the southeastern side. The older Tertiary strata predate the Tertiary plutons; the younger Tertiary beds postdate them.

Lodes containing gold and minor amounts of other metals were discovered in the Kodiak region late in the 19th century, but with the exception of two short periods of relatively active exploration and development, they have received only sporadic attention. Lode mining took place mostly before World War I, and to a lesser extent about 1935, after the price of gold was raised.

GOLD

In general, the gold deposits are metalliferous quartz veins that probably are genetically related to stocks or to apophyses from them. Some occur in the plutonic rocks, but most are in the enclosing rocks within a few miles of an igneous contact. The veins commonly are fissure fillings, many of them with more than one generation of quartz, but replacement of the wallrock by quartz is locally important. The metallic minerals in the veins are arsenopyrite and pyrite, minor sphalerite, chalcopyrite, and galena, and small amounts of gold and silver.

The most productive lode in the region was on the Amok property (12, see fig. 15) at Uyak Bay, from which at least $8,000 in gold was recovered early in the present century. The deposit consists of auriferous quartz veins in slate, but the only visible metallic mineral is pyrite. The principal vein strikes northwest, dips steeply southwest, and averages 3 feet in thickness. Workings and improvements consisted of about 500 feet of underground workings, several surface trenches, and two mills.

Several other gold lodes were prospected in the Uyak Bay area (9–12) around the turn of the century. All are quartz veins that cut slate or graywacke near felsic dikes. The veins, which commonly are a foot or so thick, contain arsenopyrite and pyrite, a little free gold, and rare galena. Some gold was probably taken out of these lodes by their discoverers, but there is no recorded production, and after minor development, they were abandoned.

The lode on the Baumann and Strickler prospect (6), on the east shore of Uganik Passage, is in graywacke and slate and consists of a northward-striking eastward-dipping sheared quartz vein carrying visible free gold. The exposed part of the vein is 2–8 inches thick and is bordered by an inch or so of reddish gouge. A 6-inch dike, parallel to the vein, overlies the hanging-wall gouge. Although assays showed high gold tenor and a small mill was installed on the property in 1935, there is no record of production.

Visible free gold has also been reported in a quartz vein 2½ feet in maximum thickness on the Brenneman prospect (2) on the northeast side of Viekoda Bay. A 60-foot adit was driven on the vein before World War II, but no production was recorded.

An irregular network of quartz stringers occurs at the Moyle prospect (5) on the north side of Uganik Passage. The lode, which is at

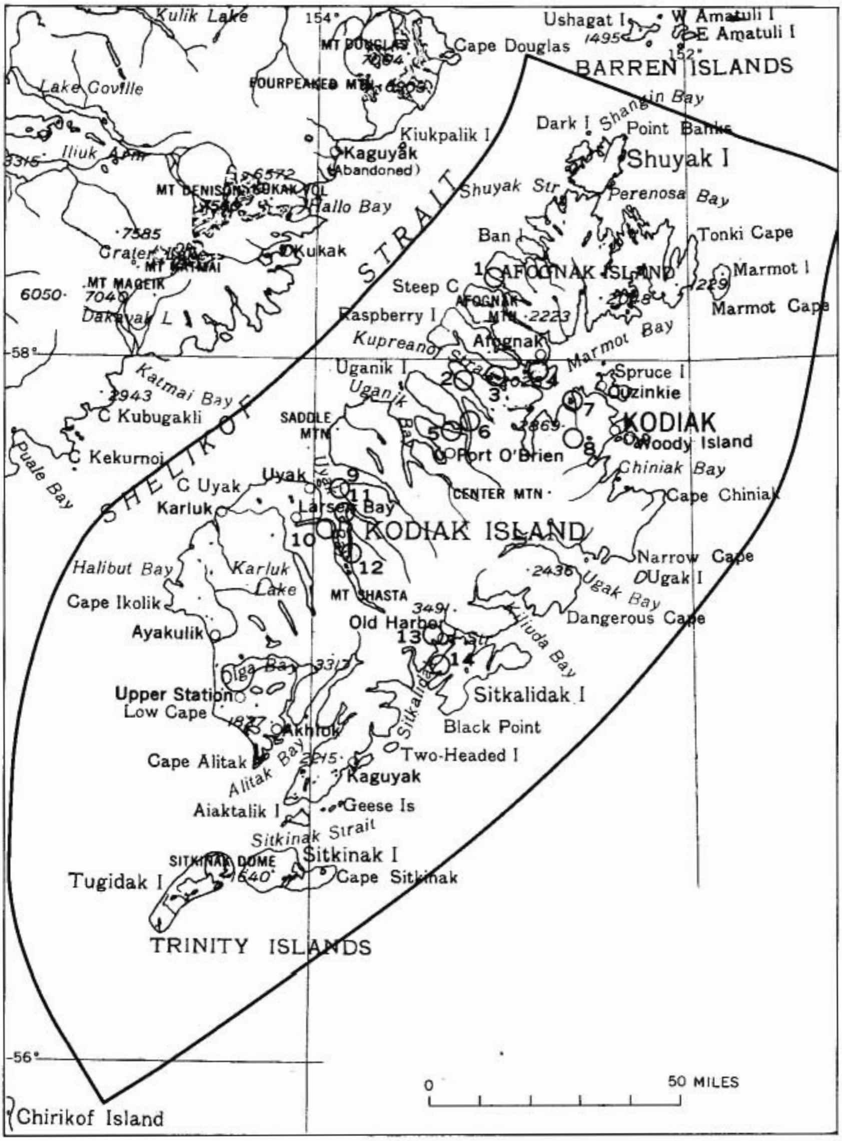

FIGURE 15.—Metalliferous lode deposits in the Kodiak region. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 15

1. *Malina Bay
2. *Brenneman
3. *Dry Spruce Island
4. *Friedland & associates (Whale Island)
5. *Moyle
6. *Baumann & Strickler
7. *Kizhuyak
   *Womens Bay
8. *Chalet Mountain

Uyak Bay area

9. Wanberg & Boyer
10. Bear
    Calaveras
    Dan
11. Lake
12. *Amok
    Wanberg

13. *Barling Bay
14. *Old Harbor (Sitkalidak Island)

*Cited individually in text.

the contact of diorite and contact-metamorphosed slate and graywacke, reportedly assayed $7.60–$11.67 per ton in gold and silver. It was explored by three short adits but was not productive.

Several tons of ore were shipped about 1900 from a stockwork of reticulated, sparsely metallized quartz veins in slate on the northeastern end of Dry Spruce Island (3). Workings, aggregating a total length of about 140 feet, consisted of a shaft, adit, and crosscut. Although it was reported that some very high precious-metal assays were obtained from this deposit, the returns were too low for profitable mining operations.

An early attempt was made to mine an auriferous quartz vein in slate and graywacke on Whale Island (4) a short distance east of Chiachi Point. A shallow shaft was sunk on the vein, and a water wheel and arrastre constructed to extract gold, but the tenor was low, and little gold was produced.

In 1906 a 22-foot shaft and 152-foot adit were driven on a large quartz vein, called the Womens Bay lode (7), that crops out at an altitude of 600 feet about a mile east of Kizhuyak Point. The vein is in a diorite stock and ranges in thickness from 12 to 14 feet; reportedly it was traced on the surface for 1,800 feet. The vein strikes N. 60° W. and dips about 75° SW., and consists of milky quartz, a few small diorite inclusions, and subordinate arsenopyrite, pyrite, chalcopyrite, sphalerite, and galena. It is banded and jointed parallel to the walls and shows two generations of quartz. The first generation evidently was barren; the second was accompanied by sulfides. At the shaft, the sulfides form a lenticular mass as much as 18 inches thick that thins abruptly to a thickness of 4–6 inches. Assays of the lode reportedly showed up to $8.40 in gold (gold valued at $35 an ounce) and 1.19 ounces of silver per ton.

Numerous gold- and sulfide-bearing quartz veins occur along the southern extension of the diorite stock near Kizhuyak Point. They are marked by conspicuous rust-colored zones that are especially prominent on an island and peninsula in a small bay about 5 miles south-southwest of the Womens Bay lode. The deposits, called the Kizhuyak lode (7), were discovered around 1903, and although some work was done on them from time to time, they produced little gold. The northward-striking westward-dipping deposit on the island is in diorite and consists of a 3-foot-thick quartz vein locally containing abundant pyrite and arsenopyrite. A random sample of this material assayed 0.14 ounce of gold and 0.74 ounce of silver per ton. The deposit on the peninsula is about a mile south of and on strike with the one on the island. It consists of numerous irregular quartz veins a fraction of an inch to 4 inches thick near the contact between diorite and interbedded slate and graywacke. The veins, which cut both the diorite and the sedimentary rocks, locally contain arsenopyrite and pyrite and are stained with iron oxides and a greenish secondary arsenic(?) mineral. The precious-metal content of this deposit is probably similar to that of the deposit on the island.

Claims were staked about 1934 on auriferous quartz veins at Barling Bay (13) about 3 miles west-northwest of the village of Old Harbor. The veins are in slate and graywacke and may be genetically related to a nearby 8-foot vertical dike. The largest vein is faulted, but is exposed for a length of 90 feet and reportedly has been traced for several miles. Near the dike and the fault, the vein consists of about 15 feet of shattered quartz carrying specks and small masses of arsenopyrite and pyrite, and, reportedly, several dollars a ton in gold and silver. Other parts of the vein are made up of alternating layers of sparsely mineralized quartz and altered sedimentary rocks.

A quartz vein 14 feet thick containing gold and a little silver reportedly is on the north side of Malina Bay (1) on Afognak Island. It is said to be at the contact of slate and granitic rocks and to be cut by a porhyry dike. A 140-foot adit was probably driven on the vein in the early 1900's.

TUNGSTEN

In 1956, the U.S. Geological Survey investigated a tungsten prospect in faulted graywacke and slate on Chalet Mountain (8) about 10 miles west of Kodiak. The deposit consists of scheelite in sparsely disseminated grains and in thin coatings on quartz veins and fractures in graywacke. An ultraviolet-light traverse revealed 16 small scheelite showings, mostly parallel to the strike of the graywacke and slate, in an area 300 feet wide and 1,600 feet long. Assays showed 0.06–0.56 percent tungstic oxide (WO_3), but a geochemical survey near the prospect failed to reveal anomalous amounts of tungsten in the soil overburden. The results of the investigation indicated that the lode, as exposed, is too small and lean to warrant further work.

COPPER

The Old Harbor copper lode (14), on the northwestern side of Sitkalidak Island, consists of a sulfide-bearing shear zone, at least 2,500 feet long and 10–20 feet wide, along the footwall contact between a gabbro sill and slate and graywacke. In general, the mineralization consists of uniformly disseminated pyrrhotite, pyrite, and sparse chalcopyrite, but in two places the sulfides are concentrated into small masses of pyrrhotite and pyrite containing abundant chalcopyrite. The two masses are separated by a 1,250-foot interval, most of which is covered. Assays range from 0.09 percent copper in the disseminated material to 5.52 percent copper in one of the chalcopyrite-rich masses. The deposit was prospected sometime before World War II by three short adits and several trenches. It was also examined in 1944 by the U.S. Bureau of Mines, which concluded that under the prevailing economic conditions, the deposit was of subeconomic size and grade.

Additional information on this region is given in the following references: Capps (1937); Seitz (1963b).

KUSKOKWIM RIVER REGION

The Kuskokwim River region (pl. 1; figs. 16–18) includes Nunivak Island and the mainland area drained by streams flowing into Baird Inlet, Etolin Strait, and Kuskokwim Bay. It is divided into the Aniak, Bethel, Goodnews Bay, and McGrath districts.

The region (pl. 1) is dominated by the Kuskokwim Mountains, a succession of rounded northeast-trending ridges 1,500–2,000 feet in altitude surmounted locally by rugged mountains as much as 4,000 feet high. Other upland areas include the Ahklun Mountains, the Nushagak-Big River Hills, and Nunivak Island. The eastern boundary of the region follows the 6,000–10,000 foot crest of the Alaska Range. About a third of the region consists of lowlands whose average altitude is less than 1,000 feet.

The region (pl. 1) is underlain by rocks ranging in age from Precambrian(?) to Tertiary, and in variety from metamorphic rocks and hypabyssal and deep-seated plutons to lava flows, cinder cones, and barely consolidated continental deposits. Bedrock in the lowlands is hidden by thick accumulations of Quaternary sand, silt, and gravel.

The oldest rocks, gneiss and schist that are possibly of Precambrian age, form a belt about 7 miles wide and 75 miles long in the Ahklun Mountains. Next younger are pre-Carboniferous Paleozoic limestone, sandstone, and shale that crop out mainly in the northeastern and southwestern parts of the region. Still younger, and most abundant, are Carboniferous to Cretaceous graywacke, slate, conglomerate, and intermediate volcanic rocks that underlie most of the central third of the region. The youngest consolidated rocks are Tertiary and Quaternary lava flows and tuff that are mainly near Baird Inlet and on Nunivak Island.

Upper Cretaceous or lower Tertiary granitic stocks intrude Mesozoic beds near the Lime Hills, and Paleozoic beds near the head of the Tonzona River. Tertiary(?) dikes, sills, and plugs, some of which are associated with quicksilver or gold lodes, are widespread, and ultramafic intrusives near Goodnews Bay are the source of important placer platinum deposits.

Nearly all the quicksilver lodes in Alaska are in the Kuskokwim River region, and most of the rest are close to its borders. In general, they consist of cinnabar, commonly with stibnite, in faults and breccia zones in and near hydrothermally altered basaltic sills and dikes. Mercury has been recovered from eight deposits, and a little antimony ore was also shipped from one. The region's gold and silver lodes, some of which have been productive, are associated with intermediate to felsic plutons. Lodes containing copper, lead, zinc, molybdenum, tungsten, bismuth, and arsenic have also been found but not worked, although a little scheelite was recovered from a placer downstream from one of the tungsten-bearing lodes.

ANIAK DISTRICT

The Aniak district (fig. 16) is the area drained by the Kuskokwim River and its tributaries above Bethel as far as and including the Stony River.

Only mercury and a little byproduct antimony have been produced from lodes in the Aniak district. Other lodes containing gold, silver, copper, antimony, mercury, tungsten, lead, arsenic, zinc, and molybdenum minerals have been prospected, but there is no evidence that any were worked successfully.

More than half of the quicksilver deposits known in the district are in an area that extends downstream from the village of Sleetmute for about 10 miles along both sides of the Kuskokwim River (11–13, see fig. 16). The Red Devil mine (12), Alaska's leading mercury producer until it suspended operations in 1963, is about 6 miles below Sleetmute on the southwest band of the Kuskokwim River. Between 1939 and 1963, it produced between 20,000 and 25,000 flasks of mercury, and a little byproduct antimony, from about 9,600 feet of underground workings on five main levels. The country rock consists of graywacke and shale intruded by altered diabase dikes consisting of silica, carbonate, and clay minerals. The rocks in the mine area are cut by many northwest-trending faults that are mainly parallel to the bedding of the sedimentary rocks. The ore bodies, which consisted of massive aggregates and encrustations of quartz, clay, calcite, cinnabar, stibnite, and minor realgar and orpiment, formed near the intersections of the faults and dikes in a zone at least 600 feet wide and 1,500 feet long. They were elongate, plunged southward, and ranged from a few inches to about 4 feet in stope width and thickness and from a few feet to several hundred feet in length. Most of the ore formed by open-space filling, although some of it replaced altered dike rock.

Several other lodes near Sleetmute, all geologically similar to the Red Devil deposit, have produced some mercury. The Alice and

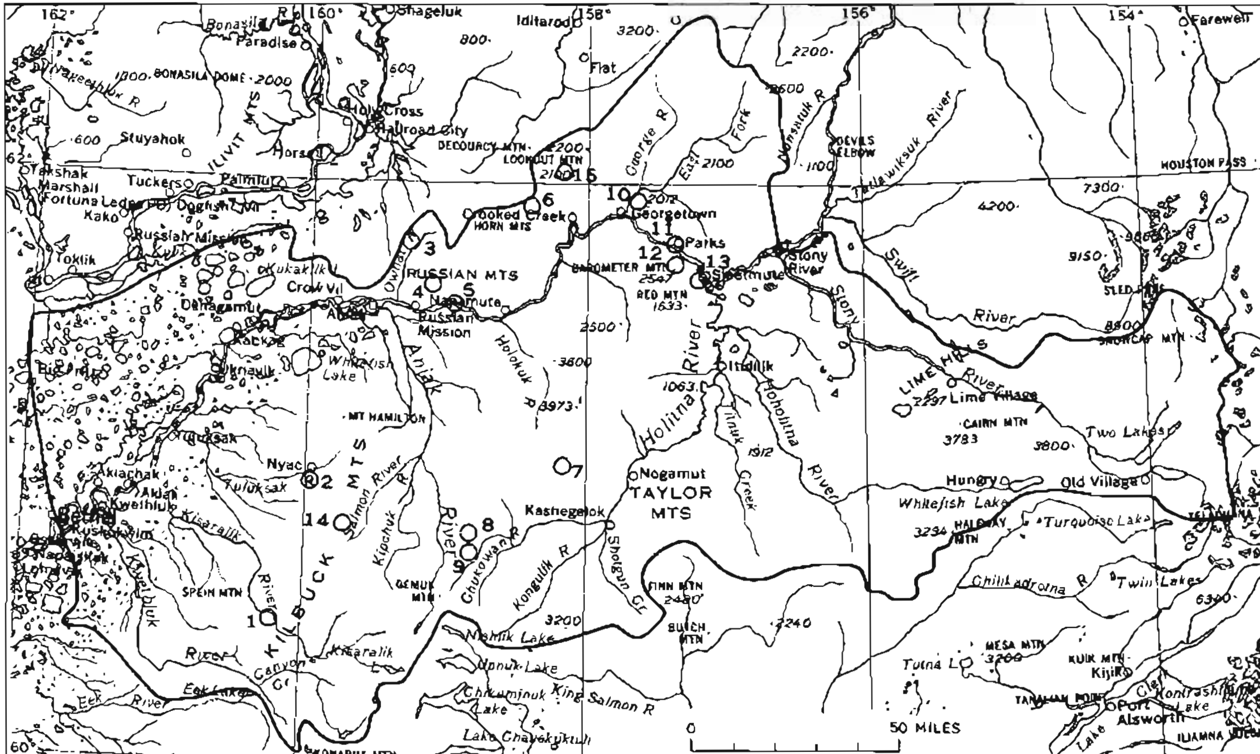

Figure 16.—Metalliferous lode deposits in the Aniak district.

LOCALITIES

1. *Golden Gate Falls
2. *Tuluksak River
3. *Black Mountain
   *Brink (Owhat River)
4. *Cobalt Creek
   *Mission Creek (Konechney)
5. *Kolmakof
6. *Rhyolite
7. *Fortyseven Creek
8. *Broken Shovel
   *Cinnabar Creek
9. *Lucky Day
   Redskin
10. *Harvison

Sleetmute area

11. *Alice and Bessie (Parks)
    Ammeline
    Two Genevieves
    *Willis
12. *Barometer
    Fairview

Sleetmute area—Contiued

(12.) McCally Creek
      Mercury
      *Red Devil
      Vermillion
      Unnamed
13. Landru
    Mellick's

14. *Fisher Dome
15. *Donlin Creek

*Cited individually in text.

Bessie (or Parks) mine (11), on the northeast bank of the Kuskokwim River, was staked in 1906 and developed by several hundred feet of underground workings and by shallow surface diggings. Probably about 120 flasks were produced before 1924 and sold to local placer-gold miners. At the neighboring Willis property (11), a few flasks of mercury were produced during World War I. The Barometer mine (12), which adjoints the Red Devil property, was discovered in 1921 and developed by a 122-foot adit, a crosscut, and pits and trenches. Sixteen flasks of mercury were produced in 1938 and 1940, and a smaller amount was recovered during assessment work in later years. Many other quicksilver claims have been staked in the Sleetmute area, but few have been thoroughly prospected and none is known to have been mined successfully.

At Kolmakof (5), site of the first cinnabar discovery in Alaska (probably about 1838), a 25-foot altered sill in graywacke and shale is exposed for a horizontal distance of about 400 feet. Cinnabar occurs in narrow stringers in the sill and enclosing sedimentary rocks. A small shipment of ore reportedly was made in the 1890's, and about 1910 two flasks of mercury were recovered in a homemade retort. In 1954, however, bulldozer stripping of the deposit failed to uncover a minable ore body.

Cinnabar has also been found at the Rhyolite (6) and Harvison (10) prospects. The Rhyolite deposit (6), discovered in 1956, is on the south flank of Juninggulra Mountain. There, graywacke and shale are cut by altered basaltic dikes and sills and by still younger albite rhyolite dikes and sills. Cinnabar, accompanied by small amounts of clay, occurs as small lenses and stringers in the altered basaltic intrusives, and at contacts between them and the graywacke and shale. Exploration by bulldozer trenching was done by the owners and by the U.S. Bureau of Mines. The Harvison deposit (10) consists of small lenses or pods of cinnabar in brecciated silicified shaly sandstone. The sandstone is cut by a dike or sill said to be similar to an intrusive exposed at the Alice and Bessie mine. The deposit was discovered by soil sampling followed by shallow stripping and trenching.

Another productive quicksilver mining area is near Cinnabar Creek (8), where sedimentary and volcanic beds are intruded by basaltic sills and dikes, some of which have been altered to rock composed of silica, carbonate, and clay minerals. The lodes are mainly in or near faults parallel to the altered rocks and consist of quartz, cinnabar, stibnite, pyrite, and a little native mercury. More than 500 flasks of mercury were recovered from ore mined from opencuts near Cinnabar Creek between 1955 and 1960. Placer cinnabar has also been produced from Cinnabar Creek and some of its tributaries.

During World War II, 26 flasks of mercury were recovered from the Lucky Day deposit (9) about 3½ miles south of Cinnabar Creek, and a small amount was shipped from the Broken Shovel prospect (8), a short distance across the divide from the head of Cinnabar Creek.

A lode containing gold, silver, tungsten, and antimony reportedly was discovered in 1947 at the head of Fortyseven Creek (7). The deposit, said to be in a shear zone in graywacke and slate, consists of quartz veins carrying small amounts of native gold, scheelite, wolframite, arsenopyrite, jamesonite, stibnite, argentite, and traces of gold-silver tellurides. The deposit may be genetically related to a Tertiary(?) rhyolite pluton that crops out a few miles to the north and may underlie the deposit at depth. There is no record of production from the lode, although both gold and scheelite have been recovered from placer deposits on Fortyseven Creek.

Metalliferous quartz fissure veins and breccia fillings are within, and near the periphery of, a Tertiary(?) monzonite stock cutting graywacke and slate about 15 miles east of Aniak. The quartz contains arsenopyrite, chalcopyrite, pyrite, pyrrhotite, hematite, galena, sphalerite, chalcocite, native copper, scheelite, secondary iron, copper, and arsenic minerals, and traces of metazeunerite (a rare copper-uranium-arsenic mineral). Assays also indicate small amounts of gold, silver, and tin. One such lode, near the head of Cobalt Creek (4), was discovered before 1900 and explored by three shallow shafts and a few trenches and pits. A specimen from one of the dumps is said to have assayed 11 percent copper, somewhat less than 0.25 ounce of gold per ton, and a trace of silver. Two samples from one of the shafts are reported to have contained 1.40 and 1.22 percent tin. A prospect at the head of Mission Creek (4), about a mile south-southwest of the Cobalt Creek prospect, was discovered in 1920 and explored by 900 feet of adits and several pits and trenches. Assays of a metalliferous zone traced on the surface for 1,000 feet are said to average 1.0 percent copper, 0.1 ounce of gold, and 1.0 ounce of silver per ton. Metazeunerite was identified in a sample collected from a dump.

On Black Mountain (3), a 2-inch stibnite(?) vein in shaly sandstone near a granitic pluton was traced for about 200 feet. A sample representing a 50-foot section of the vein contained 48.9 percent antimony, 0.02 ounce of gold, and 0.2 ounce of silver per ton. Stibnite also occurs in a small quartz vein cutting rhyolite at Fisher Dome (14) 15 miles southeast of Nyac.

Traces of copper minerals were found in andesitic bedrock brought up by a gold dredge on the Tuluksak River (2) near Nyac and in a fault zone in amphibole schist near Golden Gate Falls (1) on the

Kiseralik River. Molybdenite has been reported on the Brink claims (3), near the Owhat River, about a mile east of Black Mountain.

There are two metalliferous occurrences in the Donlin Creek area (15), about 14 miles north of the village of Crooked Creek. At one locality, float specimens of brecciated rhyolite containing quartz and stibnite were found near the apparent contact of an albite rhyolite intrusive and interbedded graywacke and shale. At the other locality, specimens of auriferous quartz(?) are said to have contained about $10 per ton in gold and a small amount of silver. Lodes such as this probably were the source of the gold in the Donlin Creek placers.

Additional information on this district is given in the following references: Cady, Wallace, Hoare, and Webber (1955); Ebbley and Wright (1948); Hoare and Coonrad (1959); Jasper (1961b, 1963); MacKevett and Berg (1963); Maddren (1915); Malone (1962); Maloney (1962b); Sainsbury and MacKevett (1965); West (1954).

BETHEL DISTRICT

The Bethel district (fig. 17) includes the area drained by the Kuskokwim River below Bethel, and by streams flowing into Baird Inlet, Etolin Strait, and Kuskokwim Bay as far south as, but excluding, Carter Bay. It also includes Nunivak Island.

Mercury, arsenic, and antimony minerals have been found in lodes near Mount Oratia in the easternmost corner of the Bethel district. Several placers in the southeastern part of the district have been mined for platinum and gold, but the lode sources of these metals have not been found.

At Arsenic Creek (1, see fig. 17) a small tributary of Rainy Creek 6 miles northwest of Mount Oratia, several quartz veins carrying cinnabar, realgar, and orpiment were explored by trenching by the U.S. Bureau of Mines in 1947. The veins are closely associated with small hydrothermally altered diabase sills that cut Cretaceous sandstone and shale. About 2,000 pounds of cinnabar concentrates were recovered from gold placers in Rainy Creek near the mouth of Arsenic Creek, but there has been no production of cinnabar from the lodes.

The Kagati Lake, or Mount Oratia, prospect (2), about 3 miles east of Mount Oratia, was discovered in 1927 and explored by an adit. Further prospecting was carried on from 1956 to 1958, but no ore was produced. The deposit, which was traced on the surface for several hundred feet, consists of quartz, cinnabar, stibnite, realgar, and orpiment sporadically distributed in shear zones in Tertiary quartz monzonite.

Additional information on this district is given in the following references: Hoare and Coonrad (1961b); Malone (1962); Rutledge (1948); Sainsbury and MacKevett (1965).

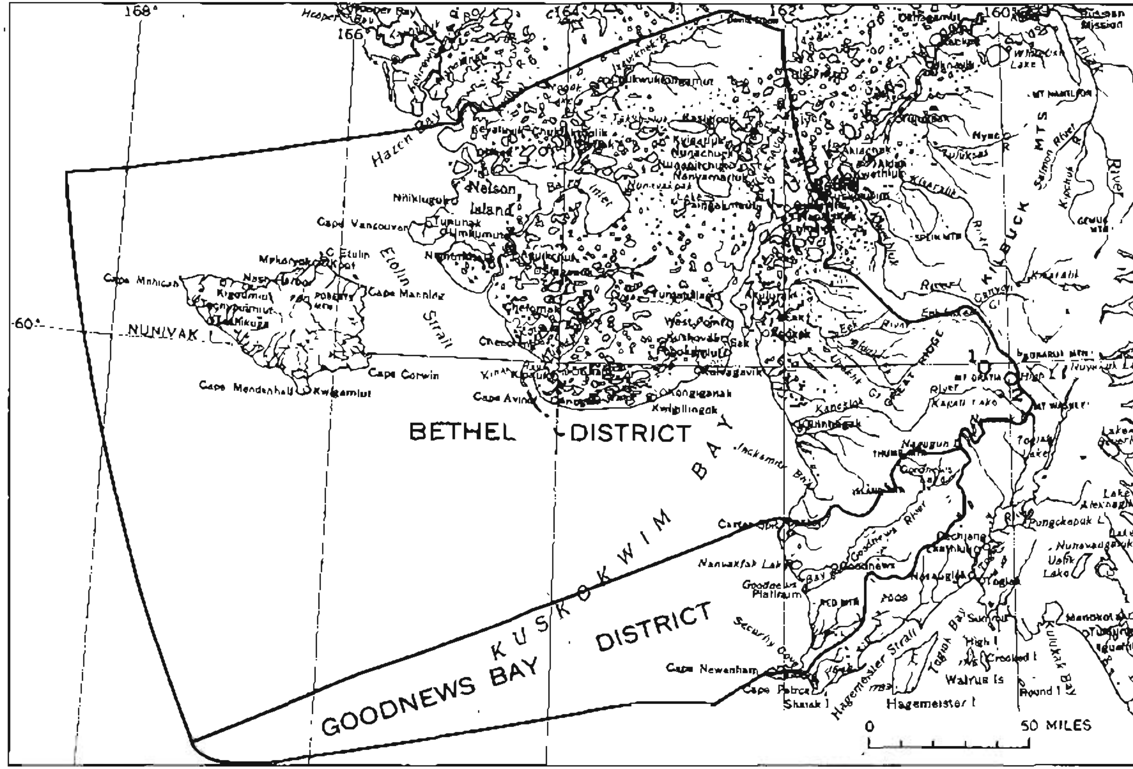

Figure 17.—Metalliferous lode deposits in the Bethel and Goodnews Bay districts.

Bethel district: 1. Arsenic Creek (Rainy Creek) 2. Kagati Lake (Mount Oratia) **Goodnews Bay district:** None

GOODNEWS BAY DISTRICT

The Goodnews Bay district (fig. 17) is the area drained by streams flowing into Kuskokwim Bay from and including Carter Bay to Cape Newenham.

Although metalliferous lodes have not yet been found in the district, it is the site of the only current production of platinum in Alaska, all from placers near Red Mountain, an ultramafic pluton south of Goodnews Bay that probably is the source of the placer material. The pluton also contains about 0.4 percent disseminated chromite.

Additional information on this district is given in the following references: Berryhill (1963); Hoare and Coonrad (1961a, b); Mertie (1940).

McGRATH DISTRICT

The McGrath district (fig. 18) includes the area drained by the Kuskokwim River and its tributaries above Story River.

Mercury and gold have been recovered from mines in the McGrath district. Deposits containing copper, lead, zinc, bismuth, tungsten, manganese, and possibly nickel minerals have been prospected, but not worked.

The White Mountain (5, see fig. 18) quicksilver lodes, discovered in 1958, consist of cinnabar in brecciated and dolomitized Paleozoic limestone, locally near basaltic dikes and sills. They are in a belt about a mile wide and 4–5 miles long on the west side of the prominent Farewell fault; most occur along fractures subsidiary to the main fault. An undisclosed amount of mercury has been recovered from the White Mountain lodes, mainly since 1963.

Cinnabar also occurs in a limestone inclusion in monzonite on the east flank of Mount Joaquin (1) 20 miles west-southwest of McGrath. The lode, discovered in 1957, has not been productive.

Lode mines in the Nixon Fork area (4) have produced an estimated 40,000–60,000 ounces of gold and a little silver, mainly between World Wars I and II. The principal lodes are in recrystallized Paleozoic limestone near the contact with Tertiary quartz monzonite. The primary minerals, chiefly gold-bearing iron and copper sulfides, have been extensively oxidized, with a resultant release of gold from the sulfide minerals and consequent residual enrichment in the oxidized zone. The ore consisted mainly of secondary iron and copper minerals, gold, and a little native bismuth. The copper content ranges from 2 to 12 percent, but no effort was made to recover copper. The ore bodies, which commonly were less than 100 feet in vertical and horizontal dimensions, were worked by several shafts with extensive branching levels and by a few pits and trenches. In 1953, traces of scheelite and radioactive minerals were found in the dump beside one of the shafts, and radioactive parisite, a rare-earth fluocarbonate, was found in bedrock nearby.

The Stone gold mine (3), on Eagle Creek, is near the contact of Paleozoic limestone and a small intrusive body similar to the one in the Nixon Fork area. No data are available on the amount of development work done at the mine or on the amount of gold recovered.

The J & K and Mespelt lead-silver prospects (6) are in metamorphosed sedimentary rocks and granitic rocks and contain arsenopyrite, pyrrhotite, pyrite, chalcopyrite, sphalerite, argentiferous galena, and malachite. Siderite, generally associated with iron and manganese oxides, is the most common gangue mineral. The deposits were explored between 1921 and 1923 and again after World War II by several trenches, shallow shafts, and a short adit but were not productive.

A rock sample containing pyrite, chalcopyrite, and a trace of nickel, said to have been collected from Roundabout Mountain (2), was sent to the Geological Survey in 1919. Neither the mode of occurrence nor the amount of the material represented by the sample is known.

A manganese deposit (7), discovered about 1960, is exposed on the north bank of the Kuskokwim River about 5 miles southwest of Medfra. The deposit, which could be traced for 500 feet in 1961, consists of sedimentary managnese carbonate in northward-dipping shale and sandstone. The manganese-bearing material, samples of which assay up to 23 percent manganese, contains a trace of iron and is intergrown with quartz(?) needles.

Additional information on this district is given in the following references: Capps (1927); Ebbley and Wright (1948); Jasper (1961a); Mertie (1936); Sainsbury and MacKevett (1965); White and Stevens (1953).

NORTHERN ALASKA REGION

The northern Alaska region (pl. 1; fig. 19) is the part of Alaska drained by streams flowing into the Arctic Ocean and Chukchi Sea from the Alaska-Yukon boundary to and including the Wulik River. The region is divided into the Barrow, Canning, Colville, Lisburne, and Wainwright districts.

The region includes the Arctic Coastal Plain, nearly all of the Arctic Foothills, and about half of the Brooks Range and DeLong Mountains (pl. 1). The lake-dotted coastal plain rises gradually from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin, where it merges with rolling plateaus and uplands. The southern part of the region is marked by rugged eastward-trending mountains 4,000–8,000 feet in altitude.

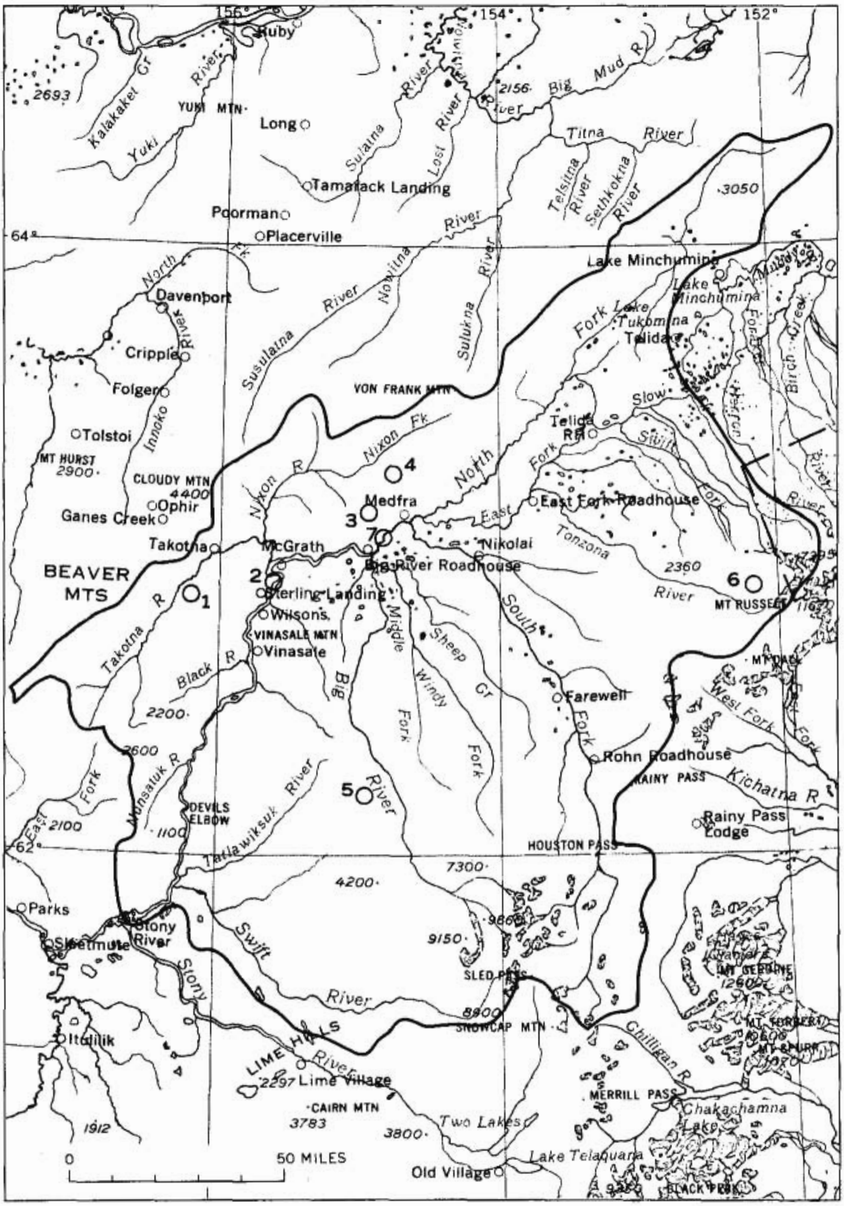

FIGURE 18.—Metalliferous lode deposits in the McGrath district. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 18

1. *Mount Joaquin
2. *Roundabout Mountain
3. *Stone

Nixon Fork area

4. Hidden Creek (Matthews & Blackburn)

Nixon Fork area—Continued

(4.) *Nixon Fork (Mespelt) Whalen

5. *White Mountain
6. *J & K
   *Mespelt
7. *Unnamed

*Cited individually in the text.

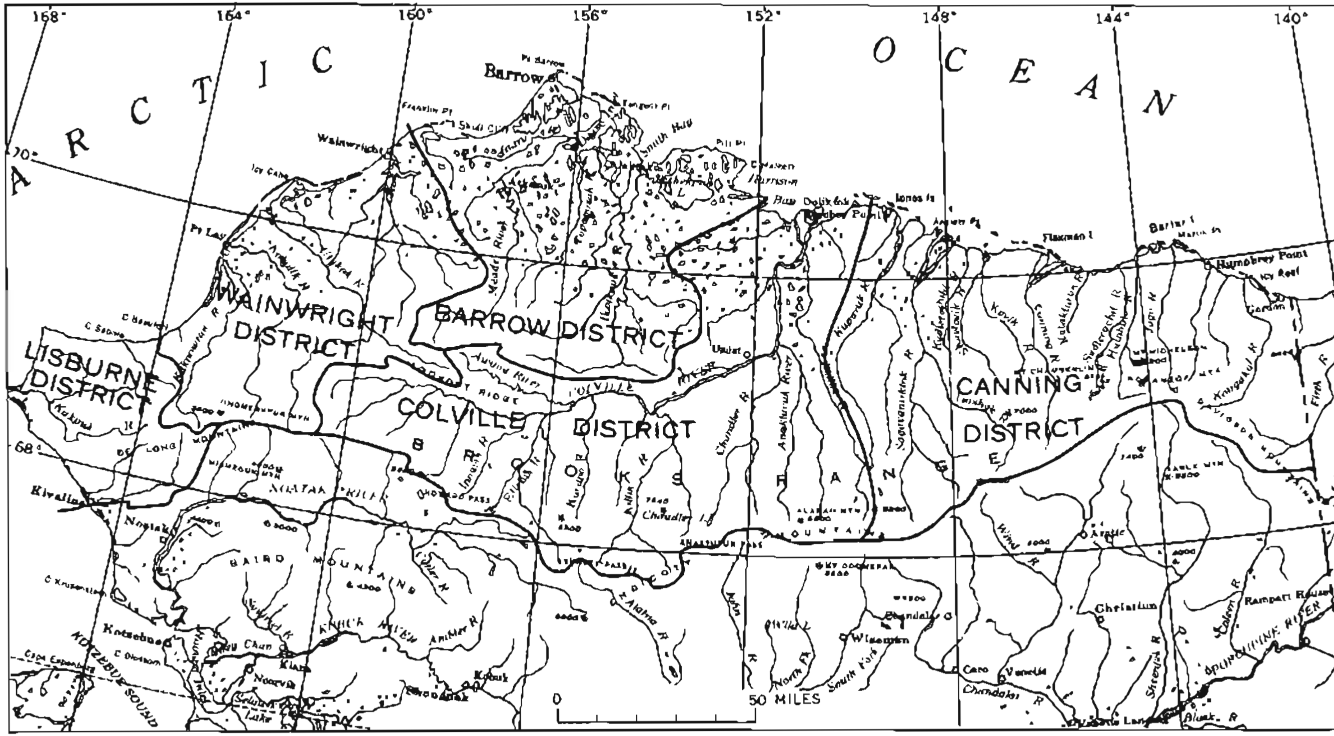

FIGURE 19.—Northern Alaska region and included districts.

The bedded rocks (pl. 1) form two major eastward-trending belts: a southern belt of Devonian to Permian clastic and carbonate rocks and a northern belt mostly of Mesozoic graywacke, shale, and volcanic rocks. Parts of the Canning and Colville districts are also underlain by Tertiary conglomerate, siltstone, and sandstone. The structure of the bedded rocks is dominated by eastward-striking folds, nappes, and overthrusts.

Plutonic rocks, which are relatively scarce, include granite, which cuts pre-Mississippian beds on Mount Michelson (Canning district), and mafic intrusives of Jurassic age in the western Brooks Range and Arctic Foothills.

Most of the coastal plain is covered by Quaternary deposits of sand, silt, and gravel.

Economic interest in the northern Alaska region is centered on its fossil-fuel resources. Oil and gas have been found in significant quantities, and oil shale, some very rich, is widespread; the coal resources probably aggregate 120 billion tons.

No metalliferous mineral deposits, either lode or placer, have been found in the region although specimens of cinnabar purported to have come from the Canning River were sent to an assay office of the Alaska Territorial Department of Mines (now State of Alaska Division of Mines and Minerals) sometime before 1947. What is known of the geology near the Canning River, however, makes it unlikely that the specimens actually originated there. In the late 1880's pyrite(?), said to contain \$3.50–\$8.50 in gold per ton, was reported on a tributary of the Pitmegea River in the northeastern part of the Lisburne district, but recent work in neighboring areas indicates that geologic conditions are not favorable for auriferous lodes. Iron-sulfide nodules, however, are common in Mesozoic sedimentary rocks that extend into the Pitmegea River basin. Eskimos have brought specimens of galena and sphalerite to Barrow, but it is not known where they were collected.

Additional information on this region is given in the following references: Anderson (1947); Gates and Gryc (1963); Lathram (1965); Smith and Mertie (1930).

NORTHWESTERN ALASKA REGION

The Northwestern Alaska region (pl. 1; fig. 20) is the area drained by streams flowing into Kotzebue Sound from the Wulik River on the north to and including the Kauk River on the south. It is divided into the Kiana, Noatak, Selawik, and Shungnak districts.

The region includes several groups of rugged, eastward-trending mountains 3,000–5,000 feet in altitude, separated by lake-dotted tundra-floored lowlands (pl. 1). A few peaks in the eastern part of the region reach heights of about 8,000 feet.

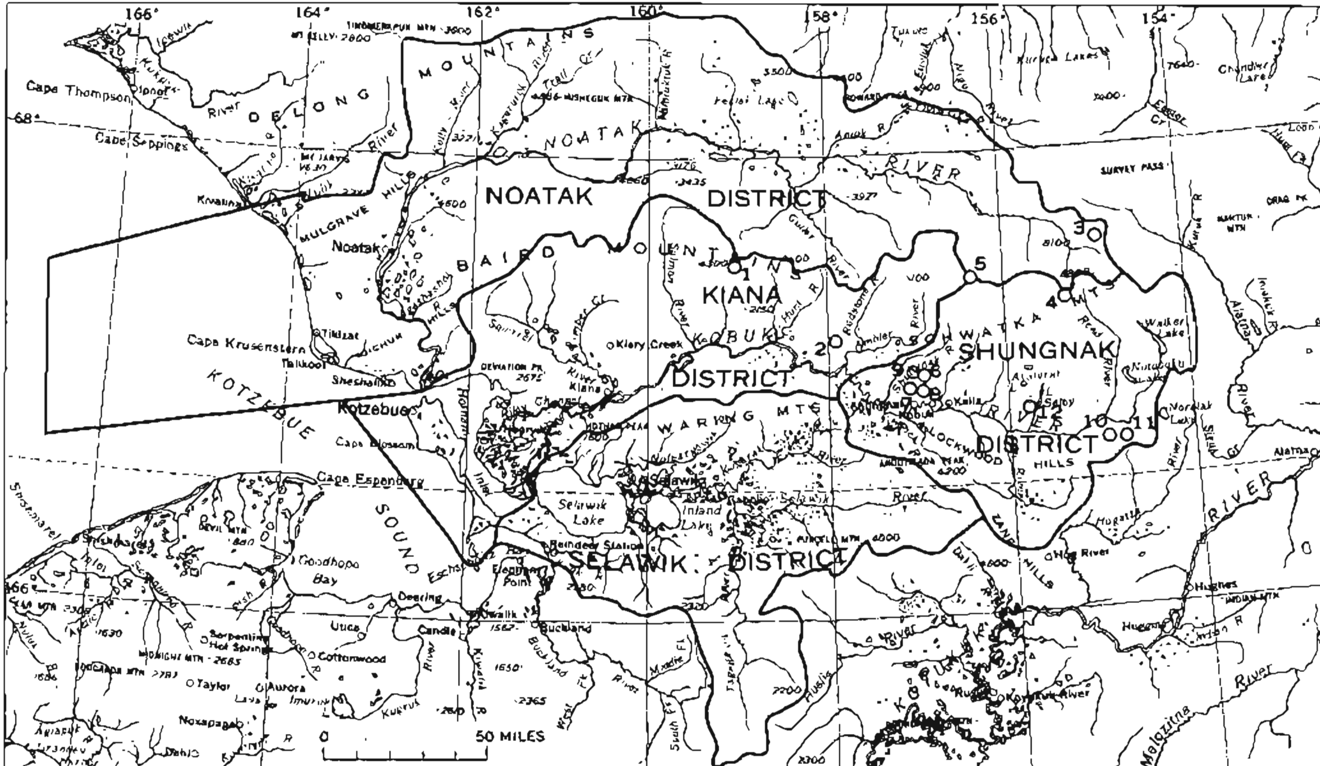

FIGURE 20.—Metalliferous lode deposits in the Northwestern Alaska region.

