FINAL REPORT

MINERAL RESOURCES OF NORTHERN ALASKA

M.I.R.L. Report No. 16

Submitted to the NORTH Commission

by

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SUMMARY

Introduction

PURPOSE. This is the final report on the work authorized on July 29, 1967, by the NORTH Commission. The purpose is to inventory mineral resources in northern Alaska and to delineate favorable mineral areas, insofar as possible. Later, a mineral policy study was added and a survey of available airborne geophysics.

The Alaska Railroad made possible the large scale dredging at Fairbanks and became a feeder to all Interior districts. It allowed the building of military bases during and after World War II. Freight moves predominantly north.

Mining Regions and Mineral Commodities

NORTHERN ALASKA REGION

Resources are mainly mineral fuels. Coal bearing rocks underlie 27,000 square miles. Reserves of about 80 million barrels of oil and 5-7 billion cubic feet of gas are known. A recent strike at Prudhoe Bay is very encouraging. Extensive, though unexplored areas of low to medium grade phosphate rock occur.

NORTHWESTERN ALASKA REGION

Placer mining has been carried on in two areas on the Kobuk River. The major interest at present is the copper deposit of the Kennecott Copper Corporation at Bornite. No firm estimate of grade or reserves can be made now, but the deposit is very large, The area is being extensively prospected.

YUKON RIVER REGION

The Fairbanks district has been the largest producer in Alaska. The Manley and Rampart districts, west of Fairbanks, have moderate reserves of gold and placer tin. A lode-tin source has been sought, but has not been located. There is a large, virtually unprospected area between the Yukon and Koyukuk rivers, and two placer gold districts on the Koyukuk. The upper Koyukuk contains reserves of placer gold and small amounts of stibnite. The Chandalar district, west of the Koyukuk has reserves of relatively high grade gold quartz. One dredge is operating on the Hogatza River, near the head of the Kobuk.

SEWARD PENINSULA REGION

This region contains widespread mineralization; it contains fair reserves of placer gold and possibilities for offshore gold placers.

Tin deposits are well know, but known reserves are limited in size. Past production-2000 tons metal from placers, 350 tons from lode. Reserves-36,750 tons tin at 0.2%-1.3% at Lost River. Few thousand tons at Ear Mountain and vicinity.

Fluorite occurs at Lost River

Production - none
Reserves - 2 million tons of 50% fluorite

Beryllium occurs with the fluorite and tin.

Production - none
Reserves - Indicated and inferred, 2 million tons of metal at 0.18% to 0.29% Be. "Large indicated and inferred reserves" at 0.04% to 0.07% Be and up to 0.3% tin.

Tungsten occurs with the tin at Lost River.

Production - small
Reserves - 63,350 units (20 lbs.) WO_3 plus indicated ore at 0.60%
193,000 units of inferred ore at 0.5% WO_3 containing up to 1% tin.
130,000 units of inferred ore at 0.2% WO_3 and up to 0.4% tin.

A lead deposit is being drilled

Graphite occurs in the Kigluaik Mountains

Production - 270 tons
Reserves - 50 tons sorted material; 65,000 tons of 52%, 300,000 tons of 10%

Lode gold small reserves exist on the Seward Peninsula

Possible Immediate Tonnages

PLACER GOLD

A fair sized placer mine would require 80-100 tons of freight per season.

COPPER AT BORNITE

It is probable that the ultimate plans for production for this deposit have not yet been formulated. Based on varying production rates the following could be expected:

At 500 tons per day of 10% copper, 45,700 tons of concentrate per year

At 5,000 tons per day of 2.5% copper, 114,000 tons per year of concentrate

At 10,000 tons per day of 1.5% copper, 137,000 tons per year of concentrate

At 20,000 tons per day of 1% copper, 183,000 tons per year of concentrate

COAL

There are no immediate tonnages of coal. If coal with the right characteristics for blending can be located, a market exists in Japan for 1 million tons per year.