LOCALITIES

Kiana district

1. Malfiatti
2. Jade Hills

Noatak district

3. Lucky Six Creek
4. Angunelechak Pass
5. Shishakshinovik Pass

Selawik district

None

Shungnak district

5. Shishakshinovik Pass
6. Riley Creek
   Ruby Creek (Bornite)
7. Wesley Creek
8. Stockley Creek
9. Aurora Mountain
10. Unnamed
11. Unnamed
12. Lake Selby

The bedded rocks of the region (pl. 1) include a belt 25–50 miles wide of probable early Paleozoic schist and marble extending from Kotzebue Sound to and beyond the eastern boundary of the region; undivided Paleozoic sedimentary rocks and Devonian to Triassic marine carbonate and clastic beds, mainly in the Noatak and Shungnak districts; Mesozoic graywacke, slate, and volcanic rocks in the Kiana, Selawik, and Shungnak districts; and Quaternary lava flows in the Selawik district.

A granitic batholith and several smaller plutons of Cretaceous age cut the bedded rocks in several parts of the region, and mafic and ultramafic intrusives of probable Jurassic age crop out north of the Kobuk River and near Misheguk Mountain.

Large tracts along the Noatak and Kobuk Rivers and near Selawik Lake are covered by Quaternary deposits of sand, gravel, and silt. The geology of much of the northern half of the region is still incompletely mapped.

Asbestos and jade have been mined, and a little gold has been recovered from stream placers, but ore has not yet been shipped from metalliferous lodes in the region. Most of the exploration has been on copper lodes although deposits containing gold, silver, lead, zinc, nickel, and iron also have been reported. All the lodes are in Paleozoic slate, schist, or carbonate rocks.

KIANA DISTRICT

The Kiana district (fig. 20) includes the area drained by the Kobuk River and its tributaries up to and including the Ambler River and most of the Baldwin Peninsula.

The only mineral production from the Kiana district has been a small amount of placer gold from streams near Kiana.

A copper lode was discovered about 1912 on the Malfiatti claims (1, see fig. 20) near the head of a tributary of the Hunt River. It was reported to be between limestone and schist, but no other data on it are available. For many years there have been reports of lodes carrying gold, copper, and lead in the district, and in 1935 a specimen of cassiterite, said to have come from north of Kiana, was sent to an Alaska Territorial Department of Mines (now State of Alaska Division of Mines and Minerals) assay office. Nothing is known of the whereabouts or geologic settings of the reported lodes nor is it known whether the cassiterite was from a lode or placer source. Garnierite, a nickel silicate, has been found in the Jade Hills (2) about 70 miles east-northeast of Kiana.

Additional information on this district is given in the following references: Anderson (1945, 1947); Smith, P. S. (1913).

NOATAK DISTRICT

The Noatak district (fig. 20) is the area drained by the Noatak River and by coastal streams between its mouth and the Wulik River.

The only recorded mineral production in the Noatak district consists of a few ounces of placer gold from Lucky Six Creek (3, see fig. 20) near the head of the Noatak River.

Specimens of quartz veins containing chalcopyrite, stibnite, bornite, and malachite were collected in the early 1900's in the Lucky Six Creek area and submitted to the U.S. Geological Survey for assay. The richest contained less than $2 per ton in gold, but other assays, as high as $90 per ton, were reported by prospectors. Several claims were staked on these veins, but little work was done.

Selected specimens from a lode on the Noatak side of Shishakshinovik Pass (5) were reported by a prospector to have assayed 9.81 percent copper, 27.73 percent lead, and some gold and silver. He also reported silver ore on the Noatak side of the divide near Angunelechak Pass (4) and at Lucky Six Creek (3).

Additional information on this district is given in the following references: Anderson (1947); Smith, P. S. (1913); Smith and Mertie (1930).

SELAWIK DISTRICT

The Selawik district (fig. 20) includes the base of the Baldwin Peninsula and the area drained by streams flowing into Selawik Lake and Eschscholtz Bay between the Kobuk and Kauk Rivers.

No metalliferous lodes have been found in the Selawik district. The only mineral deposit known is a gold placer on a northward-flowing tributary of the Selawik River near Purcell Mountain.

Additional information on this district is given in the following references: Patton (1966); Smith, P. S. (1913).

SHUNGNAK DISTRICT

The Shungnak district (fig. 20) is the area drained by the Kobuk River and its tributaries above the Ambler River.

Jade, asbestos, and placer gold have been mined in the district, and a copper lode currently being developed at Ruby Creek may soon be brought into production. Other occurrences of copper minerals, locally accompanied by a little galena and small amounts of gold and silver, have been found but not worked.

The best known lodes in the district are at Ruby Creek (Bornite) (6, see fig. 20) about 13 miles north of Shungnak. Copper was discovered in the area in 1901, but except for a brief flurry of early activity, exploration has been in progress only since about 1955. Recent operations include trenching, test pitting, diamond drilling, and sinking an exploratory shaft; no estimates of grade and ore reserves have been made public. The deposits, in Devonian limestone and dolomite reef breccia on the north flank of an anticline, consist of disseminated sulfides, chiefly chalcopyrite and bornite, and small amounts of galena and sphalerite; a little gold has been panned from a gossan overlying one of the deposits. The origin of the Ruby Creek deposits is uncertain. Some geologists believe that the copper was derived from nearby stratified rocks and that the metal was mobilized during regional metamorphism and deposited in the permeable breccia; others believe that the deposit is of hydrothermal origin and that the copper was derived from a concealed magmatic source.

A copper lode that may be similar to the one at Ruby Creek is on Aurora Mountain (9), where assays of bornite showed 0.04 ounce of gold and 1.4 ounces of silver per ton.

Metalliferous vein material from the south side of Shishakshinovik Pass (5), supposedly from the continuation of a lode carrying copper and lead minerals on the Noatak side of the pass (p. 105), assayed about $1.24 per ton in gold and silver.

A semiquantitative spectrographic analysis of a random sample of chalcopyrite, limonite, quartz, and secondary copper minerals from near Lake Selby (12) indicated that the copper is accompanied by 0.01 percent silver and traces of zinc, nickel, and other metals. The deposit is in Cretaceous conglomerate near older mafic volcanic rocks. Recently, members of the U.S. Geological Survey examined two gossans formed over disseminated pyrite deposits about 25 miles east-southeast of Lake Selby (10, 11). A random sample of one deposit (11) contained 0.2 percent chromium, but another sample from the same deposit carried only 0.0005 percent.

Sparse galena occurs in one or more quartz veins on a hill west of Wesley Creek (7) between Shungnak and Aurora Mountain, and small auriferous quartz veins cut black slate and schist near the head of Riley Creek (6).

A little nickel has been found in asbestiform minerals near the mouth of Stockley Creek (8), about 5 miles from the village of Kobuk, and float specimens of magnetite weighing as much as 100 pounds have been found on the slopes of Iron Mountain, just west of Ruby Creek. The magnetite fragments seem to be most common near bedrock contacts between limestone and schist, but the mineral has not been found in place.

Additional information on this district is given in the following references: Anderson (1945); Matzko and Freeman (1963); Patton and Miller (1966); Smith, P. S. (1913); Smith and Mertie (1930).

SEWARD PENINSULA REGION

The Seward Peninsula region (pl. 1; figs. 21–23) includes the Seward Peninsula and the drainage basins of the Buckland, Ingultalik, Ungalik, and Shaktolik Rivers and Egavik Creek. It consists mostly of rounded hills and flat divides 500–2,000 feet in altitude, but there are also isolated groups of rugged glaciated mountains 20–60 miles long and 10 miles wide that rise to peaks 2,500–4,700 feet in altitude. A relatively small part of the region consists of lowlands, such as the Imuruk Basin, the Niukluk River valley, the Kuzitrin Flats, and the coastal plain fringing much of the peninsula (pl. 1).

About half of the region is underlain by schist, gneiss, limestone, and slate, which is predominantly of Paleozoic age, but locally, as in the Kigluaik and Bendeleben Mountains, may be as old as Precambrian (pl. 1). Most of the region's lode deposits are in the Paleozoic rocks, especially near granitic intrusive bodies.

Mesozoic rocks broadly divisible into two major groups are abundant in the eastern part of the region. One group consists chiefly of slightly metamorphosed intermediate volcanic rocks, and the other mainly of marine sandstone and shale.

The youngest stratified rocks are volcanic ash and basaltic lava flows that may be as old as late Tertiary, but which are mainly Pleistocene in age. One lava flow near Imuruk Lake is no more than a few centuries old.

The bedded rocks are cut by dikes, sills, and stocks probably emplaced during several intrusive episodes. Chlorite- and epidote-rich plutons (greenstone) of possible Paleozoic age intrude the lower Paleozoic metamorphic rocks, and Mesozoic and Tertiary(?) granitic bodies cut strata ranging in age from Paleozoic to Cretaceous. The main outcrop areas of intrusive rocks are in the Kigluaik, Darby, and Bendeleben Mountains; in an area south of Eschscholtz Bay between the Kiwalik River and the West Fork of the Buckland River; and near the western tip of Seward Peninsula, where felsic dikes and stocks are associated with tin and beryllium lodes.

Sand, gravel, and silt thinly mantle bedrock throughout the Seward Peninsula region and form deposits as much as 100 feet thick in the lowlands.

The bedded rocks are complexly deformed. In the eastern part of the region they are characterized by northward-trending folds, and in the western part by northward-trending folds superimposed upon a west-southwest-trending arch. These structures in turn are warped by gentle flexures and cut by normal faults. In many places, the deformation was accompanied by metamorphism and the emplacement of intrusive and extrusive igneous rocks. Recent deformation is indicated by fault scarps in alluvium and glacial deposits.

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Metalliferous lodes that have produced significant amounts of ore, or that contain important resources, include deposits of tin, tungsten, and beryllium minerals, and gold. Small amounts of antimony, bismuth, copper, silver, lead, and quicksilver have also been recovered, but no major deposits of these metals are known. There is a residual iron deposit near Nome, and zinc, arsenic, uranium, and molybdenum occur in minerals in or near the tin and base-metal lodes.

According to C. L. Sainsbury (written commun., 1963), the part of the Seward Peninsula region with the greatest economic potential is the Lost River area (Port Clarence district), where there are lodes containing an important part of the United States resources of tin and beryllium.

COUNCIL DISTRICT

The Council district (fig. 21) is the area drained by the Kwiniuk and Topkok Rivers and intermediate streams flowing into Norton Sound.

Two lode deposits in the Council district have produced silver, lead, gold, and quicksilver, and others have been explored for precious metals, copper, and antimony. Some of the deposits also contain a little tin and zinc.

The most noteworthy lodes, from the standpoint of production and exploration, are in the Omilak area, where one lead-silver deposit was successfully worked at the Omilak mine (4, see fig. 21), and another, at the Foster prospect (5), was recently sampled by the U.S. Bureau of Mines (Mulligan, 1962).

The Omilak mine, one of the first productive lodes in Alaska, operated from 1881 to 1890 and shipped between 300 and 400 tons of ore averaging 10 percent lead and 4 ounces of silver per ton. One lot of 41 tons of picked ore contained 75 percent lead and 142 ounces of silver per ton. The principal underground workings, now inaccessible, consisted of a 180-foot shaft with two working levels and a 500-foot adit. Mining ceased in 1890, but sporadic efforts to resume operations continued until the early 1920's.

The Omilak deposit is in slightly recrystallized, partly dolomitic limestone that is intercalated with schist on the west limb of a gently northward-plunging anticline. The mineralized limestone layer, which has an outcrop width of more than 700 feet, is marked by small-scale folds and faults. Greenstone (probably an altered mafic igneous rock) occurs in limestone about 2,000 feet south-southwest of the Omilak mine shaft, but there is no evidence that it is genetically related to the lode. Granitic igneous rocks crop out about 9 miles east of the mine.

The Omilak deposit consists of argentiferous galena, stibnite, and gold in irregular, discontinuous replacement lodes in the limestone.

Locally, the sulfides are oxidized to secondary lead, iron, antimony(?), and silver(?) minerals.

Analyses of four samples by the U.S. Bureau of Mines in 1954 gave the following results: Galena-rich material—up to 71 percent lead, 12 percent iron, and 1.0 percent antimony, and 0.13–0.27 ounce of gold and 36–88 ounces of silver per ton; stibnite-rich material—up to 32 percent antimony, 0.75 percent lead, and 3.4 percent iron, and 0.05 ounce of gold and 0.19–1.70 ounces of silver per ton. The analyses also showed small amounts of copper, tin, and zinc, and traces of other metals.

The deposit on the Foster property, about 3 miles east-southeast of the Omilak mine, is on the crest of the same anticline. It is in bleached and weathered limestone and consists of about 700 feet of lead- and silver-bearing gossan along a possible fault zone that strikes northwest and is vertical. The only recognizable primary mineral in the gossan is galena, which forms nodules as much as 2 feet in diameter; the nodules are most abundant near the surface, where they have been residually concentrated. The gossan is chiefly an earthy aggregate of secondary iron and lead minerals, together with clay, quartz, and zones of hard, partly decomposed siliceous limestone.

The Foster lode, probably discovered before 1900, was trenched by prospectors in 1949, and several tons of hand-sorted ore piled nearby. In 1953 and 1954 it was diamond drilled and trenched by the U.S. Bureau of Mines, whose samples assayed a trace to 25.6 percent lead, 5.7–42.5 percent iron, up to 7.6 percent zinc and 0.3 percent tin, traces of antimony and copper, and 0.02–14.9 ounces of silver and a trace to 0.05 ounce of gold per ton.

Fragments of oxidized lead minerals are scattered for about 3,500 feet south and southeast of the Foster prospect. Their bedrock source is not exposed, but one small gossan occurs 3,000 feet southeast of the prospect. Some of the fragments, which consist chiefly of limonite, cerussite, and galena, contain up to 6.3 percent lead and a trace of zinc. Lead minerals also occur at an altitude of about 1,000 feet on a tributary to Fish River, about 5 miles from the Omilak mine. The deposit, which consists of irregular masses and veinlets of galena in limestone, was discovered in 1948 and was explored by trenching.

The only other productive lode in the Council district is reportedly on Fish River (12), about 6 miles above the mouth of the Niukluk River. It contains cinnabar and probably argentiferous galena, and is said to have been worked for a little lead-silver ore and several flasks of mercury. There is no other information about the deposit, and recent attempts to locate it have not been successful.

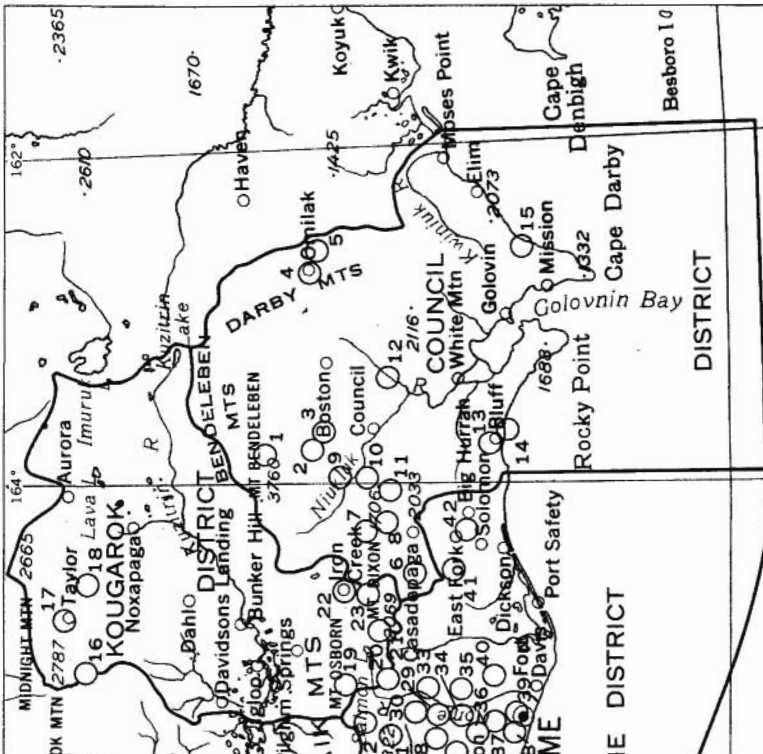

FIGURE 21.—Metalliferous lodes deposits in the Council, Kougarok, and Nome districts.

Council district

1. *Unnamed
2. *Crooked Creek
3. *Crooked Creek
4. *Omilak
5. Dry Creek
*Foster
Unnamed
6. *Moonlight Divide
7. *Mount Dixon
8. *Spruce Creek
9. *Post Creek
10. *Brookins
11. *Camp Creek
12. *Fish River
13. *Bunker Hill
14. *Daniels Creek
*Koyana Creek
*Swede Creek
15. *Carson Creek

*See footnote at end of list.

Kougarok district

16. *Worcester
17. *Kougarok River
18. *Harris Creek
19. *Unnamed (2 occurrences)
20. *Copper Creek (see also Nome district)
21. *Slate Creek
*Wheeler (Iron Creek)
22. *Iron Creek
*Wheeler [Pilgrim (Kruzgamepa) River]
23. *Benson Creek
Dome Creek, Left Fork
Sherrette Creek
*Wheeler (Sherrette Creek)

Nome district

20. Copper King (also see Kougarok district)

Nome district—Continued

(20.) *Copper Mountain
Unnamed (2 occurrences)
24. *American
*Mogul
*Monarch
*Tub Mountain
25. *Cub Bear
*Galena
Iron Creek
Unnamed
26. *Steiner
27. *Christophosen
28. *California (Connelly and Jensen)
*Last Chance Creek
*North Fork
*Waterfall Creek
29. *Breen
*Grouse Creek

Continued on following page.

LOCALITIES SHOWN ON FIGURE 21—continued

Nome district—Continued

(29). Holmason and Helde
*McDuffee
*Manila Creek
*Nelson
*Sliscovich
Tanner
Unnamed
30. *Hed and Strand
Unnamed
31. *Charley Creek
32. *Unnamed (2 occurrences)
33. Lindfors
Nelson Creek
*Rocky Mountain Creek
Spring
Thompson
Unnamed (2 occurrences)
34. Pioneer Gulch
Unnamed

Nome district—Continued

35. *Bonita Creek
Nelson
36. Boulder
*Boulder Creek
Goodluck Gulch
Lilly
*Twin Mountain Creek
37. *Albion Creek
*Glacier Creek
*Gold Hill
*Jorgensen
*New Era (Big Four)
*Nugent
*Prospect Creek
*Reinisch
*Rock Creek
*Snow Gulch
*Sophie Gulch
*Stipek & Kotovic (2 occurrences)

Nome district—Continued

*West (Gold Bug)
38. *Peterson & Lamoreaux
Unnamed
39. *Anvil Creek
Bursick & Kern
*Dexter Creek
King Mountain
Newton Gulch
Rex

Solomon area

40. *Osborn Creek
41. *West Creek
42. *Big Hurrah
*Big Hurrah Creek
*Flynn
*Quigley (Gray Eagle)
*Silver
*Unnamed

*Cited individually in text.

A quicksilver lode at the mouth of Swede Creek (14), about 1½ miles east of Bluff, consists of sparse irregular masses of cinnabar in limestone. The masses are as much as 7 feet in maximum dimension, but most are much smaller. A chip sample across the largest mass assayed 2.36 percent mercury. The deposit was explored by two short tunnels and a few shallow shafts, but there is no record that any ore was shipped.

The best known gold lodes in the district are near Bluff, where deposits at Daniels and Koyana Creeks (14) are probably the source of nearby gold placers worked in the early 1900's. Most of the lodes consist of oxidized auriferous quartz veins in shear zones in chlorite schist. Sparse sulfide minerals, including pyrite and arsenopyrite, are disseminated throughout the quartz veins and schist, but in the richer lodes they are concentrated, together with minute particles of free gold, in the quartz near the schist contact. The gold tenor of the veins ranges from 0.1 ounce to 8.5 ounces per ton. The deposits were explored by pits and trenches, and by numerous shafts and other underground workings, but they failed to locate sizable ore bodies. Some ore was mined but little was shipped.

On the Bunker Hill property (13), a northward-striking vertical quartz vein at the contact between limestone and schist was exposed by shallow trenches for a width of 5½ feet and a length of 20 feet. The vein, stained with secondary iron and copper minerals, carries sparse chalcopyrite, pyrite, and gold, mostly near its borders, and is said to assay as much as 3.9 ounces of gold per ton.

Quartz stringers cutting schist or limestone and carrying pyrite and small amounts of gold and silver occur near old gold placers in the Crooked Creek area (3). A sample of one of the stringers assayed 0.06 ounce of gold per ton and a trace of silver.

Another lode associated with placer deposits is near the head of Crooked Creek (2). It is near the contact between limestone and schist and consists of one or more quartz veins containing as much as 2 ounces of gold per ton.

Other auriferous lodes are on Post Creek (9), where an 8-foot quartz vein that reportedly assayed about 1.7 ounces of gold to the ton is at a schist-limestone contact, and on Camp Creek (11), where a quartz vein carries visible free gold.

Copper- and gold-bearing quartz veins occur near schist-limestone contacts at Moonlight Divide (6), Mount Dixon (7), and Spruce Creek (8). Most of the veins show only light staining by secondary copper minerals, but a few contain chalcopyrite and a little free gold.

About 1900, two low-grade copper deposits near Carson Creek (15) were explored by a small opencut and a short tunnel. One contains malachite, azurite, and minor chalcocite that have partly replaced schist country rock. The only sign of mineralization at the other is a little superficial copper staining in brecciated limestone.

Lodes prospected for copper in the early 1900's in the Bendeleben Mountains (1) consist mainly of chalcopyrite and secondary copper minerals in scattered lenses and stringers near the contact between limestone and schist. The country rock is complexly faulted and is intruded by small granitic dikes. A little gold is said to accompany the copper.

The Brookins prospect (10) explored an antimony lode consisting of stibnite lenses and stringers in schist. The largest lens, up to a foot thick, was explored by a 8-foot shaft and 60-foot tunnel.

Additional information on this district is given in the following references: Anderson (1947); Cathcart (1922); Collier, Hess, Smith, and Brooks (1908); Herreid (1965a); Mertie (1918c); Mulligan (1962); Smith, P. S. (1907, 1908); Smith and Eakin (1911).

FAIRHAVEN DISTRICT

The Fairhaven district (fig. 22) is the area drained by the Buckland and Goodhope Rivers and intermediate streams entering Kotzebue Sound and Eschscholtz Bay.

Lodes containing lead, silver, gold, copper, a little iron, and traces of zinc were discovered, explored, and abandoned before 1925; they are all small or low grade and with one exception have been nonproductive.

The Independence mine (3, see fig. 22), about 20 miles east-northeast of Imuruk Lake, worked argentiferous galena(?) veins in marble near a granite contact. The lode, exposed in opencuts for a width of 7–12 feet and traced on the surface for 2,000 feet, was developed by several hundred feet of underground openings from which several hundred tons of ore was probably mined by 1922. The ore reportedly contained 30 percent lead and a trace of zinc, and 150 ounces of silver and 0.1 ounce of gold per ton. Specimens from the Independence dump average about 20 percent lead and 20 ounces of silver per ton.

On Hannum and Harry Creeks (1), deeply weathered and oxidized deposits of argentiferous galena, pyrite, and rhodochrosite in limestone were discovered by gold placer miners in the early 1900's. The deposits were explored by the U.S. Bureau of Mines in 1956, 1959, and 1963 (Mulligan, 1965a). The more recent work, which included trenching, sampling, and geologic studies, disclosed a northwest-trending mineralized zone several hundred feet wide and at least 4,000 feet long. Chemical analyses of three specimens of oxidized material showed as much as 0.73 percent lead, 1.12 ounces of silver per ton, and a trace of gold, but the continuity and average grade of the deposits could not be determined.

Other lead and lead-silver deposits in the district are near the Inmachuk River (2), where specimens containing argentiferous(?) galena, limonite, magnetite, and pyrite were collected about 1916; on Patterson Creek (4), where several veins 8 inches–3 feet thick containing argentiferous galena were explored by a shallow shaft and surficial workings; on Candle Creek (5), where small veins of galena in bedrock were exposed during placer operations; and on Canoe Creek (6), where a specimen of argentiferous galena reportedly was taken from a vein 1½ feet thick.

The Beltz copper prospect (7), explored by several opencuts in the early 1900's, consists of sparse chalcopyrite and secondary copper minerals in a quartz vein in andesite. Gold-bearing quartz veins reportedly also occur in the area.

On Bear Creek (7), about 2 miles southeast of the Beltz prospect, sparse sulfide minerals occur in greenstone near a northwest-trending syenite dike. The lodes consist of pyrite, sphalerite, and galena disseminated in greenstone adjacent to quartz-pyrite veinlets; galena- and pyrite-bearing calcite veinlets; and disseminated pyrite and galena in greenstone breccia zones as much as 2½ feet wide. The deposit is marked by a thin oxidized zone from which a little gold can be panned.

Additional information on this district is given in the following references: Anderson (1947); Brooks (1923); Brooks and Capps (1924); Cathcart (1920); Gault, Killeen, West, and others (1953); Herreid (1965c); Mertie (1918c); Moffit (1905); Mulligan (1965a).

KOUGAROK DISTRICT

The Kougarok district (fig. 21) includes the area drained by the Kaviruk, Kuzitrin, and Pilgrim (Kruzgamepa) Rivers and their tributaries, all of which drain into Imuruk Basin.

The district contains lodes from which modest amounts of lead, silver, and copper ore were shipped, as well as deposits prospected for gold, tungsten, lead, silver, and copper.

A little lead-silver ore was mined sometime before 1922 at the Wheeler prospect (22, see fig. 21) on the Pilgrim (Kruzgamepa) River. The deposit is in slightly recrystallized limestone interbedded with quartz-mica schist and consists of argentiferous galena, pyrite, minor sphalerite and chalcopyrite, in a quartz and calcite gangue. The principal mineralization is near a limestone-schist contact, which is also marked by appreciable pyrite disseminated in the schist and by sporadic secondary copper minerals. The country rock is tightly folded near the contact, but the deformation is confined to a zone

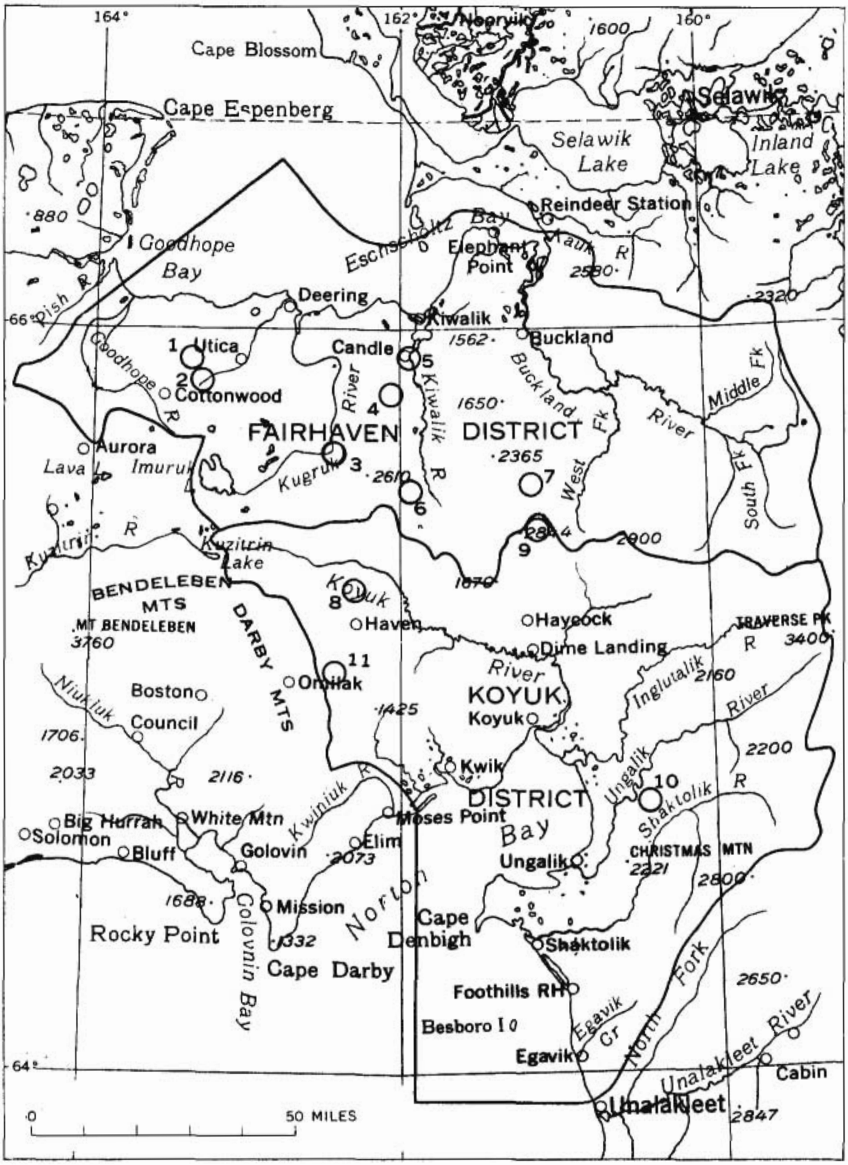

FIGURE 22.—Metalliferous lode deposits in the Fairhaven and Koyuk districts. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 22

Fairhaven district

1. *Hannum
   *Harry Creek
2. *Inmachuk River
3. *Independence (Purkeypile and Ford)
4. *Patterson Creek
5. *Candle Creek
6. *Canoe Creek

Fairhaven district—Continued

7. *Bear Creek
   *Beltz
   Unnamed

Koyuk district

8. *Timber Creek
9. *Peace River
10. *Moon
11. *Otter Creek

* Cited individually in text.

about 20 feet wide, beyond which the rocks dip gently northward. Greenstone (possibly intrusive) occurs in a few places along the contact. The ore came from two lenticular masses of silver-bearing galena that were probably several tens of feet long; they assayed 14–23 percent lead and 14.5–20 ounces of silver per ton. There is evidence that the lode was formed at least partly by replacement.

Galena-bearing veins in bedrock reportedly were discovered during early placer-mining operations in the Harris Creek area (18), about 6 miles southeast of Taylor.

The Wheeler copper claim (23) near the head of Sherrette Creek is at the contact between limestone and schist and consists of a 5-foot-thick quartz-calcite stringer lode containing malachite and subordinate chalcopyrite, bornite, pyrite, and limonite. Before 1920 the lode was worked for about 25 tons of ore that assayed 17.2–35.7 percent copper, 7.6 percent iron, and up to 5.2 ounces of silver and 1.8 ounces of gold per ton. Workings consisted of a 200-foot adit, a 90-foot shaft, and several pits.

Near Iron Creek (22, 23), several copper deposits occur in limestone close to schist contacts; they were explored by adits, shafts, and pits, but none was productive. Most are approximately parallel to the bedding of the limestone and consist of roughly tabular stringer lodes of quartz and calcite carrying chalcopyrite, pyrite, malachite, and azurite. A few consist of relatively persistent, iron-stained, locally vuggy quartz veins or lenses as much as 6 feet thick cutting limestone and schist. These veins, however, contain only sparse copper minerals or are barren.

Several tons of copper ore were reportedly shipped from the Wheeler property (21) about 10 miles southwest of Iron Creek. The deposit, which was explored by a 60-foot tunnel and an 80-foot shaft, consists of a northeast-striking zone carrying malachite and sparse chalcopyrite and bornite. A 9-foot-wide quartz vein (or stringer lode) stained with secondary copper minerals and containing stringers of malachite crops out southwest of the workings. The country rock at the prospect probably is limestone and schist.

Lodes explored mainly for copper occur on Copper Creek (20), where copper minerals are in schist cut by granitic sills; on the Worcester claim (16), where lodes reported to contain malachite, azurite, and galena were prospected about 1916; and on the Kougarok River (17), where copper sulfides reportedly are disseminated in limestone.

A gold prospect on Slate Creek (21), about 10 miles southwest of Iron Creek, consists of a quartz-calcite stringer lode in fractured and altered fine-grained dikes cutting greenstone. The lode, explored by a small opencut about 1913, contains little gold and probably was abandoned without significant production.

Contact metamorphic deposits containing scheelite, galena, and sphalerite occur in marble near its contacts with granitic sills about 7 miles northwest of Salmon Lake (19). The metallic minerals are closely associated with silicate minerals, mainly diopside, garnet, and quartz. Four such deposits have been discovered (Hummel, 1961), but they evidently are small and difficult to recognize because they are camouflaged by subsequent regional metamorphism that produced silicate minerals similar to those that mark the lodes.

Additional information on this district is given in the following references; Anderson (1947); Cathcart (1922); Chapin (1914b); Hummel (1961, 1962b); Mertie (1918c); Smith, P. S. (1908).

KOYUK DISTRICT

The Koyuk district (fig. 22) is the part of the Seward Peninsula region drained by streams flowing into Norton Bay and Norton Sound between and including Egavik Creek and the Tubutulik River.

Copper, gold, silver, and stibnite lodes are known in the Koyuk district, but none has been productive.

Several prospect pits were dug about 1907 on copper-stained greenstone near a limestone contact on Timber Creek (8, see fig. 22). Most of the deposit probably consists of malachite in joints and fractures in the greenstone. Picked samples reportedly assayed up to 70 ounces of silver and 0.05 ounce of gold per ton and had a high copper content, but the minerals were too sparse to encourage further prospecting.

Copper sulfides occur in granite on the upper part of the Peace River (9), about 17½ miles north of Haycock, but the amount of mineralization is slight.

The Moon antimony and precious-metal(?) lode (10), discovered in 1911 about 18 miles northeast of Ungalik, probably consists of small veinlets and lenses of stibnite in several large quartz veins. Reports of unusually high gold and silver assays, however, are unsubstantiated. Little work was done on the lode.

Near the head of Otter Creek (11), an old gold prospect explored by a 20-foot shaft consists of sparse sulfides in minute quartz veins cutting quartz-mica schist. Assays of the quartz-bearing material show up to 0.03 ounce of gold and 0.27 ounce of silver per ton. Traces of tin have been found in the alluvium near the prospect.

Additional information on this district is given in the following references: Anderson (1947); Herreid (1965b), Smith and Eakin (1911).

NOME DISTRICT

The Nome district (fig. 21) is the part of the Seward Peninsula drained by the Solomon River and other streams flowing into Norton Sound and the Bering Sea as far west as Cape Douglas.

The district, site of the famous gold rush of 1898, is best known for the rich beach placers near Nome, from which many millions of dollars in gold were recovered. Less heralded is a comparatively small but significant production of gold, tungsten, and antimony ore from lode mines, for now that most placer mining has ended, the area's lode-mineral resources may play an increasingly important role in its economic development.

Lodes carrying iron, copper, lead, zinc, quicksilver, molybdenum, and bismuth also occur in the district, but despite knowledge of their existence since the early 1900's, none has been worked successfully.

Most of the lodes are in an area about 20 miles wide extending from Nome to the northern boundary of the district (fig. 21). The rest are in the Solomon area in the eastern part of the district.

NOME AREA

Individual lodes in the Nome area were broadly classified by early prospectors either as disseminated deposits or as vein deposits. This classification may not be valid on geologic grounds. The two types grade into each other, which suggests that they have a common origin. Their distinction may be mostly a matter of scale. For convenience, however, the early classification is followed in this report.

The disseminated deposits are in schist and limestone and consist of abundant quartz-feldspar-calcite veinlets carrying gold, scheelite, pyrite, arsenopyrite, stibnite, chalcopyrite, and rare galena, sphalerite, cinnabar, and bismuthinite. Locally the metalliferous minerals, unaccompanied by quartz, occur as veinlets and disseminated grains in the country rock. Small gold-bearing veins are abundant in the Nome area, and although no individual vein has proved rich enough to mine, the erosion of these low-grade lodes led to the formation of some of the world's richest placer deposits.

The vein deposits are relatively persistent quartz veins and lenses as much as 20 feet thick occupying well-defined faults or shear zones. Some contain feldspar or calcite and many are barren, but a few carry conspicuous amounts of sulfides and were mined successfully for gold and antimony.

Brooks (in Collier and others, 1908, p. 22) emphasized that many of the lode and placer deposits in the Nome area are near limestone-schist contacts. During folding such contacts are commonly surfaces of differential movement, accompanied by brecciation and shearing of the adjoining rocks. The attendant increase in permeability permits freer circulation of solutions and greater opportunity for the formation of veins. Moffit (1913, p. 130), on the other hand, pointed out that in some of the most heavily mineralized parts of the area, it is difficult to prove that the contact zones are more highly mineralized than the rock away from the contacts.

DISSEMINATED DEPOSITS

Although there is no evidence that any single vein in a disseminated deposit was rich enough to mine, some gold, and all the scheelite produced in the Nome area, were recovered from deposits of this type. Whether a deposit could be mined profitably depended upon the degree to which it was weathered, for decomposed disseminated lodes could be worked at the same time as nearby placer deposits—by the same methods and just as cheaply. In addition to being easily worked, some of the lodes showed a little residual enrichment in gold, because other constituents of the rock had been partly removed by weathering. There is no record, on the other hand, that a significant amount of ore was ever produced from any of the fresh, unweathered disseminated lodes.

The best known disseminated deposit in the Nome area is at Sophie Gulch (37, see fig. 21), where, from 1916 to 1918, several tons of scheelite concentrates were recovered by placer mining a weathered lode. The deposit consists of iron-stained mica schist containing numerous irregular quartz, quartz-feldspar, and quartz-calcite veins ranging from a fraction of an inch to at least a foot in thickness. Most of the scheelite is at the margins of the quartz veins and disseminated in the neighboring schist. Gold reportedly occurs in the iron-stained schist outside the zone of scheelite mineralization, and stringers carrying arsenopyrite, pyrite, galena, sphalerite, and stibnite cut the scheelite-bearing veins. The zone of scheelite mineralization, said to be about 50 feet wide, has been traced on the surface for about 1,000 feet. It trends northeastward, about parallel to the strike of the foliation of the schist. Early workings included two shafts, a tunnel, and several opencuts, and in 1942 and 1943, three bulldozer cuts were made in the deposit to determine the distribution of the scheelite. The material from the cuts was sluiced to recover the scheelite, but although the amount recovered was regarded as considerable, the tenor of the deposit was well below the economic limits for lode mining, and there was too little weathered material to justify further placer-mining operations. According to Coats (1944b, p. 3):

> The depth of the softened and residually weathered rock at the Sophie Gulch prospect ranges from 3 or 4 feet up to 15 feet. It apparently is greater where the rocks had a high content of sulfides, most of which are now oxidized to red hematitic material. * * * Only a very small amount of residual material, containing a few pounds of scheelite per cubic yard, is available here.

Deposits similar to the one at Sophie Gulch have been worked on Twin Mountain Creek (36), where about 500 pounds of scheelite was reportedly sluiced from a weathered lode; on Glacier Creek (37), where about 600 pounds of scheelite was recovered by sluicing lode material raised to the surface from a 60-foot shaft; and on the Stipek and Kotovik prospect (37), where a small amount of scheelite was recovered by hydraulic methods.

Contact metasomatic deposits (32) containing disseminated scheelite, galena, and sphalerite occur near the contact of metamorphosed granitic and sedimentary rocks about 12 miles west of Salmon Lake (Hummel, 1961).

A lode prospected mainly for zinc, but which reportedly also carries some gold, is in a thin limestone layer intercalated with schist on the Christophosen property (27). There is probably no well-defined vein, as the deposit appears to consist of a northward-trending iron-stained zone carrying sphalerite, pyrite, and quartz. The lode was explored by a shallow shaft, but no ore was mined.

The Nelson zinc-lead deposit (29), on the south slope of Mount Distin, consists of abundant irregular stringers and disseminated particles of sphalerite, galena, and pyrite in bleached limestone near its contact with quartz-mica schist. The deposit was formed by replacement of the limestone, commonly parallel to the original bedding. Development work consisted of a tunnel, opencut, and several pits, but there is no evidence that any ore was shipped.

VEIN DEPOSITS

Among the myriad veins in the Nome area that were prospected for gold and other metals, the most productive, and hence the best known, were the California (28), Waterfall Creek (28), Sliscovich (29), Hed and Strand (30), Stipek and Kotovik (37), and Anvil Creek (39) deposits. All the antimony ore produced in the area came from veins; most was a byproduct of gold mining, but some came from veins that were worked for stibnite alone.

The California lode (28) consists of gold- and sulfide-bearing quartz veins in a shear zone in graphitic quartz-mica schist. The zone, reportedly traced for 3 miles, cuts across the foliation of the schist and also transects a system of older relatively barren quartz veins. Pyrite and arsenopyrite are the most abundant sulfides; a little free gold was visible in the ore, but most of it was combined with the sulfides. Molybdenum and tungsten were revealed in assays, and stibnite veins as much as 2 inches thick were reported. The ore was mined from a heavily iron-stained 4-foot section of shattered quartz and country rock just below the hanging wall of the shear zone. Workings included a shaft and opencut, and a mill was built to process the ore, practically all of which was mined before 1916. Records of the amount of gold recovered are no longer available, but the 4 feet of ore along the hanging wall reputedly assayed about $50 a ton in gold.

About 2½ tons of high-grade stibnite ore was shipped from a lode near the head of Waterfall Creek (28) sometime before 1922. The lode is in schist and consists of an iron-stained stockwork of quartz and stibnite veins up to a foot thick, subordinate pyrite and pyrrhotite, and a little gold. Most of the quartz is milky white and commonly forms lenses as much as 3 feet thick. This quartz predates the major period of sulfide mineralization, for it is cut by veins of well-crystallized stibnite containing crystals of clear quartz. The stockwork is part of a vertical northeastward-striking shear zone about 100 feet thick. The ore, mined by two tunnels and several opencuts, assayed more than 58 percent antimony and carried some gold and silver. Assays of the schist and quartz in the shear zone also showed a little gold. Lodes containing chalcopyrite, galena, and secondary copper minerals have also been reported near Waterfall Creek.

The Sliscovich lode (29), staked in 1905, is a northeast-striking northwest-dipping gold- and stibnite-bearing quartz vein up to 4 feet thick. It was originally worked for gold, but in 1915 high prices induced the operators to mine the antimony-rich parts of the vein, and some of this ore was shipped. The vein, whose walls are marked by gouge, characteristically pinches, swells, and splits. Its stibnite content varies. In the parts which were rich enough to mine, quartz and stibnite were present in approximately equal amounts, with stibnite locally forming lenses as thick as 13 inches. Gold, both native and combined with stibnite, is sparsely disseminated throughout the lode. Workings consisted of several pits and about 500 feet of underground openings including two adits and an inclined shaft. Assays of the antimony ore, most of which was mined from a stope 70 feet long near the foot of the shaft, showed about 36 percent antimony and undisclosed amounts of gold and silver.

The Hed and Strand lode (30), discovered in 1909, was developed by about 1,200 feet of underground workings, and a total of 106 tons of antimony ore was shipped in 1915–16. The lode, near a schist-limestone contact close to a granitic intrusive, consists of stibnite-bearing quartz veins in fractures transverse to the foliation of the enclosing schist. The principal vein, containing masses of almost pure stibnite up to 2 feet thick, is as much as 4 feet thick, but it pinches and swells irregularly and is offset slightly by numerous small faults. Lower grade quartz veins containing stibnite, pyrite, arsenopyrite, and a little gold occur on the property, and the same metallic minerals are probably disseminated in the schist. Several other stibnite-bearing veins were prospected near the Hed and Strand mine, but none was rich enough to mine.