GAS AND OIL

Umiat - 70,000,000 barrels oil

Fish Creek - prospective oil field

Gubik - 300 billion cubic feet gas

Mead and Square Lake - prospective gas fields

Geology of Western North America

TECTONICS AND GEOLOGY OF NORTHWEST NORTH AMERICA

Except for the Arctic Coast, Alaska is part of the Western Cordillera, the ranges of mountains and valleys that extend the length of the Americas. The Cordillera has yielded the great metallic bonanzas of the past, and is still producing. Most of the structures of the present Cordillera in North America have been formed in Mesozoic and Cenozoic time. This history was very closely followed in Alaska; in early Paleozoic time eugeosynclinal rocks were deposited in southern Alaska, and miogeosynclinal rocks in Central Alaska with a shoreline in northern Alaska. In late Paleozoic time the sequence moved northward. In Mesozoic time, geanticlinal areas raised, and geosynclinals were depressed between them. In Cenozoic time there were further uplifts that gave Alaska its present shape.

A composite map of northern Alaska (Plate I) was drafted from all known sources at a scale of 1: 1,000,000. Descriptions of all rock units and their distributions accompany the map.

Favorable Areas Based on Geology

During the formation of the Mesozoic geosynclines and geanticlines (inversions) it is postulated that deep fractures formed at their boundaries. Using these boundaries and the allignment of known faults, other lineations, and the distribution of igneous intrusions, certain areas are delineated as favorable for the formation of minerals. These are:

Borders of Romanzof Mountains
South side Brooks Range east to Chandalar
Line from Darby to Candle (W. Seward Peninsula)
North side Ruby geanticline (Ruby to Chandalar)
Length of Major fault (Unalakleet to Eagle)
Axis of Kuskokwim geosyncline (unconformity at base of Mesozoic rocks occurred along this line before erosion)
Margins of Kandik segment and Nation Arch

It is also postulated that the presence of a placer deposit, especially a weak one, will signal a lode deposit.

Favorable Areas Based on Statistical Evidence

By comparing the areas and geology of Alaska, Canada, and Western United States, it appears that Alaska is underdeveloped and should be capable of much more mineral production. By comparing the geology of a control area in southwestern United States, Harris (1967) delineates several cells 20 miles square that statistically could contain high values of mineral wealth. Five of these cells could contain $400 million, and 16 of then, $100 million.

Mineral Policy

Any mineral policy adopted should recognize the traditional methods of acquisition of mining claims and leases, and also the unique nature of mineral deposits in that new ones cannot be grown.

Costs of mining in northern and northwestern Alaska may run fifty percent more than in the Western U. S. and Canada.

Direct deduction of exploration expenses and depletion allowances are the chief tax incentives in the United States. In Canada, rapid depreciation, no capitol gains tax, a three year tax free period on new mines, and subsidies have created a very favorable climate for mining.

The Canadian government has launched a northern exploration program in which companies can participate on a cooperative basis. There is also a comprehensive road building program in the north. Alaska, the chief financial aids are O. M. E. participating loans, prospectors' aid, and help on building access roads.

A number of rules and customs are examined to determine their effect on the mining industry. The prohibition on export of certain minerals, stringent financial rules, the fixed price of gold, large land withdrawals, and anti-hydraulicking laws adversely affect mining in Alaska.

The Canadian and Alaskan technical aids and services are comparable in kind, but Canada provides more.

Education and research in geology and mining must be supported by the State, and more services and research by the Federal Government must be pushed for by the State.

Herbert (1967) compares the mining laws of Canada and Alaska and suggests several changes in Alaskan law.

Several specific mineral development policies are offered as suggestions. These can be summarized in a few broad statements:

Create a favorable environment and encourage exploration.
Provide tax incentives.
Study carefully the relative economic advantages to alternate courses of action where minerals are concerned.
Obtain expert counsel in mining law revisions
Provide all available technical assistance possible.
State government should actively seek help from Federal government.
Legislation should provide stability for the industry.
Long range coordinated plans should be made.
Mineral fuels should be developed along with other minerals.

Airborne Geophysical Prospecting

Airborne geophysics probably provides the most practical and economic method of exploring for new deposits in the area. Methods considered for a survey in Alaska are magnetic, electromagnetic, and radiometric. Each of these can detect a different type of anomaly.

A number of geophysical companies were contacted; nine are interested in doing work in Alaska. Services offered by these nine companies vary greatly in scope, which is reflected in quoted costs. These costs vary from $8 to $50 per line mile.

The U. S. Geological Survey and one private company have already flown parts of northern Alaska with an airborne magnetometer and plotted the results on maps which are available for purchase by mining companies.