In addition to the scheelite-bearing disseminated deposit already noted on the Stipek and Kotovic property, there are several metalliferous quartz veins, the largest of which were prospected for gold. The main vein, on Rock Creek just below Sophie Gulch, is in quartz-chlorite schist and consists of as much as 12 feet of shattered and iron-stained quartz and feldspar carrying a little pyrite, arsenopyrite, and ilmenite. Sometime before 1920 it was explored by two tunnels, a shaft, and an opencut; a mill test was made, but there is no evidence that much ore was shipped. The test showed 250 pounds of concentrates per ton of mill heads and $6.25 a ton in free gold. The concentrates, chiefly arsenopyrite and pyrite, reportedly assayed $48–$65 a ton in gold. According to the owners, the adjoining schist carried more gold than the mineralized quartz.

Lodes in the Anvil Creek-Dexter Creek area (39) are in schist and, less commonly, in limestone. They consist of iron-stained quartz-feldspar-calcite veins up to 7 feet thick containing stibnite, pyrite, arsenopyrite, galena, gold, and possibly chalcopyrite and molybdenite. Stibnite lenses as thick as 5 feet have been reported, and assays, probably of selected material, showed as much as $72 a ton in gold, $28 in silver, and some copper. Records show that several tons of antimony ore was mined about 1900 from one of the veins, and it is likely that small amounts of antimony and gold ore were shipped from other properties. About 1,500 pounds of stibnite reportedly was also mined on the Peterson and Lamoreaux property (38), but the ore was never shipped. Almost all the veins exposed in the Anvil-Dexter Creeks area were prospected at one time by opencuts, tunnels, and shafts, but few of these workings are still accessible.

About 14 tons of float ore was shipped from the Breen property (29), where gold- and stibnite-bearing quartz-calcite veins cut schist and limestone. The ore carried about 10 percent antimony, but the seller was penalized for the antimony and was paid only for the gold. Other stibnite and gold-bearing veins were explored on the McDuffee (29) and Bonita Creek (35) claims.

Veins prospected primarily for gold are on the Steiner (26) and Boulder Creek (36) properties, and on the following properties at locality 37: Albion Creek, Gold Hill, New Era, Nugent, Reinisch, Snow Gulch, and West. The veins on the Reinisch property probably also carry some scheelite.

Quartz and quartz-feldspar veins in schist were prospected for silver and gold on Last Chance Creek (28), where a 5-foot vein was reported to contain argentiferous galena, pyrite, stibnite, and gold. Quartz-feldspar veins carrying galena are also known on Grouse Creek (29); on Prospect Creek (37), where bismuth is also reported; on Rock Creek (37), where arsenopyrite and stibnite accompany the galena; and at the Jorgensen prospect (37), where the galena is associated with pyrite, arsenopyrite, scheelite, and gold.

Copper-bearing quartz veins, some of which carry gold, have been explored near the head of the North Fork of Last Chance Creek (28), on the ridge at the head of Manila Creek (29), and on Twin Mountain Creek (36), Glacier Creek (37), Dexter Creek (39), and Osborn Creek (40). At Copper Mountain (20), bornite, chalcopyrite, copper carbonates, and galena occur in quartz-calcite veins up to 8 inches thick and as sparsely disseminated grains in partly silicified limestone. Assays of samples from the veins reportedly showed 15 percent copper, 20 percent lead, and high silver and low gold content.

Quartz veins containing a little bismuthinite crop out in the channel of Charley Creek (31), about 25 miles north of Nome. They are up to 10 inches thick, strike westward, dip moderately to the north, and are separated by a foot or more of schist. The bismuthinite forms minute veinlets in the quartz, but the mineralized material probably contains less than 2 percent sulfide. Opencuts on both sides of the creek exposed the veins for a length of about 50 feet and a depth of 10 feet, but they could not be traced beyond the creek bottom because of the moss and talus cover on the valley sides.

Scheelite has been reported in an adit driven on a thick quartz vein on the north fork of Rocky Mountain Creek (33), but none was found by a U.S. Geological Survey investigator (Coats, 1944b, p. 4). Scheelite was found, however, in a northeastward-striking westward-dipping quartz-feldspar vein not far from the reported locality. This vein, traceable for about 18 feet, ranges in thickness from 1½ to 2 inches and contains about 3 percent scheelite by volume. Float containing quartz and scheelite is sparsely distributed south of Rocky Mountain Creek at least as far as Nelson Creek, a fact that suggests that there may be other tungsten-bearing lodes in the area.

Several deposits prospected for iron are in the Sinuk River-Cripple Creek area (24, 25) about 25 miles northwest of Nome. They were discovered early in the 1900's, and although the most promising have been explored by opencuts, shallow shafts, and short drifts, no ore has been shipped. The lodes are in brecciated limestone and consist of veins and stockworks of botryoidal limonite and goethite and small amounts of hematite, galena, sphalerite, pyrolusite, and gold. According to Mertie (1918a, p. 444), the deposits are

> a residual concentration, a superficial enrichment of an underlying lode. The iron content of this lode at depth cannot be judged from the surface indications; in fact, it is entirely possible that this deposit is only a surface capping, or "iron hat," covering some other metalliferous deposit.

The limonite veins range in thickness from a few inches to about 30 feet. The veins evidently are vertical, but neither their lateral nor vertical extent is known. Samples of iron-rich material from the Monarch claim (24), the most promising of the known lodes, contained 54.81 percent iron, 1.06 percent manganese, 0.057 percent phosphorus, and a trace of sulfur (Eakin, 1915, p. 363). Eakin (1915, p. 364) estimated that the residual high-grade material on the Monarch property aggregates at least several hundred thousand tons. This material, which seems to cover a 600- by 800-foot area to an average depth of several feet, reportedly has been penetrated in some places by shafts to a depth of 12 feet. Shallit (in Mulligan and Hess, 1965, p. 2, 18) estimated that the surface concentrations in all the Sinuk deposits aggregate more than 600,000 tons of rock containing 10–45 percent iron and about 0.005 percent manganese.

The American, Mogul, Tub Mountain (24), and Cub Bear (25) deposits are similar to the Monarch lode but are smaller, probably leaner, and less extensively explored.

The lode on the Galena property (25) is similar to the one on the Monarch claim, but in addition to iron it contains lead and zinc, in the form of galena and sphalerite. The galena occurs with quartz along a vertical joint in limestone; assays of this material reportedly showed considerable gold. The sphalerite, together with a little pyrite, is disseminated in the limestone. Fluorite was found near the sphalerite occurrence.

OTHER DEPOSITS

In addition to the deposits already described, there are many lodes in the Nome area about which little is known other than the principal commodity for which they were prospected. They are probably similar to the better known lodes, however, and include deposits prospected for antimony (29, 30, 33, 38), copper (29, 20, 33, 34, 36), gold (34, 35, 36), lead (20,38), tungsten (20, 33, 36), and zinc (33).

SOLOMON AREA

The best known lode in the Solomon area, and the most productive gold mine in the Nome district, was the Big Hurrah mine (42), which was discovered in 1900 and yielded at least 10,000 fine ounces of gold in the ensuing 40 years. Attempts to resume operation since World War II, however, have met with little success.

The Big Hurrah deposit is in brittle black siliceous slate and consists of three principal northwestward-striking southwestward-dipping quartz fissure veins 4–8 feet thick and several hundred feet long. The veins are mainly vitreous white quartz carrying sparsely disseminated minute particles of gold and small amounts of pyrite and scheelite. In some of the higher grade ore, the gold formed masses an inch or more in maximum dimension, but most is said to have averaged less than $20 per ton in gold.

A little scheelite is irregularly distributed in a vein exposed in an adit of the Big Hurrah mine, and pieces of gold ore remaining in the bins of the mill in 1943 contained as much as 10 percent scheelite. The average scheelite content of the material in the bins, however, was only about 0.25 percent. Small amounts of scheelite were also reported in quartz veins at the R. W. Silver mine (42) on Trilby Creek.

Three types of ore were mined at the Big Hurrah: massive quartz veins; ribbon rock, composed of alternate laminae of quartz and slate; and stringer lodes of abundant small irregular quartz veinlets in slate. The ribbon rock reportedly yielded the best returns and constituted most of the ore mined.

The veins have numerous vugs that contain well-terminated quartz crystals, an indication of open-space filling at relatively low temperature and shallow depth. The ribbon rock, however, probably was formed mainly by replacement of slate by quartz at moderate temperature and depth. This probable contrast in origin, coupled with the likelihood that there are quartz veins of several ages (Smith, 1910, p. 89–94), supports the widely held belief that the Solomon area has had a complex history of mineralization.

Considerable prospecting for gold was done in the early 1900's on the Flynn property (42), northeast of the mouth of Big Hurrah Creek. Mineralization on the property consists of arsenopyrite in ribbon rock similar to that at the Big Hurrah mine and of arsenopyrite in chlorite schist like that in the lodes near Bluff in the Council district (p. 113). The deposit was explored by numerous shafts and trenches, but little ore was produced.

Many other quartz veins were prospected for gold in the area near the Big Hurrah mine, but none was significantly productive. Most are similar to the veins at the Big Hurrah mine and contain sparse sulfides, but a few carry relatively abundant pyrite, arsenopyrite, chalcopyrite, and pyrrhotite.

Early prospectors drove several hundred feet of underground workings on a gold lode on West Creek (41), evidently with indifferent success. The lode, in weathered chlorite schist, consists of white quartz veins containing small stringers and vugs of pyrite and possibly marcasite, chalcopyrite, and stibnite. Their tenor is unknown, but the wallrocks were reported to carry $8–$10 a ton in gold.

Two lodes in the Solomon area were prospected mainly for antimony. One, in black slate on the Quigley (Gray Eagle) property (42), on the north side of Big Hurrah Creek about a mile from the Solomon River, reportedly consists of a 4-foot quartz vein containing a lens of nearly pure stibnite as much as 18 inches thick. Smaller concentrations of stibnite are said to occur throughout the rest of the northeastward-striking northwestward-dipping vein, which was explored by a shaft and several trenches, and from which 4 tons of ore was shipped in 1914.

The other lode, reportedly on Big Hurrah Creek about a mile below the Quigley prospect, is a stibnite lens similar to the one on the Quigley property. It is smaller, however, and seems to have attracted little attention.

Additional information on this district is given in the following references: Anderson (1947); Brooks (1916); Cathcart (1922); Coats (1944a, 1944b); Collier, Hess, Smith, and Brooks (1908); Eakin (1915); Hummel (1961, 1962a, 1962b); Mertie (1918c, 1918d); Moffit (1913); Mulligan and Hess (1965); Smith, P. S. (1908, 1910); White, West, Tolbert, Nelson, and Houston (1952).

PORT CLARENCE DISTRICT

The Port Clarence district (fig. 23) includes the area drained by streams flowing into the Arctic Ocean and the Bering Sea between Shishmaref Inlet and Cape Douglas and, with the exception of the Kuzitrin River, by streams flowing into Imuruk Basin.

The district is known principally for its beryllium, tin, and tungsten lodes. The deposits also contain a variety of other metals including copper, lead, silver, antimony, zinc, bismuth, mercury, molybdenum, and gold, but with few exceptions they are subordinate in importance to the three principal commodities.

BERYLLIUM

Almost all of Alaska's beryllium lodes are in Paleozoic limestone intruded by granitic stocks and dikes in the Lost River area (3, 4, see fig. 23) of western Seward Peninsula. They are in an area about 7 miles long and 2–3 miles wide, within which are four distinct mineralized zones, each about 4,000 feet long and 1,000 feet wide. According to Sainsbury (1963, p. 3):

> Except for minor amounts of beryllium in tactite (skarn) near granite contacts, the beryllium deposits are replacement lodes in limestone and consist of veins, pipes, and irregular stringer lodes. Veins range from a few hundred to 2,000 feet in length and from less than 2 to 12 feet in thickness. Some stringer lodes cover areas of several thousand square feet. In any one [mineralized zone], veins, pipes, and stringer lodes generally occur together.

The lodes consist mainly of fluorite, diaspore, chrysoberyl, mica, and tourmaline, and minor amounts of other beryllium minerals, hematite, sulfides, and manganese minerals. The beryllium content of bulk samples ranges from 0.11 to 0.50 percent beryllium; high-grade nodules contain as much as 2.6 percent beryllium.

The largest of the four beryllium-bearing zones is near the Lost River mine (4), where a discontinuous vein or stringer lode has been traced for 5,000 feet. The lode is mostly in fractured limestone, but in the immediate area of the Lost River mine small beryllium-

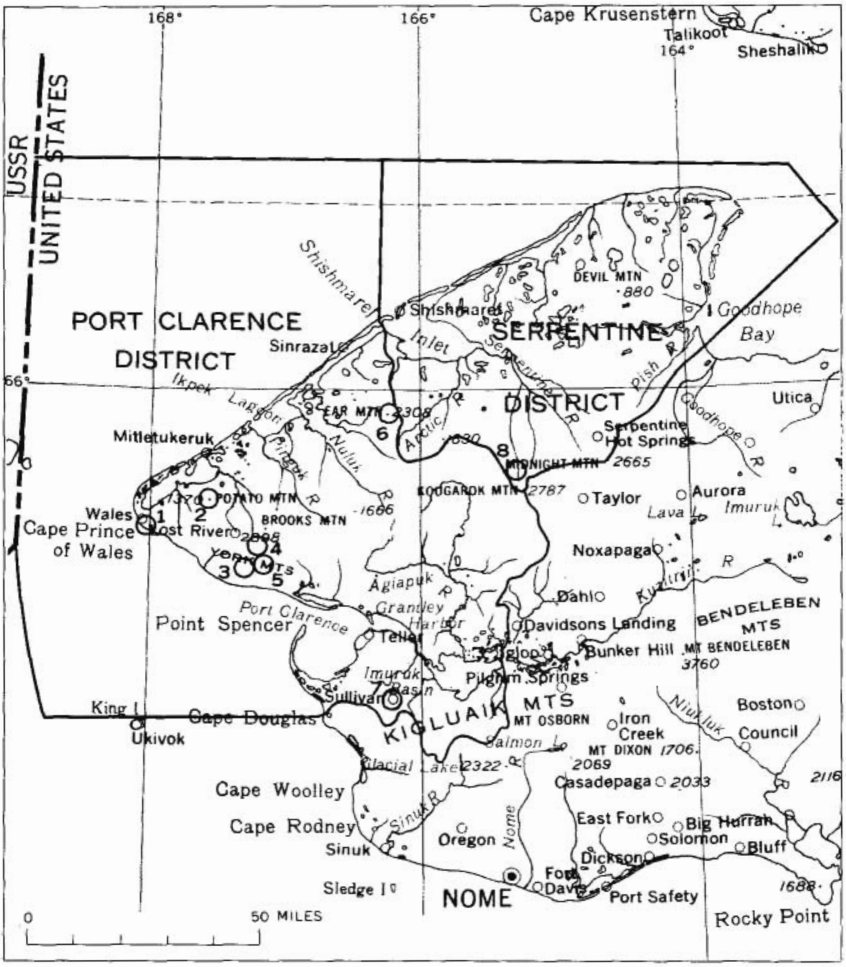

FIGURE 23.—Metalliferous lode deposits in the Port Clarence and Serpentine districts.

LOCALITIES

Port Clarence district

1. Cape Mountain
2. Potato Mountain

Lost River area

3. Alaska Chief
   Bessie-Maple
   Rapid River
   Wolframite-topaz
4. Idaho
   Lost River (mine)

Lost River area—Continued

(4.) Lost River (valley)
   Tin Creek
   Yankee Girl

5. Brooks Mountain
6. Ear Mountain
7. Alder Creek

Serpentine district

8. Ward

bearing veins occur in places along the contact of the Cassiterite dike, a tabular intrusive otherwise noted for its tin and tungsten deposits. (See discussion "Tin and tungsten.")

The second largest beryllium lode (4), about 1½ miles south of the Lost River mine, consists of a group of en echelon replacement veins that forms an eastward-trending belt about 1,000 feet wide and 4,200 feet long. The veins, which are mainly fluorite-diaspore-chrysoberyl rock, are mostly in fractures in limestone, but locally they lie along the walls of mafic dikes.

The third most important mineralized zone is near Rapid River (3), where the beryllium minerals occur in veins, pipes, and stringers in brecciated and dolomitized argillaceous limestone. The deposits, in an area about 4,400 feet long and 1,000 feet wide, consist of fluorite- and chrysoberyl-bearing rock similar to that in the Lost River valley lodes, but tourmaline is more common in the Rapid River lodes than elsewhere. Many quartz diabase and rhyolite porphyry dikes, some of which predate the beryllium lodes, crop out about 1,300 feet south of the zone, but only sparse beryllium minerals have been found near these dikes.

The fourth mineralized area is near Tin Creek (4), about 1¾ miles southeast of the Lost River mine. At Tin Creek, two types of deposits are associated with a small granite plug that intrudes limestone. The more promising type consists of replacement veins of fluorite, diaspore, chrysoberyl, and mica in or near radial fractures in limestone south of the granite. Many of the veins are at the margins of felsic porphyry dikes in some of the radial fractures. The other type consists of beryllium-bearing and base-metal-bearing tactite along the granite-limestone contact. The tactite deposits, however, contain relatively little beryllium. The Tin Creek lodes locally contain more manganese and sulfide minerals than the beryllium deposits elsewhere in the Lost River area, and weathering of the sulfides has produced porous "oxidized ore" heavily stained with limonite.

Sainsbury (1963, p. 11, 13) noted that in general, the Lost River beryllium deposits do not coincide with the area's tin, tungsten, and other base-metal deposits. At Tin Creek, for example, the fluorite-chrysoberyl veins lie well away from the granite, beyond the tactite and tin deposits. The separation of deposits carrying significant amounts of beryllium from those important for tin and tungsten is also conspicuous near the Lost River mine.

Recent computations by C. L. Sainsbury (in Berg and others, 1964, p. 97) indicated that beryllium resources in the Lost River area amount to about 1,960,000 short tons of indicated and inferred material containing 0.18–0.20 percent beryllium and 50 percent fluorite. In addition, substantial amounts of material that contains 0.04–0.07 percent beryllium are probably also present. These beryllium resources are a substantial part of those of the entire United States, but to date no beryllium ore has been produced from the Lost River deposits.

Geochemical reconnaissance indicates that additional beryllium lodes may be found elsewhere on western Seward Peninsula, particularly at Brooks Mountain (5), Ear Mountain (6), and Cape Mountain (1), and possibly at other places where granite plutons cut calcareous rocks.

TIN AND TUNGSTEN

Lodes containing tin, tungsten, and a variety of other metals, including a little beryllium (see preceding discussion), occur throughout much of the western part of the Port Clarence district. The largest and richest are in the Lost River mine area (4), where the tin and tungsten minerals occur in hydrothermally altered parts of dikes and other bodies of rhyolite porphyry that cut limestone; quartz, mica, and calcite veinlets that intersect both the porphyry bodies and the adjacent limestone and are traceable for a few hundred feet; the upper part of a concealed granite intrusive found at a depth of several hundred feet below the surface by diamond drilling; and irregular veinlike zones of silicate alteration (tactite) in the limestone. The main metalliferous minerals at the Lost River mine are cassiterite and wolframite; others include stannite, arsenopyrite, pyrite, galena, scheelite, chalcopyrite, marmatite, molybdenite, stibnite, and bismuthinite. The chief nonmetallic gangue minerals are fluorite, quartz, topaz, tourmaline, mica, and calc-silicate and clay minerals.

Virtually all the lode tin produced in Alaska came from the Lost River mine, which operated intermittently from 1904 through 1955, and yielded ore containing about 350 short tons of tin. Most of the workings are along the Cassiterite dike, a highly altered rhyolite porphyry pluton about 12 feet thick that strikes eastward, dips steeply southward, and can be traced on the surface for about 8,000 feet. The main ore shoot in the dike rakes eastward at an angle of about 30°. Assays show that the tin content is uniform from footwall to hanging wall but that tungsten is more abundant near the hanging wall.

Sainsbury (1964, p. 50; in Berg and others, 1964, p. 119–120) estimated that the lode tin resources in the Lost River mine area consist of 2,600 short tons of tin in measured and indicated material containing 1.3 percent tin; 15,450 short tons of tin in inferred material averaging about 1.0 percent tin; and 18,700 short tons of tin in inferred material containing 0.2–0.75 percent tin. He also estimated that the lode tungsten resources amount to 63,350 units (one unit equals 20 lb of WO_3 to a short ton) of WO_3 (tungstic oxide) in measured plus indicated material averaging 0.60 percent WO_3 and 130,000 units in inferred material carrying 0.2 percent WO_3. There is no recorded production of tungsten ore from the Lost River lodes.

Tin and tungsten minerals have been found at other places near the Lost River mine, but available data indicate that the deposits are small and low grade. On upper Tin Creek (4) lodes in limestone near a granite contact contain galena, cerussite, arsenopyrite, chalcopyrite, and cassiterite; the margin of the granite contains pyrite and cassiterite. Near the mouth of Tin Creek (4), limestone country rock contains fluorite associated with lepidolite veinlets carrying arsenopyrite, cassiterite, and sphalerite. At the long-abandoned Idaho claim (4), south of the mouth of Tin Creek, fluorite, pyrrhotite, and chalcopyrite occur in an eastward-striking breccia zone in limestone. At the Yankee Girl claim (4), about a mile southeast of the Lost River mine, a gossan in limestone contains cerussite, cassiterite, arsenopyrite, chalcopyrite, fluorite, and calcite. The deposit was explored by a short tunnel early in the present century, and although a little lead ore was piled near the workings, there is no record that any was shipped.

The Bessie-Maple lode (3), explored prior to 1918 by trenches, pits, and tunnels, consists of a zone at least 1,500 feet long of kaolinized dikes and brecciated limestone containing veinlets and disseminated grains of galena, pyrite, stannite, chalcopyrite, wolframite, stibnite, and sphalerite. The principal gangue minerals are fluorite, topaz, mica, calcite, and limonite. Samples from the lode assayed a trace to 0.03 ounce of gold and 4.2–25.6 ounces of silver per ton, 0.5–9.1 percent lead, 0.48–1.53 percent copper, about 3 percent zinc, 0.30–1.6 percent tin, up to 3.2 percent WO_3, and 3.8 percent antimony. Although the assays show that parts of the lode contain substantial amounts of metal, the continuity of the deposit has not been established, and no workable ore has yet been found.

The Wolframite-topaz lode (3) is probably an eastward-striking mineralized fault (breccia) zone in limestone. Surficial workings on the zone early in the 1900's exposed a foot-thick stringer lode of wolframite, galena, stannite, topaz, and fluorite veinlets, an assay of which showed 22.9 ounces of silver per ton.

Tin lodes in the Cape Mountain area (1) are near the contacts of limestone with a granite stock and related dikes and include the following types: limestone partly replaced along granite contacts by quartz, tourmaline, cassiterite, calcite, and, locally, pyrite; granite partly replaced by cassiterite and quartz along faults and near limestone contacts; and quartz-cassiterite and quartz-mica-cassiterite veins, locally with tourmalinized margins, cutting either limestone or granite.

The Cape Mountain lodes were discovered in 1903 and explored until 1909, after which little work was done. Workings, mostly at the Bartell mine, the area's principal occurrence, included numerous opencuts and various underground openings totaling several hundred feet in length. The only recorded production from the Cape Mountain lodes was about 10 short tons of concentrates that contained 64 percent tin and reportedly was shipped in 1905. In 1943 and 1944, a program of trenching and channel sampling of the Cape Mountain deposits by the U.S. Bureau of Mines indicated four small bodies of potentially minable ore. The samples contained as much as 32.9 percent tin and traces of tungsten, but the most promising deposit averaged only about 7.24 percent tin.

Tin deposits on Brooks Mountain (5) are in limestone cut by granite and pegmatite. Both the limestone and the granite are hydrothermally altered, particularly along their contact on the southwestern flank of the mountain, but most of the lodes are confined to the limestone near the contact. The tin minerals consist of cassiterite, hulsite, and paigeite, which are intergrown chiefly with galena, pyrrhotite, and sphalerite. The gangue consists of fluorite, axinite, tourmaline, calcite, idocrase, diopside, and phlogopite. Metalliferous minerals present in small amounts are scheelite, arsenopyrite, pyrite, magnetite, hematite, chalcopyrite, chalcocite, bornite, ludwigite, tetrahedrite, bismuth, azurite, malachite, siderite, cerussite, and zeunerite. According to Sainsbury (1964, p. 10):

> Most of the deposits are along distinct fissures or veins in the limestone, though a very little cassiterite, and a little zeunerite, a secondary uranium mineral, were found in marginal parts of the granite.

The Brooks Mountain deposits were explored by shallow trenches and short shafts and adits, mostly before 1918. Early assays reportedly showed as much as 34 percent lead and 11 ounces of silver per ton, but there was no recorded production. In 1951, the U.S. Geological Survey trenched and sampled the deposits to determine their uranium (zeunerite) content. A few specimens contained as much as 2.1 percent equivalent uranium, but the main zeunerite-bearing deposit—a lens-shaped concentration in granite about 15 feet in diameter and 4–5 feet thick—averaged about 0.15 percent, and the main deposit combined with the surrounding zeunerite-bearing granite only about 0.07 percent.

Lode tin also occurs at Ear Mountain (6), where a granite stock and felsic to mafic dikes and sills cut limestone and slate. The limestone near the intrusive contacts is converted to marble containing abundant calcite, quartz, and calc-silicate minerals, subordinate tourmaline, fluorite, axinite, topaz, scapolite, paigeite, cassiterite, chalcopyrite, pyrite, pyrrhotite, and arsenopyrite, and sparse to rare stannite, chalcocite, galena, sphalerite, stibnite, scheelite, magnetite, gold, cinnabar, malachite, and cerussite. The tin lodes consist chiefly of scattered minute grains and veinlets of cassiterite and paigeite in the contact-metamorphosed limestone, and, less commonly, in some of the dikes. The intrusive rocks near the contacts contain a little tourmaline, some of which is replaced by chalcopyrite.

Early prospectors explored the Ear Mountain lodes first for gold and then for tin and other metals, and by 1915 had dug a few shallow shafts, several hundred feet of drifts and tunnels, and a number of trenches. Although assays showed as much as 18.7 percent tin, 4 percent copper, 1.04 percent zinc, and traces of gold and silver, the prospectors did not find ore and abandoned the ground. In 1953 and 1954, the U.S. Bureau of Mines (Mulligan, 1959) undertook to determine the extent and grade of the tin mineralization at Ear Mountain by trenching and channel sampling the lode and placer deposits. The best lode material was found in and near the Winfield shaft on the northeast side of Ear Mountain, where limestone adjacent to granite is sparsely metallized in a zone about 1,000 feet long and 65 feet wide. Small parts of the zone contain as much as 2 percent tin and 3 percent copper, but its average metal content is 0.2 percent tin, 0.3 percent copper, and negligible amounts of zinc, gold, silver, tungsten, and lead. Analyses of a mafic dike exposed in the Winfield shaft showed 0.2 percent tin, a little zinc, gold, and silver, and a trace of copper.

Tin lodes near Potato Mountain (2) are in tourmaline-bearing slate and schist cut by granite porphyry dikes and consist of numerous irregular quartz veinlets containing cassiterite, tourmaline, pyrite, arsenopyrite, and clay minerals. The most common type of lode is a cluster or stockwork of cassiterite-bearing quartz veinlets in the metamorphic rocks near faults or joints filled with clay or crushed country rock. Many of the smaller clay-filled fractures also contain quartz and cassiterite, but none of the larger faults carries more than traces of tin. A little cassiterite is also sparsely disseminated in the tourmalinized slate and schist. The richest lodes contain 1–10 percent tin, but they are separated by relatively barren zones of veins that probably average no more than 0.25 percent tin. The largest deposit known is on Little Potato Mountain, where a stockwork carrying about 1 percent tin is exposed for a length of 300 feet and a width of 10–30 feet. The Potato Mountain lodes were discovered about 1900 and explored until about 1920, but although trenches and pits were dug in almost every exposure of quartz, no tin ore was shipped. The main workings, now mostly caved or filled with ice, consisted of two shafts and an adit on three of the deposits, but with the exception of about a half-ton of cassiterite-bearing quartz heaped near one of the shafts, the prospect dumps contain only traces of tin. In 1961, the U.S. Bureau of Mines sampled the Potato Mountain lodes by trenching and diamond drilling; much of the foregoing description has been summarized from their report of this investigation (Mulligan, 1965b).

OTHER METALS

The Alaska Chief lode (3), prospected mainly for lead, consists of galena-bearing gossan in faulted and brecciated limestone cut by a quartz porphyry dike(?). The deposit was explored prior to 1918 by a shaft and two tunnels, one of which was 600 feet long, but there is no evidence that any ore was shipped.

A 16-foot stringer lode in bedrock exposed during placer mining operations on Alder Creek (7) was prospected for gold early in the 1900's. The lode, which has a limestone hanging wall and a schist footwall, is in talcose rock and consists of numerous quartz veinlets containing streaks of pyrite. Fine gold reportedly was panned from the pyritic quartz, a sample of which assayed 0.06 ounce of gold and a trace of silver per ton. The lode was prospected to a depth of 60 feet, but no ore was shipped.

Additional information on this district is given in the following references: Berg, Eberlein, and MacKevett, Jr. (1964); Brooks (1916); Collier, Hess, Smith, and Brooks (1908); Heide, Wright, and Sanford (1946); Knopf (1908a, b); Lorain, Wells, Mihelich, Mulligan, Thorne, and Herdlick (1958); Mulligan (1959, 1965b); Sainsbury (1963, 1964); Steidtmann and Cathcart (1922); West and White (1952).

SERPENTINE DISTRICT

The Serpentine district (fig. 23) includes the area drained by streams flowing into the Arctic Ocean and Kotzebue Sound from and including the Pish River to Shishmaref Inlet.

The only lode known in the district is at the Ward mine (8, see fig. 23) near the head of the Serpentine River. It consists of quartz, malachite, azurite, and a little chalcopyrite that form one or more veins—or possibly a stringer lode—in limestone near the contact with mica schist. A northwestward-dipping ore body, reportedly 6–21 inches thick, was worked by several opencuts and shallow shafts, and about 40 tons of ore averaging 35 percent copper was shipped from 1906 to 1918.

Additional information on this district is given in the following references: Mertie (1918c); Wright, W. S. (1947).

SOUTHEASTERN ALASKA REGION

The southeastern Alaska region (pl. 1; figs. 24–28) includes all of Alaska east of the southern extension of the Alaska-Yukon boundary, that is, east of the 141st meridian. The region is divided into the Admiralty, Chichagof, Hyder, Juneau, Ketchikan, Kupreanof, Petersburg, and Yakutat districts.

Southeastern Alaska (pl. 1) is a mountainous area composed principally of closely spaced islands and a narrow mainland strip having numerous prominent peninsulas. The mountains vary from rugged glacier-mantled peaks and ridges 8,000–10,000 feet or more in altitude to rolling uplands, generally with rounded summits except for a few spirelike peaks as much as 3,800 feet high. The region is also marked locally by a narrow coastal lowland, by large braided rivers that cross the mainland mountains, and by numerous linear depressions (lineaments) the most prominent of which is Lynn Canal-Chatham Strait—a deep straight trench 4–15 miles wide and at least 200 miles long.

The outcrop pattern of southeastern Alaska (pl. 1) is dominated by two northwest-trending belts of generally northwest-striking Mesozoic sedimentary and volcanic rocks—one adjacent to the Coast Range batholith and the other along the seaward side of the region. The two belts are separated by a band of Paleozoic bedded rocks that widens both northwestward and southeastward from a constriction at the latitude of southern Admiralty Island.

Intermediate to mafic lava flows and tuff of Tertiary and Quaternary age are exposed on Admiralty, Kruzof, Kuiu, and Revillagigedo Islands. The flows on Kruzof Island were derived from a volcano that may have been active in historic time. Sedimentary rocks of Tertiary age that locally are petroliferous and coal bearing crop out near Yakutat and on Admiralty Island, respectively.

About a third of the region is underlain by plutonic rocks varying in composition from ultramafic to felsic and ranging in age from early Paleozoic to Tertiary. The largest pluton is the Coast Range batholith, a composite, structurally complex mass exposed along the Alaska–British Columbia boundary for the length of southeastern Alaska. Smaller batholiths, stocks, dikes, and sills, many of which are probably satellitic to the Coast Range batholith, occur throughout southeastern Alaska.

All the pre-Quaternary bedded rocks of the region are marked to some degree by folds and faults and, in areas of plutonism, by regional and contact metamorphism. Locally, the Paleozoic and Mesozoic strata reflect a structural history complicated by several episodes of folding, intrusion, and metamorphism. Among the myriad faults that cut the rocks of southeastern Alaska, the most notable are persistent northward- and northwestward-trending high-angle fractures. Along most of these major faults the displacement was right lateral, possibly on the order of several miles. Recent estimates of the right-lateral separation on the prominent fault along Chatham Strait and Lynn Canal range from 50 to 150 miles.

Extensive Pleistocene alpine glaciation has greatly modified the surface of southeastern Alaska. Valleys and interisland waterways have been scoured and deepened, and most preglacial placer deposits have been destroyed. Remnants of Pleistocene glaciers still cover large areas in the higher mountains and glacial deposits mantle the bedrock in many lower areas. Thick spruce-hemlock forest and heavy growths of underbrush cover the lowlands and most of the lower slopes.

Most of the region's metalliferous lodes are in metamorphic rocks adjacent to the Coast Range batholith and satellitic plutons; a few are confined entirely to the plutons. Gold, silver, copper, lead, zinc, palladium, tungsten, and uranium have been mined commercially in southeastern Alaska. Exploratory work, some of it rather extensive, has been carried on at prospects potentially valuable for nickel, chromium, iron, molybdenum, antimony, cobalt, and rare-earth elements.

ADMIRALTY DISTRICT

The Admiralty district (fig. 24) comprises Admiralty Island and smaller adjacent islands.

Only gold has been produced from lodes in the Admiralty district. A copper-nickel deposit has been extensively explored, however, and additional occurrences of copper, gold, chromium, nickel, lead, zinc, and rare-earth elements have been found.

The most thoroughly explored lodes in the district are in the Funter Bay-Hawk Inlet area on northern Admiralty Island, where metamorphosed sedimentary and volcanic rocks are cut by quartz diorite stocks, dikes of varied composition, and at least one gabbro pipe. Before 1900 gold lodes were discovered on what is now the property of the Admiralty-Alaska Gold Mining Co. (2, see fig. 24), on the adjoining Alaska Dano (Nowell-Otterson) (2) claims at Funter Bay, and at Hawk Inlet (3). The three lodes produced small amounts of gold for many years, and their combined production probably totaled 10,000–15,000 ounces. The gold is a constituent of quartz veins in the metamorphic rocks and is accompanied by small amounts of specular hematite, sphalerite, galena, and chalcopyrite.

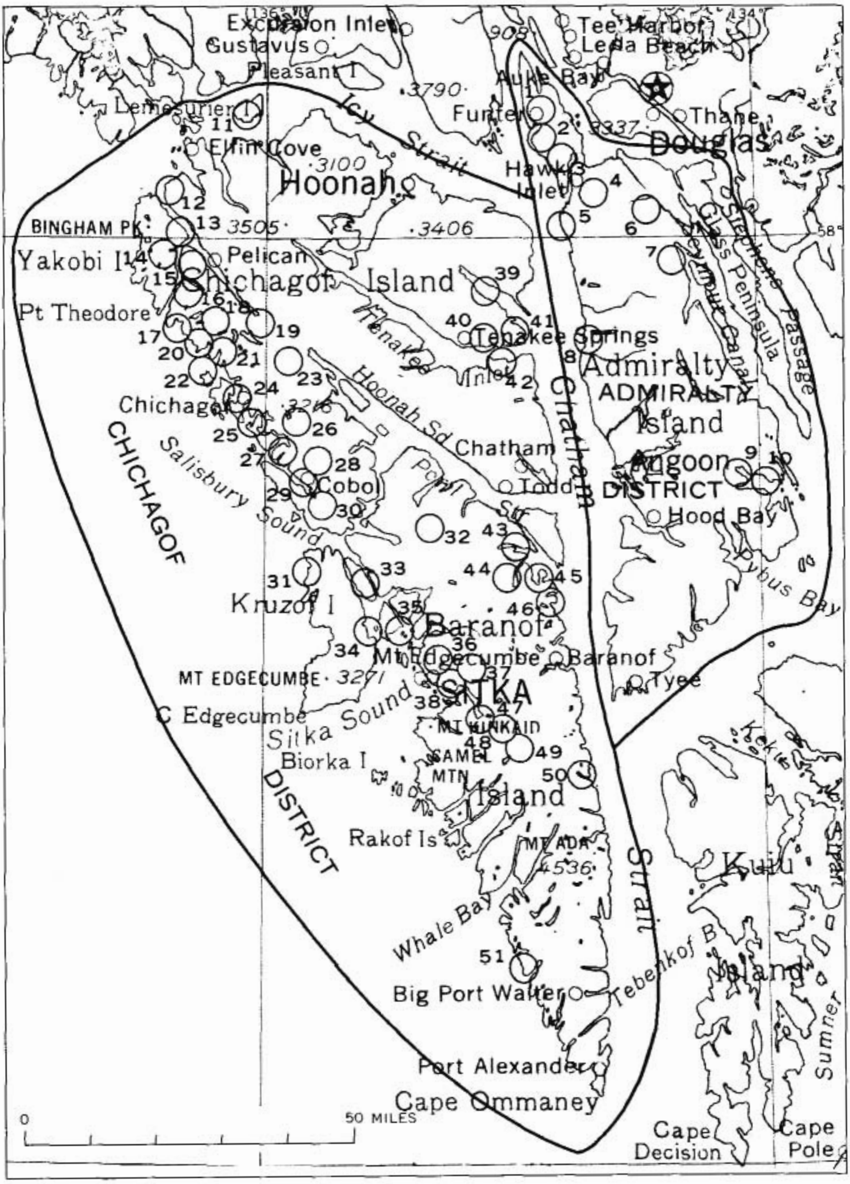

FIGURE 24.—Metalliferous lode deposits in the Admiralty and Chichagof districts. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 24

Admiralty district

1. *Portage
2. *Admiralty-Alaska
   *Alaska-Dano (Nowell-Otterson)
   *Mansfield
3. *Hawk Inlet
4. *Mammoth
5. *Unnamed
6. *Unnamed
7. *Seymour Canal
8. *President
9. *Gambier Bay
10. *Kloss

Chichagof district

11. *Whitney
    *Willoughby Cove
12. *Marvitz
13. *Yakobi Island
14. *Bohemia Basin

Apex-El Nido area

15. *Apex-El Nido
    Cann Creek
    *Goldwin
    Wakefield
    Unnamed

Stag Bay area

16. Cub Mountain
    Etna
    *Stag Bay

17. *Bertha Bay

Baker Peak-Pinta Bay area

18. Baker Peak
    *Cobol (mine)
    Lake Elfendahl
    Mine Mountain
    South Side

19. *Koby
20. *Little Bay
    *Mirror Harbor
    *Princess Pinder
    *Snow Slide
21. *Golden Hand
    *New Chichagof

*See footnote at end of list.

Chichagof district—Continued

22. *Congress
23. *Unnamed

Klag Bay-Kimshan Cove area

24. *Alaska-Chichagof
    American Gold Co.
    Bauer & Soni
    Chichagof Extension
    *Chichagoff
    Chichagof Prosperity
    Flora
    Gloria B.
    Handy-Andy
    Hanlon
    Hill & Berkland
    *Hirst-Chichagof
    Lillian & Princella
    Marinovich
    McKallick
    Radio
    Smith
    Submarine
    Tillson
25. Anderson
    Baney
    Elbow Passage
    Lake Anna
    Lucky Shot

26. *Unnamed
27. *Falcon Arm
28. *Unnamed
29. *Cobol (prospect)
30. *Unnamed
31. *Sea Lion Cove
32. *Rodman Bay
33. *Neva Strait
34. *Magoun Island
35. *Siginaka Island

Sitka area

36. *Unnamed
37. *Blue Lake
38. Billy Basin
    *Blue Lake
    Boston
    Cascade
    *Haley & Hanlon

Continued on following page.

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LOCALITIES SHOWN ON FIGURE 24—continued

Chchagof district—Continued
39. *Pavlof Harbor
    *Redcliff Islands
40. *Three J
    *Unnamed
41. *Big Ledge
42. *Trap Bay

Kelp Bay area
43. *Middle Arm
    *Portage Arm
44. *South Arm

Kelp Bay area—Continued
45. *Kelp Bay
46. *Graystone Cliff

Silver Bay area
47. Liberty
    *Silver Bay
48. Silver Bay

49. *Hill
50. *Red Bluff Bay
51. *Snipe Bay

*Cited individually in the text.

A nickel- and copper-bearing gabbro pipe, called the Mertie lode, is also on the Admiralty-Alaska property. It has been explored extensively, both under a Defense Minerals Exploration Administration contract and with the owner's funds. The metal content of the pipe varies; in some parts sulfides form 1 percent or less and in others a mixture of pyrrhotite, pentlandite, chalcopyrite, and pyrite makes up nearly a third of the rock. A typical specimen of sulfide-rich gabbro contained 1.36 percent nickel and 0.85 percent copper, whereas analyses of material used by the U.S. Bureau of Mines for beneficiation tests during World War II showed 0.26 percent nickel, 0.30 percent copper, and 0.07 percent cobalt. There has been no commercial production from the Mertie lode.

At the Portage claims (1) an irregular quartz vein carries considerable pyrite and chalcopyrite and small amounts of galena, but assays are said to have been too low to encourage much development work.

In the early 1900's the Mansfield Gold Mining Co. (2) explored a copper deposit composed of small quartz veins containing chalcopyrite, pyrrhotite, galena, and sphalerite, just east of the head of Funter Bay. There is no evidence that any ore was shipped.

The Mammoth prospect (4) consists of pyritic schist cut by narrow seams of galena, sphalerite, and a little free gold. Apparently no work has been done at the prospect since 1910. Similar deposits were prospected at about the same time on the west shore of Seymour Canal (7), and at the President claims (8) on the west coast of Admiralty Island.

A random sample collected by the U.S. Geological Survey from a serpentinized ultramafic sill (5) about 4 miles south of the entrance to Hawk Inlet contained traces of chromium and nickel in disseminated sulfide and oxide minerals. Two samples collected from pegmatite (6) about 3 miles west of the head of Seymour Canal contained trace amounts of zirconium and cerium and several other rare-earth elements.

Copper-gold and copper-nickel lodes occur in complexly folded and faulted sedimentary, volcanic, and metamorphic rocks near Gambier Bay. A copper-gold prospect staked near the head of the bay (9) before 1906 is said to consist of stringers and small masses of quartz, pyrite, and chalcopyrite from which samples containing a little gold have been collected. Gold and copper have also been reported at a probably similar deposit nearby. A trench dug across a shear zone 150–200 feet wide on the Kloss prospect (10) reportedly disclosed small amounts of copper and nickel oxides. A nearby parallel zone is said to carry copper minerals.

Additional information on this district is given in the following references: Barker (1963a); Buddington (1926); Herbert and Race (1964); Holt and Moss (1946); Lathram, Pomeroy, Berg, and Loney (1965); Mertie (1921); Reed (1942); Wright (1906, 1907).

CHICHAGOF DISTRICT

The Chichagof district—formerly the Sitka mining district—(fig. 24) comprises Chichagof, Baranof, Kruzof, Lemesurier, Catherine, and Inian Islands and smaller islands nearby.

Almost a million ounces of gold and some silver were recovered from lodes in the Chichagof district, mostly from two mines on southwestern Chicagof Island. There has been no production of other metallic mineral commodities although several nickel-copper and chromite deposits have been investigated, and occurrences of molybdenum, iron, tungsten, lead, and zinc minerals are also known.

The mines on southwestern Chichagof Island were second only to mines near Juneau in total lode-gold production in Alaska. From the time the lodes were discovered in 1905 until mining was ordered suspended during World War II, more than three-quarters of a million ounces of gold and a small amount of silver were recovered, mostly from the Chichagoff mine (24, see fig. 24) near Klag Bay and the Hirst-Chichagof mine (24) at Kimshan Cove. The area is underlain by metamorphosed sedimentary and volcanic rocks cut by felsic to intermediate stocks and dikes. The rocks are also cut by faults that generally are parallel to the layering and foliation of the metamorphic units. The lodes are in the fault zones and consist of quartz veins containing 3 percent or less pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, and gold. Many of the ore bodies occurred near distinct wraps in the fault surfaces or at the intersections of the main faults and large divergent splits. The ore bodies were tabular, plunged steeply, and were commonly a few feet thick and a few hundred feet long. Their plunge length ranged from several hundred to a few thousand feet. Practically all the ore mined came from either the Chichagof fault or the Hirst fault, the two most prominent fault zones in the area. Production records indicate that the ore averaged a little more than an ounce of gold per ton.

The only other productive mine in the area was that of the Alaska Chichagof Mining Co., just south of the Chichagoff property. The company is known to have mined at least 300 tons of ore, from which about $9,000 in gold and silver was recovered. Two or three dozen other prospects in the Klag Bay-Kimshan Cove area (24, 25) were explored to some extent, but none reached the productive stage. A little ore, however, reportedly was mined near Kimshan Cove on claims that were not part of the Hirst-Chichagof property.