There are no known large reserves of untapped commercial ore awaiting a railroad at the present time, with the exception of the Bornite copper deposit. Mineralization, however, is widely scattered throughout Alaska and statistical considerations suggest that Alaska has produced mineral wealth far below its potential. Rapid means of reconnaissance prospecting are urgently needed; airborne geophysics has been very successful in other parts of the world and should be seriously tried in Alaska.

Canadian mining companies are investing an average of 4.6% of their production in exploration. It is recommended that Alaska, in order to catch up, invest 10% of State revenues from minerals per year. A suggested division of this investment is 9% for the Division of Mines and Minerals, 5% of which would be earmarked for airborne geophysics, and 1% for research. It is also suggested that the airborne geophysics be contracted to a private company, with the Division of Mines and Minerals administering the program.

It is difficult to evaluate the chances for success of an airborne geophysical survey; such chances depend chiefly on the favorability of the areas flown. Most companies decline to estimate chances, but two suggest the following:

1. One producing mine per 100,000 miles flown in a favorable area
2. One major discovery for an expenditure of a million dollars per year over a 5 to 10 year period.

Consultants Reports

Reports by Marvin J. Andresen, Charles F. Herbert, and Eskil Anderson are included. Andresen describes what has been done and is being done in oil exploration and production. He concludes that the best chances for oil are along the Arctic Coast, where upper Paleozoic rocks are not buried so deeply as in the northern foothills of the Brooks Range.

Herbert names several specific prospects and areas that are not in the literature, and suggests changes in laws that affect mining. His suggestions have been drawn on freely.

Anderson evaluates the potential of Seward Peninsula, quadrangle by quadrangle. He believes that deep weathering has created very thick gossans which might be proved to cover ore when they are drilled.

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INTRODUCTION

Purpose of this Report

This report is the result of the desire of the NORTH Commission to bring together information on the mineral resources and geology of Northern Alaska, to delineate potentially favorable areas for exploration, and to investigate mineral policy ideas for the development of this area.

On July 29, 1967, the NORTH Commission accepted a proposal by the Mineral Industry Research Laboratory to delineate potentially favorable areas for mineral exploration through review of the literature available, assembling of opinions of informed people, and by using statistical methods, should enough geologic information be available. In addition the Commission desired to have an economist added to the study, and that the University of Alaska obtain cost estimates for airborne geophysics.

The proposal, as submitted to the NORTH Commission, may briefly be summarized as follows:

1. Review of the literature and interview of informed people to compile a listing of presently known ore bodies and prospects
2. Have experienced Alaskan geologists and engineers assess the geology and known mineralization for the purpose of outlining areas that they would choose for exploration
3. Evaluate the area based upon regional structures that are believed favorable to ore formation for the purpose of delineating areas favorable for exploration efforts
4. Evaluate the area utilizing statistical and computer techniques.

A mineral economist has been added to the study, and data on airborne geophysical prospecting are contained in this report.

The original proposal stipulated that a preliminary report based partly on the consultants' views would be prepared. A report entitled "Preliminary Report - Mineral Resources of Alaska", by Wolff, Heiner, and Lu was submitted to meet this requirement. This report was delivered to the NORTH Commission and presented orally on November 13, 1967 in Washington, D. C. Information contained in the preliminary report has been expanded and has been incorporated into this report.

A progress report was also submitted to the NORTH Commission in Juneau, March 19, 1968.

Some Effects of the Present Railroad

E. N. Wolff

The present Alaska Railroad was authorized in 1914 and completed in 1924. The original purpose of the railroad was to service the mineral and other resources of the country, and the authorization stipulated only that the road not exceed one thousand miles in the aggregate, be so located as to connect one or more open Pacific harbors with the navigable waters of the Interior and the coal fields, and that the total expenditure not exceed $35,000,000.

In 1914, placer districts were still being discovered, but in the largest of the Interior camps, Fairbanks, the rich areas that could be mined by underground methods, were practically worked out. By 1924, this condition had progressed to where Fairbanks was becoming a ghost town. Whether or not the railroad was conceived to revitalize the Fairbanks district, the effect was immediate and drastic. Several companies began to look at the placer reserves around the area, and by 1925 the U. S. Smelting, Refining, and Mining Company began to acquire claims. Except for a shutdown during World War II, the company operated dredges until 1964, making in all, about 40 years of activity. The company still operates two dredges, one at Chicken and one at Hogatza.