At Falcon Arm (27), a crosscut more than 2,200 feet long was driven to explore sulfide-bearing dikes in massive graywacke. Some of the dikes, which are fine grained and probably felsic, contain pyrite, galena, and sphalerite and reportedly carry gold and silver. The graywacke is also cut by many faults, some of which contain thin quartz veins. On the Cobol prospect (29), two tunnels, each over 1,300 feet long, were driven along a quartz vein in a fault zone in graywacke. Metallic minerals, chiefly pyrite, galena, and gold, are sparsely distributed in the quartz vein and in the fault gouge.

Among the numerous gold and base-metal lodes northwest of Chichagof, only the Apex and El Nido deposits (15) were worked extensively. They are on adjoining claims but under the same ownership and are described together. Production through 1939, the last year the mines were operated, was probably between 10,000 and 50,000 ounces of gold and about the same amount of silver; more accurate figures are not available. The lodes are in a large diorite pluton and consist of quartz fissure veins carrying free gold, pyrite, arsenopyrite, chalcopyrite, galena, sphalerite, tetrahedrite, and scheelite.

The Goldwin prospect (15), 3 miles northwest of the Apex-El Nido property, is in the same pluton and consists of quartz veins containing pyrite, chalcopyrite, gold, and silver. Some gold and silver were recovered, but the amount, probably small, was not made public. Other auriferous veins occur nearby in the same pluton (15), in a smaller diorite mass and adjacent metamorphic rocks near Stag Bay (16), and on the divide between Lisianski Inlet and the Pacific Ocean; none was productive.

About a mile south of the entrance to Stag Bay (16), two trenches exposed sheared fine-grained gabbro or diorite locally made up of about equal parts of magnetite and rock containing epidote, quartz, pyrite, and minor chalcopyrite.

At the Cobol mine (18) (not to be confused with the Cobol prospect (29) near Slocum Arm), about $3,500 in gold was recovered in 1933 from a quartz vein that roughly follows a contact between quartz diorite and greenstone. In addition to free gold, the vein contains sparse arsenopyrite, sphalerite, galena, and chalcopyrite. Similar veins were found at several places within a 2-mile radius of the Cobol mine, and claims were staked on a few; however, none was the scene of much exploration.

The Golden Hand and New Chichagof prospects (21) are about 4 miles southeast of the Cobol mine. The Golden Hand was explored by several opencuts and the New Chichagof by two tunnels. At both prospects, metamorphosed bedded rocks are cut by diorite, and quartz was deposited as veins or fault-breccia cement. No metallic minerals other than gold were reported, and there was no recorded production.

At the Koby prospect (19), lenticular quartz veins in a shear zone in greenschist were explored by several pits and trenches and by an adit and crosscut 280 feet in total length. The quartz reportedly contains free gold and about 1 percent sulfides, including arsenopyrite, pyrite, sphalerite, and galena.

Auriferous lodes also occur near the northwestern tip of Chichagof Island, where the Marvitz (12) and other claims were staked on quartz veins about a foot thick and a few tens of feet long. The veins carry free gold, pyrite, and galena.

A quartz vein exposed at sea level on Yakobi Island (13) is probably in a shear zone in a mafic intrusive. A 35-foot tunnel was driven on the vein, and about $1,000 worth of gold is said to have been recovered about 1917.

In 1871 the first attempt at lode-gold mining in Alaska was made on a quartz vein near Sitka (38). The property was soon abandoned, but the next year placer miners discovered another auriferous quartz vein near the head of Silver Bay (47), and by 1880 many other veins had been staked (38, 47, 48), and a mill erected. Some ore is known to have been milled, but there is no record of the amount of gold recovered. Although there were several costly attempts to develop major gold mines in the Sitka area, such as the attempt to mine gold near Rodman Bay (32), none was successful. Most of the prospects were staked on quartz veins that are in shear zones in Mesozoic graywacke and slate and that contain sparse pyrite, pyrrhotite, and arsenopyrite, and rare galena, sphalerite, and native gold.

Copper-nickel deposits have been explored extensively in Bohemia Basin on Yakobi Island and near Mirror Harbor on Chichagof Island. The Bohemia Basin lodes (14) are in a noritic facies of a composite stock that intrudes Mesozoic graywacke and volcanic rocks and gneissose granite. The deposits are magmatic segregations, chiefly of pentlandite, chalcopyrite, and pyrrhotite, that form a troughlike body above the lower contact of the basin-shaped norite intrusive. Estimated resources, based on magnetic exploration (by the U.S. Geological Survey) and a core-drilling program (by the U.S. Bureau of Mines) conducted during World War II, consist of 20,700,000 tons of indicated and inferred material containing an average of 0.33 percent nickel and 0.21 percent copper. About one-third of the material in the two major sulfide bodies is virtually barren; if it could be excluded by selective mining, the grade could be increased to about 0.51 percent nickel and 0.27 percent copper (Kennedy and Walton, 1946a, p. 39).

The Mirror Harbor deposits (20), which are smaller than those in Bohemia Basin, are also in norite that is part of a composite stock cutting Mesozoic bedded rocks. About 5 square miles of the stock are above sea level. The sulfide minerals are intergrown pyrrhotite, pentlandite, and chalcopyrite that generally are disseminated throughout the norite but locally are concentrated into podlike masses. A 180-foot shaft and about 150 feet of other underground workings were driven in one of the masses, and the deposits were trenched and diamond drilled by the U.S. Bureau of Mines. According to their estimate, the largest concentrated sulfide body contains about 8,000 tons of material averaging about 1.57 percent nickel, 0.88 percent copper, and small amounts of gold and silver. The other bodies are similar but contain only a few tons each of concentrated sulfide material. The disseminated sulfide deposit probably contains several million tons of material containing about 0.2 percent nickel and 0.1 percent copper.

Assays of chalcopyrite and pyrrhotite from the head of Little Bay (20), about a mile from Mirror Harbor, showed copper, silver, gold, and a trace of nickel. At the Snow Slide claims (20), near the head of Baker Arm, two claims were staked on a 6-foot zone of quartzose greenschist carrying pyrite, chalcopyrite, and possibly pyrrhotite. A 171-foot tunnel driven to find the metalliferous zone at depth failed to intersect it. A little chalcopyrite and pyrrhotite also have been found at Bertha Bay (17), at the Congress claims (22) on the west side of Hill Island, and at the Princess Pinder claim (20), where the sulfides contain a trace of gold.

A short adit on the Haley and Hanlon nickel-copper prospect (38) explored a fault that cuts hornblendite and contains small irregular masses of pyrrhotite and subordinate chalcopyrite. Analysis of the sulfide material showed 0.99 percent copper, 0.20 percent nickel, and 0.09 percent cobalt.

A nickel-copper deposit, discovered in 1922 at Snipe Bay (51), consists of magnetite, pentlandite, and chalcopyrite irregularly distributed in altered mafic igneous rock that cuts Mesozoic quartzite and schist. The size and grade of this poorly exposed deposit are not known, but it probably contains less than 0.3 percent each of nickel and copper.

At the Big Ledge prospect (41), a mafic dike contains disseminated pyrrhotite, chalcopyrite, pentlandite, and a little sphalerite and pyrite. Much of the pentlandite is altered to a secondary nickel mineral.

In 1941 the Three J claim (40) was staked on a molybdenite-chalcopyrite lode about 5½ miles east of Tenakee. The sulfides are in biotite-hornblende quartz diorite and in dikes of finer grained lighter colored rock. Random chip samples, one of the dike rock and another of the quartz diorite, showed the molybdenum content of each to be only 0.01 percent.

Another molybdenum-copper occurrence is in quartz diorite on one of the Magoun Islands (34), where a quartz vein contains molybdenite plates as much as one-half inch in diameter and chalcopyrite, pyrite, and covellite.

The Whitney claims (11) near Willoughby Cove on Lemesurier Island, were staked on quartz stringers carrying molybdenite and a little chalcopyrite. The lode, in hornfels near the contact of marble and quartz diorite, was explored by tunnel and crosscut, but no ore was shipped. Other quartz stringers carrying molybdenite, chalcopyrite, and bornite have been reported near the Whitney prospect.

Chromite occurs on Baranof Island in several serpentinized ultramafic masses in contact with metamorphosed sedimentary and volcanic rocks. The largest lode is at Red Bluff Bay (50), where chromite-bearing rocks underlie a 1¼-square-mile area north and east of the bay and crop out on several small islands. Of the eight deposits known at Red Bluff Bay, five contain a total of about 570 tons of material averaging more than 40 percent Cr_2O_3; the other three deposits aggregate about 29,000 tons of rock carrying 18–35 percent Cr_2O_3.

Chromite also occurs at the Hill claims (49), where it forms small lenses, thin layers, and disseminated grains in altered dunite and pyroxenite. The deposits, which are mostly in the dunite, are small and probably do not contain more than 100 tons of chromite.

Small amounts of copper, lead, zinc, chromium, cobalt, nickel, and molybdenum minerals were found in many places on Chichagof, Baranof, and nearby smaller islands during recent mapping investigations by the U.S. Geological Survey (Loney and others, 1963). Few of these occurrences have been investigated in detail, and most are probably only of passing interest, but they indicate areas that might warrant further prospecting.

A gossan in diabase or greenstone west of the outlet of Blue Lake (38) contains traces of chromium, nickel, copper, cobalt, and zinc. Serpentine in a nearby area (36) carries a little magnetite, chromite, and a trace of nickel. Copper-bearing sulfide minerals are disseminated in iron-stained felsic igneous rock about a mile north of Blue Lake (37). Limonite-stained greenstone on one of the Siginaka Islands (35) contains pyrite, chalcopyrite, and covellite, and volcanic rocks on Neva Strait (33) contain disseminated pyrite carrying a trace of chromium. The only metalliferous lode found on Kruzof Island is near Sea Lion Cove (31), where quartz veins in hornfels near pegmatite contain sparse chalcopyrite and molybdenite.

Sparse sulfide minerals occur in the vicinity of Kelp Bay (43–46). Near the head of South Arm (44), brecciated siliceous rock contains pyrite and chalcopyrite, and spectroscopic examination indicates that zinc is also present. Quartz veins on the shores of Middle Arm and Portage Arm (43) contain copper sulfides and pyrite. Copper was detected spectrographically in sulfide minerals sparsely disseminated in quartz veins and an aplite dike near the south entrance to Kelp Bay (45) and in hornfels at Graystone Cliff (46). A few of the Kelp Bay occurrences also contain trace amounts of nickel.

The Redcliff Islands (39) in Freshwater Bay are underlain by aphanitic volcanic rock, a sample of which contained a little zinc. The mineral of which the zinc is a component, however, could not be identified. A sample from Pavlof Harbor (39) of similar rock containing visible sulfide minerals showed, on analysis, lead and zinc.

A diabase dike about half a mile north of Tenakee Inlet (40) contains chalcopyrite, secondary copper minerals, and traces of nickel, zinc, and chromium. At Trap Bay (42) sulfide clots in sheared quartz carry trace amounts of cobalt, copper, and zinc; 3 miles from the northwest end of Hoonah Sound (23), sparse sulfides in iron-stained quartz contain copper and molybdenum.

Chalcopyrite, pyrite, and secondary copper minerals occur in amygdaloidal greenstone on a mountain top between Patterson Bay and Ford Arm (26), and secondary copper minerals are also in similar rocks 6 miles to the southwest (28). A sample of greenstone from the divide southeast of the head of Slocum Arm (30) contained disseminated iron and copper sulfides, secondary copper minerals, and traces of chromium and zinc.

Additional information on this district is given in the following references: Berg and Hinckley (1963); Buddington (1925); Guild and Balsley (1942); Kennedy and Walton (1946a); Knopf (1912b); Loney, Berg, Pomeroy, and Brew (1963); Loney, Pomeroy, Brew, and Muffler (1964); Overbeck (1919); Pecora (1942); Reed (1938); Reed and Coats (1942); Reed and Gates (1942); Rossman (1959); Smith, P. S. (1942); Twenhofel, Reed, and Gates (1949); Wright and Wright (1905).

HYDER DISTRICT

The Hyder district (fig. 25) includes the part of southeastern Alaska drained by streams tributary to Portland and Pearse Canals. The northern and eastern boundaries of the district coincide with the Alaska–British Columbia boundary.

Exploitation of metalliferous lodes in the Hyder district began about 1922 after the discovery of rich silver lodes in adjoining British Columbia. Most mining ended by 1929, and no more took place until just before the United States entered World War II. There are no active mines in the district at present.

Almost all the production in the district came from the Riverside mine, whose ore yielded about 3,000 ounces of gold, 100,000 ounces of silver, 100,000 pounds of copper, 250,000 pounds of lead, 20,000 pounds of zinc, and 3,500 units (70,000 pounds) of WO_3.

The district's lodes are mainly in the Hyder area, where metamorphic, sedimentary, and volcanic rocks are intruded by granodiorite and quartz monzonite batholiths and by younger dikes of diverse composition. Most of the mineral deposits are in schist inclusions in granodiorite and consist of quartz veins that contain varying combinations of galena, pyrite, sphalerite, chalcopyrite, pyrrhotite, molybdenite, tetrahedrite, freiburgite, scheelite, native gold, and native silver. The most common metalliferous mineral is galena, which generally carries moderate amounts of silver and some gold. Tetrahedrite, although not abundant, is important because it usually carries considerable silver and gold. Native silver, which is plentiful in mines on the Canadian side of the border, occurs only rarely on the Alaskan side. Scheelite has also been found in veins cutting roof pendants in granodiorite.

The Riverside mine (5, see fig. 25), in granodiorite and a large sheared schist inclusion, worked quartz veins carrying scheelite, lead-, zinc-, copper-, and silver-bearing sulfides, and native gold. Most of the production was from the so-called Lindeborg shear zone in the inclusion. The mine consisted of more than 6,000 feet of underground workings; it was also explored by about 4,600 feet of diamond-drill holes, mainly by the U.S. Bureau of Mines during World War II. All the production credited to the Hyder district, except the returns on what essentially were test shipments from about half a dozen other properties, was from the Riverside mine.

Similar veins on the Mountain View property (5), near the Riverside mine, were explored by about 4,200 feet of drifts and crosscuts, but the only ore shipments were for mill tests. Other lodes from which some ore was shipped include the Heckla (1), Homestake (3), Cantu (4), Last Chance (Olympia Extension) (5), and Fish Creek (5).

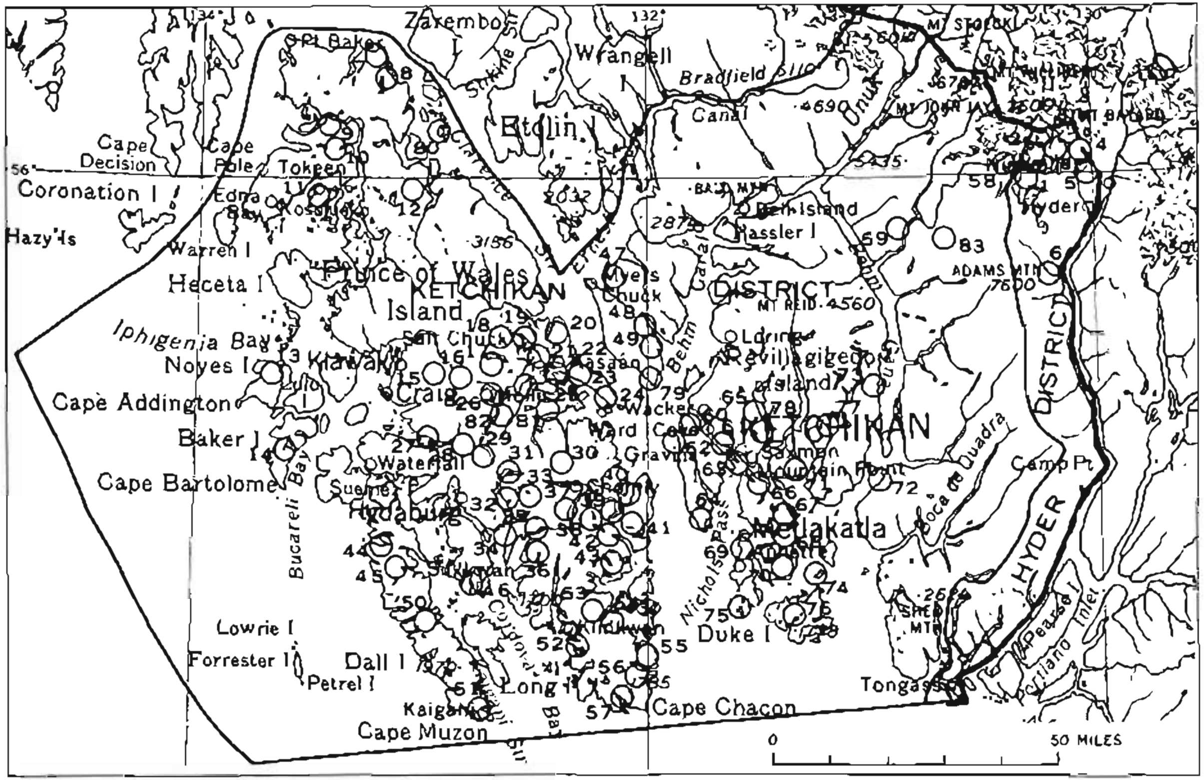

FIGURE 25.—Metalliferous lode deposits in the Hyder and Ketchikan districts.

Hyder district

Hyder area

1. *Heckla
2. Bevacque
   Blasher
   Chickamin
   Double Anchor
   Dugas
   Engineer
   Hummel
   Hyder Lead
   Iron Cap
   Jumbo
   Juneau
   Keno
   Lake
   Marietta
   Morning
   North Star
   Silver Bell
   Silver King
   Silver Star
   Sunset
   Texas Discovery
3. Evening Star
   *Homestake
   Ibex

*See footnote at end of list.

Hyder district—Continued

Hyder area—Continued

   Liberty (Jackson)
   Nothiger
   Silver Bar
   Silver Coin
4. Bartholf
   Border
   *Cantu
   Charles, Nelson & Pitcher
   Gold Cliff Premier
   Ninety-Six
5. Alaska Premier
   Bertha
   Bishop
   Bluebird
   Brigadier
   Crest
   Cripple Creek
   Daly-Alaska
   *Fish Creek
   Hobo
   Howard
   Hyder Skookum
   Iron
   *Last Chance (Olympia Extension)
   Last Shot

Hyder district—Continued

Hyder area—Continued

(5.) Lucky Boy Extension
   Monarch
   *Mountain View
   Portland
   *Riverside
   Sixmile
   Stoner
   Stoner-Clegg-O'Rourke
   Swede
   Titan
   Virginia
   Western

6. *Commonwealth

Ketchikan district

Salmon Bay area

7. *Salmon Bay
8. *Pitcher Island
   *Salmon Bay

Dry Pass area

9. *Castle & Co.
   *Dry Pass
   *Lillie

Continued on following page.

LOCALITIES SHOWN ON FIGURE 26—continued

Ketchikan district—Continued

Dry Pass area—Continued

(9.) *Shakan

10. *Devilfish Bay
11. *Tokeen
12. *McCullough
13. *Noyes Island
14. *Baker Island
    *Port San Antonio
15. *Saxe
16. Constitution
    Dew Drop
    Independent
    *Lucky Nell
    Rose
    Summit
17. *Flagstaff
    *Granite Mountain
    *Salmon Lake

Kasaan Peninsula area

18. North Pole Hill
    Paul Young Creek
    *Rush & Brown
    Venus
    Young
19. Copper Center

*See footnote at end of list.

Ketchikan district—Continued

Kasaan Peninsula area—Continued

(19.) *Haida
    Leibrant
    *Salt Chuck
    Stevens
20. *Big Five
    *Iron Cap (Mahoney)
    Tolstoi
    Wallace
21. *Alarm
    *Brown & Metzdorf
    Charles
    Copper King
    *It
    Morning Star
    *Poor Man and Iron King No. 1
    Reed
22. *Baker Point
    Copper Queen
    Elm City
    Skookum
    *Sunny Day
    *Uncle Sam
23. Hole in the Wall
    *Mamie
    *Mount Andrew

Ketchikan district—Continued

Kasaan Peninsula area—Continued

(23.) Peacock
    *Rich Hill
    *Stevenstown
    Tacoma
24. *Big Six
    Cachelot
25. *Kina Cove

26. *Cascade
    Copper Hill
    *Crackerjack
    *Dawson (Julia)
    Gervis
    *Hollis
    Monday
    Mountain Bell
    *Puyallup
    Stella
27. *Big Harbor
28. *Marble Heart
    *Nancy
29. *Dolly Varden
    *Twelvemile Creek

McKenzie Inlet area

30. Anderson

Ketchikan district—Continued

McKenzie Inlet area—Continued

(30.) Bertha
Hecla
*Khayyam
Red Rose
*Stumble-On (Mammoth)

Hetta Inlet area

31. *Gould Island
*Houghton
*Sultana
*Unnamed
32. *Copper Mountain
*Corbin
Gould
Hetta Mountain
*Iron Crown
*Jumbo
Miller Brothers
Paris
Russian Bear
Texas
33. *Green Monster
*Rex
34. *Copper City
35. *Nutkwa Lagoon

*See footnote at end of list.

Ketchikan district—Continued

Hetta Inlet area—Continued

36. *Kete Inlet

South Arm Cholmondeley Sound area

37. *Friendship
*Hope
*Ketchikan Copper Co.
*Moonshine
*Research (Polymetal)

38. *Lucky Boy

Cholmondeley Sound area

39. Alameda
*Croesus
Frisco
Kid
Oregon
Washington
40. Equator
O. K.
Park View
Saco

Dolomi area

41. Alpha
Amazon

Ketchikan district—Continued

Dolomi area—Continued

(41.) Beauty
Beulah
*Fortune
*Golden Fleece
House
Jumbo
Matilda
Moonshine
Pauline
Salmon
Standby
Triangle
*Valparaiso
Welcome
Wellfleet

Niblack-Moira Sound area

42. *Cymru
Excelsior
*Navaho (Hope)
Vesta
*Westlake
43. Copper Chief
*Dama (Copper Cliff)
Edith M.
*Lookout

Continued on following page.

LOCALITIES SHOWN ON FIGURE 25—continued

Ketchikan district—Continued

Niblack-Moira Sound area—Continued

(43.) *Niblack
Trio
Wakefield
Westcott

44. *Moonshine
*Yellowstone
45. *Miller
*Shellhouse
*Silver Star
46. *Gould
*Lakeside
47. *Union Bay (Mount Burnett)

Helm Bay area

48. Bay View
*Blue Jay (Libe)
*Gold Standard
*Helm Bay
*Helm Bay King
*Melville
South Lakeview
49. *Gold Mountain
Gold Nugget
Kingston
Last Chance

Ketchikan district—Continued

Helm Bay area—Continued

(49.) Little Maumee
Mary T.
*Old Glory (American Eagle)
Rainy Day
United States

50. *Lucky Strike
*Mount Vesta
51. *McLeod Bay
52. *Hunter Bay
*Tah Bay
53. *Moira Sound, South Arm
54. *Bokan Mountain
55. *Gardner Bay
*Nelson & Tift
*MacLean Arm
56. *MacLean Arm-Mallard Bay
*Stone Rock Bay
57. *Nichols Bay

Banded Mountain area

58. *Banded Mountain
*Edelweiss
*Glacier

59. *Gnat

Ketchikan district—Continued

60. *Easter
61. *Six Point
*White Knight

Tongrass Narrows area

62. *Hoadley
Laskawonda
*Wild Cat
63. Birdseye
*Goldstream
*Heckman

Seal Cove-Dall Head area

64. Carita
Dall
Seal Cove
Washington

65. *Mahoney (Asche's)
66. *Annette Bay
*Nadzaheen Cove
67. *Cascade Inlet
68. *Crab Bay
69. *Yellow Hill
70. *Annette Island
71. *Moth Bay
72. *Roe Point

*See footnote at end of list.

LOCALITIES SHOWN ON FIGURE 25—continued

Ketchikan district—Continued

73. *Ella Point
74. *Cat Island
75. *Percy Islands
76. *Duke Island

Thorne Arm area

77. Baby George
    Baltic
    Baltic Star
    Golden Banner
    Golden Rod
    *Goo Goo
    High Horse
    Lake
    Massachusetts

Ketchikan district—Continued

Thorne Arm area—Continued

(77.) *Peerless Consolidated
    Queen
    Salve
    Sea Breeze
    *Sealevel
    Tyee
    Wild West

78. *Londevan
    *Peterson
79. *Caamano Point
80. *Blashke Islands
81. *Hatchet
82. *Shelton
83. *Chickamin River, South Fork

*Cited individually in text.

More than 50 other prospects in the Hyder area are similar to the Riverside and Mountain View deposits. A few were explored by underground workings, but most were prospected only by trenches and pits.

The Commonwealth lode (6), about 14 miles southwest of Hyder, is in a narrow inclusion of quartzite, schist, and marble in quartz monzonite and consists of quartz(?) veins carrying a little molybdenite, sphalerite, chalcopyrite, and gold. The veins, which are mostly near the contact of the metamorphic rocks and the pluton, were explored by about 100 feet of drifts, but the workings failed to disclose an ore body.

Additional information on this district is given in the following references: Buddington (1929); Byers and Sainsbury (1956); Thorne, Muir, Erickson, Thomas, Heide, and Wright (1948).

JUNEAU DISTRICT

The Juneau district (fig. 26) includes the mainland of southeastern Alaska north of Tracy Arm and South Sawyer Glacier, and east of a line from Mount Fairweather to Cape Spencer. It also includes Douglas, Pleasant, and numerous smaller islands.

From 1880, when the first metalliferous deposits were discovered, until World War II, when the last of the large mines was shut down, the Juneau district was the source of most of the ore produced from lodes in Alaska. The Treadwell mines (41, see fig. 26) on Douglas Island and the Alaska-Juneau (39), Perseverance (39), Ebner (39), Silver Queen (42), and a few much smaller mines on the mainland near Juneau accounted for more than 6½ million ounces of gold, several million ounces of silver, and more than three-quarters of the lead produced from Alaska. Other mines in the district, notably those near Berners Bay (24), Eagle River (31, 32, 34), and Reid Inlet (10) produced a total of about 150,000 ounces of gold. The Juneau district has been the source of almost three-fourths of all the lode gold mined in Alaska since the first lode was staked near Sitka in 1871.

The Juneau gold belt, of which the lodes near Juneau are typical, extends for more than 100 miles from a point just south of Windham Bay (in the Petersburg district) to one a few miles north of Berners Bay. In most of this area the gold deposits are confined to a belt of metamorphic rocks about 4 miles wide along the southwest margin of the Coast Range batholith. The major metamorphic rock types are schist, slate, greenschist, and greenstone, all of which have been folded, faulted, and locally intruded by apophyses of the main batholith.

On the mainland near Juneau, most of the large ore bodies—typified by those of the Alaska-Juneau mine (39)—were masses of slate containing swarms of quartz veinlets carrying gold, pyrrhotite, sphalerite, galena, pyrite, arsenopyrite, chalcopyrite, and tetrahedrite. On Douglas Island, the ore bodies in the Treadwell mines (41) consisted of impregnations and networks of veins in albite diorite dikes that cut slate and greenstone. The Treadwell lodes contain the same metallic minerals as the mainland deposits, plus molybdenite, magnetite, and a little scheelite, native arsenic, realgar, and orpiment. Few of the ore bodies mined in the Juneau gold belt would have been considered rich by ordinary standards; much of the ore produced from the major mines contained less than a dollar's worth of gold and silver per ton, and most of the ore bodies were bounded by assay rather than geologic limits. The Alaska-Juneau mine, the last to close, could not reopen after World War II because the margin between the fixed price of gold and rising operating and labor costs had disappeared. A little gold, however, was recovered during cleanup operations in the mill and by placer-mining methods from tailing piles.

The Clark prospect (40) on Carlson Creek and two occurrences on Lemon Creek near the terminus of Lemon Creek Glacier (37) differ from most of the other lodes near Juneau in that they are not in slate. The Clark prospect, in schist and pegmatite injection gneiss, consists of quartz veins containing small inclusions of silicified country rock and minor amounts of pyrite, stibnite, arsenopyrite, sphalerite, and galena. The prospect was explored by a 150-foot tunnel and several trenches; assays of samples taken by the owner in 1924 showed 0.12–1.03 ounces of gold to the ton. The occurrences on Lemon Creek consist of pyrrhotite, galena, sphalerite, and chalcopyrite in two narrow quartz veins in a gneissic diorite dike.

At Limestone Inlet (45), claims were staked on quartz veins carrying free gold and small amounts of galena, sphalerite, chalcopyrite, and pyrite; some ore is reported to have been processed about 1916. A silver prospect high on a mountainside near the Whiting River (46) has been explored several times since 1896 but was never brought into production. The deposit consists of a quartz fissure vein in a dolomite inclusion in quartz diorite. Sulfide minerals in the vein are arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite; very high silver assays have been reported from selected specimens.

The Crystal and Friday mines (47), near the entrance to Port Snettisham, probably produced about 2,000 ounces of gold between 1899 and 1905. Sporadic mining continued until the early 1930's, but no data on production after 1905 are available. The lodes are in slate near its contact with diorite and consist of quartz veins containing pyrite and gold. The ore was mainly pyrite, in much of which small crystals and particles of gold were visible. Auriferous quartz that

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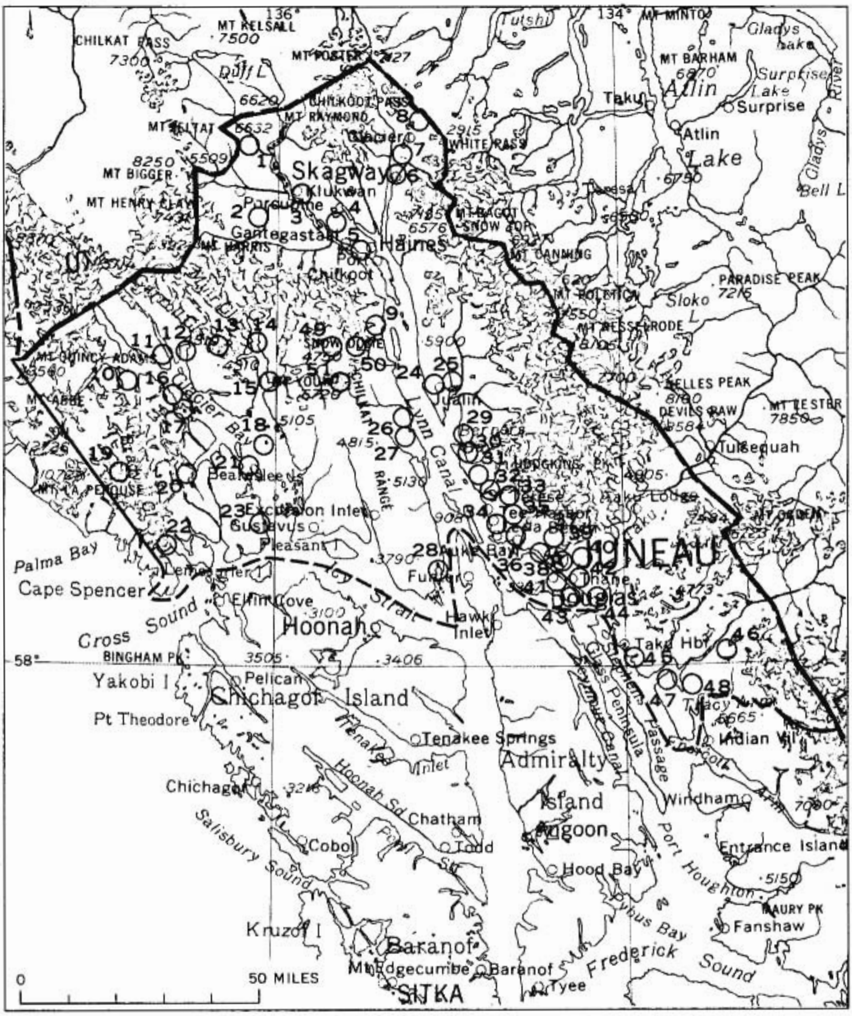

FIGURE 26.—Metalliferous lode deposits in the Juneau district. (Localities listed on p. 157–158.)

LOCALITIES SHOWN ON FIGURE 26

Juneau area

37. Clark
    *Lemon Creek
38. Doran
    Wagner
39. *Alaska-Juneau
    Boston
    Bull Consolidated
    *Ebner
    Ground Hog
    Hallam
    Humboldt
    *Perseverance
40. *Clark
41. Douglas Mining Co.
    Jersey City
    *Treadwell mines
42. Anderson
    Gould & Curry

Juneau area—Continued

(42.) Middle Peak
    Nelson-Lott (Gold Belt)
    Reagan
    *Silver Queen
43. Nevada Creek
44. Penn-Alaska

45. *Limestone Inlet
46. *Whiting River
47. *Crystal
    *Friday
    *Port Snettisham
48. *Sweetheart Lake
49. *Berg Mountain
50. *Unnamed
51. *Mount Young
    *Unnamed

*Cited individually in the text.

also carries considerable galena has been found in schist near the outlet of Sweetheart Lake (48), about 5 miles east of the Crystal mine.

The Eagle River lodes (29–36), between Auke Bay and Berners Bay, produced about 23,000 ounces of gold, mainly from ore containing half an ounce or less of gold per ton. The ore bodies were mostly metalliferous quartz stringer lodes in slate and graywacke adjacent to the Coast Range batholith, but a few consisted of discrete quartz fissure veins or mineralized gabbro or albite diorite dikes. The chief metallic minerals were arsenopyrite, pyrite, galena, pyrrhotite, and sphalerite; the highest gold tenor was generally associated with large quantities of arsenopyrite and galena.

The earliest lode mining operations in the Eagle River area took place in 1882, when auriferous veins were discovered and staked in Montana Basin (35) and near Auke Lake (36). Eagle River mine (32), the major mine in the area, operated intermittently from about 1903 to 1933 and consisted of more than 2,500 feet of underground workings. The ore was trammed about 3½ miles to a mill near tidewater.

Gold was also recovered from a metalliferous quartz vein on the Aurora Borealis property (31), about 3½ miles northwest of the Eagle River mine. The vein was worked by two 200-foot tunnels and yielded about 260 ounces of gold, all before 1895. Some underground exploration was also done on the adjoining Bessie and Alaska-Washington properties.

Minor production was reported from the Peterson claims (34), where large masses of quartz containing arsenopyrite and free gold are said to average a little more than a third of an ounce of gold per ton. The claims were staked about 1897 and worked intermittently on a small scale until at least as late as 1922.

In Yankee Basin, near the Eagle River mine, several prospects were staked in the early 1900's, and a few were explored by fairly extensive underground workings. The only productive property, however, was the Rex claim (31), where a small relatively rich quartz vein is reported to have yielded $3,000 in gold in 1903.

In Windfall Basin, about halfway between the Eagle River and Mendenhall Glacier, two tunnels on the Smith and Heid property (35) exploited a quartz vein carrying appreciable auriferous arsenopyrite. The ore was roasted, then treated in an arrastre; the amount of gold recovered was not reported but probably was small. The only other productive lode in the Windfall Basin area was on the Dull & Stephens property (36), where several ounces of gold were obtained by sluicing the weathered part of a quartz vein.

The St. Louis and Summit lodes (33) and the Mitchell & McPherson prospect (32) were not productive but are of interest because they were in diorite gneiss rather than in metamorphosed bedded rocks. The St. Louis deposit is a metalliferous shear zone reported to average a quarter of an ounce of gold per ton. The Summit deposit is a quartz vein, transverse to the layering of the gneiss, that carries considerable arsenopyrite and visible free gold. At the Mitchell & McPherson prospect, crushed gneiss containing quartz and carbonate minerals was prospected by two tunnels and several opencuts. The lode, exposed in the opencuts for about 6 feet, was reported to carry $5–$12 in gold per ton.

The Berners Bay lodes (24, 25) are low grade, but unlike most of the other deposits in the Juneau gold belt, they are nearly all in diorite rather than in metamorphosed bedded rocks. The lodes consist of quartz veins and stockworks carrying pyrite, chalcopyrite, galena, sphalerite, and gold that is only rarely visible to the naked eye. They were discovered about 1886 and were productive until shortly after the turn of the century, when litigation forced the mines to suspend operations. Mining was revived both before and after World War I for a total of perhaps 5 years, but activity since then has been restricted to unsuccessful attempts to rehabilitate and operate the Kensington (24) and Jualin (24) mines. Total production from the Berners Bay area was probably about 70,000 ounces of gold.

The principal mines during the pre-1900 heyday of the Berners Bay area were the Comet (24) (later part of the Kensington properites) and the Jualin (24), about a mile and a half apart on opposite sides of a ridge. Both consisted of extensive underground workings on quartz veins in diorite and, except for one vein in the Jualin mine that yielded about 1½ ounces of gold per ton, worked low-grade ore averaging less than half an ounce of gold per ton. Comet ore was processed, along with that from some of the neighboring mines, at the Kensington mill; the Jualin had its own mill.

The Ivanhoe (24), Bear (24), Horrible (24), Kensington (24), and Northern Bell (24) mines are also known to have produced ore; other lodes may have been productive, but the data are incomplete and changes in ownership have made the interpretation of records uncertain.

Of all the mines and prospects in the Berners Bay area that have been described in published reports, only the Ivanhoe (24) is not in quartz diorite. Instead, it is in altered basaltic lava flows about 3,000 feet from the nearest contact with quartz diorite. Prior to 1903, when it ceased operations, the Ivanhoe mine shipped 3,000 tons of ore that yielded about $7,000 in gold. The ore was mined from an 850-foot drift and a stope in a quartz vein 1–9 feet thick.

The Greek Boy prospect (25), near the Berners River, consisted of a 700-foot tunnel that explored sparsely pyritic quartz at the sheared contact of quartz diorite and altered basalt.

Outside the Juneau gold belt, the only area in the Juneau district where a substantial amount of ore was mined is near Reid Inlet (10) in Glacier Bay National Monument. Here metalliferous lodes are near the contact of granodiorite and metamorphosed Paleozoic(?) clastic rocks and limestone. The lodes are in both the igneous and bedded rocks and consist of quartz fissure veins and mineralized altered zones extending a few tens of feet into the country rock on either side of the veins. The deposits contain gold, silver, galena, and pyrite, and sparse sphalerite, arsenopyrite, and chalcopyrite; gold tenor is highest where galena is most abundant.

The Reid Inlet lodes were discovered in 1924, but governmental restrictions prohibited mining until 1938, when operations began at the LeRoy mine. Production from the Reid Inlet area through 1951, when mining ceased, was probably about 10,000 ounces of gold, mainly from the LeRoy and Rainbow mines. Minor production was also recorded from the Hopalong, Whirlaway, Sentinel, Monarch, Galena, and Incas properties. Recovery was about $100 per ton for ore mined and milled between 1938 and 1950.

Small amounts of gold and silver were recovered from several other lodes near Glacier Bay. A deposit worked for silver on the west side of Willoughby Island (21) probably consisted of a small kidney-shaped mass of chalcopyrite, pyrite, and tetrahedrite in limestone cut by a lamprophyre dike. Chalcopyrite has also been reported elsewhere on Willoughby Island.

On Francis Island (21), 1½ miles northwest of Willoughby Island, two claims were staked in the early 1920's on a diorite dike cutting marble and bordered by garnet-bearing contact rock. A pocket of bornite that yielded gold and silver reportedly was found in the contact rock, and one end of the dike is impregnated with pyrite and pyrrhotite.

Quartz veins, some of which contain tetrahedrite, galena, sphalerite, and gold, crop out on the south and west sides of Gilbert Island (17). The largest vein, near Blue Mouse Cove, is more than a foot thick and is said to carry silver as well as gold.

A small number of auriferous quartz veins have been found in metamorphic rocks on the west side of the mountain between Dundas Bay and Brady Glacier (22). The veins are generally not more than a few inches thick.

A reportedly rich silver lode crops out on the west shore of Rendu Inlet (11). It is in an altered zone along a minor fault and consists of a small quartz vein containing wire silver and tetrahedrite. It was discovered in 1892 and developed by a short tunnel from which ore was probably taken before 1900.

Sphalerite and magnetite occur in limestone on North Marble Island (18), and argentiferous galena- and sphalerite-bearing quartz veins reportedly are on the eastern shore of Glacier Bay and on adjacent islands. The locations of the lodes, however, are too uncertain to put on figure 26.

A lode on the Inspiration Point Mining Company property (8), near White Pass, consists of quartz diorite that contains small lenses and masses of argentiferous galena and probably other sulfides. Exploratory work was done annually from about 1926 until 1932, and a few tons of ore containing silver, lead, zinc, and copper may have been shipped.

In the Porcupine gold-placer area northwest of Haines, altered Paleozoic limestone and clastic beds southwest of the Coast Range batholith contain numerous quartz-calcite stringers, some of which carry sulfide minerals. No lode mines have been developed in the area, and most samples assayed have contained little gold. Near Summit Creek (2), however, several veinlets carrying argentiferous galena have been found whose maximum metal content is said to be about 60 ounces of silver per ton, 35 percent lead, and $3 a ton in gold; one sample assayed nearly 3 percent copper.

A silver-lead-zinc lode is reported to have been discovered in 1921 at Howard Bay (28), on the west shore of Lynn Canal, but nothing further is known about it.

Originally prospected as a copper deposit, the Alaska-Endicott mine (27) at William Henry Bay produced 200 tons of ore from which a total of about 50 ounces of gold and 20 ounces of silver was recovered. The lode is in Paleozoic greenstone and consists of chalcopyrite and pyrite in a faulted quartz-breccia vein. The material mined, although of too low grade to constitute copper ore at the time (about 1920), probably contained at least 8 percent sulfide minerals; what is left in the deposit contains less than 2 percent.

Four miles north of William Henry Bay (26), a radioactive anomaly that was detected from the air by prospectors was explored by several pits and a diamond-drill hole. The rock is quartz monzonite containing sparse veinlets of pyrite, chalcopyrite, galena, ilmenite, and traces of a thorium mineral. X-ray spectroscopic examination of samples also indicated trace amounts of zirconium, niobium, and uranium(?).

The Alaska Chief property (23), a copper prospect that was the site of some underground exploration in the early 1900's, is on the west side of Glacier Bay. The old workings, which followed the contact between diorite and calcareous metasedimentary rocks, revealed pyrite, chalcopyrite, and pyrrhotite in marble and contact rock (tactite?).

Near Kelsall River (formerly called Bear Creek) (1), a quartz vein, which is apparently only a few inches thick, contains pyrite, pyrrhotite, chalcopyrite, and sphalerite.

Bornite has been reported in prospects on the ridge between the Chilkat and Chilkoot River valleys (4) a few miles northwest of Haines, and on Mount Young (51) between Lynn Canal and Glacier Bay. Chalcopyrite has been found near the Mount Young occurrence and also on an unnamed mountain 7 miles north of Mount Young (50), where it is associated with pyrrhotite that probably contains traces of cobalt. Traces of the rare-earth metal yttrium were found in pyritic siliceous rock near Berg Mountain (49).

The Hayes copper-iron prospect (9) consists of magnetite in marble, and chalcopyrite and hematite in schistose limestone partly altered to skarn. Another copper lode has been reported north of the Hayes property, but no information about it is available.

Nickel-copper deposits on two nunataks in Brady Glacier (19) consist of masses, veinlets, and disseminated particles of pyrrhotite, pyrite, pentlandite, and chalcopyrite in a layered gabbroic pluton. Analyses show that the sulfide masses contain as much as 3 percent nickel, 2 percent copper, and 0.25 percent cobalt. The deposits have been extensively explored in recent years.

Molybdenite is widespread in the vicinity of Glacier Bay, but none has been mined. The best known deposit is at the Nunatak prospect (14) on Muir Inlet, where tightly folded metasedimentary rocks are cut by a small quartz monzonite porphyry pluton surrounded by an auriole of myriad quartz veinlets. The principal metallic mineral in the veinlets is molybdenite; it is accompanied by minor amounts of pyrite, magnetite, and chalcopyrite. Analysis of a random sample also showed 0.04 ounce of gold and 7.07 ounces of silver to the ton. Two types of lodes have been recognized at the Nunatak prospect: a stockwork underlying an area of about 46 acres and smaller deposits along faults. After detailed study by the Geological Survey and the U.S. Bureau of Mines, the largest fault-controlled lode was found to include about 280,000 tons of material carrying 0.102 percent molybdenum; the estimate for the stockwork was about 8,500,000 tons of rock containing 0.075 percent molybdenum and many times more material of lower grade.

Smaller lodes that are generally similar to the Nunatak deposit have been found at Adams Inlet (15), in the Bruce Hills (13), at the head of Geikie Inlet (20), and on Gilbert Island (16). A little molybdenite was also found on Triangle Island (12) near the head of Glacier Bay, but most of the deposit reportedly was removed by one man in one day. Specimens of molybdenite-bearing quartz have been found in float in front of Brady Glacier, west of Glacier Bay, but their bedrock source is unknown.

A deposit that once attracted considerable attention is near Clifton station (7) on the White Pass & Yukon Railroad. It consists of light-colored granite containing about 1 percent disseminated molybdenite that is locally concentrated along joints. Sometime between 1915 and 1917 the deposit was explored by a 15-foot shaft and a 30-foot tunnel.

Titaniferous magnetite deposits near Klukwan (3) and Haines (5) have been known since before 1900. The deposits consist of intergrown magnetite and ilmenite in pyroxenite surrounded by epidote-bearing granite.

The Klukwan deposit, discovered in 1899, has been explored by private interests and by Federal agencies since World War II, but the only ore taken out was for metallurgical testing. Sampling and dip-needle surveys suggest the presence of two or three tabular zones in which the rock has an average magnetic-iron content of 20 percent. The entire deposit comprises several billion tons of rock containing about 13 percent magnetic iron. An alluvial fan adjoining the pyroxenite contains several hundred million tons of broken rock averaging about 10 percent magnetic iron.

The presence of the Haines deposit was suspected when magnetite-bearing rock was found on the beach in 1879. A few years later claims were staked on pyroxenite near the west end of the town and a 100-foot tunnel (now caved) was driven. Widely spaced dip-needle traverses and sampling along the shore and in roadcuts in the early 1950's indicated that the Haines deposits contained several billion tons of low-grade magnetite-bearing pyroxenite. Data are inadequate to estimate the grade, but the magnetic iron content seems to be less than 10 percent.

Pyroxenite that underlies a land area of at least 390 acres near Port Snettisham (47) contains titaniferous magnetite and minor amounts of pyrrhotite, chalcopyrite, ilmenite, and spinel. In 1918, 4 or 5 tons of magnetite ore from an opencut was shipped to Douglas, Alaska, for testing; the material reportedly contained 4–5 percent titanium, but its iron content was not disclosed. In 1952–53 the U.S. Bureau of Mines made a dip-needle survey of the pyroxenite body and explored it with more than 6,500 feet of diamond-drill holes. The owner of the property also made an airborne magnetometer survey. Individual core samples assayed 11 to about 45 percent total iron, and a large composite sample assayed 18.9 percent iron, 2.6 percent titania, 0.29 percent sulfur, 0.32 percent phosphorus, and 0.05 percent vanadium. The Bureau of Mines concluded that a high-grade titaniferous magnetite concentrate could be recovered from this potentially large deposit using standard, comparatively low-cost beneficiation methods.

The detection of a radioactive anomaly at Skagway (6) in 1956 resulted in the exploration of a small zone of altered red- and yellowish-brown-weathering quartz diorite that is cut by several faults and andesite dikes. Radioactive material, associated with iron oxide minerals and clay, occurs next to a steeply dipping fracture in the altered rock. The richest sample analyzed contained 0.72 percent equivalent uranium and 1.2 percent uranium, but most of the deposit contains no more than 0.22 percent equivalent uranium. One prospect pit yielded a few hundred pounds of specimens, but at the time of a U.S. Geological Survey examination in 1956, no ore was in sight.

Additional information on this district is given in the following references: Buddington (1925, 1926); Buddington and Chapin (1929); Chapin (1916); Eakin (1919); Freeman (1963); Herbert and Race (1964); Knopf (1911, 1912a); Lathram, Loney, Condon, and Berg (1959); Matzko and Freeman (1963); Reed (1938); Robertson (1956); Rossman (1958, 1963b); Spencer (1906); Thorne and Wells (1956); Twenhofel, Reed, and Gates (1949); Twenhofel and Sainsbury (1958); Wayland (1960); Wright, C. W. (1909).

KETCHIKAN DISTRICT

The Ketchikan district (fig. 25) is the mainland and islands of southeastern Alaska south of Sumner Strait, Clarence Strait, Ernest

Sound, Bradfield Canal, and a line connecting the head of Bradfield Canal with Mount Cloud and Mount Lewis Cass. The eastern boundary of the district is the divide that separates Behm Canal and Revillagigedo Channel from Pearse and Portland Canals.

More than 40 individual mines have operated in the Ketchikan district at one time or another since the first copper prospect was located on Prince of Wales Island in 1867, the year of the purchase of Alaska. Copper, gold, silver, palladium, lead, zinc, and uranium have been produced commercially, and deposits containing iron, antimony, molybdenum, beryllium, rare-earth metals, thorium, and chromite have been investigated, some extensively and others cursorily. Nickel, cobalt, bismuth, and tungsten occurrences are also known. Total production from mines cannot be stated accurately because records are even less complete for this district than for most Alaskan mining districts. Conservative minimum production figures are: copper, 28 million pounds; gold, 45,000 ounces; silver, 200,000 ounces; palladium (containing a little platinum), 11,000 ounces; uranium, 15,000 tons of ore containing 0.80 percent U_3O_8; zinc, 74,819 pounds; and lead, 42,100 pounds.

One of the major lode mining centers was the Kasaan Peninsula area of Prince of Wales Island (18–25, see fig. 25), where the first copper lodes in the district were staked and the most productive mines subsequently developed. The peninsula is underlain chiefly by moderately metamorphosed Paleozoic(?) sedimentary rocks and Mesozoic(?) andesitic greenstone. The greenstone may have been emplaced as sills that broke the older strata into discontinuous slabs which now form crenulated lenses and layers in the greenstone. The rocks are folded and faulted, and intruded by numerous dikes and stocks ranging in composition from pyroxenite to aplite. The lodes, which may have been formed toward the close of the latest intrusive episode, occur in a variety of rock types, including pyroxenite, greenstone, calcareous clastic material, and, rarely, limestone. Most of the productive deposits were small and irregular but of relatively high grade. The chief metallic minerals are magnetite, pyrite, and chalcopyrite, and many of the deposits also contain traces to recoverable amounts of gold and silver. Pyrrhotite and smaller amounts of molybdenite and specular hematite are not uncommon, and sphalerite has been found at the Venus prospect (18). A sample from a pyrrhotite-pyrite vein at the Rush & Brown mine (18) contained 0.07 percent cobalt and a trace of nickel.

About 670,000 tons of ore valued at more than $6,200,000 were mined on the Kasaan Peninsula before production ceased in 1941. At least 10 mines were active, but the Salt Chuck (19), Mamie (23), and It (21) mines, each of which produced more than $1 million worth of copper ore, accounted for more than two-thirds of the total. In addition, appreciable amounts of gold and silver were recovered as byproducts.

The iron and copper resources of the Kasaan Peninsula have been estimated to total more than 4 million long tons of magnetite-bearing rock containing an average of 50 percent iron and 1.5 million short tons of rock averaging something less than 2 percent copper. More than 85 percent of the iron resources are in the Mount Andrew (23) and Poor Man (21) deposits, but, to date, neither has been mined commercially for iron.

The Salt Chuck mine (19) (originally called the Goodro mine and known also as the Joker group) exploited ore bodies in pyroxenite and gabbro. The ore consisted of abundant veinlets and disseminated particles of bornite, a little chalcopyrite and native copper, and recoverable amounts of gold, silver, and palladium that carried a trace of platinum. Locally, magnetite makes up about 10 percent of the lode, and covellite, chalcocite, and secondary copper minerals have also been reported. The approximate average tenor of the ore was 0.9 percent copper, and 0.025 ounce of gold, 0.12 ounce of silver, and 0.053 ounce of palladium per ton. The amount of platinum recovered was negligible. The mine, which operated intermittently from about 1907 to 1941, consisted of three levels and several glory holes connected by raises, ore chutes, and stopes. The lode was also explored by diamond drilling both by the owners and by the U.S. Bureau of Mines. Remaining resources probably are less than the amount of ore already removed.

The Mount Andrew, Mamie, and Stevenstown mines (23), which adjoined one another, collectively produced more than 270,000 tons of copper ore containing minor amounts of gold and silver. The Mount Andrew copper deposits were discovered in 1898, and the first ore shipments were made in 1906; meanwhile, production began at the Mamie and Stevenstown mines in 1905. Ore was shipped from all three properties until 1918. During World War II the Geological Survey and the U.S. Bureau of Mines studied the deposits, and private interests have since carried out additional exploration. The lodes, most of which form contorted tabular masses, are of contact-metamorphic origin and consist of magnetite, chalcopyrite, and pyrite, that, together with calcite and calc-silicate gangue minerals, have replaced sedimentary layers in greenstone. Locally, magnetite has also replaced brecciated greenstone. The ore bodies consisted of several large irregular masses of chalcopyrite (now almost entirely mined out) along the fringes of predominantly magnetite bodies.

The Mamie mine consisted of three glory holes, three adits, and other interconnected underground workings. The mineralized material that remains is chiefly massive magnetite containing finely disseminated chalcopyrite and pyrite. Analyses indicate that the material contains 53–59 percent iron, 0.26–0.90 percent copper, and 1.69–3.88 percent sulfur. The Mount Andrew mine was similar to but less extensive than the Mamie mine, and production was much less. The mineralized rock remaining in the mine and elsewhere on the property is of interest for its iron content, which, in samples taken by the U.S. Bureau of Mines, averaged 47.8 percent. The analyses also showed 0.32 percent copper and 0.71 percent sulfur. Iron resources of the Mount Andrew–Mamie area are estimated to be about 2,684,000 long tons, of which 2,289,000 tons is classified as indicated and the rest is inferred. About 80 percent is in deposits on the Mount Andrew property, mainly in a body south of the mine workings; most of the remainder is at the Mamie mine.

In the Stevenstown mine, chalcopyrite containing a little magnetite was mined from a 550-foot tunnel connected with four glory holes by ore chutes. Small masses of magnetite-bearing rock were left in place while the mine was being operated, but this material is probably leaner than that remaining in the Mount Andrew and Mamie mines.

The chalcopyrite-magnetite deposit on the Poor Man property (21) is similar to the one at the Mount Andrew mine. It was explored by several shafts and adits in the early 1900's, by the U.S. Geological Survey and the U.S. Bureau of Mines during World War II, and most recently by private interests. Originally prospected for copper, the property is currently of interest because of the presence of a magnetite-rich lode about 1,500 feet long, 85 feet wide, and 200 feet deep. Pyrite and subordinate chalcopyrite make up less than 10 percent of the lode, which averages 52.4 percent iron, about 0.04 percent titanium, 0.03 percent phosphorus, 3.72 percent sulfur, 0.25 percent copper, a trace of manganese, and 0.032 ounce of gold and 0.071 ounce of silver per ton. The precious metals are combined with the sulfide minerals.

The It mine (21), one of the major producers of copper ore in the Kasaan Peninsula area, exploited ore bodies in fractured tactite near marble lenses. The ore, which consisted of chalcopyrite and pyrite, subordinate magnetite and hematite, and minor molybdenite, averaged 3.99 percent copper, and about 0.07 ounce of gold and 0.5 ounce of silver per ton. Two small magnetite deposits found during mining were left in place. The mine, which ultimately consisted of several interconnected levels and stopes and three glory holes, was opened in 1907, and ore was shipped until 1919. When the copper ore exposed in the workings was exhausted, the owners tried to locate additional ore by diamond drilling but reportedly were not successful. The nearby Alarm and Brown & Metzdorf mines (21) were on similar deposits. The amount of ore taken from them is not known but undoubtedly was small.

The Rush & Brown copper mine (18) operated almost continuously from 1906 to 1923 and again in 1929. Most of the ore shipped consisted of chalcopyrite and minor pyrite and pyrrhotite that occurred as lenses and networks of veinlets in sheared greenstone. Considerable sulfide-rich rock probably remains below the 500-foot level but would be costly to extract. Some ore was also mined from magnetite-rich rock containing small amounts of pyrite and chalcopyrite. Workings included a glory hole, vertical and inclined shafts, and a series of levels and stopes. Data on production and grade are not available for publication.

An unknown but probably small amount of copper ore was shipped from the Rich Hill (23) mine about 2 miles northwest of the Mount Andrew mine. The ore body consisted of a rich chalcopyrite lens that was mined out, but lower grade material, consisting of chalcopyrite, pyrite, and magnetite in greenstone, remains in a block about 100 feet long, 35 feet wide, and 80 feet deep. Minor production was also recorded from the Uncle Sam (22) and Haida (19) mines.

Several contact-metamorphic iron-copper deposits in the Tolstoi Mountain area of Kasaan Peninsula were prospected between 1900 and 1908. The only lode on which much work was done, however, was the Iron Cap, or Mahoney, property (20), where lenses of magnetite and subordinate chalcopyrite in greenstone and metamorphosed clastic rocks were explored by an adit, trenches and pits, and several hundred feet of diamond drilling. Estimated resources at the Iron Cap and neighboring prospects total about 100,000 long tons of magnetite-bearing rock, the average grade of which probably does not exceed 40 percent iron and 0.25 percent copper.

A small lode on the Big Five claim (20) is in limestone near a diorite dike and consists of stringers and pods of pyrrhotite, magnetite, and chalcopyrite. It was explored by an adit and winze and is of interest mainly because it is one of the few lodes in the area formed by the replacement of limestone. Another lode evidently formed by replacement of limestone by chalcopyrite and other sulfides is on the Big Six claims (24), near the southern tip of Kasaan Peninsula.

Small pods and lenses of magnetite are in banded chert and argillite near Baker Point (22) on the southwestern shore of Kasaan Bay. At the nearby Sunny Day claims (22), a vein adjacent to a porphyry dike carries chalcopyrite and a little gold and silver. Near Kina Cove (25), 4 miles west of Baker Point, chalcopyrite occurs in recrystallized limestone, and chalcopyrite, pyrite, and pyrrhotite have been found in tactite(?) bordering a quartz diorite pluton.

On Granite Mountain (17), a diorite stock that intrudes metamorphosed Paleozoic sedimentary and volcanic rocks is cut by numerous quartz veins containing galena, chalcopyrite, pyrite, sphalerite, and covellite; a little sooty chalcocite, copper, carbonate, gold, and silver; and rare native copper. The Flagstaff mine (17), the only one of the Granite Mountain properties known to have achieved production, was staked before 1905 and operated intermittently until 1941. The workings included a main level 1,120 feet long, a 55-foot winze, and five small stopes. Ore was milled on the property, but recovery was poor. Although production records are not available, it is known that gold, silver, copper, and lead were recovered. At the northern margin of the stock, near Salmon (Karta) Lake (17), pyrrhotite, pyrite, galena, and a little chalcopyrite are disseminated in the metamorphic rocks and in quartz veinlets. A sample of one veinlet contained traces of scheelite, a mineral not reported elsewhere on southern or central Prince of Wales Island.

Near Hollis (26) and near the divide between Maybeso and McGilvery Creeks (16), more than a dozen mines and prospects sought to exploit quartz veins in metamorphosed sedimentary and volcanic rocks cut by dikes of wide-ranging composition. The veins, which carry free gold, pyrite, chalcopyrite, sphalerite, and galena, were discovered about 1900 and prospected solely for precious metals; those rich enough to mine produced only gold and silver, and no attempt was made to recover the base metals.

The Dawson mine (26) (also known at times by other names, including Julia, Dunton, Rogers, Harris Creek, George, Hendy, and Kasaan), is about 2 miles southwest of Hollis. It was discovered about 1900, operated for many years before World War II, and was reopened for several years after the war. It probably produced several thousand ounces each of gold and silver. The lode is in black graphitic slate and consists of a 2- to 6-foot zone of quartz stringers and veins containing relatively sparse pyrite, sphalerite, chalcopyrite, galena, and gold. The mine was developed to a depth of at least 600 feet, and the ore was milled on the property. The Puyallup mine (26), about 1½ miles northwest of Hollis, consisted of three adits and several stopes on a thin auriferous quartz vein. It operated intermittently until at least 1946 and milled an amount of ore not made public but less than that produced by the Dawson mine. About 85 percent of the gold was free milling. Other gold- and sulfide-bearing quartz veins in the Hollis area were worked on a small scale at the Cascade and Crackerjack mines (26). Of the half dozen other prospects explored by underground workings, one or two may also have achieved minor production.

The Lucky Nell mine (16), the largest in the Maybeso Creek-McGilvery Creek divide area, consisted of several hundred feet of tunnels, a shaft, and a winze. It worked a quartz vein said to be rich in sulfides and to contain considerable gold and silver, but only a small amount of ore was shipped, mainly in 1913 and possibly in a few other years. Other prospects in the area were on veins similar to the one on the Lucky Nell property, and although some were explored by surface stripping and short tunnels, there is no record that any was productive.

At the Shelton copper prospect (82), a short tunnel and a 25-foot shaft explored a quartz vein containing 1 or 2 percent pyrite and chalcopyrite. A 6-foot sample taken across the vein indicated only 0.25 percent copper, but gold and silver reportedly were also present.

The Dolly Varden claims (29), a mile east of the head of Twelvemile Arm, were staked about 1900 on quartz veins in marble interbedded with metamorphosed sedimentary and volcanic rocks. The veins, which were only cursorily prospected, contain tetrahedrite, much of which is altered to azurite and malachite. In 1964, State of Alaska Division of Mines and Minerals investigations found pyrite and chalcopyrite in limestone quarries on Twelvemile Creek (29), 3 miles south of the Dolly Varden property.

A shallow shaft and short tunnel on the Marble Heart prospect (28), near the east end of the pass between Twelvemile Arm and Trocadero Bay, explored a galena vein in crystalline limestone. On the Nancy claim (28), a short distance west of the crest of the pass a 25-foot silicified shear zone in greenstone contains pyrite and chalcopyrite, but the size and grade of the deposit are unknown.

In 1913 and 1916 a total of 136 tons of copper ore was shipped from the Big Harbor mine (27) about 3½ miles from the head of Trocadero Bay. Workings originally included a vertical shaft, several levels, and a few small stopes, but they were flooded to within 25 feet of the surface at the time of an examination by the U.S. Geological Survey in 1944. The ore, which occurred as lenses of pyrite and chalcopyrite at the contact of greenschist and quartz-mica schist, contained between 6 and 7 percent copper and probably some gold and silver. A chip sample of mineralized rock exposed in a 75-foot adit on another part of the property contained 1.9 percent copper.

The Martin Saxe prospect (15), near Klawak Lake, is on a quartz-carbonate vein and numerous stringers in andesite porphyry breccia. Where exposed in an opencut, the vein contains abundant galena, pyrite, sphalerite, and a trace of chalcopyrite and assays 0.07 ounce of gold and 1.96 ounces of silver per ton. The country rock between the stringers contains disseminated pyrite and is cut by fractures coated with pyrrhotite-bearing quartz. Development work was not extensive, and no ore is known to have been shipped.

Copper-iron deposits similar to those on Kasaan Peninsula have been mined near Hetta Inlet (31–36) in an area underlain by metamorphosed sedimentary and volcanic(?) rocks intruded by stocks ranging in composition from monzonite to gabbro. The area also is marked by swarms of andesite and basalt dikes that locally make up as much as 50 percent of the bedrock. The principal deposits are contact-metamorphic replacement lodes in bedded calcareous rocks and in fractured volcanic(?) rocks near the margins of the stocks. The metalliferous minerals are magnetite, chalcopyrite, and subordinate to rare pyrite, pyrrhotite, sphalerite, molybdenite, specular hematite, and secondary copper minerals. Beyond the contact-metamorphic zones, veins of massive sulfides (chiefly combinations of galena, chalcopyrite, pyrite, or sphalerite) cut greenstone at the following places: On Gould Island (31) near the head of Hetta Inlet; at a prospect a short distance north of the head of the Inlet; and on one of the claims of the Green Monster group (33) 2 miles south of the head of Hetta Inlet. Samples of pyrrhotite from the Sultana claim (31) on the north shore of the Inlet and from the Iron Crown claim (32) near the abandoned settlement of Coppermount contained 0.1–0.2 percent nickel and traces of cobalt.

The only mine in the Hetta Inlet area with a record of sustained production was the Jumbo mine (32) in Jumbo Basin, which shipped ore from 1907 to 1918 and again in 1923. Production, valued at $1,768,342, included 10,194,264 pounds of copper, 7,076 ounces of gold, and 87,778 ounces of silver. The mineralized rock visible in the 2,300 feet of workings still accessible in 1944 contained lenses and veinlets of chalcopyrite, spotty concentrations of molybdenite, a few masses of specular hematite, and a little pyrite, pyrrhotite, and sphalerite. Appreciable chalcopyrite is reportedly in some of the lowest (now-flooded) workings, but the ore in the accessible part of the mine apparently has been exhausted.

Several other copper and precious-metal mines near Hetta Inlet operated for a few years, but their aggregate production was only a fraction of that of the Jumbo mine.

The lodes of greatest current interest in the Hetta Inlet area are contact-metamorphic magnetite deposits near the Jumbo mine. They were sampled in 1944 by the U.S. Bureau of Mines, which estimated that the three largest lodes, the so-called Magnetite Cliff bodies, contain a total of about 370,000 long tons of material carrying 45.2 percent iron, 0.73 percent copper, and 0.01 ounce of gold and 0.08 ounce of silver per ton (weighted averages for 637.5 lineal feet of channel samples). The sulfur content of 10 composite samples was about 2 percent. Five smaller deposits on the Jumbo property probably aggregate less than 50,000 tons of material whose iron and copper content is comparable to that of the Magnetite Cliff bodies.

The Copper Mountain mine (32), first operated in 1902, exploited rich surficial concentrations of secondary copper carbonate minerals

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derived from primary chalcopyrite. The deposit was in skarn at the contact between diorite and limestone. When the surficial ore was exhausted, the tenor of the unoxidized lode proved to be too low to constitute ore, and the mine and its 250-ton smelter at Coppermount were closed in 1907.

The Houghton prospect (31), about 2 miles north of the Jumbo mine, explored contact-metamorphic lodes containing chalcopyrite, magnetite, pyrite, and pyrrhotite. There is no record of production from this prospect or from similar deposits on the Green Monster and Rex claims (33) several miles to the east. Other claims were staked on similar occurrences in the area, but little beyond the required assessment work seems to have been done.

The Corbin mine (32), in greenstone near tidewater on Hetta Inlet, worked a fissure vein consisting of pyrite, subordinate chalcopyrite, and minor quartz and calcite. In 1905, an unknown but probably small amount of ore averaging about $3 per ton in gold and silver was shipped to the smelter at Coppermount. A similar sulfide vein at the Copper City mine (34), 7 miles south of the Corbin property, was mined in a small way for several years. The ore differed from that at the Corbin mine in carrying 6–9 percent zinc and somewhat more gold and silver.

On the northwest shore of Nutkwa Lagoon (35), a quartz-calcite vein with small quantities of pyrite, chalcopyrite, and galena was prospected by a 400-foot adit and a 50-foot winze. Near the head of Keete Inlet (36) a little work was done on a shear zone containing lenses and disseminated particles of chalcopyrite, pyrite, and possibly bornite.

The Khayyam and Stumble-On (also known as the Mammoth) lodes are in metamorphosed sedimentary and volcanic rocks cut by diorite near the divide south of the head of McKenzie Inlet (30). In general, they are elongated lenses parallel to the schistosity of the enclosing metamorphic rocks, and consist of pyrite, disseminated chalcopyrite, and a little pyrrhotite, sphalerite, and magnetite. In 1945 the U.S. Bureau of Mines sampled both properties. Analyses of 31 samples from the Khayyam mine showed as much as 8.1 percent copper and 0.28 ounce of gold and 2.5 ounces of silver per ton; 7 of the samples were also analyzed for sulfur, which ranged from 6.8 to 52.3 percent. Samples from the Stumble-On property assayed a little higher in copper, but lower in precious metals.

The Khayyam lode was staked in 1899 and mined between 1901 and 1907; it was reopened in 1916, but no ore is known to have been shipped then. Minimum production probably totaled 100,000 pounds of copper and several thousand dollars worth of gold and silver. Workings included more than 1,000 feet of adits and several stopes.

Too little of the history of the Stumble-On property is known to determine how much ore, if any, was shipped.

Claims were staked about 1900 on other showings of sulfide minerals near the head of McKenzie Inlet, but because they are not mentioned in reports published since 1902, it is likely that the occurrences were not large or rich enough to justify much exploratory work. The Hatchet claim (81) probably falls in this category.

Several lodes, prospected in the early 1900's for gold, silver, and base metals, are on the west side of the South Arm of Cholmondeley Sound (37). They are in hydrothermally altered schist, phyllite, and marble cut by andesitic and basaltic dikes.

At the Friendship copper prospect (37), trenches and shallow shafts explored irregularly distributed bunches of chalcopyrite and bornite at the contact between schist and marble. Samples are said to have assayed as much as 26 percent copper and $1 per ton in gold.

A 300-foot tunnel on the Ketchikan Copper Company's prospect (37) explored veins and disseminated grains of pyrite, chalcopyrite, and galena(?) in schist. The material was reported by the owners to carry copper, gold, silver, and lead ranging in value from $2.50 to $25 per ton.

The Hope and Moonshine prospects (37) were on silver-, lead-, and zinc-bearing veins in marble and schist. At the Hope claim, explored by a shallow shaft and opencuts, the metallic minerals are sphalerite and galena carrying a small amount of silver. On the Moonshine property, a 100-foot shaft and 200-foot tunnel explored a lode said to contain chalcopyrite, galena, and sphalerite and to carry considerable silver. In 1947, the Research (Polymetal) lead-zinc claim (37) was staked on ground that may have been part of the old Hope or Moonshine claims.

The Lucky Boy group (38), staked in the early 1930's on ground covered by older lapsed claims, is along the southwestern and southern shores of Dora Lake about a quarter of a mile south of the head of Dora Bay. The mineral deposits, which have never been mined commercially, consist of four quartz-calcite breccia veins that transect the foliation of schist and contain sphalerite, galena, chalcopyrite, pyrite, and small amounts of gold and silver. Exploration included surface pits, two adits, a winze, and three small stopes. One vein contains about 1,500 tons of material carrying 3 percent zinc and an insignificant amount of lead; the only other vein sufficiently well exposed to allow an estimate of its contents probably contains about 7,000 tons of material averaging 0.33 percent zinc and 1 percent lead. The highest copper content of samples collected by the U.S. Geological Survey from these deposits during World War II was 0.2 percent.

Many claims were staked about 1900 on low-grade auriferous lodes near Kitkun Bay (39) and near the east shore of Cholmondeley Sound about 5 miles south of its entrance (40). The lodes consist of quartz veins that cut metamorphosed clastic, volcanic, and carbonate rocks and carry pyrite, chalcopyrite, sphalerite, galena, and generally small amounts of gold and silver. A few were prospected by adits, but work consists mostly of opencuts. The Croesus lode (39), near the head of Kitkun Bay, was probably the most thoroughly explored, and a little ore may have been shipped from it.

The area near Dolomi (41), an abandoned town on an arm of Port Johnson, was the scene of much prospecting from 1898 until the 1930's, and several lodes were worked for a probable total of between 1,000 and 5,000 ounces of gold. The lodes, in rocks similar to those at Kitkun Bay, are breccia veins 2–12 feet thick that consist of limestone fragments cemented and largely replaced by quartz, gold (most of which is free milling), tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite. Most of the production was from the Valparaiso mine (41), about 1¼ miles northwest of Dolomi. The mine, consisting of four or more shafts and several levels, opened about 1900 and is known to have been worked as recently as 1933, possibly for a mill test. One early lot of ore is said to have yielded $185 per ton in gold and silver. The Golden Fleece mine, 2 miles north of Dolomi, operated between 1901 and 1905 and produced ore worth $40–$60 per ton in gold and silver. The neighboring Fortune claims were developed in a small way between about 1900 and 1922, but only test shipments of ore were made. Other lodes in the Dolomi area were prospected, but none is known to have been productive.

Mines that produced copper ore, and several copper and gold prospects that were nonproductive, are at Niblack Anchorage (43) and near the North Arm of Moira Sound (42). The Niblack mine (43), at the head of Niblack Anchorage, operated from 1902 to 1909 and consisted of a 300-foot shaft and about a mile of underground workings. Production, estimated on the basis of incomplete records, was at least 1,400,000 pounds of copper, 1,100 ounces of gold, and 15,000 ounces of silver. The ore bodies were replacement deposits in schistose greenstone and consisted of masses of chalcopyrite and pyrite containing small amounts of sphalerite, galena, and hematite. The precious-metal content of the ore ranged from $1.50 to $2.50 per ton. Similar but lower grade deposits south of Niblack Anchorage were explored between 1900 and 1905 by several hundred feet of underground workings at the Dama, or Copper Cliff, prospect (43), and by two tunnels on the Lookout claims (43). Several other occurrences of copper sulfides within a mile or two of the Niblack mine were prospected about the same time.

The Cymru mine (42), three-quarters of a mile from the head of the North Arm of Moira Sound, exploited sulfide-bearing quartz veins in marble. The mine, consisting of shafts and several hundred feet of adits and drifts, is known to have operated in 1906–7 and 1915–16 and to have produced a minimum of about 155,000 pounds of copper, 1,500 ounces of silver, and a little gold. Accounts of the mine are too skimpy to determine if it operated at other times, and whether it finally closed because the ore was exhausted or for some other reason.

The Navaho (Hope) and Westlake claims (42) were staked about 1900 on quartz veins considered potentially valuable for their gold content, which was said to be as high as $60 per ton. The veins reportedly also contain galena, sphalerite, pyrite, and graphite. Other veins, known to carry chalcopyrite and pyrite, were prospected near the North Arm of Moira Sound in the early 1900's, but they probably were too lean to mine.

At the head of the South Arm of Moira Sound (53), a narrow opencut 8 feet long exposed auriferous calcite veins in a fault zone cutting metamorphosed volcanic rocks. The only primary metallic minerals in the veins are pyrite and a little gold.

Many claims were staked in the early 1900's on copper and gold lodes in metamorphic roof pendants and plutonic rocks in the McLean Arm–Mallard Bay area (55, 56). Despite the extensive early prospecting, the only lode with recorded production was at the Nelson and Tift mine (55), discovered in 1935. The deposit, which was mined out, was a lens composed mostly of auriferous pyrite and probably other sulfides in a roof pendant of cherty marble in quartz diorite. About 1,300 tons of ore was shipped, from which gold, silver, some copper, and a little lead were recovered. The precious-metal content ranged from 0.12 to 2.08 ounces of gold and from 0.05 to 0.40 ounce of silver per ton; data on the copper and lead content are not available.

Metalliferous quartz-calcite-barite veins between the south shore of McLean Arm and the head of Mallard Bay (56) were explored by opencuts, adits, and a few drifts. The veins follow steeply dipping faults in monzonite and contain pyrite, chalcopyrite, hematite, bornite, gold, and secondary iron and copper minerals. Assays of veins exposed in two of the adits showed 0.4–5.7 percent copper and 0.02–0.58 ounce of gold per ton. At another prospect near the head of Mallard Bay, two now-inaccessible shafts and other workings explored a 3-foot fault zone locally carrying pyrite, chalcopyrite, bornite, specular hematite, and secondary copper minerals. Small quantities of copper minerals were also found at several other places in the area.

In 1958, claims were staked on magnetic anomalies associated with magnetite- and hornblende-rich concentrations in diorite on a ridge north of McLean Arm (55) and with magnetite-bearing pyroxenite near the head of Mallard Bay (56).

About 1915, several claims were staked at Nichols Bay (57) on chalcopyrite-bearing quartz veins in granitic rocks and andesitic greenstone, and on chalcopyrite pods in limestone interbedded with the greenstone, but little work was done.

Near Tah and Hunter Bays (52), two lodes consisting of quartz veins containing irregular bunches of magnetite, chalcopyrite, and pyrite are in volcanic rocks cut by granitic dikes. The deposits were explored to some extent, but the work was insufficient to determine their size and grade.

On Sukkwan Island, lodes prospected for copper occur in metamorphosed sedimentary and volcanic rocks intruded successively by pyroxenite and quartz diorite. The Lakeside copper prospect (46), explored in 1916 by a 51-foot shaft and a 41-foot crosscut, consists of chalcopyrite-bearing rock in shear zones along the contact between pyroxenite and greenstone. The nearby Gould prospect (46) was staked in the same year on showings of chalcopyrite, pyrrhotite, and pyrite at the contact of quartz diorite and schist.

Dall Island, underlain mainly by limestone and clastic rocks locally metamorphosed by dioritic and granitic plutons, was the site of considerable prospecting early in the 20th century. Many claims, for example, were located on quartz veins and stringers in schist near McLeod Bay (51), but interest in them seems to have waned by the end of World War I. The lodes, most of which were prospected for gold, contain chalcopyrite, pyrite, and galena, mainly in the veins, but the sulfides are also sparsely disseminated in the enclosing schist. A few stringers reportedly contained appreciable gold, but on the whole the deposits were low grade, and despite considerable development work, no production was reported.

The Mount Vesta prospect (50), near Rose Inlet, was explored by opencuts and an 80-foot tunnel. The deposit, consisting of veinlets of tetrahedrite, chalcopyrite, galena, and sphalerite in limestone, was said to carry appreciable gold and silver but evidently was not rich enough to mine. The Lucky Strike claim (50), on the crest of Dall Island, was staked on a shear zone carrying chalcopyrite and quartz; the amount of development work done, if any, is unknown.

Near Coco and Sea Otter Harbors, an area noted more for limestone resources than for metalliferous lodes, claims were staked on several showings of sulfide minerals. At the Silver Star prospect (45), two parallel veins in limestone that contain sphalerite, chalcopyrite, and galena were explored by an adit and two drifts. Assays of a sample from one vein showed notable amounts of gold, silver, zinc, lead, and copper. At the nearby Shellhouse and Miller properties (45) and on the Yellowstone group (44), the lodes are quartz-calcite veins carrying chalcopyrite and pyrrhotite. Prospecting at the Moonshine claim (44) is said to have disclosed argentiferous galena, but too little work was done to determine the size or grade of the deposit.

The McCullough copper prospect (12), on northern Prince of Wales Island, was staked in the early 1900's on a quartz-breccia vein that cuts graywacke and argillite and contains chalcopyrite and smaller amounts of pyrite, sphalerite, and secondary copper minerals. Three samples of the vein, which was explored by a shaft and several opencuts, assayed 0.7, 0.9, and 3.3 percent copper.

Sulfide deposits on Kosciusko Island near Dry Pass (9) and at the head of Devilfish Bay (10) occur in an area underlain by Silurian limestone and graywacke intruded by a diorite pluton. Most of the lodes are in tactite at the margins of the pluton, but a few are in relatively unaltered limestone or in the pluton itself.

The Dry Pass area was first prospected for gold, and the earliest claims, including those staked by Castle and Co. (9) in 1901, were on quartz veins said to contain auriferous pyrite. The company reportedly had its own stamp mill, but it is not known if any ore was actually processed. The main interest in the Dry Pass lodes, however, has centered on their molybdenite content. The greatest exploration was at the Shakan prospect (9), about half a mile south of the abandoned village of Shakan, where a 1- to 10-foot breccia zone in hornblende diorite contains molybdenite and smaller amounts of pyrite, pyrrhotite, chalcopyrite, sphalerite, magnetite, and secondary iron and copper minerals. The metallic minerals aggregate about 5 percent of the lode, whose measured and indicated resources are between 10,000 and 20,000 tons of material containing about 1.5 percent MoS_2. A little molybdenite is also disseminated in the diorite outside the breccia zone, which is commonly bounded by gouge-filled fractures. During and shortly after World War I the property was developed by 570 feet of tunnel and 14 opencuts, but development work was halted when the price of molybdenum dropped after the war, and no ore was shipped.

The Lillie deposit (9), a mile and a half north of the Shakan prospect, consists of molybdenite and chalcopyrite disseminated in a 100-foot tactite zone in diorite. Development work was restricted to several trenches, one of which disclosed a small mass of magnetite, chalcopyrite, and pyrite.

Other lodes containing molybdenite or various combinations of pyrite, pyrrhotite, chalcopyrite, molybdenite, and galena were discovered at nearly a dozen places in the Dry Pass area. Lodes carrying metalliferous minerals other than sulfides include a scheelite-bearing quartz vein in a marble lens in a shear zone; disseminated scheelite in silicified(?) rock near a marble-diorite contact; and magnetite, reportedly in a 2½-foot zone at the contact between a diorite dike and marble.

Chalcopyrite, molybdenite, and magnetite deposits similar to those near Dry Pass have been found near the head of Devilfish Bay (10), about 5 miles southwest of Shakan. The only work done on any of these showings was small-scale trenching.

In 1952, U.S. Geological Survey geologists found a small galena-bearing vein at the contact between diorite and calcareous sedimentary rocks near Tokeen (11) on Marble Island.

Lodes prospected for molybdenum on eastern Baker Island (14), about a mile south of Port San Antonio, are in quartz diorite and consist of intensely brecciated and silicified zones containing many quartz veinlets carrying molybdenite and small amounts of pyrite, arsenopyrite, and pyrrhotite(?). The metallic minerals are concentrated in transverse fractures in the veinlets and near the borders of the veinlets. The deposits were discovered and staked in 1931, diamond drilled by private interests in 1932 and 1943, and appraised by the U.S. Geological Survey in 1943. Their molybdenite content was estimated to be less than 0.1 percent and probably less than 0.05 percent. Although the deposits contain several million tons of mineralized rock, further development did not appear to be warranted. The only other mineral deposit known on Baker Island is a stockwork of metalliferous quartz veinlets in argillite near the head of Port San Antonio (14). The veinlets, explored by opencuts, contain sphalerite, galena, and pyrite, and reportedly carry considerable gold.

On northern Noyes Island (13), quartz veins, probably at the contact between a pluton and bedded rocks, contain chalcopyrite and pyrrhotite and assay 0.1–0.2 percent nickel. Molybdenite is also reported on Noyes Island, but nothing is known about its mode of occurrence.

The Helm Bay area (48, 49), on the east coast of Cleveland Peninsula, was the site of much early prospecting for gold. The lodes are in a mile-wide belt of schistose volcanic rocks extending from the head of Smuggler Cove (49) to and beyond the head of Helm Bay (48), and consist of quartz veins containing free gold, pyrite, a little galena and arsenopyrite, rare chalcopyrite and bornite, and, reportedly, telluride minerals. They were discovered about 1897 and mined intermittently until World War II. The history of the Helm Bay lodes is so fragmentary and inexact that no estimates of the tenor of the ore or of production are possible; it seems reasonable to assume, however, that any gold-mining camp active for more than 40 years produced gold and silver measurable in thousands of ounces. The mine with the longest history of activity, the Gold Standard (48), began operations in 1898 and reported some production as recently as 1940. Other producers were the Helm Bay King (48), Melville (48), Blue Jay (Libe) (48), Gold Mountain (49), and Old Glory (American Eagle) (49) mines; their aggregate gold production, however, was probably less than that of the Gold Standard mine.

An antimony deposit at Caamano Point (79) on the southwestern tip of Cleveland Peninsula was discovered about 1916 and explored by two shallow shafts and several opencuts. It is in brecciated partly dolomitized and silicified limestone and consists of veinlets and irregular masses of stibnite. The only ore shipped from the property was a 1-ton test shipment. Geochemical prospecting near Caamano Point by the U.S. Geological Survey in 1952 and 1953 located other stibnite lodes concealed by several feet of muskeg and peat. The buried lodes were subsequently explored by drilling, trenching, and underground workings, and the antimony content of one was found to average 1.3 percent. Tonnage estimates have not been released.

Gold lodes discovered about 1900 on both sides of Tongass Narrows near Ketchikan are in metamorphic rocks cut by dikes and consist of quartz veins containing a little visible free gold, and pyrite, pyrrhotite, galena, sphalerite, arsenopyrite, and chalcopyrite. Tetradymite, a bismuth telluride, was found on the Hoadley prospect (62).

The lodes on the Revillagigedo Island side of Tongass Narrows were not developed extensively; some ore from the Hoadley prospect (62) was treated in an arrastre, and a test shipment from the Wildcat lode (62) was reported to have yielded considerable gold.

On the Gravina Island side of the Narrows, the Goldstream mine (63) consisted of two shafts, several hundred feet of drifts, and stopes from which several thousand tons of ore was mined. Returns are said to have been sufficient to amortize the cost of all improvements, including a 5-stamp mill. The mine operated more or less continuously until abut 1913, the last year of recorded production. A mill test of ore from the neighboring Heckman prospect (63) reportedly indicated $3.50 worth of precious metals per ton. Quartz veins on the Easter claim (60), near the northern end of Gravina Island, were reported by the owners to assay $3–$400 per ton in gold. If these values were correct, the amount of high-grade material must have been small, for the prospect was not mentioned in reports published after 1902. In 1899 and 1900 much work was done on the Six Point and White Knight claims (61) on Gravina Island near Vallenar Bay, but no ore was shipped. The Six Point prospect was on a thin quartz vein carrying chalcopyrite and pyrite; the White Knight explored small masses of chalcopyrite, pyrite, and pyrrhotite in greenstone.

Lodes were also prospected for gold, silver, and copper in the vicinity of Seal Cove and Dall Head (64) at the southern tip of Gravina Island. They are in shear zones in metamorphic and igneous rocks and consist of quartz veins containing chalcopyrite, subordinate pyrite and sphalerite, sparse bornite and specular hematite, and, reportedly, small amounts of gold and silver. Most of the prospecting took place about 1900, when more than 20 claims were staked. Several claims were explored by underground workings, and a few were eventually patented, but activity seems to have ended by about 1915 without any recorded production.

Metalliferous lodes are known on Annette Island, an Indian reservation since 1891, but because white prospectors and miners were barred from the island by the terms of the act that set up the reservation, little is known about the mineral deposits and no mines have ever been developed. Before 1891, however, prospectors had staked a few claims and explored them to a limited extent. On the southeastern part of the island (70), small veins, some of which carry pyrite, chalcopyrite, galena, tetrahedrite, gold, and silver, are in metamorphic rocks near the contact of a granitic pluton. Near Cascade Inlet (67), quartz veins contain gold, some of which is associated with pyrite and tetrahedrite. West of Crab Bay (68), quartz veins near the contact of limestone and quartzose schist contain tetrahedrite and smaller amounts of pyrite, galena, and sphalerite. One of the veins also contains stringers of barite several inches thick. On the northern part of the island, auriferous quartz veins that contain minor amounts of pyrite and galena have been found near Nadzaheen Cove (66), and occurrences of copper and antimony minerals have been reported at the head of Annette Bay (66). There are also unconfirmed reports of copper minerals on Cat Island (74), which is near Annette Island but not part of the Indian reservation.

Most of the mining on Revillagigedo Island was near the head of Thorne Arm (77), where base- and precious-metal lodes are in metamorphic rocks cut by granite and diorite stocks and dikes. The lodes are gold- and silver-bearing quartz veins that carry varying amounts of pyrite, pyrrhotite, galena, and sphalerite; chalcopyrite and iron oxide minerals, fairly common farther to the west, have not been reported. By 1902, the Sealevel mine (77) had been developed by a 125-foot shaft and by two levels totaling more than 1,200 feet, and more than 20 other claims had been staked nearby. Several of these claims were also prospected by shafts and tunnels, but on a much more modest scale. The Sealevel mine and its mill, however, soon became the object of litigation that ultimately halted operations. In 1915 the mine was partly dewatered but did not operate commercially; a little ore, however, was produced from the neighboring Goo Goo property (77). Attempts to revive the camp continued at least into the late 1920's, but the only recorded production was a small test shipment from the property of the Peerless Consolidated Mining Company (77) in 1927. The average grade of ore from the Sealevel lode, as reported in 1902, was $5.35 per ton in gold, and assays as high as $20 and $30 per ton were not uncommon. Concentrates were said to range from $300 to $500 a ton, but neither the amount of gold produced nor the silver tenor of the ore is known.

George Inlet, a deep embayment on the southwest coast of Revillagigedo Island a few miles east of Ketchikan, was the site of considerable underground work at three prospects, one of which was developed into a mine. The geologic setting and metal content of the lodes are generally similar to those at the head of Thorne Arm, except that the George Inlet deposits contain small amounts of chalcopyrite.

The Mahoney mine (formerly called Asche's group), on the west shore of George Inlet (65), was the source of the only zinc concentrates produced commercially from an Alaskan mine. The deposit, discovered before 1900, is a sphalerite- and galena-bearing vein in slate. It averages about a foot thick for a length of 350 feet and was formed by fracture filling and by minor replacement of the country rock. Although the vein was explored from time to time by opencuts and underground workings, it was not worked until 1947, when concentrating equipment was installed and 400–500 tons of ore was mined. In 1947–48, 100 tons of flotation concentrates containing 2 ounces of gold, 347 ounces of silver, 214 pounds of copper, 42,086 pounds of lead, and 74,819 pounds of zinc was shipped to smelters in Idaho and Canada. There was no other recorded production.

The Londevan property (78), near sea level 2½ miles south of the Mahoney mine, was explored by several shafts, a crosscut more than 2,000 feet long, and over 2,000 feet of drifts. Some ore was mined and piled near the water's edge but not shipped. The deposit comprises several small quartz veins and a main vein that is 3–4 feet thick where intersected by the long crosscut; the veins contain 5 percent or less pyrite, subordinate sphalerite and galena, and a little chalcopyrite and gold. The average tenor of the deposit has not been made public but was regarded by the owners in 1913, the last year in which activity at the property was reported, as rather low. Two short drifts on the Peterson prospect (78), about 2 miles south of the Londevan property, explored a predominantly quartz-calcite vein containing pyrite, galena, sphalerite, pyrrhotite, and chalcopyrite.

Gold and silver were also reported, but no data on tenor are available.