Disregarding for a moment other resources affected by the railroad, a rough estimate indicates about $100,000,000 in placer gold reserves waiting at the end of the line. In view of inflation, perhaps the life of the mining operation, about 40 years, gives a fairer picture of reserves. These reserves required drilling to prove, yet their existence could be predicted with fair confidence. The means of bringing heavy equipment and coal for power made possible the inauguration of large scale dredging.

Other mining districts which began to be partially served by the new railroad were at Yentna, Willow Creek, Kenai, Valdez Creek, Chistochina, Bonnifield, Hot Springs, Hughes, Innoko, Kantishna, Koyukuk, Marshall, Melozitna, Rampart, Ruby, Tolovana, and Circle. After the advent of roads and airplanes, the camps of Chandalar, Fortymile, Eagle, and Chisana were served. Fairbanks, and to a lesser extent, Nenana, become distribution centers for the Interior.

Some unrelated events increased the need for and the value of the railroad. Ten years after completion of the road, the price of gold was advanced; at about the same time the newly developed bulldozers were introduced to placer mining, greatly increasing the number of creeks that could be mined at a profit. With the approach of World War II and the establishment of a large air base at Fairbanks in 1939, the volume of freight increased sharply.

It should be pointed out, however, that basically the Alaska Railroad has brought material into the country. The hauling of coal from Healy River, first for power for the dredges, later for military installations, provided a year round dependable source of revenue, one which, incidentally will gradually decline. No large amounts of exportable commodities have been developed. The development of such commodities would greatly enhance the position of the railroad; without the railroad such development is impossible.

MINING REGIONS AND MINERAL COMMODITIES

L. E. Heiner, E. N. Wolff, and F. C. J. Lu

A standard system of names and definitions of mining regions in Alaska based on historical boundaries, has been developed by the U. S. Bureau of Mines for use in statistical and economic studies of the mineral industries of the State (Ransome, Kerns, 1954). Among fourteen regions four would be influenced by mineral developments along the proposed railroad route. These four mining regions are: Northern Alaska, Northwestern Alaska, Seward Peninsula, and Yukon River. Figure 1 depicts the mining regions and districts of Alaska.

Areas of mineral occurrences in the four regions are outlined in the following figures: Figure 2, mineral fuels; Figure 3, iron and ferro-alloy metals; Figure 4, gold, silver, and platinum; Figure 5, base-metals; and Figure 6, key industrial and chemical minerals (U. S. Senate Comm. Print, 1964).

No attempt has been made in this section to list all of the mineral occurrences known in each region. A complete listing of all occurrences mentioned in the literature, from mines to prospects, will be found later under "Tabulation of mineral occurrences".

Northern Alaska Region

The region includes all of the area of the northern part of Alaska that is drained by streams flowing into the Arctic Ocean and Chukchi Sea from the Alaska-Yukon boundary on the east to and including the Kivalina and Wulik rivers on the west. It contains the Barrow, Canning, Colville, Lisburne, and Wainwright districts.

Mineral resources in this region are mainly mineral fuels - crude oil, natural gas, and coal. Coal-bearing rocks of late Cretaceous age underlie an estimated 27,000 square miles north of the Brooks Range, in an area extending along the foot of the mountains from Cape Lisburne eastward to the longitude of the lower Colville River, and northward to the Arctic Coast at Peard Bay; the coal resources probably aggregate 120 billion tons. This estimate includes coals as shown in Table 1 (Barnes, 1967).

A medium-sized oil field at Umiat contains an estimated reserve of more than 70 million barrels and a small oil field at Simpson, perhaps 12 million barrels.

Natural gas was discovered at Gubik with possibly as much as 300 billion cubic feet of reserve and at Barrow with 5 to 7 billion cubic feet of reserve. Very recently (late winter of 1968) a well at Prudhoe Bay was brought in. This well in April was producing 1,152 barrels per day of oil, and there is natural gas associated with this well.