Zinc-copper deposits near the head of Moth Bay (71) were explored between 1911 and 1913 by a 75-foot adit and 100-foot inclined winze. In later years the deposits were further prospected by open-cuts, another adit, an exploratory drift, and nine short crosscuts. In 1943 the prospect was examined by the U.S. Geological Survey; in 1950 it was sampled and drilled by the U.S. Bureau of Mines. The lodes are thin layers of muscovite schist partly replaced by pyrite, pyrrhotite, sphalerite, chalcopyrite, bornite, covellite, magnetite, galena, silver, gold, and small amounts of quartz and calcite. Measured and indicated resources consist of about 100,000 tons of material containing 7.5 percent zinc and 1 percent copper; about 3,600 tons containing 2 percent zinc and 0.5 percent copper; and about 10,000 tons containing nearly 3 percent copper and little or no zinc. About 100,000 additional tons of lower grade material is inferred.

A zinc-bearing lode that may be similar to the one at Moth Bay is on the west shore of Behm Canal near Ella Point (73), where pyrite and sphalerite reportedly replace sericitic schist.

Near Roe Point (72), on the mainland shore of Behm Canal, pyrite, pyrrhotite, chalcopyrite, and, reportedly, gold and silver, together with quartz and calcite, form a replacement(?) lode in mica schist. The deposit was discovered in 1898 and by 1908 had been explored by about 100 feet of underground workings.

A few precious-metal- and copper-bearing lodes were prospected in the 1920's near Banded Mountain (58) in the northeastern corner of the Ketchikan district. At the Glacier group of claims, thin quartz veins cut graywacke and contain abundant pyrite, small amounts of pyrrhotite and chalcopyrite, and sparse galena. Assays showed $0.80 in gold and 6 ounces of silver per ton and 3 percent copper, but little work was done. The nearby Edelweiss claim reportedly was on a quartz vein carrying galena, pyrite, gold, and silver. Elsewhere in the Banded Mountain area, many similar veins, all undeveloped, were found in graywacke cut by altered gabbro dikes.

Other lodes in the northeastern part of the district are in an area drained by the Chickamin River and underlain by granitic plutons and by large roof pendants of metamorphic rocks. Many schist masses contain disseminated pyrite, pyrrhotite, and chalcopyrite, and a few glassy quartz veins carrying small amounts of pyrite, molybdenite, and gold have been found in metamorphic rocks along the Chickamin River near Behm Canal. In addition, pyrite veinlets containing a little chalcopyrite and magnetite reportedly occur in a persistent shear zone on the South Fork (83) of the Chickamin River.

The only claim known to have been staked along the Chickamin River below Banded Mountain, however, was the Gnat (59), staked about 1900 on a glassy quartz vein carrying sparse pyrite, molybdenite, and probably gold.

Iron deposits that are parts of ultramafic plutons have been investigated at various times since 1940 by the U.S. Geological Survey and by private interests. Unlike the chalcopyrite-magnetite bodies on Kasaan Peninsula and near Hetta Inlet, however, the plutons are of interest almost solely for their iron content.

Probably the best known magmatic iron deposit is near Union Bay (47), on Cleveland Peninsula. There, where a composite ultramafic lopolith has intruded gabbro and metamorphic rocks, a large zone of pyroxenite containing 10–25 percent magnetite, some ilmenite, and a little chromite forms the northern and western part of the lopolith. The magnetite content of the pyroxenite is about 20 percent by weight throughout an area of about 3 square miles.

Of several ultramafic plutons that crop out on Duke Island (76) and on the Percy Islands (75), the two largest on Duke Island and the one on the Percy Islands include magnetite-bearing hornblende pyroxenite. The deposits were explored by diamond drilling, but data on grade and tonnage have not been released.

A concentrically zoned ultramafic body exposed on the Blashke Islands (80) contains sulfide minerals—principally pyrrhotite and chalcopyrite—in its marginal pyroxenite and gabbro phases, but unlike the Union Bay, Duke Island, and the Percy Islands plutons, it contains no magnetite. Analyses of the sulfide-bearing gabbro showed 0.0086–0.016 percent copper, 0.03–0.05 percent nickel, and somewhat less than 0.1 ounce per ton of platinum-group metals (mainly palladium).

Yellow Hill (69), 2 miles south of Metlakatla on Annette Island, is underlain by a poorly exposed small ultramafic plug. The plug, mainly of serpentine that probably replaced dunite, may be bordered on one side by a thin zone of pyroxenite. The only metallic mineral reported is a little chromite.

The Bokan Mountain uranium-thorium lodes (54), the only commercially productive uranium deposits in Alaska, are in an area underlain chiefly by plutons ranging in composition from ultramafic to felsic. Most of the lodes are genetically related to a peralkaline granite stock and occur either within it or in a contact aureole that surrounds it. The radioactive minerals have four modes of occurrence: concentrations of accessory minerals in the peralkaline granite; veins or local replacements of hydrothermal origin in or near fractures; disseminated primary minerals in pegmatite and aplite dikes; and minerals of hydrothermal origin occupying interstices in metasedimentary rocks in the contact aureole. Many radioactive minerals and a few that contain rare-earth elements, niobium, and beryllium have been identified. Pyrite, galena, and fluorite are locally abundant. The Ross-Adams deposit on Bokan Mountain was discovered in 1955 and brought into production in 1957, when about 15,000 tons of ore containing more than 0.80 percent U_3O_8 was shipped. Subsequent shipments, however, were smaller owing to unfavorable market conditions rather than to depletion of the deposit. Radioactive minerals have also been found in small pegmatite dikes near Gardner Bay (55) and in altered andesite(?) dikes on the headland between Stone Rock and Mallard Bays (56).

Significant concentrations of radioactive minerals were discovered in the early 1950's near Salmon Bay (7, 8), on northeastern Prince of Wales Island. There, carbonate-hematite veins carrying parisite, bastnaesite, fluorite, thorite, zircon, topaz, monazite, pyrite, magnetite, chalcopyrite, and marcasite occur in Silurian graywacke cut by lamprophyre, basalt, and phonolite dikes. The principal radioactive element is thorium. Few of the veins are more than a foot thick, and although some can be traced for about 100 yards, most are relatively short.

The largest deposit in the Salmon Bay area is on Pitcher Island (8), where the Paystreak vein averages 2.4 feet in thickness and is exposed for 100 feet at extreme low tide. It can be seen to extend about 40 feet farther under water, but its inland extension is hidden by dense forest cover. Calculations based on sampling the accessible part of the vein indicate that its average equivalent thorium content is 0.16 percent, or 70 pounds of thorium per foot of depth for the 100-foot section. The content of rare-earth oxides (including thorium oxide) ranges from 0.07 to 0.73 percent; in one selected sample of high-grade material it was 5 percent.

Veins similar to those on Pitcher Island also occur near the north entrance to Salmon Bay (7).

Additional information on this district is given in the following references: Brooks (1902); Buddington (1925, 1926, 1929); Buddington and Chapin (1929); Chapin (1916, 1918, 1919a); Fosse (1946); Gault (1945); Herbert and Race (1964); Herreid and Kaufman (1964); Holt and Sanford (1946); Houston, Bates, Velikanje, and Wedow (1958); Kennedy (1953); Kennedy and Walton (1946b); MacKevett (1964a); Robinson (1943); Robinson and Twenhofel (1953); Ruckmick (1957); Sainsbury (1957, 1961); Smith, P. S. (1914, 1942); Taylor and Noble (1960); Twenhofel, Reed, and Gates (1949); Twenhofel, Robinson and Gault (1946); Warner, Goddard, and others (1961); Wedow and others (1953); Wright, C. W. (1909, 1915); Wright and Wright (1906, 1908); Wright and Fosse (1946); Wright and Tolonen (1947).

KUPREANOF DISTRICT

The Kupreanof district (fig. 27) is bounded on the north by Frederick Sound, on the south by Sumner Strait, on the east by Wrangell Narrows, and on the west by Chatham Strait between Frederick and

Christian Sounds; it includes Kuiu, Kupreanof, Woewodski, Coronation, and numerous smaller nearby islands.

Lodes in the Kupreanof district contain gold and silver, traces of platinum, and lead, copper, zinc, and barium minerals.

The earliest prospecting was on Woewodski Island (7, see fig. 27), where metamorphosed sedimentary and volcanic rocks of Paleozoic age are cut by dioritic intrusives. Claims were staked along both the east and west coasts of the island about 1900, and a map published in 1908 shows a dozen crosses labeled "Finzen's prospects" near the east coast; nothing, however, is known about these occurrences. The Helen S. group (7), staked in 1902 near the northwestern corner of the island, is on quartz veins in interbedded black slate and schistose greenstone, and on a disseminated lode about 40 feet wide and at least 1,000 feet long in greenstone and diorite (or altered gabbro). Both types of deposit contain galena, sphalerite, pyrite, and gold, most of which is combined with the sulfides. Development work, mostly in 1903–4 and 1907, consisted of sinking two shafts and driving about 650 feet of drifts and crosscuts. A 20-stamp mill processed an unknown but certainly small amount of ore reported to have averaged $3.66 a ton in gold. Work was also done in 1915, but no ore was shipped; shortly thereafter the surface improvements were dismantled and the property abandoned.

The Hattie lode (7), near tidewater about 2½ miles south of the Helen S. prospect, was explored by about 500 feet of underground workings, but no ore was mined. The deposit is in sheared greenstone and consists of quartz fissure and breccia veins containing 3 percent or less of pyrite, chalcopyrite, galena, sphalerite, and gold.

More than 1,000 feet of underground workings at the Maid of Mexico mine (7), near the center of Woewodski Island, exploited a quartz vein at the contact between slate and siliceous dolomite. The vein, which was traced for 2,000 feet, is 2–6 feet thick and contains sphalerite, pyrite, argentiferous galena, some visible free gold, and a little chalcopyrite. Small test shipments were made in 1917 and 1929, and ore was milled on the property in 1931 and 1933. The last year in which activity was reported was 1939. Total production probably did not exceed 100 ounces each of gold and silver. Minor exploration on a neighboring claim has been reported, but the type of deposit and results of the exploration are not known.

A barite deposit was discovered in 1913 by the U.S. Geological Survey on one of the Castle Islands (6) in Duncan Canal. The deposit, subsequently explored by private interests, may have been formed by preferential replacement of one or more limestone beds intercalated with schist. It is estimated to contain about 60,750 tons of barite carrying small amounts of sulfide minerals, quartz, mag-

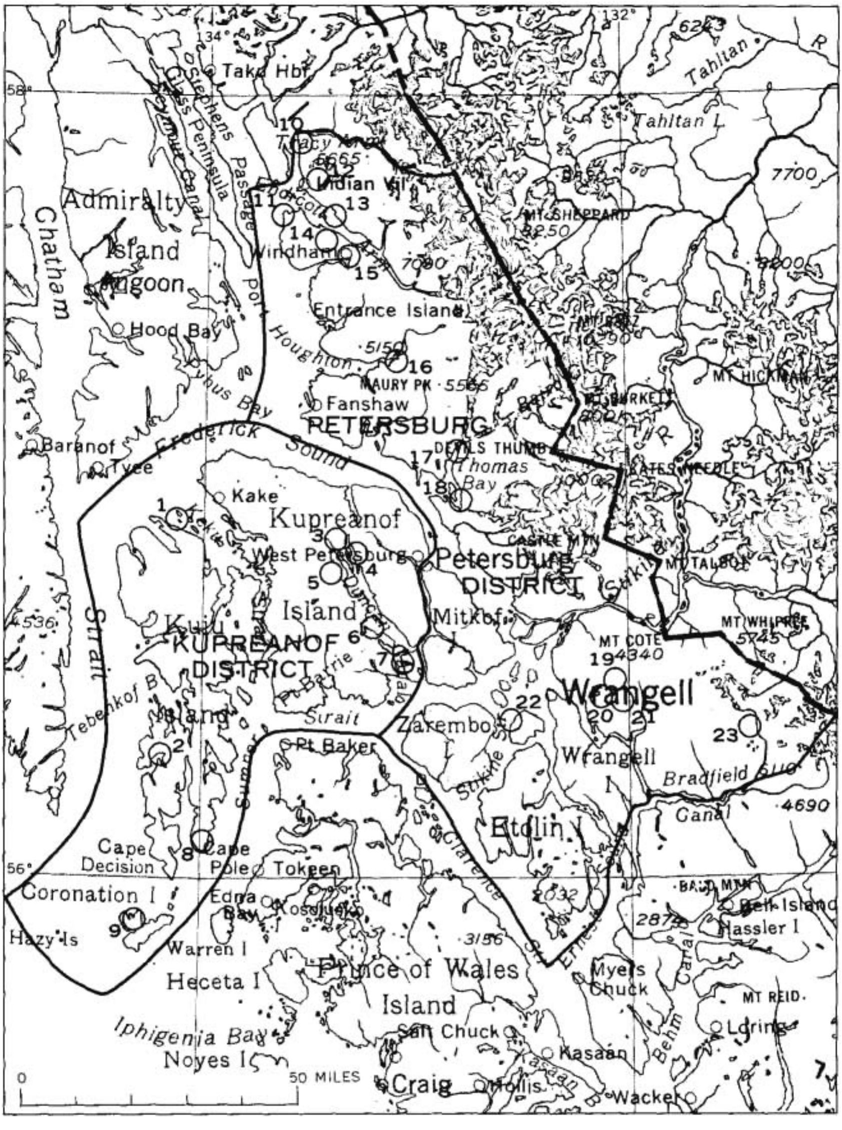

FIGURE 27.—Metalliferous lode deposits in the Kupreanof and Petersburg districts. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 27

Kupreanof district

1. Keku Islets
2. Port Malmesbury
3. Northern Copper Co.
4. Portage Mountain
5. Taylor Creek
6. Castle Islands
7. Hattie
   Helen S.
   Maid of Mexico
8. Point Saint Albans
9. Coronation Island

Petersburg district

10. Tracy Arm
11. Point Astley
12. Sumdum

Petersburg district—Continued

13. Portland
14. Holkham Bay
    Jack Pot
    Sumdum Chief
15. Windham Bay
16. Port Houghton
17. Colp & Lee
18. Thomas Bay
19. Groundhog Basin
20. Lake
21. Berg Basin
    Copper King
    Glacier Basin
22. Exchange
23. North Bradfield River

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netite, and graphite. Analyses of ten samples averaged 1.38 percent zinc, 1.07 percent iron, and 0.04 percent copper; lead was not reported in the analyses although galena is known to be present.

Base-metal deposits near the head of Duncan Canal (3–5) were prospected in the early 1900's, but none is known to have produced any ore. The property of the Northern Copper Co. (at one time also known as the Kupreanof group), just west of the salt chuck at the head of the canal (3), was explored by several hundred feet of underground workings, a 120-foot trench, and several opencuts. The deposit is in pyroxene granulite at the contact between greenstone and slate and consists chiefly of veinlets and blebs of sulfide minerals. The mineralized rock contains about 1 percent chalcopyrite, 5–10 percent pyrrhotite, and small amounts of pyrite, sphalerite, gold, and silver.

Near Portage Mountain (4), pyritic black schist enclosed by diorite gneiss is exposed along a small creek. Assays of the schist showed about 0.4 ounce of gold, 2 ounces of silver, and 0.0006 ounce of platinum per ton, a little copper, and possibly a trace of iridium. Nearby, small veins carrying chalcopyrite and small amounts of gold and silver were prospected by opencuts.

On Taylor Creek (5), lead-zinc claims were staked in 1903 on dolomitic limestone containing scattered small masses of galena, sphalerite, pyrite, and chalcopyrite. In 1948, the U.S. Bureau of Mines explored the lode by 770 feet of diamond-drill holes and 280 linear feet of trenches. Assays of samples from the trenches showed as much as 0.7 percent lead, 4.3 percent zinc, and 1.2 ounces of silver per ton; samples from the drill cores were much leaner. No assay indicated more than 0.005 ounce of gold per ton.

Argentiferous sphalerite has been found in transverse fractures in a basalt dike of probable Tertiary age on one of the Keku Islets (1). In addition, the shattered sandstone and conglomerate wallrocks adjacent to the dike contain pyrite and marcasite veinlets that have been minutely brecciated and the fractures filled with sphalerite. Witherite and barite veins, some of which contain traces of galena, cut limestone on another of the Keku Islets.

A zinc-lead deposit, said to contain gold and silver but about which very little information has been made public, is reported near Port Malmesbury (2) on the west coast of Kuiu Island, and a zinc prospect is on the southeastern coast of the island about 1½ miles north of Point St. Albans (8). The only published information about the Point St. Albans occurrence is that a random sample of sphalerite-bearing vein material contained 0.001 percent equivalent uranium.

Lodes containing tetrahedrite, sphalerite, and galena were discovered in 1900 on Coronation Island (9), where the sulfides form lenticular masses in fault zones in Paleozoic limestone or marble locally cut by diorite. In 1902, and for several years thereafter, three separate masses were mined and more than 100 tons of ore was shipped to a smelter. No ore remained in either of the two deposits that could be found by a U.S. Geological Survey team in 1944.

Additional information on this district is given in the following references: Buddington (1923, 1925); Burchard (1914); Chapin (1918); Houston, Bates, Velikanje and Wedow (1958); Kerns (1950); Twenhofel, Reed, and Gates (1949); Wright and Wright (1908).

PETERSBURG DISTRICT

The Petersburg district (fig. 27) comprises the mainland of southeastern Alaska between Tracy Arm and Bradfield Canal, and Mitkof, Zarembo, Woronkofski, Etolin, Wrangell, and several smaller islands.

At least 25,000 ounces of gold and some silver were recovered from lodes in the Petersburg district, mainly before 1905. Several zinc and lead deposits, some having a moderate silver content, were explored, but except for a 1-ton smelter test, no ore is known to have been shipped. A copper-zinc lode and a group of deposits potentially valuable for iron have been prospected since World War II, and an occurrence of molybdenite has also been found.

The northeastern part of the Petersburg district is in the Juneau gold belt and was the site of much early lode prospecting and placer mining. The area is underlain by the Coast Range batholith and by northwest-trending belts of schist and slate that flank the batholith on the southwest.

A zinc-copper lode on Tracy Arm (10, see fig. 27) was discovered in 1916 and has been restaked several times since then. It is in a shear zone parallel to the foliation of schist and consists of a quartz replacement vein up to 12 feet thick containing sphalerite, chalcopyrite, galena, and pyrrhotite; pyrite is disseminated in the schist on either side of the shear zone. The vein was explored by pits and a 16-foot shaft; it has been traced horizontally for 1,400 feet and vertically for 110 feet. Inferred resources are estimated to be about 40,000 tons of material per 100 feet of depth averaging 3.2 percent zinc, 1.5 percent copper, 0.013 ounce of gold and 0.75 ounce of silver per ton. A little gold and silver reportedly was recovered by early prospectors.

The Sumdum copper-zinc prospect (12), near the terminus of Sumdum Glacier, was explored in 1959 by trenching and diamond drilling. It is in schist within a few thousand feet of the Coast Range batholith and consists of replacements, disseminations, and open-space fillings of pyrite and pyrrhotite, subordinate chalcopyrite and sphalerite, and minor bornite, galena, and chalcocite; the dominant gangue mineral is quartz. Some outcrops contain abundant hematite and limonite and minor amounts of malachite and azurite. Assays indicate that the lode contains 0.5–1.0 percent copper, slightly less than 0.5 percent zinc, and about 0.25 ounce of silver per ton.

Claims were staked by early prospectors on silver-bearing veins in slate and schist just east of Point Astley (11). The veins, which are lenticular and parallel to the foliation of the country rock, consist of pyrite, sphalerite, bornite, pyrrhotite, galena, chalcopyrite, malachite, covellite, chalcocite, and native silver in a gangue of quartz, calcite, and fragments of schist. They were explored, mainly about 1900 and between 1916 and 1920, by three shafts, about 230 feet of crosscuts, and several adits, and are rumored to have been worked for some silver ore. Assays of samples taken in two of the adits in 1962 showed 0.07–0.95 percent copper, 0.11–0.27 percent lead, 0.08–3.36 percent zinc, and as much as 1.23 ounces of silver per ton.

The Portland lode (13), discovered about the same time as the Point Astley deposit, consists of auriferous pyrite, galena, and sphalerite disseminated in phyllite immediately southwest of the Coast Range batholith. It was explored by opencuts and by two adits with a total length of about 300 feet. Gold assays of $0.50–$3 per ton were reported in 1906; samples taken in 1962 contained up to 0.4 percent copper, 0.11–0.23 percent lead, 0.09–0.52 percent zinc, and a trace of gold.

The Sumdum Chief (or Sumdum) mine (14), is said to have produced nearly $500,000 in gold and silver between about 1896 and the time it ran out of ore and closed in 1904. The ore was mined from two veins—the Bald Eagle and the Sumdum Chief—by stoping to the surface from a 3,500-foot tunnel that intersected the veins at a vertical distance of 500 and 1,200 feet below their respective outcrops. The ore bodies were in black slate and consisted of well-defined quartz-calcite fissure veins carrying free gold, auriferous pyrite, galena, sphalerite, and arsenopyrite. The average value of the ore was $8 per ton. At the nearby Holkam Bay prospect (14), an auriferous lode was explored by several hundred feet of underground workings, but it is not known to have produced any ore. It is in schist adjoining the Coast Range batholith and is composed of quartz veinlets and fragments of country rock containing galena, pyrite, arsenopyrite, chalcopyrite, and gold.

Near the head of Windham Bay (15), many auriferous lodes found during placer-mining operations were explored between about 1900 and 1937. Underground workings probably aggregated more than 1,000 feet, but incomplete records make it impossible to determine the number of productive lodes, or the amount of gold recovered, although it probably did not exceed 10,000 ounces. The lodes, which are in white sericitic and siliceous schist, comprise quartz stringers that contain pyrite, pyrrhotite, galena, sphalerite, arsenopyrite, chalcopyrite, and free gold. Pyrite and pyrrhotite are also disseminated in the schist near the veins. Some of the deposits reportedly were rich, but assay data are not available.

The Jack Pot prospect (14), which is in the Windham Bay drainage basin, is on gold- and sulfide-bearing quartz veins in black slate and thus resembles the Sumdum Chief deposit rather than the other Windham Bay lodes.

There is an old copper prospect about a mile from the head of Port Houghton (16), beyond what are usually considered the limits of the Juneau gold belt. The deposit, a fissure vein 2–12 feet thick in a shear zone between quartz-feldspar schist and hornblende schist, consists of intergrown pyrrhotite, pyrite, magnetite, chalcopyrite, quartz, garnet, and amphibole. It was explored by opencuts, two short adits, and a tunnel leading to a 115-foot drift. A sample, taken across the vein so as to include both mineralized material and barren rock, contained 1.34 percent copper and possible traces of gold and nickel.

Two gold lodes are on the shores of Thomas Bay, about 15 miles north of Petersburg. The Colp & Lee prospect (17), near Elephant Head at the north end of the bay, is in quartz diorite and consists of a 140-foot-wide shear zone containing quartz stringers carrying pyrite, galena, and a little sphalerite and chalcopyrite. The average tenor of the lode is about $3 per ton, but the richest part of the shear zone, an interval about 5½ feet wide, was reported in 1921 to carry about $16 per ton in gold. The other prospect, on the east side of the south arm of Thomas Bay (18), is in hornblende and quartz-mica schist, some of which contains enough quartz veinlets to constitute a stringer lode. One vein carrying pyrite, arsenopyrite, and minor chalcopyrite, pyrrhotite, and argentiferous galena was explored by a short tunnel sometime before 1921, but its tenor is unknown.

In 1942–43 the U.S. Geological Survey investigated lead-zinc deposits at Groundhog Basin (19), Glacier Basin (21), Berg Basin (21), and at the Lake claims (20) near Virginia Lake. None of the deposits has been productive.

The Groundhog Basin deposits are in a belt of metasedimentary rocks between the Coast Range batholith on the east and a smaller quartz diorite mass on the west. The lodes and country rock are cut by quartz porphyry and basalt dikes and sills. The deposits, formed by the selective replacement of favorable layers of metamorphic rock, are of two general types: solid sulfide bodies, composed principally of pyrrhotite, sphalerite, and galena, that contain about 8 percent zinc, 1.5 percent lead, and 1.5 ounces of silver per ton; and disseminated sphalerite and other sulfides in pyroxene granulite averaging about 2.5 percent zinc and 1 percent lead. The deposits also contain subordinate chalcopyrite, pyrite, magnetite, tennantite(?), tetrahedrite(?), and cubanite(?). The lodes were discovered in 1904 and have since been explored by surface cuts, about 450 feet of underground workings, and at least 600 feet of diamond-drill holes. The exploration, which took place mainly in 1916–17 and during the early part of World War II, was insufficient to estimate resources, but it is reasonably certain that several hundred thousand tons each of solid and disseminated material are present.

Molybdenite, unaccompanied by other sulfides, has been found in a thick granite sill in Groundhog Basin. No samples have been analyzed, but the grade is estimated to be less than 0.05 percent molybdenum.

Sulfide-bearing granulite similar to and probably continuous with the disseminated-sulfide deposits of Groundhog Basin has been found in Glacier Basin (21), where the so-called ore beds probably aggregate many hundreds of thousands of tons of material containing about 1.65 percent zinc and 1.1 percent lead. In addition, quartz-fluorite veins occur in shear and breccia zones and carry about 0.14 percent zinc and 0.09 percent lead. Twelve such veins, each of which is at least 3 feet thick and 600 feet long, are estimated to contain more than a million tons of lead- and zinc-bearing material, but they are considered too lean to constitute ore under present (1966) conditions. The Glacier Basin deposits were discovered about 1899 and have been explored by three short adits.

At Berg Basin (21), metasedimentary rocks are intruded by the Coast Range batholith on the east and by sill-like granitic plutons on the west. Rhyolite, basalt, and pegmatite sills and dikes cut both the igneous and metamorphic rocks, but quartz veins are rare. The first prospect in the basin was staked about 1900 on a foot-thick auriferous quartz vein. It was explored by several pits, several hundred feet of diamond-drill holes, and a tunnel nearly 800 feet long. The tunnel was driven to explore the downward extension of the vein, which reportedly carried $14 in gold per ton, but failed to intersect it. A basalt dike exposed near the tunnel contains pods of galena and minor pyrite and sphalerite. Analyses of two samples of the galena indicated 27.9 and 28.7 ounces of silver per ton. Galena and sphalerite have also been found in other basalt dikes and iron sulfides are common in the metamorphic rocks.

At the Copper King prospect (21), about 2 miles from Berg Basin, a sulfide-bearing vein(?) was staked in 1906 and restaked in 1951. Very little is known about the deposit, but it is said to contain copper, zinc, and lead minerals and to carry some gold and silver.

The Lake claims (20), about 6½ miles from tidewater by trail and boat across Virginia Lake, were probably staked about 1900. They were explored by several trenches and stripped areas and by about 200 feet of underground workings; in 1920 a ton of ore was shipped to a smelter in California. The deposits are in a prominent fault zone, 10–25 feet wide, in metamorphic rocks near quartz diorite. They consist of quartz-calcite veins, breccia fillings, and stringer lodes containing galena, sphalerite, pyrite, and chalcopyrite. Their average grade, based on seven samples collected and analyzed by the U.S. Geological Survey, is 0.99 percent lead, 1.01 percent zinc, and 0.12 ounce of silver per ton.

In 1955, an iron- and copper-bearing lode was staked near the North Bradfield River (23). It was prospected by a few trenches and pits, an aeromagnetic survey, and 186 feet of diamond-drill holes. It has also been examined by the State of Alaska Division of Mines and Minerals and by the U.S. Geological Survey. The lode consists of several contact-metamorphic deposits in marble near the northwestern end of a large metamorphic roof pendant in quartz monzonite. Roof pendant and pluton are cut by felsic and intermediate dikes. The deposits are confined to skarn zones in the marble and consist of magnetite and subordinate hematite, hydrous iron oxides, pyrrhotite, chalcopyrite, and malachite. They are crudely stratiform and discontinuous and are 2–40 feet thick and 50–350 feet long along the strike; knowledge of their downdip configuration is scant. Except at the site of the original discovery, where outcrops are extensively stained reddish brown and green, secondary minerals are inconspicuous. Most of the deposits probably contain between 50 and 65 percent iron; their copper content is erratic but probably is between 0.1 and 0.5 percent.

The Exchange prospect (22), near Elephant Nose on Woronkofski Island, was staked in 1900 on a quartz vein in granite. The chief metallic mineral in the vein, which was said to carry moderate amounts of gold, is pyrite.

Additional information on this district is given in the following references: Buddington (1923, 1925); Gault and Fellows (1953); Gault, Rossman, Flint, and Ray (1953); Herreid (1963); Houston, Bates, Velikanje, and Wedow (1958); MacKevett and Blake (1963, 1964); Spencer (1906); Twenhofel, Robinson, and Gault (1946); Wright and Wright (1908).

YAKUTAT DISTRICT

The Yakutat district (fig. 28) is the part of Alaska that lies between the 141st meridian and a line connecting Mount Fairweather and Cape Spencer. It includes the Fairweather Range and a coastal lowland bordering the range on the southwest (fig. 2). The moun-

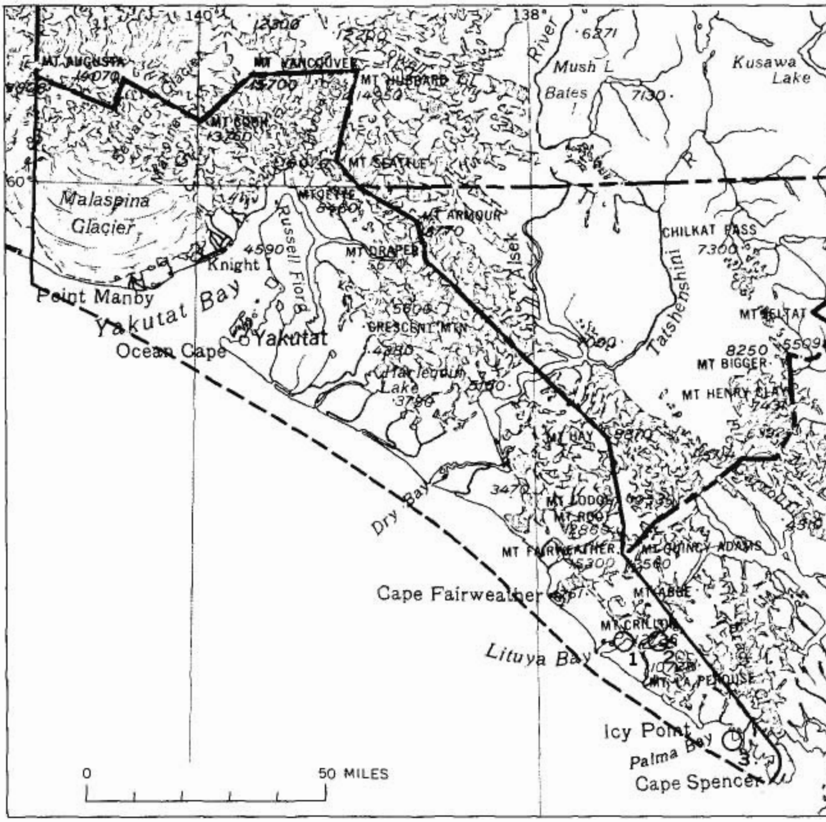

FIGURE 28.—Metalliferous lode deposits in the Yakutat district.

LOCALITIES

1. Lituya Bay
2. North Crillon Glacier
(2.) South Crillon Glacier
3. Astrolabe Peninsula

tains are made up mainly of metamorphosed sedimentary and volcanic rocks, probably of Mesozoic age, cut by granitic and gabbroic plutons (fig. 3). Locally, Tertiary clastic rocks fringe the metamorphic and igneous rocks on the southwest. The coastal lowland is underlain chiefly by sand, gravel, and silt.

Lodes containing iron, titanium, and copper minerals, and possible chromite, are known in the district, but few have been thoroughly explored, and none has produced any ore.

Some of the layers in a stratiform gabbro stock on Astrolabe Peninsula (3, see fig. 28) contain as much as 20 percent titaniferous magnetite. The layers lie between 1,100 and 2,000 feet in altitude and seem to extend through the mountain that makes up the peninsula.

In the Lituya Bay-Mount Crillon area, granite and a layered mafic pluton that includes norite and anorthosite, cut metamorphosed sedimentary and volcanic rocks. On the southwestern shore of the southeast arm of Lituya Bay (1), a gabbro dike in the granite contains irregular veinlets and blebs of pyrrhotite and chalcopyrite, but the sulfides are estimated to constitute less than 1 percent of the rock. Along the south wall of the valley of North Crillon Glacier (2), a layer in the mafic pluton contains as much as 60 percent ilmenite and 2–3 percent pyrrhotite and chalcopyrite; on the north wall of South Crillon Glacier (2), specimens from the contact zone between the pluton and schist contain 5–6 percent sulfide minerals, principally pyrrhotite and chalcopyrite. Chromite has been reported in float on the glaciers but has not been found in place.

In 1906, a claim was staked on a showing of chalcopyrite somewhere on the shore of Russell Fiord near Yakutat, and green copper stains were reported in the canyon of the Alsek River, possible in Canadian territory. Neither occurrence, however, has been mentioned in reports published since 1907.

Additional information on this district is given in the following references: Blackwelder (1907); Kennedy and Walton (1946b); Rossman (1963a).

YUKON RIVER REGION

The Yukon River region (pl. 1; figs. 29–35) is the area drained by the Yukon River and its tributaries from the Alaska-Yukon boundary to the Bering Sea and by the Unalakleet and Manopiknak Rivers and intermediate streams flowing into Norton Sound and the Bering Sea. The region is divided into 26 districts, which are described below in alphabetical order.

ANVIK DISTRICT

The Anvik district (pl. 1; fig. 29) comprises the western drainage of the Yukon River between and including the Nulato and Koserefski Rivers and the area drained by streams flowing into Norton Sound between Unalakleet and St. Michael. It is mostly an area of rounded, even-crested ridges 1,000–2,000 feet in altitude (pl. 1), and is underlain by pre-middle Cretaceous volcanic and sedimentary beds; Cretaceous marine and nonmarine sedimentary rocks, and Cretaceous to Tertiary lava flows and tuff (pl. 1). Intermediate and felsic plutons cut the pre-middle Cretaceous and Cretaceous beds in the central part of the district.

In 1962, members of the U.S. Geological Survey discovered traces of cinnabar and stibnite on Wolf Creek Mountain (1, see fig. 29), about 40 miles northeast of Marshall. The minerals are in hydrothermally altered rhyolite that intrudes basalt and andesite of Cretaceous or Tertiary age. Although the mineralization at this locality

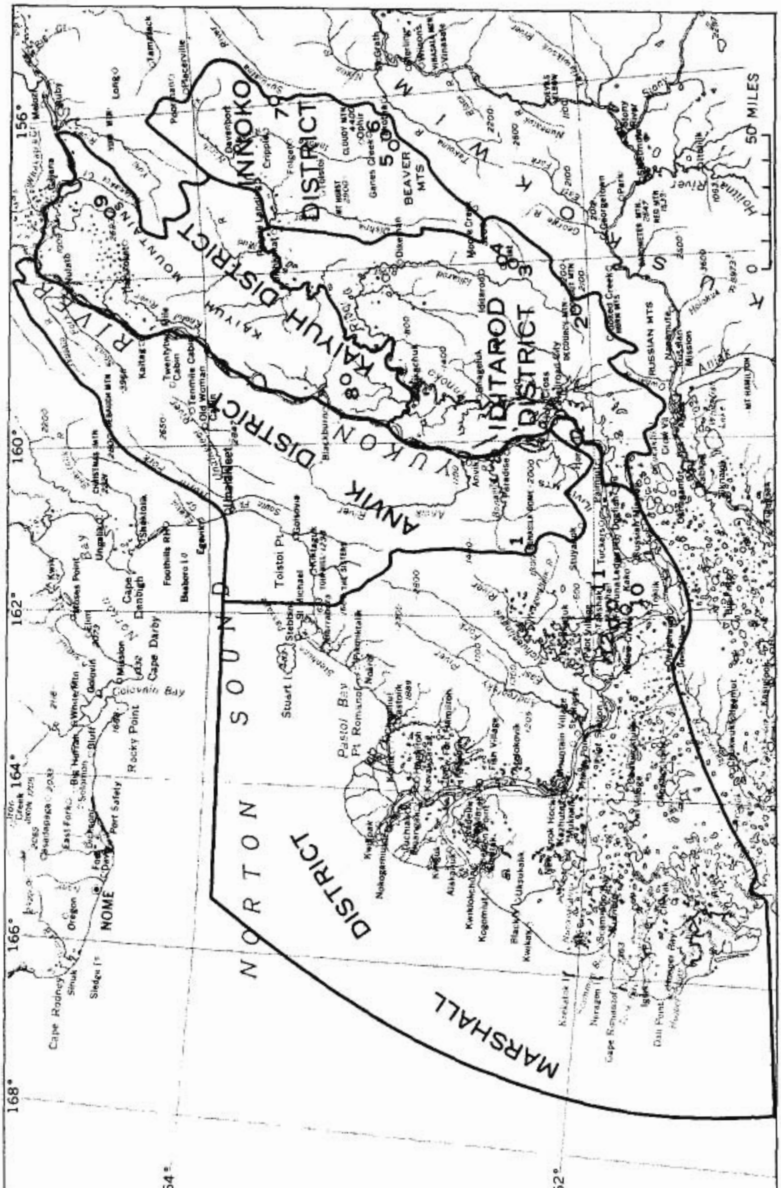

FIGURE 29.—Metalliferous lode deposits in the Anvik, Iditarod, Innoko, Kaiyuh, and Marshall districts.

Anvik district

1. *Wolf Creek Mountain

Iditarod district

2. *DeCourcy Mountain

Willow Creek-Flat area

3. Chicken Creek
   Flat Creek
   Happy Creek
4. Black Creek
   Garnet
   Glen Gulch
   *Golden Horn
   Malamute Gulch
   Marigold
   Minnie Gulch
   Otter Creek

Iditarod district—Continued

Willow Creek-Flat area—Continued

(4.) Slate Creek

Innoko district

5. *Kaatz
6. *Independence
7. *Wyoming Creek

Kaiyuh district

8. *McLeod
9. *Perseverance
   *Valley

Marshall district

10. *Arnold
11. *Edgar Creek
12. *Marshall

*Cited individually in text.

is slight, it nevertheless indicates the presence of quicksilver where none was known before and suggests that careful prospecting might reveal other, possibly larger, deposits.

No other lodes have been described in the district.

Additional information on this district is given in the following reference: U.S. Geological Survey (1963).

BLACK DISTRICT

The Black district (pl. 1; fig. 30) is bounded on the east by the Alaskan-Yukon boundary, on the west by a straight line from Graphite Point to Circle, on the south by the Yukon River, and on the north by the divide between the Black and Porcupine Rivers.

Most of the district is an area of rounded ridges averaging 1,500–2,000 feet in altitude. Its southeastern corner includes rugged mountains as much as 5,000 feet high, and its western part is a gently rolling lowland (pl. 1).

The bedded rocks consist of a sequence of marine and continental sedimentary and volcanic rocks ranging in age from Precambrian to Quaternary. Cretaceous(?) granitic plutons cut the Precambrian beds in the headwaters of the Black River. Bedrock in much of the district is covered by loess and alluvium (pl. 1).

The only lode-mineral resource known in the Black district consists of Precambrian hematitic and siliceous red beds (Tindir Group) that contain 5–27 percent Fe_2O_3. The red beds crop out along and near the Tatonduk River (1, see fig. 30), about 15 miles north of Eagle.

Additional information on this district is given in the following reference: Mertie (1933).

BONNIFIELD DISTRICT

The Bonnifield district (pl. 1; fig. 31) is the area drained by southern tributaries of the Tanana River between and including the Little Delta and Teklanika Rivers.

From south to north the district contains high mountains of the Alaska Range, a belt of foothill ranges, and lowlands of the Tanana River and its tributaries (pl. 1). The higher terrains are underlain chiefly by diverse assemblages of metamorphic rocks that constitute the Birch Creek and Totatlanika Schists and less extensively by granitic plutons of probably Mesozoic age. Thick sequences of Tertiary nonmarine sedimentary rocks, some of which are coal bearing, are common in the foothill ranges, and unconsolidated Quaternary deposits are dominant in the lowlands (pl. 1).

Production from lodes in the Bonnifield district was small and consisted mainly of gold with subordinate amounts of silver. The lodes are chiefly sulfide disseminations, veins, and lenses in schist

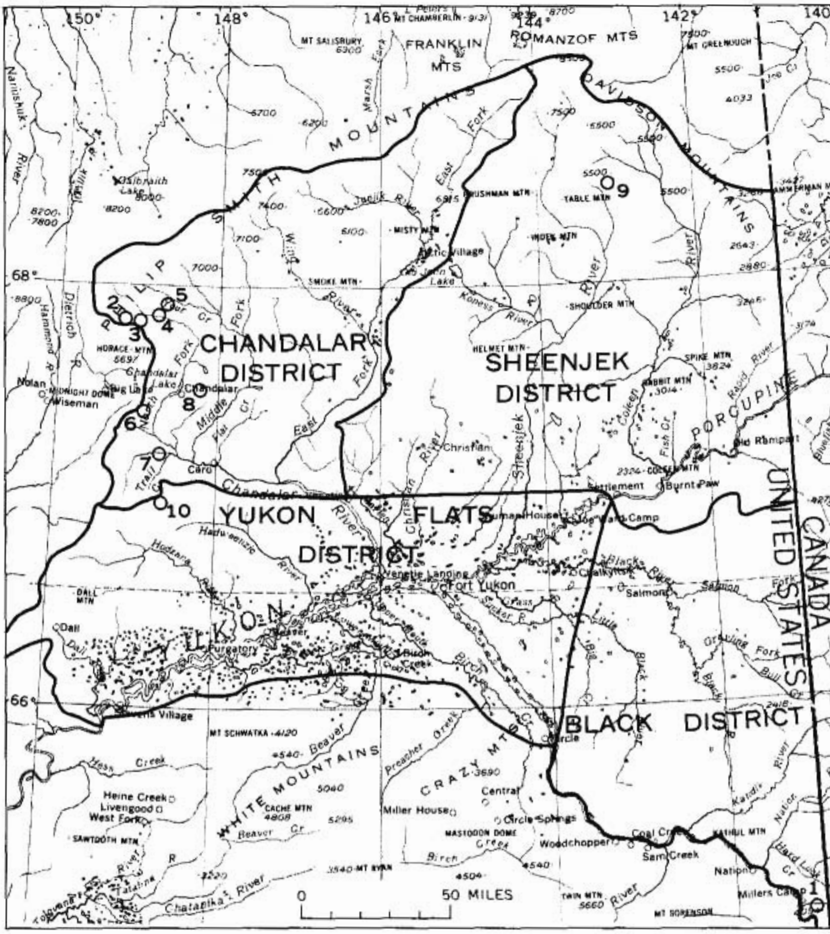

FIGURE 30.—Metalliferous lode deposits in the Black, Chandalar, Sheenjek, and Yukon Flats districts.

LOCALITIES

Black district

1. *Tatonduk River

Chandalar district

2. Quartz Creek
3. Unnamed
4. Unnamed
5. Unnamed
6. *Horse Creek
7. *West Fork

Chandalar district—Continued

8. Big Creek
   Big Squaw Creek
   *Little Squaw

Sheenjek district

9. *Coleen River

Yukon Flats district

10. *Trout Creek

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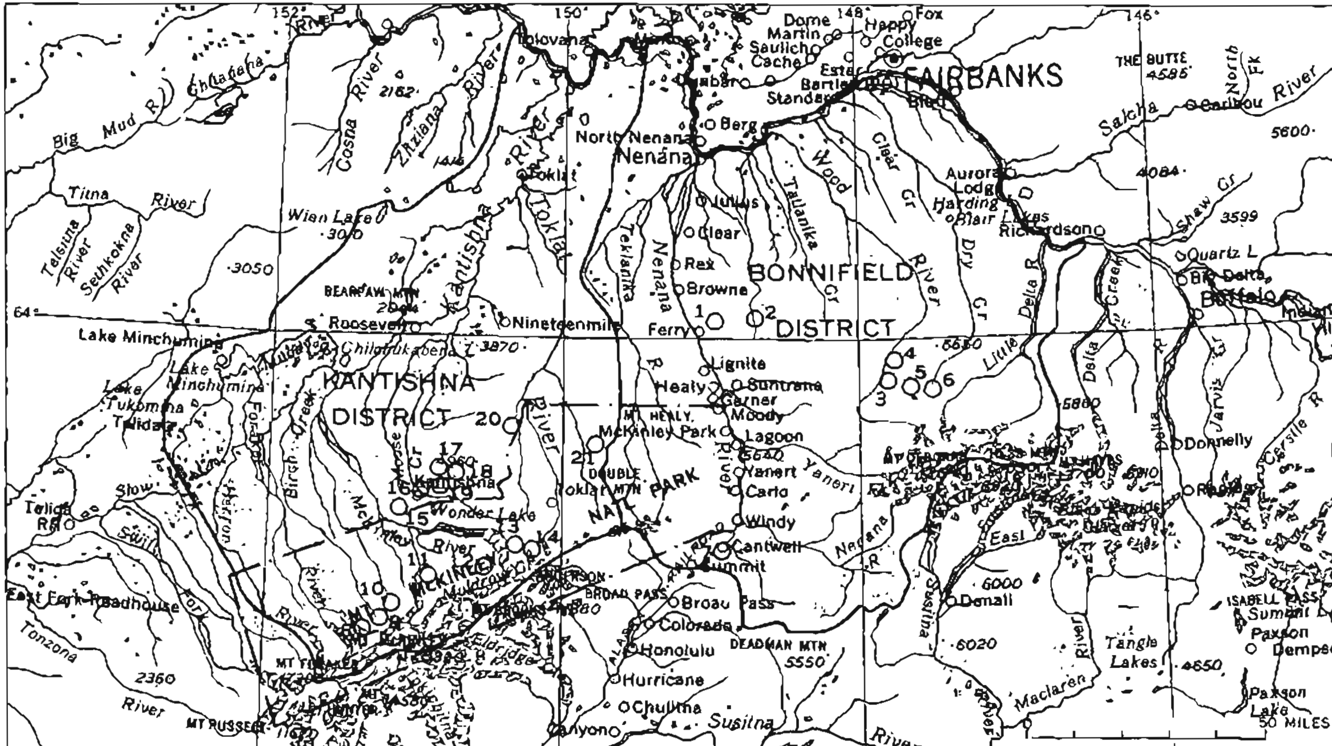

Figure 31.—Metalliferous lode deposits in the Bonnifield and Kantishna districts.

LOCALITIES

Bonnifield district

1. *Eva Creek
   *Liberty Bell
   Moose Creek
   *Rambler
   *Spruce Creek
2. *California Creek (Prospect Mining Co.)
   *Caribou Creek
   *Eagle Creek
   *Elsie Creek
   *Martin Creek
   *Rex Creek
3. *Kansas Creek
   *Rock Creek
4. *Chute Creek
5. *Kansas Creek
6. *Glory Creek
7. *Cantwell

Kantishna district

8. Straightaway Glacier

Kantishna district—Continued

Slippery Creek–Clearwater Ceek area

9. *Merinser
   Stibner
10. Greenback
    Magnet
    Old Sourdough
    Question Mark
    Terminus
11. Copper Lode
    Galena Lode
12. Carlson and Averil
    Twin Hills

Mount Eielson area

13. *Mount Eielson
14. Highway
    Thorofare River (Creek)

Friday–Eureka Creeks area

15. Alpha

Kantishna district—Continued

Friday–Eureka Creeks area—Continued

(15.) Neversweet
   *Taylor (Slate Creek)
16. Eureka Creek
    *Quigley Hill (about 35 mines and prospects)
17. *Caribou
    Home Lode
18. Lena
    North Star
    Silver Wire
19. Arkansas
    Glen
    Glen Creek divide
    Glen Ridge No. 1
    Humboldt (Stendall)
    McGonogill
    Lloyd

20. *Stampede
21. *McCall

*Cited individually in text.

and related metamorphic rocks, locally near felsic plutons. Two types of deposits are dominant: quartz veins or lenses that contain gold associated with pyrite or arsenopyrite and quartz veins in which either stibnite or jamesonite are the metallic minerals. Silver, copper, lead, zinc, bismuth, and arsenic minerals are minor constituents in some of the deposits, particularly the jamesonite-bearing veins.

The gold lodes are exemplified by the Liberty Bell and other deposits near Eva Creek (1, see fig. 31), where the deposits are in several kinds of schist cut by numerous faults. At the Liberty Bell mine, the ore body constituted a nearly horizontal lode 6–30 feet thick made up of sulfides that were disseminated or that occurred in small lenses or stringers parallel to the foliation of the schist. The gold was mainly combined with arsenopyrite, the dominant sulfide, but some was free. Other metallic minerals included minor amounts of chalcopyrite, pyrite, lollingite, and bismuthinite. Quartz occurs in some of the lenses and stringers, but generally it was a minor constituent of the ore. In 1931, the U.S. Geological Survey estimated the proved resources at the Liberty Bell mine to be 25,000 tons averaging $22 in gold per ton, and the probable resources to be 12,000 tons averaging $22 in gold per ton. The chances of finding additional tonnages of comparable material in unprospected areas contiguous to the mine were considered good. Moreover, the deposits near Eva Creek are favorably situated for access because they are within 15 miles of Ferry on The Alaska Railroad.

At a prospect on Chute Creek (4), gold is associated with disseminated pyrite in altered rhyolite poryhyry that cuts schist. Assays of the richest material averaged about $9 per ton. A few gold-bearing lodes also occur near Spruce Creek (1), a few miles west of California Creek.

The California Creek lode (2), formerly held by the Prospect Mining Co., is of interest mainly because of its silver (argentiferous galena) content. It is in schist and consists of small quartz veins carrying, along with silver, a little gold, copper, lead, and zinc(?). According to an Alaska Territorial Department of Mines (now State of Alaska Division of Mines and Minerals) report (Joesting, 1943, p. 14), one small fissure vein assayed 0.27 ounce of gold and 259 ounces of silver per ton.

Lodes prospected for antimony are widespread in the district. They are commonly quartz veins in schist that contain stibnite or complex lead-antimony sulfosalts, chiefly jamesonite. Several such deposits include small veins near the mouth of Elsie Creek (2) containing arsenopyrite, pyrite, bismuthinite, and sulfosalts that carry antimony, lead, zinc(?), copper, arsenic, and silver; quartz veins carrying stibnite, pyrite, and chalcopyrite near Rex Creek (2); several small stibnite lodes on Martin and Eagle Creeks (2); and a stibnite-bearing quartz vein on Caribou Creek (2). Small jamesonite-bearing veins occur at the head of Spruce Creek (1), west of California Creek.

About 2 tons of ore containing 47 percent antimony was mined from small discontinuous bunches of stibnite in black slaty schist at the Rambler prospect (1) on Cody Creek. The ore also contained traces of gold, silver, arsenic, and lead.

A lode between the forks of Kansas Creek (5), which flows westward into the Wood River, contains stibnite and minor galena and sphalerite. Concentrates containing about 50 percent antimony probably could be hand sorted from this deposit. A few miles downstream (3), a black quartzitic rock with visible pyrite is said to carry some gold. A small stibnite prospect is on Rock Creek (3), about a mile north of Kansas Creek; and on Glory Creek (6), several small lodes contain stibnite and subordinate galena, sphalerite, pyrite, silver, and gold.

A manganese-bearing deposit (7) discovered in 1926 is on the west bank of the Cantwell River half a mile southeast of Cantwell on The Alaska Railroad. It reportedly consists of a nearly vertical outcrop of light-gray rock about 8 feet wide that contains pink, green, and black manganese minerals. A sample of this rock assayed 33.35 percent manganese, mostly in rhodochrosite. Other minerals in the sample included hydrous manganese silicate(?), manganese oxide(?), and quartz. The rhodochrosite shows evidence of crushing and partial recrystallization after deposition.

A little manganese oxide(?) also occurs parallel to the bedding or foliation of slate in a railroad cut half a mile northeast of Cantwell. A feldspathic dike that may be related to the manganese mineralization cuts the slate nearby.

Additional information on this district is given in the following references: Capps (1912); Ebbley and Wright (1948); Joesting (1942, 1943); Moffit (1933b); Overbeck (1918); Smith, P. S. (1937); White, West, Tolbert, Nelson, and Houston (1952).

CHANDALAR DISTRICT

The Chandalar district (pl. 1; fig. 30) is the area drained by the Chandalar River and its tributaries above the village of Venetie. The northern part is dominated by the Brooks Range, a system of east-trending rugged glaciated ridges as much as 8,000 feet in altitude. The southern part consists mostly of lower mountains and rolling uplands (pl. 1). The district is underlain chiefly by low- to medium-grade metamorphic Devonian rocks intruded by intermediate and felsic batholiths, stocks, and smaller plutons of Jurassic or Cretaceous age (pl. 1).

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Lodes containing gold, antimony, lead, and zinc occur in the Chandalar district.

The best known deposits are in a 100-square-mile area east-northeast of Chandalar Lake (8, see fig. 30), where prospecting for lode and placer gold began about 1900 and flourished during the early part of the century. After a relatively dormant period between 1930 and 1952, exploration and development of the gold lodes was renewed. The most recent activity has been on the Little Squaw property (8), about 9 miles east of Chandalar Lake, where development work has included driving more than 1,500 feet of underground workings, surface bulldozer trenching, road building, and the construction of a new mill.

The deposits consist of numerous steeply dipping sheeted auriferous quartz veins in schist cut by granite gneiss. The main veins trend westward and are thought to be controlled by high-angle faults. They carry some free gold, appreciable arsenopyrite, pyrite, and sphalerite, and traces of stibnite, galena, chalcopyrite, and siderite. Development completed before 1930 included about 1,000 feet of underground workings, most of which are now inaccessible. Early assays showed about 3–11 ounces of gold per ton, but no lode production figures were ever issued. The value of the lode gold was probably included in the placer gold production figures, which amounted to about $356,000 as of 1930.

In 1959 and 1960, geologists of the U.S. Geological Survey found traces of copper minerals (chalcopyrite and secondary copper salts) at the top of the Skajit Limestone (2–5). They also reported small amounts of copper minerals in Devonian(?) volcanic rocks on the West Fork of the Chandalar River (7) and in Devonian schist on Horse Creek (6), southwest of Chandalar Lake. Most of the occurrences consist of small widely scattered pods and veinlets of sulfide minerals and of surficial coatings of malachite and azurite.

Additional information on this district is given in the following references: Brosgé and Reiser (1964); Maddren (1913); Mertie (1925).

CHISANA DISTRICT

The Chisana district (pl. 1; fig. 32) is the Alaskan part of the area drained by the White River and southern tributaries of the Tanana River as far west as and including the Nabesna River. From south to north it includes the summit areas and north-facing slopes of the Wrangell Mountains, the Nutzotin Mountains and the eastern part of the Mentasta Mountains, and a lake-studded lowland with a few hills (pl. 1).

The district contains thick sequences of upper Paleozoic and Mesozoic sedimentary and volcanic rocks cut by several large Mesozoic plutons, chiefly composed of granodiorite and quartz diorite; there are also a few small Tertiary intrusive bodies. The Wrangell Lava, a thick Tertiary and Quaternary volcanic sequence, caps the higher mountains. Unconsolidated fluvial and glacial deposits cover most of the lowlands (pl. 1).

Prospecting, mainly for gold and copper, began in the 1890's and flourished during the Chisana gold rush of 1913. The district's only recorded lode production was from the Nabesna mine (1, see fig. 32) and consisted of gold and subordinate copper and silver. Other metals known in the district include lead, zinc, molybdenum, iron, and antimony(?).

GOLD AND SILVER

Most of the gold, together with a little silver, is associated with copper and other base metals in pyritic quartz or calcite veins in or near intrusive rocks. The gold lodes include the Nabesna (1) and the Orange Hill (3) (discussed under "Copper") deposits near Nabesna and several prospects east of Chisana. The prospects east of Chisana include the Erie prospect (5) and other lodes near Bonanza and Cathenda Creeks (5); prospects on Carden (7), Fourmile (8), and Eureka (8) Creeks; and the Wiley prospect (14).

The Nabesna mine, near Nabesna on the south slope of White Mountain, operated from 1930 until World War II and produced about $1,870,000, chiefly in gold but including some silver and copper. The lode is mainly contact metamorphic in origin and formed near the east side of a quartz diorite stock that has invaded Triassic limestone. It includes the following three types of deposits, most of which are oxidized to depths of several tens of feet: masses of magnetite with pyrite and calcite, veins and masses of pyrrhotite locally accompanied by pyrite, and pyrite-calcite veins containing subordinate chalcopyrite, galena, and sphalerite, and quartz. Only the third type, formed by replacement of the limestone, especially at the contact of tactite or quartz diorite, has been productive. Most of the veins that were mined were parallel to the steep, eastward-dipping contact between quartz diorite and limestone and averaged about 5 feet thick. The ore, all of which came from above the 550 level, was treated by gravity and flotation methods, and the concentrates were shipped to Tacoma. Magnetite-rich bodies, some more than 200 feet long, are locally abundant at the mine and elsewhere near White Mountain.

The gold lodes near Bonanza and Cathenda Creeks are in an area underlain by upper Paleozoic volcanic rocks invaded by granodiorite plutons and andesite dikes. They are in both the intrusive and volcanic rocks and commonly consist of quartz veins or groups of

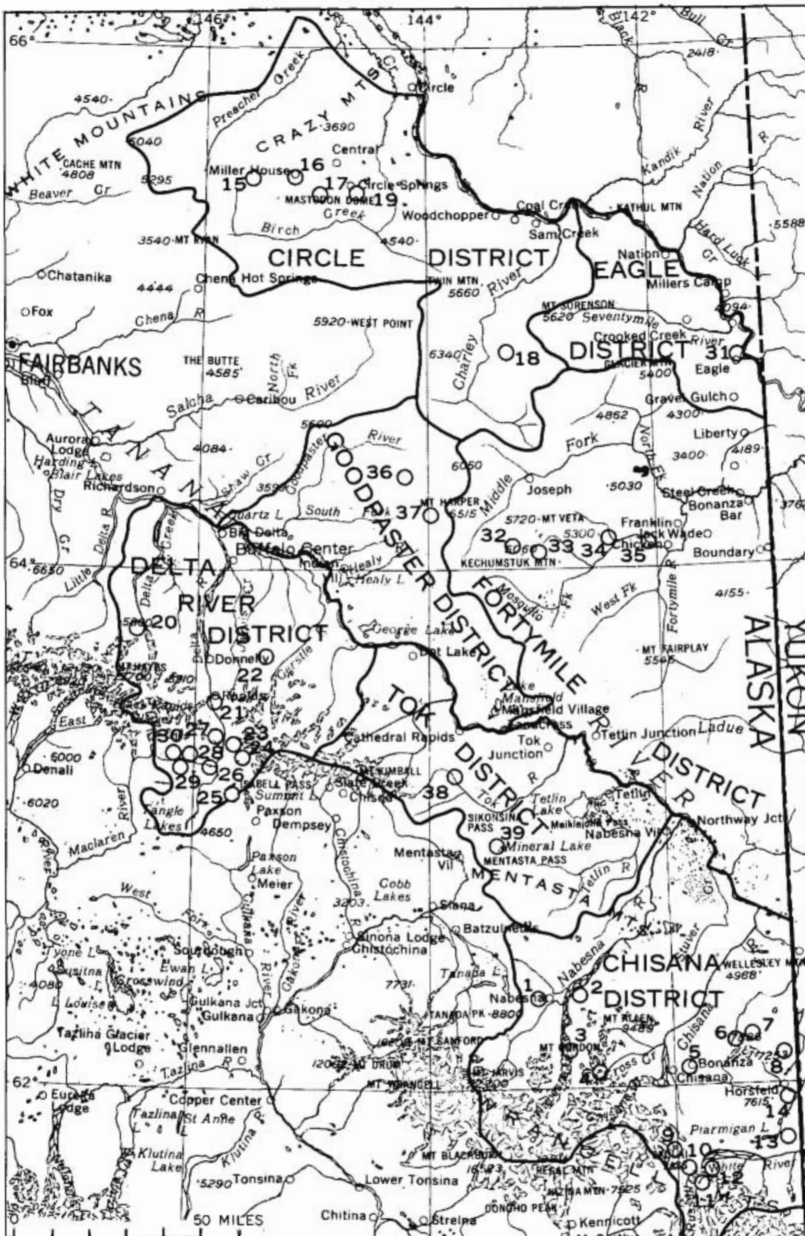

FIGURE 32.—Metalliferous lode deposits in the Chisana, Circle, Delta River, Eagle, Fortymile, Goodpaster, and Tok districts. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 32

Chisana district

1. *Nabesna
2. *Camp Creek
3. *Orange Hill
4. *Cross Creek
5. *Cathenda Creek
   *Erie

Snag River area

6. O'Hara (Sulzer)
   Reynolds
7. *Carden Creek

8. *Eureka Creek
   *Fourmile Creek

White River area

9. *Copper King
10. White River
11. *Moraine Creek
12. Sheep Creek
    Wiley Creek

13. *Rabbit Creek
14. *Wiley

Circle district

15. *Porcupine Dome
16. *Bedrock Creek
    *Miller House
17. *Deadwood Creek
18. *Copper Creek
19. *Portage Creek

Delta River district

20. *Ptarmigan Creek
21. *Black Rapids
    *Gunnysack Creek
22. *McCumber Creek

Rainbow Mountain area

23. Emerick
    Glacier Lake

Delta River district—Continued

Rainbow Mountain area—Continued

(23.) Rainbow Mountain
24. Rainbow Mountain

25. *Paxson Mountain
    *Tripp

Rainy Creek area

26. *Unnamed
27. *Bee Mining Co.
28. *Eastern Star
    Moneta-Porcupine Mining Co.
    *Pioneer
    *Rainbow
    *Unnamed (6 occurrences)
29. *Green Wonder
    *Unnamed (2 occurrences)
30. *Unnamed (2 occurrences)

Eagle district

31. *Eagle Bluff

Fortymile district

32. *My Creek
    Ruby Silver
33. *Mitchell (Ketchumstuk Creek)
34. *Tweeden
35. *Lilliwig Creek
    *Norvill

Goodpaster district

36. *Blue Lead
    Boulder Creek
    *Grizzly Bear
    *Tibbs Creek
37. *Healy River (Johnson)

Tok district

38. *Stibnite (Boulder) Creek
39. *Mineral Point

*Cited individually in text.

veinlets carrying auriferous pyrite and, locally, subordinate copper minerals and argentiferous galena. A prospect at the mouth of Bonanza Creek mainly sought to exploit auriferous pyrite in a dike.

The prospects on Eureka and Fourmile Creeks are on quartz veins as much as 12 feet thick in sedimentary and volcanic rocks near granitic apophyses. The veins contain gold, argentiferous galena, sphalerite, and meager amounts of chalcopyrite and azurite.

The Wiley deposit, probably explored for gold, consists of a brecciated(?) small gabbroic mass containing quartz, pyrrhotite, and arsenopyrite.

COPPER

Copper minerals occur in the following settings: sulfide contact-metamorphic deposits; sulfide disseminations or veinlets in plutonic rocks (porphyry copper deposits); as minor constituents of gold-bearing veins; in amygdaloidal deposits characterized by native copper in lava flows; and in veins, veinlets, or disseminations of copper sulfides and a little native copper in volcanic rocks.

The contact-metamorphic deposits are characterized by chalcopyrite and bornite that either are disseminated or form small parts of massive sulfide bodies in tactite. Examples include the Nabesna mine (described under "Gold and silver"), part of the Orange Hill (3) lode, and probably similar deposits reported about 5 miles northeast of Orange Hill. A chalcocite vein 6 inches to 2 feet thick reported on Camp Creek (2), a few miles east of Nabesna, may also be of contact metamorphic origin.

The Orange Hill porphyry copper deposit constitutes the only lode of its type known in Alaska. It consists chiefly of pyrite, chalcopyrite, and molybdenite that are disseminated or form veinlets in quartz diorite near its contact with interbedded graywacke, mafic lava flows, and limestone. The metamorphosed limestone near the quartz diorite also contains copper and molybdenum minerals, and both the intrusive rock and the limestone contain a little gold and silver. Assays made in conjunction with an investigation of the property by the U.S. Geological Survey during World War II indicate that part of the quartz diorite near the contact contains an average of 0.4 percent copper and 0.02 percent molybdenum, and 0.02 ounce of gold and 0.08 ounce of silver per ton. It was estimated that more than 200 million tons of this material is in the Orange Hill lode at altitudes higher than the terraces of the Nabesna River. Lack of sufficient information concerning the copper and molybdenum deposits in the metamorphosed limestone precluded an estimate of their size and grade. Some of the copper sulfide deposits in the metamorphic rocks are richer than the mineralized quartz diorite, but they are small and irregular.

The Chisana district, particularly the part of it drained by the White River (9–12), has long been noted for native copper. Most of the metal has been found in placers, but numerous occurrences in lodes are also known. Typically, the native copper occurs in discrete basaltic amygdaloidal lava flows that are part of a thick volcanic sequence of probable late Paleozoic age. It is mainly in amygdules, commonly with calcite, prehnite, and zeolites, but some is in veins or veinlets, together with chalcocite and other copper minerals.

The best known deposits are in the upper part of the White River drainage basin. There native copper, calcite, prehnite, and zeolites occur in amygdules in basalt flows about 6 feet thick at the Copper King prospect (9), and veinlets containing chalcocite and native copper cut amygdaloidal basalt at Moraine Creek (11). Similar but smaller deposits are known in the volcanic rocks east of Russell Glacier (12).

Copper minerals are minor constituents of some of the gold lodes east of Chisana, and a prospect at Cross Creek (4) is on a thin quartz vein carrying chalcopyrite and minor amounts of galena.

Copper prospects near the Snag River (6), on the northern slopes of the Nutzotin Mountains, are in andesite and basalt flows and breccias. They are mainly on veins that contain bornite, chalcocite, and minor malachite, specularite, and calcite; or on disseminations and veinlets of pyrite and subordinate copper sulfides and secondary copper minerals.

Minor amounts of disseminated chalcopyrite and copper carbonates are also found in volcanic rocks at Rabbit Creek (13), east of Ptarmigan Lake.

OTHER METALS

Sphalerite and argentiferous galena are minor constituents of many of the gold lodes in the district, particularly those near Bonanza, Cathenda, and Eureka Creeks; they also occur in small amounts in the copper deposits on Cross Creek, at Orange Hill, and at the Nabesna mine. Molybdenite is known only at Orange Hill, where it occurs in both the quartz diorite stock and adjacent rocks. Stibnite has been reported near the Nabesna mine.

Additional information on this district is given in the following references: Capps (1916a); Mendenhall and Schrader (1903a); Moffit (1943, 1954a); Moffit and Knopf (1910); Van Alstine and Black (1946b); Wayland (1943).

CIRCLE DISTRICT

The Circle district (pl. 1; fig. 32) is the area drained by the Charley River, Birch Creek above the latitude of Circle, and most of Preacher Creek. It is largely an upland above whose general level rise many ridges and isolated domes and below which a ramifying drainage system is entrenched (pl. 1).

The bedrock includes the Birch Creek Schist, part of which may be as old as Precambrian; noncalcareous sedimentary rocks and greenstone ranging in age from Ordovician to Devonian; Silurian or Devonian limestone; the Rampart Group, mainly an assemblage of mafic flows of Mississippian age; some Mississippian chert; and Mesozoic granitic rocks (pl. 1). Unconsolidated Quaternary deposits dominate the stream valleys.

The district has produced substantial amounts of placer gold, but there has been no production from lodes. The few lode prospects that are known were explored mainly for gold, copper, or lead. The Copper Creek prospect (18, see fig. 32), examined by the U.S. Geological Survey in 1948, is on Copper Creek about 6 miles above its confluence with Charley River. It is in a metamorphic roof pendant and consists of chalcopyrite, bornite, malachite, azurite, and minor galena in calc-silicate rock near an amphibolite contact. Assays also show traces of gold, silver, tungsten, and uranium.

Quartz veins prospected for gold are on the ridge west of Porcupine Dome (15), and faults containing quartz, pyrite, and galena cut schist on upper Deadwood Creek (17). Small amounts of lead and copper minerals have been found in granitic rock near Miller House (16), and similar rock at Bedrock Creek (16) and Portage Creek (19) contains small amounts, respectively, of scheelite and sphalerite.

A small wolframite-bearing vein has been reported on the west side of Deadwood Creek (17) near wolframite- and cassiterite-bearing placer deposits that were worked in 1916. The wolframite and cassiterite are probably linked genetically to porphyritic granite that crops out near Deadwood Creek.

Additional information on this district is given in the following references: Mertie (1938a); Nelson, West, and Matzko (1954); Saunders (1961b); Wedow White, and others (1954).

DELTA RIVER DISTRICT

The Delta River district (pl. 1; fig. 32) is the area drained by the northward-flowing tributaries of the Tanana River between and including the Johnson River and Delta Creek.

The southern part of the district is the high and rugged summit area of the Alaska Range; the central part forms an elevated plateau that has been deeply incised by the major streams; and the northern part consists of the lowlands of the Tanana River (pl. 1).

Most of the district is underlain by schist and gneiss that probably are correlatives of the Birch Creek Schist (pl. 1). The metamorphic rocks are cut by Mesozoic(?) felsic and intermediate dikes, sills, and stocks, and locally are overlain by a thick accumulation of Tertiary coal-bearing sandstone, shale, and conglomerate. Unconsolidated Quaternary deposits cover extensive areas in the lowlands.

The district contains lodes carrying gold and silver, and molybdenum, antimony, copper, lead, zinc, nickel, and chromium minerals.

A molybdenum prospect on Ptarmigan Creek (20, see fig. 32), in the northwestern part of the Mount Hayes quadrangle, consists of relatively sparse molybdenite in quartz veins that cut granite. It has been explored intermittently since 1914, and a few tons of ore were mined but not shipped. The veins range from a few inches to 2 feet in thickness and the molybdenite occupies small transverse fractures. Samples, probably of selected, hand-picked material, contained as much as 2.71 percent molybdenite and a little gold.

A gold prospect at Gunnysack Creek (21) is on a nearly vertical quartz vein, in places more than 20 feet thick, that cuts quartzitic mica schist. The vein contains sparse gold and pyrite.

A small antimony lode in schist near Black Rapids (21) consists of a 6-inch quartz vein containing about 50 percent stibnite. Galena has been found in quartz stringers in schist on the ridge northeast of McCumber Creek (22).

Recent investigations by the Alaška Division of Mines and Minerals (Hanson, 1963) in the Rainbow Mountain area (23, 24) have resulted in the discovery of nickel, copper, and lead minerals and a little gold and silver. Part of the copper and virtually all of the nickel are associated with ultramafic intrusive rocks that carry small lenses and disseminated particles of chalcopyrite, pyrrhotite, pentlandite, and pyrite. Channel samples of some of the sulfide-bearing lenses assay 0.46–2.68 percent copper and 0.38–8.07 percent nickel; an assay of disseminated material showed slightly more than 2 percent combined copper and nickel. Most of the copper and all the lead minerals—in the form of chalcopyrite and galena—are in quartz veins as much as 2 feet thick that cut graywacke, limestone, and volcanic rocks. Assays of the veins, which may be related to faults, show as much as 4 percent copper and 2.6 percent lead, and 0.46 ounce of gold and 2.4 ounces of silver per ton. Disseminated sulfides (chiefly pyrite) have also been noted in silicified volcanic and sedimentary rocks in the area.

Studies have been made by the Alaska Division of Mines and Minerals (Rose, 1965a) of lodes in the Rainy Creek area (26–30), where most of the deposits are similar to those near Rainbow Mountain. At the claims of the Bee Mining Co. (27), pyrrhotite, pentlandite, chalcopyrite, and a little galena occur as disseminated grains and as lenses up to 18 inches thick in gabbro. An assay of one of the lenses showed 2.01 percent nickel and 0.61 percent copper. Samples of the richest disseminated material assayed 0.20–0.46 percent nickel, 0.17–0.32 percent copper, and small amounts of gold and silver.

On the Rainbow, Eastern Star, and Pioneer copper prospects (28), chalcopyrite forms disseminated grains in altered gabbro dikes and plugs and also occurs in a shear zone in the gabbro. A chip sample across 5 feet of the shear zone assayed 1.13 percent copper; random samples of the disseminated material contained about 1 percent copper and traces of gold and silver. Other lodes in the area consist of copper- and nickel-bearing minerals in ultramafic intrusive rocks; chalcopyrite, pyrrhotite, magnetite, pyrite, and secondary copper minerals in contact-metamorphosed limestone; and chalcopyrite and secondary copper stains in sheared and brecciated dacite porphyry.

The Green Wonder claim (29) is on altered ultramafic rock that contains one or more zones rich in sphalerite and chromium-bearing garnet, and a little pyrite. The mineralized zone at the prospect is less than a foot thick and contains 10 percent zinc, 4 percent chromium, 2 percent nickel, and traces of lead and arsenic. Other lodes near the Green Wonder property include sparse chalcopyrite in iron-stained serpentine and light copper staining in fractured andesite.

Two low-grade copper-nickel occurrences are known between the Middle and East Forks of Broxson Gulch (30). At one, several small lenses of massive sulfides, chiefly marcasite and subordinate chalcopyrite and pyrrhotite, are in ultramafic host rocks. The other consists of iron-stained silicified sandstone that contains disseminated pyrrhotite and carries small amounts of nickel, copper, gold, and silver.

On the West Fork of Rainy Creek (26), small amounts of secondary copper minerals and pyrite have been found in amphibole-epidote-chlorite rock next to a gabbro dike.

Several copper lodes in the Paxson Mountain area (25) typically consist of chalcopyrite, bornite, chalcocite, epidote, and quartz in amygdules, veinlets, and small pods in basaltic lava flows. Locally, the sulfides are oxidized to malachite and chrysocolla. One such lode, at the Tripp prospect (25) near mile 7 on the Denali Highway, was explored by a few pits. A random sample of quartz veins less than an inch thick containing chalcopyrite and bornite assayed 1.38 percent copper, and a trace of gold and 0.30 ounce of silver per ton.

Additional information on this district is given in the following references: Ebbley and Wright (1948); Hanson (1963); Joesting (1942); Moffit (1954a); Rose (1965a); Smith, P. S. (1942).

EAGLE DISTRICT

The Eagle district (pl. 1; fig. 32) is the area drained by the southern tributaries of the Yukon River between the Charley River and the Alaska-Yukon boundary. It consists of low mountains, plateaus, and gently rolling uplands (pl. 1) underlain mainly by sedimentary beds ranging in age from Devonian to Tertiary. In the southern part of the district some of the beds are cut by a Jurassic or Cretaceous granitic batholith and have been converted to quartz-mica schist, amphibolite, and gneiss. Several tabular or lenticular mafic and ultramafic plutons cut Paleozoic strata elsewhere in the district (pl. 1).

The only evidence of lode mineralization in the district consists of several samples of sulfide-bearing rock encrusted with cobalt bloom, purportedly collected from a gold- and nickel-bearing vein in basaltic greenstone on Eagle Bluff (31, see fig. 32) near the mouth of Mission Creek.

Additional information on this district is given in the following reference: Wedow (1954).

FAIRBANKS DISTRICT

The Fairbanks district (pl. 1; fig. 33) is the area drained by the Chatanika River and the northern tributaries of the Tanana River from Minto to and including Shaw Creek.

The district is a dissected plateau characterized by many broad valleys and by broad rolling interstream areas from which rise numerous rounded domes and a few large mountainous masses (pl. 1).

The dominant rocks are the Birch Creek Schist and Mesozoic igneous rocks (pl. 1). The Birch Creek Schist in this area includes quartzite, quartz-, mica-, graphite-, carbonate-, hornblende-, and chlorite-rich schist, crystalline limestone, amphibolite, and gneiss. The igneous rocks include quartz diorite, biotite granite, granitic and dioritic porphyries, and small amounts of peridotite(?) and olivine basalt.

Lodes in the Fairbanks district have produced important amounts of gold and smaller quantities of silver, tungsten, and antimony ore. The gold lodes also contain some lead, copper, zinc, and bismuth, and a little nickel, chromium, and cobalt have been reported in ultramafic rocks in the eastern part of the district. The lodes near Fairbanks are probably genetically related to biotite granite plutons and are the sources of most of the nearby major placer-gold deposits.

GOLD AND SILVER

The gold mines and prospects in the Fairbanks district are too numerous to permit individual descriptions in this report. For such descriptions, the reader is referred to the publications listed at the end of this chapter, particularly U.S. Geological Survey Bulletin 849–B (Hill, 1933). Silver is a subordinate constituent of most of the gold lodes, and the two commodities are described together even though a few of the deposits were explored mainly for silver.

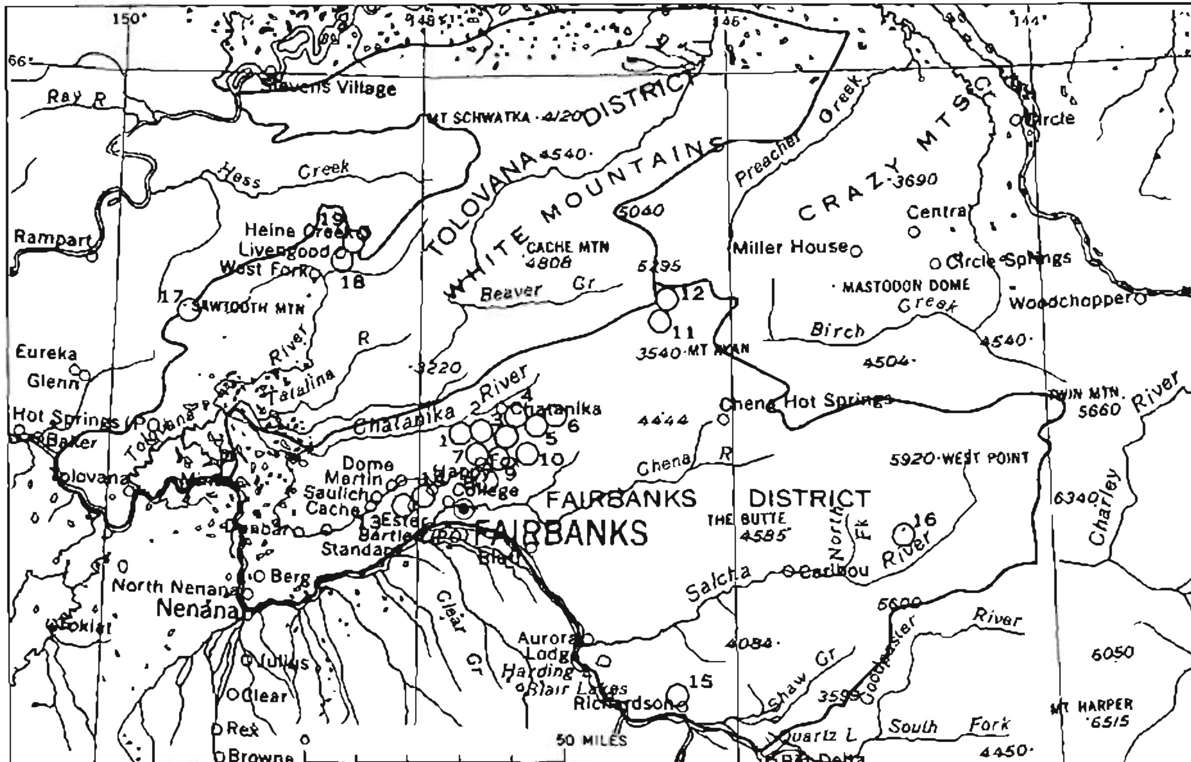

Figure 33.—Metalliferous lode deposits in the Fairbanks and Tolovana districts.

Fairbanks district

Pedro Dome area

1. Frederick
   Gilmer
   Goodwin
   Hoel Brothers, Johnson & Witmer
   *Scrafford
   Thrift
   Treasure Creek
2. Markovich
   Mother Lode
   *Old Glory (Leslie)
   Seattle Creek
   *Silvertone
   Soo (Reliance)
   Spruce Creek
3. Burnet
   Burnet Galena
   Cheechako No. 1 (Eldorado)
   Cheyenne
   David (Apex)
   Dome View

*See footnote at end of list.

Fairbanks district—Continued

Pedro Dome area—Continued

(3.) Egan
   Emma (Katherine)
   Goepfert
   Goepfert Galena
   Hidden Treasure
   Hirschberger & Zimmerman
   Hoover (Birch & Anderson)
   Independence
   Jackson
   Mohawk (Heilig & Creighton)
   Moonlight
   Mother Lode
   Newsboy
   Nightingale
   North Star
   North Star Extension (Center Star)
   *Rainbow
   S.S.
   Steil
   Thompson

Fairbanks district—Continued

Pedro Dome area—Continued

(3.) Wackwitz (Bedrock Creek)
   Westonvich
   White Elephant
   Whitman & Murray
   Zimmerman (2 prospects)
4. Alaska (Jupiter-Mars)
   Banner
   Bobbie
   Butler & Petree (B-P)
   Chatham
   *Cleary Hill (Rhoads-Hall)
   Cunningham
   Empire (New York)
   Harris & Brown
   Herschberger, Beall & Phipps
   Homestake (Rexall)
   *Johnson
   McCarty (Henry Ford)
   McCarty (Pioneer)
   Mary
   Pioneer

Continued on following page.

LOCALITIES SHOWN ON FIGURE 33—continued

Fairbanks district—Continued

Pedro Dome area—Continued

(4.) Quemboe Brothers
Sky High
Solomon
Sunrise
*Tolovana
*Wackwitz (Wyoming)

5. Branholm-Jenkins
Excelsior
Fairbanks Creek
Gilmore
Governor
Hi-Yu (Crites & Feldman; Nars, Anderson, and Gibbs)
Kellen
*Mizpah
Ohio
Perrault
Rob & Roy
Saucy
Whitehorse (Too Much Gold Creek)

*See footnote at end of list.

Fairbanks district—Continued

Pedro Dome area—Continued

(5.) Wolf

6. Charles
Coffee Dome
Egan & Egan
Eureka
McCarty (Alder Creek)

7. Bunker Hill
Freeman & Scharf
Goodwin

8. Engineer
Ridge

9. Anderson
Black Bear
*Blossom
*Columbia
Green Mountain
Rose Creek
*Spruce Hen
*Tanana
*Tungsten Hill
Woodpecker

Fairbanks district—Continued

Pedro Dome area—Continued

10. American (Perrault)
American Eagle
*Colbert
Franklin
Melba Creek
Monte Cristo
Ptarmigan
*Schubert
*Stepovich
Voght
White Association
*Yellow Pup

Sourdough Creek area

11. *Dempsey Pup

12. Hope Creek

Ester Dome area

13. Barker & McQueen
Blue Bonanza
Cottonblossom

LOCALITIES SHOWN ON FIGURE 33—continued

Fairbanks district—Continued

Ester Dome area—Continued

(13.) Farmer
Jennie C. (McQueen)
Koegley
Maloney
Mother
Ready Bullion
Silver Dollar
Tyndall & Finn
Vuyovich (2 prospects)

14. Billy Sunday
Blue Bird
Blue Bird Mining Co.
Clipper
Crown Point
Dorothy & Dorice
Elmes
Eva Quartz Co.
Fair Chance
First Chance
Grant
Happy Creek

Fairbanks district—Continued

Ester Dome area—Continued

(14.) McDonald
Michley
Mohawk
Prometheus
Royal Flush
Ryan
Saint Paul
Sanford
Stay (Little Eva)
*Stibnite
Wandering Jew

15. *Democrat

16. Nickel Creek
*Salcha River

Tolovana district

17. *Sawtooth Mountain

18. *Lillian Creek
*Olive Creek (Hudson)
*Ruth Creek

19. *Livengood Creek

* Cited individually in text.

Almost all the district's precious-metal deposits are in the uplands north of Fairbanks. They are mainly in two areas, one near Pedro Dome (1–10, see fig. 33) and the other near Ester Dome (13, 14). The Pedro Dome area contains 113 mines and prospects, and the Ester Dome area 35. A few deposits are known in other locations nearby, and one gold lode, the Democrat (15), is in the southern part of the district near Richardson.

Prior to 1960, the total recorded lode production of precious metals amounted to 239,247 ounces of gold and 39,078 ounces of silver. Much of the antimony ore and a little of the tungsten ore produced in the district were recovered as byproducts of gold mining.

Most of the gold lodes are geologically similar and can therefore be described together. They are commonly in fissure veins that cut schist, usually near felsic intrusive rocks. The most productive veins were 2 inches to 3 feet thick; in a few of the mines, silicified schist that contained numerous closely spaced quartz veinlets was rich enough to mine over zones 8–12 feet wide. Several wider zones of schist rich in quartz stringers are known, but they are generally of low grade. The dominant alinement of many of the intrusive masses and veins is eastward although the veins at Ester Dome and at a few other localities deviate from this trend. Most of the veins cut the schistosity at high angles and occupy persistent, nearly straight fractures.

The higher grade lodes consist largely of crushed or cracked white quartz. Where sulfides are present, however, they are made up mainly of fine-grained grayish-white quartz. The silica was introduced in at least four stages, the third of which was accompanied by gold and its associated sulfides. The sulfides, which make up less than 2 percent of the deposits, consist mainly of arsenopyrite, pyrite, stibnite, and jamesonite, and less commonly of bismuthinite, boulangerite, chalcopyrite, covellite, galena, chalcocite, sphalerite, and tetrahedrite. In addition, minor amounts of secondary antimony, copper, iron, and manganese minerals, and lollingite, scorodite, scheelite, calcite, and mariposite have been reported. Much of the silver is in the galena, jamesonite, boulangerite, and tetrahedrite.

The Silvertone silver-lead deposit (2), about 2 miles southwest of Pedro Dome, was explored during the late 1950's, and about 60 tons of hand-sorted ore was shipped. It consists of a series of narrow iron-stained quartz veins up to a foot thick that cut dioritic rocks and contain argentiferous galena and jamesonite. Six channel samples contained 2–5 percent lead, and 2.9–8.8 ounces of silver and 0.06–0.36 ounce of gold per ton. Approximately 25 tons of ore was stockpiled on the property in 1958.

ANTIMONY

Antimony lodes in the district occur principally in the Pedro Dome and Ester Dome gold belts in an area that roughly extends between points 10 miles west and 23 miles northeast of Fairbanks. A few are also near Sourdough Creek (11, 12), about 30 miles farther northeast along the same trend. The lodes were worked largely in connection with gold mining, but during two periods prior to World War II, high antimony prices warranted independent production, and about 2,500 tons of stibnite ore was shipped. Probably several hundred tons of antimony ore has been produced in the district since then.

The antimony deposits occupy the same lodes as the economically more important gold deposits. They consist of stibnite and sulfosalts, in part deposited contemporaneously with late-stage quartz (in which they form disseminated crystals), and in part as the latest filling in the veins, where they form masses of virtually solid sulfide. One exceptionally large mass contained about 100 tons of ore, but most of the masses were much smaller. Much of the ore carried 40–65 percent antimony and consisted mainly of stibnite and quartz, with subordinate jamesonite, boulangerite, and antimony oxides.

Deposits containing antimony minerals are known in more than 50 localities in the district, 18 of which have been productive. Most of the ore came from five mines, only two of which were operated mainly for antimony; the remainder of the production was a byproduct of gold mining. The geologic setting of the deposits is virtually the same as that of the gold lodes discussed above; therefore, only the two mines operated mainly for antimony, the Scrafford and the Stibnite, and the deposits on Sourdough Creek, east of the gold belt, will be described.

The Scrafford mine (1), the largest producer of antimony in the district, is on a branch of Eagle Creek in the western part of the Pedro Dome area. About 1,600 tons of ore was mined from an eastward-striking southward-dipping shear zone 3–15 feet wide in schist. The shear zone is partly filled with iron-stained quartz and with kidney-shaped masses of stibnite. The largest mass mined was 40 feet long, 11 feet wide, and 6 feet thick. The property has been idle since about 1926, and in 1942 about 300 tons of low-grade material (10–20 percent antimony) remained on the dump.

The Stibnite mine (14), near the head of Eva Creek, was the principal source of antimony ore in the Ester Dome area. In 1915 and 1926, it produced 300 tons of ore carrying 51.5 percent antimony. The mine is on a shear zone 12- to 30-inches wide that strikes N. 17° W. and dips 70°–89° SW. The shear zone cuts schist and contains lenses of stibnite and quartz.

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Stibnite also occurs along Sourdough Creek (11, 12) about 70 miles northeast of Fairbanks. The Dempsey Pup (11) prospect, explored by several short tunnels, is in quartzitic schist and consists of a stibnite- and gold-bearing quartz vein. A few hundred pounds of material, selected specimens of which assayed about 23 percent antimony, were on the dump in 1942.

An estimate of the antimony resources in the Fairbanks district was made in 1942 by the U.S. Geological Survey (Killeen and Mertie, 1951). Their conservative estimate included about 30 tons of stockpiled high-grade ore containing more than 30 percent antimony; about 3,000 tons of low-grade dump material; and about 50 tons of proven high-grade material at various prospects and mines. Although Killeen and Mertie gave no estimate of inferred resources, some material in this category undoubtedly is present.

TUNGSTEN

Mines in the Fairbanks district have produced tungsten ore during economically favorable intervals since 1916. The tungsten deposits are 10–20 miles northeast of Fairbanks and consist of scheelite in thin beds and lenses of metamorphosed limestone and calcareous mica schist, in pegmatites, and in auriferous quartz veins.

The scheelite deposits are all in the Pedro Dome area (1–10), within which the most extensive developments have been near Gilmore Dome (10) and on the divide between Steele and First Chance Creeks (9). The Stepovich mines (10), near Gilmore Dome, contains the largest known scheelite deposit in the district, and in the periods 1915–18 and 1942–44 produced scheelite ore and concentrates containing about 4,000 units (20 pounds to a short ton) of WO_3. The lode consists of a series of limestone lenses, probably derived from a continuous bed a few feet thick, that have been largely replaced by calc-silicate minerals, quartz, and scheelite. The richest ore shoots were at intersections of pegmatite dikes and limestone.

The Colbert property (10) and the Yellow Pup prospect (10) are on a similar lode about 1,000 feet south of, and parallel to, the Stepovich lode. The nearby Schubert prospect (10) contains sparse scheelite in metamorphosed limestone at the contact of porphyritic granite.