Extensive resources of predominantly low to medium grade (8% to 25% or more) phosphate rock occur in the central portion of the Arctic Slope of Alaska in the Tiglukpuk Creek-Kiruktagiak River area, and substantial amounts of phosphate rock of unknown thickness and grade are indicated in the eastern Brooks Range. So far very few occurrences of metalic minerals have been reported from the Northern Alaska region. No production, and nothing more than cursory exploration has taken place. The Firth River area, in the

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

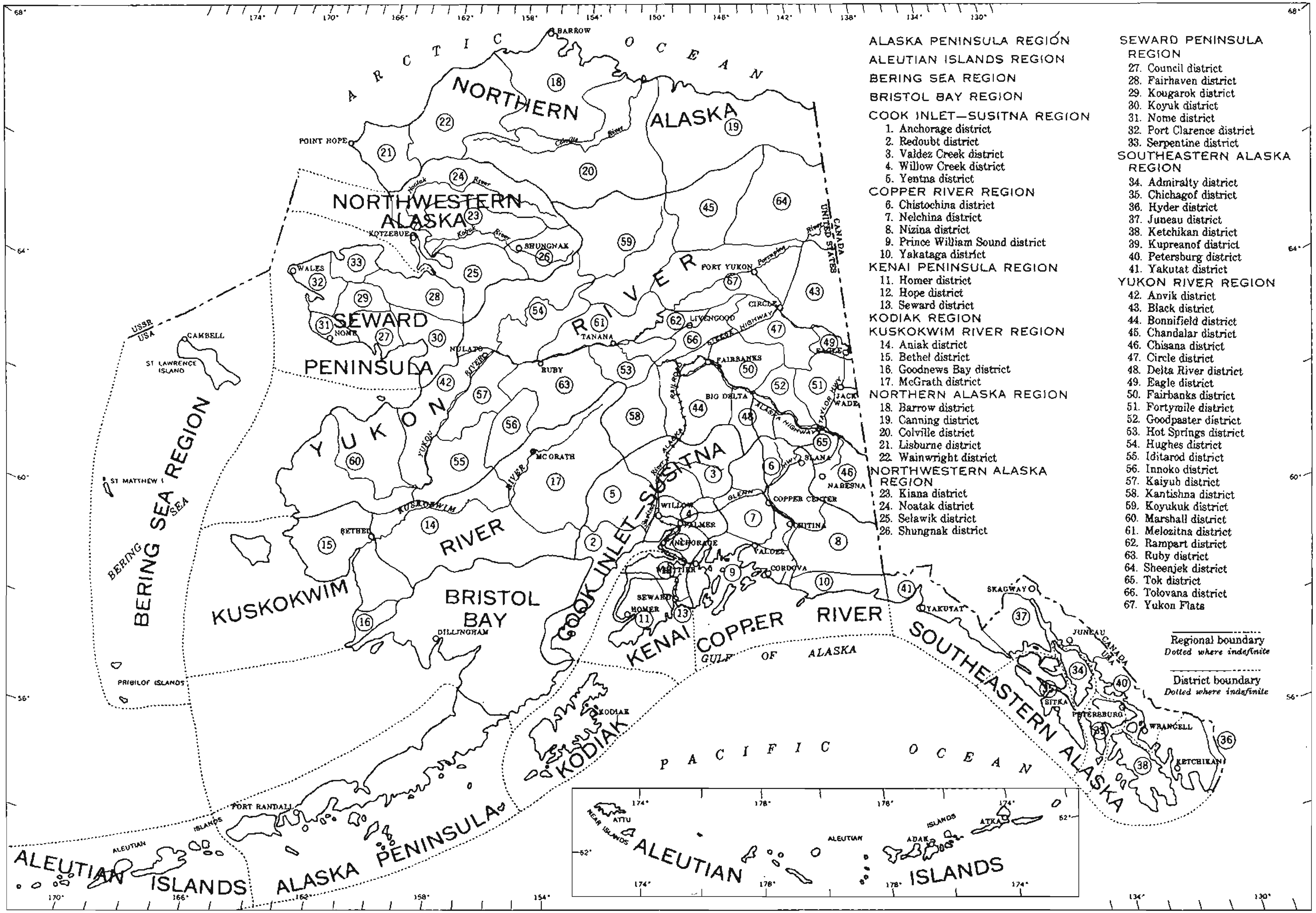


Figure 1 - MINING REGIONS AND DISTRICTS

Based on Ransome and Kerns, (1954)