The Spruce Hen, Blossom, Tanana, Tungsten Hill, and Columbia prospects, on the ridge between the heads of Steele and First Chance Creeks (9), are on scheelite deposits in tactite, silicated limestone, granitic and pegmatitic dikes, and on small scheelite-bearing quartz veins in schist. The Wackwitz (4) and Mizpah (5) mines produced small tonnages of scheelite concentrates as a byproduct of gold production from quartz veins. Scheelite has also been found in the gold mines at Cleary Hill (4), Johnson (4), Rainbow (3), and Tolovana

(4), and probably occurs in other gold mines in the Pedro Dome area. The Leslie (Old Glory) prospect (2) exposed a scheelite-bearing lode in metamorphosed limestone.

Tungsten minerals are reported to be minor constituents of some of the deposits on the upper Salcha River in the eastern part of the district.

OTHER METALS

Minor amounts of copper, lead, zinc, bismuth, and chromium minerals are known in the district, and a little nickel, platinum, and cobalt have been reported. The copper minerals, which include chalcopyrite, covellite, tetrahedrite, chalcocite, azurite, and malachite, are minor constituents of some of the gold lodes, as are galena, lead-bearing sulfosalts, sphalerite, and bismuthinite.

Disseminated grains and small crystal aggregates of chromite are uniformly distributed in two large bodies of mafic rock on the upper Salcha River (16). In most of the deposits, the chromite content is less than 1 percent. Some of the serpentine bodies in the area contain as much as 0.6 percent nickel and traces of platinum and cobalt.

Additional information on this district is given in the following references: Brooks (1916); Byers (1957); Chapin (1914a, 1919b); Hill (1933); Joesting (1942, 1943); Killeen and Mertie (1951); Mertie (1918b); Prindle (1913); Smith, P. S. (1942).

FORTYMILE DISTRICT

The Fortymile district (pl. 1; fig. 32) comprises the Alaskan part of the Fortymile River drainage basin, the area drained by streams flowing southwest into the Tanana River from Tanacross to the Alaska-Yukon border, and the Alaskan part of the western tributaries of the Yukon and White Rivers. It consists of discontinuous groups of mountains above a fairly uniform plateau (pl. 1). The district is underlain chiefly by the Birch Creek Schist, less extensively by younger Paleozoic volcanic and sedimentary rocks and their metamorphosed counterparts, and locally by Mesozoic and Tertiary quartz diorite and granite plutons (pl. 1). Lower Tertiary rhyolite and dacite and upper Tertiary and Quaternary lava flows, tuff, and terrestrial sedimentary rocks are locally abundant.

The Fortymile district is known mainly for its placer gold deposits but also contains several lodes, none of which has shipped any ore. Most of the lodes are in metamorphic rocks near granitic contacts, and they typically consist of veins or, less commonly, of irregular contact-metamorphic deposits carrying gold, silver, lead, copper, zinc, antimony, and iron.

At the Tweeden prospect (34), in the basin of Mosquito Fork, small iron-stained quartz veins in greenstone and greenschist carry a little free gold.

A gold prospect on Lilliwig Creek (35) is in sericitized quartz diorite cut by numerous quartz-calcite veinlets carrying auriferous pyrite and minor chalcopyrite. Assays by the U.S. Geological Survey of selected sulfide-rich material from the prospect dump showed 1.87 ounces of gold and 2.05 ounces of silver per ton and 0.76 percent copper.

A little work was done on a bornite-bearing lode at the Mitchell prospect (33), near the headwaters of Kechumstuk Creek, and possibly on other occurrences of copper minerals in the basin of the Middle Fork of Fortymile River, about 12 miles south of Joseph village.

Two prospects on My Creek (32) near Mount Veta are on calcite veins that cut Birch Creek Schist near the contact of granitic rocks. The veins contain argentiferous galena and minor amounts of sphalerite and malachite.

A stibnite prospect in Birch Creek Schist is in a broad saddle on the ridge south of My Creek (32). Exploration at the prospect has been impeded by a cover of silt and muck, but about 4 tons of material, estimated to contain 50 percent antimony, has been collected from exploratory pits and cuts. Stibnite has also been reported from the Norvill prospect (35) in the Chicken Creek valley.

A contact-metamorphic magnetite lode is in recrystallized limestone adjacent to granitic rocks at My Creek (32). It is 15 feet thick and can be traced on the surface for about 300 feet.

Additional information on this district is given in the following references: Ebbley and Wright (1948); Mertie (1930b); Porter (1912); Saunders (1962); Wedow, White, and others (1954).

GOODPASTER DISTRICT

The Goodpaster district (pl. 1; fig. 32), which embraces the area drained by northern tributaries of the Tanana River between Big Delta and Tanacross, is physiographically similar to the adjacent Fortymile district (p. 221). It is underlain mainly by schist and gneiss of Birch Creek and locally by intrusive rocks.

The only production from lodes in the Goodpaster district consisted of a small quantity of gold ore mined from free gold- and sulfide-bearing quartz veins on the Blue Lead and Grizzly Bear claims (36).

Jamesonite, a lead-antimony sulfide, is moderately abundant in auriferous quartz veins near the head of Tibbs Creek (36), and molybdenite has been found at several places (37, 36), generally in quartz veins that cut granitic rocks. A selected sample from the Johnson prospect (37), which is on the divide between the South Fork of the Goodpaster River and the Healy River, contained 1.2 percent molybdenum, but the average tenor of the deposit is much less. A little molybdenite is also found in quartz veins in granite near the heads of Boulder and Tibbs Creeks (36).

Additional information on this district is given in the following references: Chapin (1919c); Joesting (1942); Smith, P. S. (1939).

HOT SPRINGS DISTRICT

The Hot Springs district (pl. 1; fig. 34) is the area drained by southern tributaries of the Yukon River between Kallands and Fish Creek, including the Tanana River below Baker.

The district consists of broad river valleys studded with low mountains and hills (pl. 1). It is underlain by Paleozoic metasedimentary and metavolcanic rocks, largely serpentinized Paleozoic ultramafic rocks, Mesozoic sedimentary rocks, Tertiary granitic rocks, and unconsolidated Quaternary deposits (pl. 1).

No lode production is recorded from the Hot Springs district although its placer deposits have produced significant amounts of gold and tin. The few lodes that are known are in higher terrains, such as Hot Springs Dome (3, see fig. 34), where a low-grade mineralized belt has been known for many years. The belt, in sheared metasedimentary rocks near biotite granite, contains at least six gold-silver lodes.

The Barrett prospect (3), on the summit of Hot Springs Dome, is on a shear zone that is 20–35 feet wide. The zone is traceable for about 2,000 feet and contains argentiferous galena, limonite, and minor amounts of gold, hematite, chalcopyrite, chalcocite, pyrrhotite, pyrite, quartz, secondary copper minerals, and the cobalt mineral erythrite. Similar lodes are in nearby shear zones.

A random sample collected by members of the Geological Survey from a small gossan in quartzite west of Idaho Gulch (2) contained 1.34 ounces of silver per ton but no gold. Another Geological Survey field party found grains of chromite disseminated in serpentinized ultramafic rock, as well as pieces of chromite float up to 6 inches in diameter on the ridge south of Boulder Creek (1).

Nickel minerals reportedly occur in a pyrrhotite-bearing basalt dike south of the Barrett prospect, and small amounts of cassiterite have been found in felsic intrusive rocks in several places in the district. A lead-silver (argentiferous galena) prospect (4) is reported near the headwaters of either Eureka or Pioneer Creek.

Additional information on this district is given in the following references: Mertie (1934); Wayland (1961).

HUGHES DISTRICT

The Hughes district (pl. 1; fig. 34) includes the area drained by the Koyukuk River and its tributaries below the Kanuti River and by northern tributaries of the Yukon River between Koyukuk and

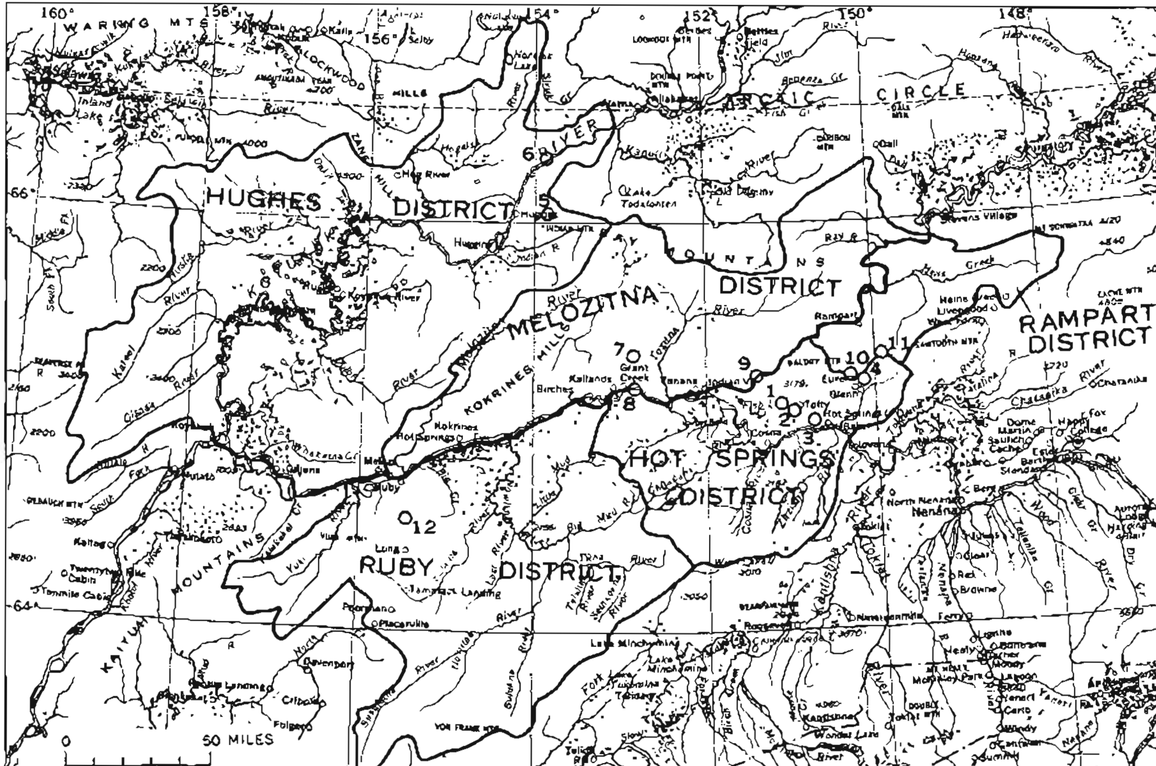

Figure 34.—Metalliferous lode deposits in the Hot Springs, Hughes, Melozitna, Rampart, and Ruby districts.

LOCALITIES

Hot Springs district

1. *Boulder Creek
2. *Idaho Gulch
3. *Hot Springs Dome (Barrett)
4. *Unnamed

Hughes district

5. *Indian River
6. *Red Mountain Creek

Melozitna district

7. *Tozimoran Creek

Melozitna district—Continued

8. *Gold Hill
9. Quartz Creek

Rampart district

10. *Avnet
    Unnamed
11. *Wolverine Mountain

Ruby district

12. *Beaver (New York) Creek

*Cited individually in text.

Melozi. It consists of a large central lowland fringed by low mountains and uplands (pl. 1) and is underlain mostly by Mesozoic volcanic and sedimentary rocks intruded by granitic batholiths and numerous smaller plutons. Most of the central part is covered by thick deposits of sand, silt, and gravel (pl. 1).

The only lode known to have been prospected in the Hughes district is a molybdenite deposit near Indian River (5, see fig. 34). It has not been systematically sampled but is said to contain mineralized rock of fairly high grade; the deposit probably is genetically related to nearby felsic intrusive rocks.

Pyritic latite porphyry near the mouth of Red Mountain Creek (6) is marked by a large gossan and contains traces of zinc, gold, and other metals (W. W. Patton, Jr., oral commun., 1965).

Additional information on this district is given in the following references: Joesting (1942); Patton and Miller (1966).

IDITAROD DISTRICT

The Iditarod district (pl. 1; fig. 29) comprises the areas drained by eastern tributaries of the Yukon River between Paimiut and Shageluk Sloughs, by southern tributaries of the Innoko River between Holikachuk and Dishkakat, and by tributaries of the Innoko below Holikachuk.

The southeastern two-thirds of the district consists of rounded northeast-trending ridges surmounted locally by isolated groups of rugged mountains 3,000–4,000 feet in altitude. The northwestern third is marked by the low plains and flats of the Yukon and Innoko Rivers (pl. 1).

The district is underlain chiefly by upper Paleozoic to Cretaceous marine sedimentary rocks and in one small area by Cretaceous or Tertiary lava flows (pl. 1). Scattered felsic plutons cut the Cretaceous beds in the southeastern part of the district. Bedrock in the lowlands is covered by alluvial deposits.

The most important lodes in the Iditarod district are the cinnabar-stibnite deposits at DeCourcy Mountain (2, see fig. 29) about 30 miles south-southwest of Flat.

The DeCourcy Mountain mine (2), the only important quicksilver mine in Alaska that is not in the Kuskokwim River region, produced more than 1,200 flasks of mercury, second only in production to the Red Devil mine (p. 89). The lode, which is in or near sill-like masses of altered basalt or diabase that intrude graywacke and shale, consist of lenses, veins, and stockworks of cinnabar and minor stibnite in a gangue of silica, carbonate, and clay minerals. Most of the ore bodies were distributed throughout a block at least 2,000 feet long, 250 feet wide, and 360 feet deep.

Numerous quartz and calcite veins carrying stibnite, cinnabar, and gold occur in felsic plutons or in adjacent bedded rocks in the Willow Creek-Flat area (3, 4). Most of the veins are no thicker than 3 feet and consist of intergrowths of quartz and stibnite, a little cinnabar, and arsenopyrite or pyrite. An unidentified mineral containing 2 percent cobalt has been reported at one prospect. Some of the veins reportedly carry considerable gold and were worked early in the century, but gold production figures are not available. No antimony or quicksilver ore has been shipped. Most of the lodes were prospected by trenches and pits, and shallow shafts were sunk on some. A stamp mill was constructed about 1912, but the value of the recoverable gold was soon offset by rising costs, and operations were suspended. Exploration of the Golden Horn property (4) on Granite Creek was undertaken as recently as 1937, and some ore, from which gold and a small amount of lead and zinc were recovered, is reported to have been shipped.

Additional information on this district is given in the following references: Brooks (1916); Cady, Wallace, Hoare and Webber (1955); Maloney (1962a); Mertie (1936); Smith, P. S. (1915); White and Killeen (1953).

INNOKO DISTRICT

The Innoko district (pl. 1; fig. 29) is, except for the Poorman area, the area drained by the Innoko River and its tributaries above Diskakat. It comprises low mountains, plateaus, rolling uplands, and a small lowland area along the upper Innoko River (pl. 1).

The district includes Paleozoic metasedimentary rocks, Carboniferous to Cretaceous volcanic and sedimentary rocks, and Cretaceous to Tertiary lava flows and tuff. Locally the Cretaceous strata are cut by granitic plutons.

Lodes containing stibnite, cinnabar, and gold are known in the Innoko district, and although only three such deposits have been described, it is likely that numerous others have been discovered but not reported.

Stibnite occurs at the Kaatz prospect (5, see fig. 29), about 15 miles south of Ophir. The deposit is in sandstone cut by a rhyolite dike and consists of a quartz fissure vein as much as 10 feet thick carrying stibnite and traces of gold and silver. The vein strikes northeast and dips steeply southeast and reportedly has been traced on the surface for several thousand feet. Stibnite occurs in specks throughout the vein but it is most abundant in a zone about a foot thick next to the footwall.

A stibnite- and cinnabar-bearing vein is reportedly near Wyoming Creek (7), in the Cripple Creek Mountains, where a monzonite stock cuts Cretaceous sedimentary rocks. The vein is about 30 inches thick and consists of alternating layers of quartz intergrown with cinnabar and of coarse stibnite with interstitial quartz. It was discovered early in the present century but has not been worked.

The Independence gold lode (6) about 10 miles west of Takotna, was mined for a year or two about 1912, but production figures are not available. The ore body consisted of an auriferous quartz vein about 2 feet thick that followed the hanging wall of a felsic dike. Some of the gold was associated with magnetite, and the vein was seamed by stringers of iron carbonate. The mine, which was probably abandoned by 1920, included several drifts and a shaft.

Additional information on this district is given in the following references: Brooks (1916); Mertie (1936).

KAIYUH DISTRICT

The Kaiyuh district (pl. 1; fig. 29) is the area drained by streams flowing west and north into the Yukon River from Shageluk Slough to, but excluding, the Yuko (Yuki) River, and by streams flowing south into the Innoko River from Holikachuk to Dishkakat. It consists of moderately rugged mountains 1,500–2,000 feet in altitude that descend northwestward to the Koyukuk Flats and southeastward to the flood plain of the Innoko River (pl. 1).

The bedded rocks comprise middle(?) Paleozoic schist and recrystallized limestone, upper(?) Paleozoic greenstone, and Mesozoic volcanic and clastic rocks (pl. 1). Jurassic or Cretaceous granite plutons cut the Paleozoic metamorphic rocks in the northeastern part of the district and the Mesozoic volcanic rocks in the north-central part. Bedrock in the lowlands is mostly covered by thick accumulations of sand, gravel, and silt.

The Kaiyuh district contains lodes that carry silver, lead, and molybdenum. A little silver-lead ore was shipped in the 1920's, but there are no reports of recent mining activity.

A small group of silver-lead deposits, called the Perseverance and Valley claims (9, see fig. 29), are at the northeastern end of the Kaiyuh Mountains, about 27 miles south of Galena. The deposits are in quartz-mica schist and consist of argentiferous galena veins as much as 3 feet thick that strike northeastward parallel to the foliation of the schist. They were worked from about 1918 to 1922 and produced about 225 tons of ore, of which approximately 175 tons was shipped to a smelter in Idaho. The shipment is reported to have averaged 73 percent lead and 104 ounces of silver to the ton, but mining operations were discontinued because of high transportation costs.

The McLeod molybdenum prospect (8) is in the southern Kaiyuh Mountains on the divide between the Yukon and Innoko Rivers. Several pits and trenches were excavated in 1942, but no production was recorded. The lode, reported to have assayed 2 percent molybdenum, is in rhyolite porphyry and consists of clumps and grains of molybdenite scattered in a northeastward-striking milky quartz vein. Vein float can be traced on the surface for several hundred feet.

Additional information on this district is given in the following references: Mertie (1937); West (1954).

KANTISHNA DISTRICT

The Kantishna district (pl. 1, fig. 31) is the area drained by the Kantishna River and its tributaries. It extends southward from the Tanana lowland through two groups of foothills to the crest of the Alaska Range (pl. 1) and is underlain generally by strongly metamorphosed Paleozoic rocks—chiefly schist and gneiss—and locally by their slightly metamorphosed equivalents. Volcanic and plutonic rocks crop out in small areas throughout the district, and nonmarine sedimentary rocks of Tertiary age, some of which are coal bearing, occur in the northermost foothills of the Alaska Range. Poorly consolidated Quaternary deposits of diverse origin cover extensive areas in the lowland (pl. 1).

Lodes in the Kantishna district have yielded small amounts of gold, silver, antimony, and lead ore. Most are quartz veins that cut strongly schistose rocks and carry varying amounts of gold, arsenopyrite, pyrite, argentiferous galena, sphalerite, stibnite and chalcopyrite. The main deposits may be divided into three groups: those containing chiefly lead, silver, and zinc; those yielding antimony; and those in which gold is the principal valuable metal. In addition, mercury and tungsten minerals are known in single deposits. The best known lead-silver-zinc deposits are near Friday and Eureka Creeks and at Mount Eielson; stibnite has been found near Stampede, Slate, and Caribou Creeks and near the head of Slippery Creek. Most of the gold-bearing quartz deposits are in the southern part of the Kantishna Hills, an area in which much placer gold has been mined.

The lead-silver-zinc deposits near Eureka and Friday Creeks (15–19, see fig. 31) are in an area underlain by quartz-muscovite and chlorite schist and by subordinate crystalline limestone and quartz porphyry. They consist of calcite-siderite-quartz veins carrying galena, sphalerite, and pyrite, and minor chalcopyrite, jamesonite, tetrahedrite, and pyrargyrite. Some of the veins are almost solid galena, which in part is very finely crystalline and in part coarsely crystalline. Those at the Red Top mine, on Quigley Hill (16) near Friday Creek, also contain minor amounts of scheelite, scorodite, and native sulfur. The Red Top mine produced approximately 100 tons of ore valued at more than $250 a ton, chiefly in silver. In 1921, the Little Annie mine, also on Quigley Hill, produced 700 tons of silver ore averaging more than \$150 a ton, and other mines nearby have produced a few hundred tons of similar ore. A few of the lodes in the area around Friday and Eureka Creeks were prospected mainly for gold, but only small amounts of the metal were recovered.

Mount Eielson (13), in the foothills of the Alaska Range, is underlain by metasedimentary rocks, quartz diorite and related intrusive rocks, and felsic(?) dikes and sills. The largest known deposits are in recrystallized limestone on the northern slopes of Mount Eielson, where approximately 30 claims have been staked. The deposits are mainly masses of argentiferous galena and other sulfides formed by replacement during contact metamorphism; less commonly the minerals occupy discrete fissures and were formed mainly by open-space filling. The chief values are in silver, and some of the deposits rich in argentiferous galena contain as much as 200 ounces of silver per ton. Typically, however, they contain less than 40 ounces of silver per ton, a small percentage each of lead and zinc, and a little gold.

Lead-zinc-silver deposits similar to those at Mount Eielson are in the area drained by Slippery and Clearwater Creeks (9–12). Some, however, are richer in copper than the Mount Eielson deposits, and several contain pyrrhotite and pyrolusite. One deposit, the Merinser (9), also contains small quantities of cinnabar and native mercury. The McCall prospect (21), about which little is known, was staked in Mount McKinley National Park near the Sushana River. Samples from the prospect are said to have assayed more than 6 ounces of silver per ton and about 55 percent lead.

The best known stibnite lode in the district is on Stampede Creek (20); others are on Slate (15), Caribou (17), and Slippery (8, 9) Creeks. Besides these deposits, at least two of which were large enough to work, a little stibnite has been found at many other places along the front of the Alaska Range in the southern part of the district.

At the Stampede mine (20), stibnite occurs in veins, lenses, and stringers in shear zones that cut a schistose quartzitic unit of the Birch Creek Schist. The shear zones probably are related to the Stampede fault, a prominent northeast-striking fault that is one of the area's major structural features. The low-grade lodes consist of stibnite disseminated in quartz veins as much as 7 feet thick and of stibnite stringers in schist. The stringer lodes form zones as much as 30 feet wide that constitute ore bodies with assay boundaries. The high-grade lodes consist of lenses and veins of stibnite generally about 5 feet thick; one exceptional ore body, however, was 26 feet thick. The low-grade mill ore assayed 10–20 percent antimony and the high-grade shipping ore more than 50 percent. From 1936 to 1951 approximately 3,300 tons of ore containing about 1,700 tons of metallic antimony were produced at the Stampede mine, but since 1951 only occasional shipments, probably aggregating less than 100 tons, have been made. In 1941 (White, 1942) the estimated proved and probable resources amounted to 70 tons of material containing 50 percent or more antimony; 6,000 tons containing 10–15 percent antimony; 1,000 tons carrying 20 percent antimony; and 5,000 tons of mill tailings averaging about 6 percent antimony. Additional undiscovered antimony resources probably are in the Stampede mine.

The Taylor stibnite deposit (15), on Slate Creek, is in a shear zone in schistose quartzite intruded by masses of light-colored coarse-grained diorite. It is 15 feet in maximum thickness and constitutes a reticulated stockwork of quartz and stibnite stringers and lenses as much as 2 feet thick in decomposed clayey schist. About 125 tons of hand-sorted ore was mined from the deposit.

The Caribou and Slippery Creek stibnite lodes are similar to the one on Slate Creek.

The earliest and most intensive lode prospecting in the district was for gold, but despite the discovery of many auriferous deposits, none was mined on a large scale, and total gold production was small. The gold lodes are similar to the other main types of lodes; they are commonly in schist near exposed intrusive rocks and consist mainly of quartz veins or stockworks carrying free gold, pyrite, and small to moderate amounts of other sulfides. Most of the gold lodes are in the Kantishna Hills, but several are along the front of the Alaska Range. Gold is also a constituent of almost all of the lead-silver-zinc deposits and a few of the antimony lodes.

Additional information on this district is given in the following references: Barker (1963b); Capps (1919a, 1927); Ebbley and Wright (1948); Joesting (1943); Moffit (1933a); Reed (1933); Reed (1961); Wells (1933); White (1942).

KOYUKUK DISTRICT

The Koyukuk district (pl. 1, fig. 35) is the area drained by the Koyukuk River and its tributaries above the Kanuti River.

The northern half of the district is in the Brooks Range—rugged, east-trending mountains separated by deep glaciated valleys. Southward the range gradually descends through low mountains and rolling uplands to the marshy flood plain of the upper Koyukuk River (pl. 1).

The district includes Paleozoic metamorphic, sedimentary, and volcanic rocks, Mesozoic volcanic and sedimentary rocks, and Tertiary and Quaternary lava flows (pl. 1). The Paleozoic rocks are cut by several granitic plutons, and the Mesozoic volcanic rocks by at least one granitic batholith. Thick sand, gravel, and silt deposits underlie the broad flats of the larger rivers.

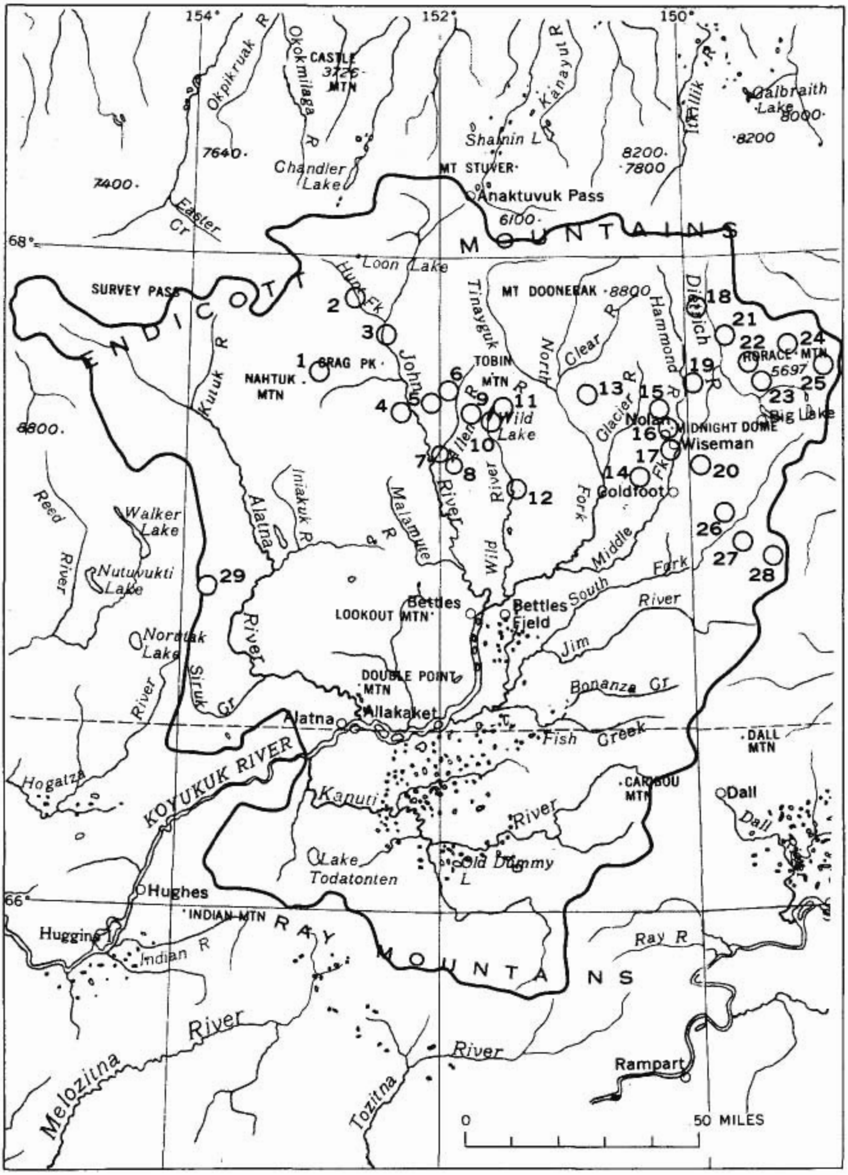

FIGURE 35.—Metalliferous lode deposits in the Koyukuk district. (Localities listed on next page.)

LOCALITIES SHOWN ON FIGURE 35

1. Unnamed
2. Hunt Fork (2 occcurrences)
3. *John River
4. Unnamed
5. Unnamed (2 occurrences)
6. Unnamed
7. Allen River
8. Crevice Creek
9. Unnamed
10. *Wild Lake
11. Unnamed
12. *Michigan Creek
13. Unnamed
14. Unnamed
15. Vermont Dome

Nolan Creek area

16. Fay Gulch
    Ferguson

Nolan Creek area—Continued

(16.) Jones & Boyle (Smith Creek)
    Wannemaker & Wortman

17. Cow Creek
    Wiseman

18. Big Jim Creek
19. Unnamed
20. Howard Creek
21. Snowdon Creek
22. Mathews River
23. Limestone Creek
24. Sheep Creek
25. Willow Creek
26. Unnamed
27. Unnamed
28. Siwash Creek
29. Unnamed

*Cited individually in text.

Metalliferous lodes containing antimony, gold, silver, copper, lead, and manganese have been discovered in the district, but the only production has been a little antimony ore shipped from one of the deposits. Most of the lodes are in a belt of Paleozoic metamorphic rocks in the northern part of the district.

Antimony-bearing lodes have been found near Wiseman (16, see fig. 35) and in the headwaters of the John River (3). The largest, near Nolan Creek (16) about 4½ miles northwest of Wiseman, are in mica schist and consist of stibnite veins 1½–6 inches thick, some of which contain quartz. Some of the veins have been traced on the surface for more than 100 feet. During World War II, about 6 tons of stibnite float containing slightly less than 50 percent antimony was sluiced from a prospect on the east side of Nolan Creek, but no other production has been reported from the Wiseman lodes.

A stibnite lode said to contain 42 percent antimony has been reported on the John River (3) near Hunt Fork.

A small amount of chalcopyrite occurs in limestone along the middle reaches of the John River (4, 5, 7, 8), and galena has been reported in a quartz or chalcedony vein in limestone on Michigan Creek (12), a tributary of the Wild River. The galena-bearing vein is said to be of considerable size and to carry gold in addition to lead.

Some of the metalliferous veins reported in the Lucky Six Creek area of the Noatak district of the Northwestern Alaska region (p. 105) may be on the Alatna River side of the divide and therefore in the Koyukuk district.

About 1960, U.S. Geological Survey investigators discovered traces of copper and lead in scattered sulfide-bearing veinlets in Devonian phyllite, limestone, and schist near Wild Lake (6, 9–11); in the area around the middle and upper reaches of the John River (1, 2, 4, 5, 7, 8); and near the middle and North Forks of the Koyukuk River (13-15, 17–22). They also detected traces of copper, zinc, silver, palladium, and nickel in and near the borders of a quartz monzonite pluton that cuts the Devonian rocks north of Big Lake (23–25), and sparse copper minerals in Devonian (?) graywacke and volcanic rocks near the South and Mosquito Forks of the Koyukuk River (26–28). Two deposits (20, 27), in addition to the one that also contains palladium (23), carry a little nickel. The investigations also disclosed rhodochrosite, manganite, and pyrolusite in phyllite in the western part of the district (29). A random sample of this material contained, in addition to manganese, 0.01 percent nickel and smaller amounts of chromium, cobalt, and other metals.

Additional information on this district is given in the following references: Brosgé and Reiser (1960, 1964)); Ebbley and Wright (1948); Joesting (1942); Patton and Miller (1966); Smith, P. S., and Mertie (1930).

MARSHALL DISTRICT

The Marshall district (pl. 1; fig. 29) is the area drained by the Yukon River and its tributaries below Paimiut and by the streams flowing into the Bering Sea and Norton Sound between Hazen Bay and St. Michael Bay. The district also includes a small area north of the Yukon River between Paimiut and Holy Cross.

Most of the district is a marshy plain studded locally by low volcanic hills and by a few craggy mountains that reach altitudes of about 2,500 feet. Northeastward, the plain merges with rounded even-crested ridges 1,000–2,000 feet in altitude (pl. 1).

The exposed bedded rocks include Permian to Lower Cretaceous sedimentary and volcanic formations, Cretaceous sedimentary beds, and upper Tertiary or Quaternary lava flows and tuff. Cretaceous or Tertiary granitic plutons and tabular fine-grained felsic intrusive masses crop out in the western and northeastern parts of the district, respectively, and at least two small ultramafic plutons have been reported along the shore of Scammon Bay. Bedrock in about two-thirds of the district is covered by alluvial and eolian deposits (pl. 1).

Lodes containing gold, lead, molybdenum, copper, and tungsten have been found in the Marshall district, mainly near Marshall. Although many have been known since about 1914, little development work has been done, and none has been productive.

The most thoroughly explored lode is on the Arnold group of claims (10, see fig. 29) near the head of Willow Creek about 7 miles southeast of Marshall. It is in greenstone and consists of quartz-calcite veins up to a foot thick that contain native gold, pyrite, galena, molybdenite, chalcopyrite, and traces of scheelite and wolframite. Locally, the greenstone carries abundant disseminated pyrite. The lode was explored by trenches and pits, and one vein, 6–12 inches thick, was traced along the strike for more than 100 feet. Several other veins were also exposed by opencuts.

Metalliferous quartz veins, similar to those at the Arnold lode, occur in bedrock along the bank of the Yukon River near Marshall (12), and free-milling gold has been reported in quartz veins near the head of Edgar Creek (11), about 5 miles east of Marshall.

The lodes may be genetically related to intermediate stocks and dikes.

Additional information on this district is given in the following references: Harrington (1918); Smith, P. S. (1942); West (1954).

MELOZITNA DISTRICT

The Melozitna district (pl. 1; fig. 34) comprises the area drained by northern tributaries of the Yukon River between and including the Melozitna and Ray Rivers. It consists mainly of rolling uplands surmounted by isolated groups of rugged mountains (pl. 1) and is underlain by metamorphic, volcanic, and sedimentary rocks ranging in age from Paleozoic to Tertiary (pl. 1). The strata are cut by Cretaceous and Tertiary granitic batholiths and smaller felsic plutons. The geology of most of the northern part of the district is still unmapped.

A few lodes were worked for gold and argentiferous galena early in the century, but there has been little recent exploration for lode deposits in the district.

A 10-foot stockwork of silver-bearing galena veins that may also contain gold occurs in limestone on Quartz Creek (9, see fig. 34) about 25 miles above Tanana. A tunnel was driven about 1915, but apparently no ore was produced, and the property was abandoned. Small galena veins also occur on Tozimoran Creek (7), about 20 miles northeast of Kallands.

An auriferous quartz vein in mica schist was discovered in 1890 at Gold Hill (8), on the north bank of the Yukon River about 20 miles below Tanana. It was worked by a 110-foot adit but was abandoned before 1910. Although the amount of gold recovered was probably not significant, the prospect has the distinction of being the first attempt to develop a lode mine in the interior of Alaska.

Additional information on this district is given in the following references: Eakin (1916); Maddren (1910); Wedow, Killeen and others (1954).

RAMPART DISTRICT

The Rampart district (pl. 1, fig. 34) is the area drained by southern tributaries of the Yukon River between Stevens and Hamlin Creeks.

The district contains many broad river valleys and intervening uplands with a few peaks rising above the general level (pl. 1). It is underlain by Paleozoic and Mesozoic sedimentary and volcanic rocks and their metamorphosed equivalents; a few Paleozoic ultramafic plutons; Tertiary granitic and coal-bearing sedimentary rocks; and unconsolidated Quaternary deposits (pl. 1).

Prospecting in the Rampart district has been hampered by poor outcrops, and only a few lodes, none of which has been productive, are known. They include a stibnite-bearing mafic dike on Wolverine Mountain (11, see fig. 34) and a stibnite occurrence on the ridge between upper Minook Creek and Granite Creek (10). A U.S. Geological Survey field party detected a strong antimony anomaly while conducting geochemical studies near Elephant Mountain, about 15 miles south-southeast of Rampart.

Manganese-bearing float was discovered in 1952 at the Avnet prospect (10), about 19 miles northeast of Tofty. The prospect was explored by a trench and two pits that did not reach bedrock. The manganese occurs in psilomelane that forms thin surficial coatings on, and veinlets and small irregular masses in, fragments of vein quartz, calcareous quartzite, and schist. The fragments are sparsely scattered throughout an area 3,000 feet long and 600 feet wide; locally, however, they are abundant, especially in frost boils and mounds. Samples assayed by the U.S. Bureau of Mines in 1964 (Thomas, 1965) contained an average of 15–20 percent manganese and up to 0.28 ounce of silver per ton.

The district contains important gold placers that also carry an array of other minerals, including cassiterite, scheelite, cinnabar, and chromite.

Additional information on this district is given in the following references: Mertie (1934); Thomas (1965).

RUBY DISTRICT

The Ruby district (pl. 1, fig. 34) comprises the Poorman area and the area drained by the Yuko (Yuki) and Nowitna Rivers and other southern tributaries of the Yukon River as far east as Kallands. It is characterized by rounded ridges surmounted by isolated groups of rugged mountains 3,000–4,400 feet in altitude and by broad lowlands (pl. 1).

Bedrock consists of middle Paleozoic to Cretaceous metamorphic, volcanic, and marine sedimentary rocks locally overlain by Tertiary or Quaternary lava flows and cut by Mesozoic and Tertiary intermediate and felsic plutons. Widespread deposits of Quaternary alluvium occur along the major rivers (pl. 1).

Although mineralized bedrock probably occurs at many places in the Ruby district, the only lode that has been described is a silver-lead deposit in schist, slate, and chert on Beaver Creek (12, see fig. 34), about 14 miles south of Ruby. It was prospected by several shafts, trenches, and pits, and an undetermined amount of ore was mined. Attempts to ship the ore, however, were unprofitable, and the property was abandoned by the mid-1930's. The deposit consists of lenticular veins as much as several feet thick that are parallel to the foliation of the enclosing rocks. The ore consisted of silver-bearing galena, cerussite, and limonite, minor rhodochrosite, manganese oxides, calcite, and siderite, and traces of gold, quartz, pyrite, and ruby silver. Several assays of the ore showed 8–82 ounces of silver per ton.

Additional information on this district is given in the following references: Brown (1926); Mertie (1937).

SHEENJEK DISTRICT

The Sheenjek district (pl. 1; fig. 30) is bounded on the east by the Alaska-Yukon border, on the north by the Brooks Range divide, and on the west by the eastern drainage divide of the East Fork of the Chandalar River. Its southern boundary is an eastward-trending arbitrary line from Venetie to Graphite Point on the Porcupine River, beyond which it follows the drainage divide between the Porcupine and Black Rivers to the Alaska-Yukon boundary.

From north to south the district includes the rugged Brooks Range, moderately mountainous foothills, a gently rolling plateau, and the flood plain of the Yukon River (pl. 1). It is underlain chiefly by Devonian to Jurassic(?) sedimentary, volcanic, and metamorphic rocks locally cut by Devonian or younger granitic stocks (pl. 1). Near the Porcupine River, the bedded rocks form a shelf-type sequence of sedimentary and volcanic rocks ranging in age from Precambrian to Quaternary.

The scant data available on the mineral resources of the Sheenjek district include reports of sulfides containing copper, lead, zinc, and silver near an alaskite plug in the headwaters of Coleen River (9, see fig. 30) and a nickel-bearing alum collected from a seep on the Porcupine River near Old Rampart.

Additional information on this district is given in the following reference: Mertie (1930a).

TOK DISTRICT

The Tok district (pl. 1; fig. 32) is the area drained by southern tributaries of the Tanana River between and including Berry Creek and the Tetlin and Kalutna Rivers. It is largely the mountainous terrain that forms the northern slopes of the Alaskan Range (pl. 1).

The district's rock units range in age from Precambrian or early Paleozoic to late Mesozoic and consist of sedimentary beds, subordinate lava flows and tuff, and a few large granitic masses (pl. 1). In the northern part of the district, the older sedimentary and volcanic rocks have been metamorphosed to siliceous and micaceous schist.

The two lodes known in the Tok district were prospected for base and precious metals around the turn of the century, but neither has been productive.

An antimony prospect on Stibnite Creek (38, see fig. 32) is in an area underlain by faulted schist, gneiss, and granitic rocks. The deposit is in a 20-foot-wide shear zone in schist and consists of massive and disseminated stibnite, quartz, and a little pyrite. The antimony content of 13 channel samples collected and assayed by the U.S. Bureau of Mines ranged from trace amounts to 34.48 percent.

Small amounts of gold, silver, copper, and possibly nickel occur at Mineral Point (39) at mile 37 on the Tok Road, where argillite interbedded with limestone is cut by a northwestward-striking 6-foot shear zone and by a granitic dike. The rock in the shear zone is altered to reddish-yellow material containing quartz and disseminated sulfides.

Additional information on this district is given in the following references: Joesting (1942); Moffit (1954a); Wedow and others (1953).

TOLOVANA DISTRICT

The Tolovana district (pl. 1; fig. 33) is the area drained by the southwestward-flowing tributaries of the Tanana River from Dugan Creek to the Tolovana River (with the exception of the area drained by the Chatanika River and Goldstream Creek and their tributaries, which are in the Fairbanks district). It is bounded on the north by an arbitrary line dividing the lowlands of the Yukon Flats from the higher ground of upper Beaver Creek and its tributaries.

The district is characterized by broad even-topped ridges that rise to an average altitude of 2,000 feet, and from which long sloping spurs extend to the valley floors (pl. 1).

The bedded rocks include Precambrian or Cambrian metamorphic rocks; Silurian(?) and Devonian sedimentary and volcanic rocks; Devonian or Carboniferous chert; and Carboniferous sandstone, slate, and argillite (pl. 1). Intrusive and extrusive igneous rocks ranging in composition from ultramafic to felsic crop out in many places throughout the district.

Lodes in the Tolovana district contain gold, silver, antimony, mercury, chromium, nickel, and iron, but, with the exception of one lode (19, see fig. 33) that yielded a little antimony ore, and another (Olive Creek, 18) from which a little mercury was recovered, the deposits that have been explored were either too lean or too small to mine.

A group of gold claims was staked in the early 1900's near the heads of Ruth, Lillian, and Olive Creeks (18). The claims were on numerous quartz-calcite veinlets, each less than 3 inches thick, that cut diverse rock types and contained gold, silver, pyrite, and arsenopyrite. Commonly, the adjacent wallrock is altered and also contains some gold. In 1917, some of the veinlets assayed $12 a ton in gold and $2 a ton in silver. The lodes probably are genetically linked to mineralized rhyolite porphyry that crops out nearby. Similar lodes have been reported elsewhere in the Livengood area.

A small amount of stibnite was shipped during World War I from a vein above Discovery on Livengood Creek (19). Stibnite-bearing stringers that may contain traces of cinnabar and gold occur in deeply weathered rock on Lillian Creek (18), and a stibnite lode reportedly at least 6 feet thick is said to be on Sawtooth Mountain (17), near the head of Chocolate Creek. Low-grade deposits of cinnabar are in altered granite at the head of Olive Creek (18).

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A lode consisting of sparsely disseminated chromite in serpentine was prospected on Ruth Creek (18) near Livengood, and chromite has been found in most of the other ultramafic plutons in the district.

Small amounts of nickel have also been detected in the ultramafic rocks; the highest reported nickel content, about 0.3 percent, is in serpentine near Livengood.

Magnetic anomalies obtained during airborne surveys indicate that some of the ultramafic bodies may also be potential sources of iron.

Additional information on this district is given in the following references: Joesting (1942, 1943); Mertie (1918a); Overbeck (1920).

YUKON FLATS DISTRICT

The Yukon Flats district (pl. 1; fig. 30) comprises all of the relatively flat alluvial basin of the Yukon River from Circle to Fort Hamlin (a few miles downstream from Stevens) and the drainage basin of the Porcupine River below Graphite Point. It is mostly a marshy, lake-dotted lowland underlain by thick deposits of sand, gravel, and silt. Bedrock, exposed mainly in bordering uplands, includes Precambrian to Tertiary metamorphic, sedimentary, and volcanic rocks locally cut by granitic batholiths (pl. 1).

The only evidence of lode mineralization in the district consists of a single lot of quartz-, pyrite-, sphalerite-, and molybdenite-bearing rock specimens from Trout Creek (10, see fig. 30) in the headwaters of the Hodzana River. The specimens were submitted to the U.S. Geological Survey in 1924 and were inspected by J. B. Mertie, Jr., who felt that the mineral assemblage was also a good indication of gold mineralization. The fact that gold has been recovered from placers on Trout Creek further supports Mertie's inference that there are gold lodes in the area.

Additional information on this district is given in the following references: Smith, P. S. (1942); Williams (1962).

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