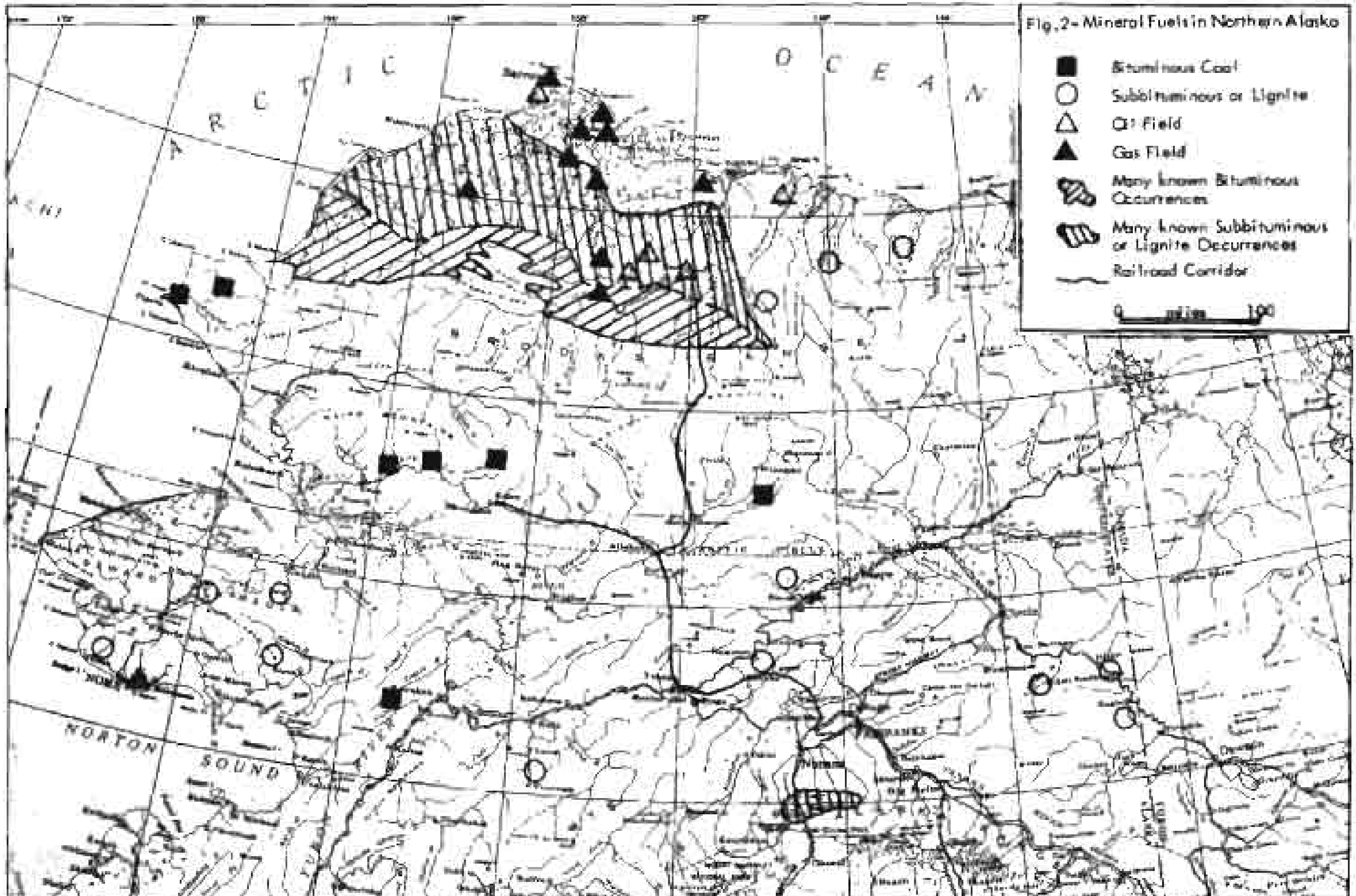


Fig. 2 - Mineral Fuels in Northern Alaska
Bituminous Coal
Subbituminous or Lignite
Oil Field
Gas Field
Many known Bituminous Occurrences
Many known Subbituminous or Lignite Occurrences
Railroad Corridor
0 miles 100
ARCTIC OCEAN
NORTON SOUND
FAIRBANKS
NOME

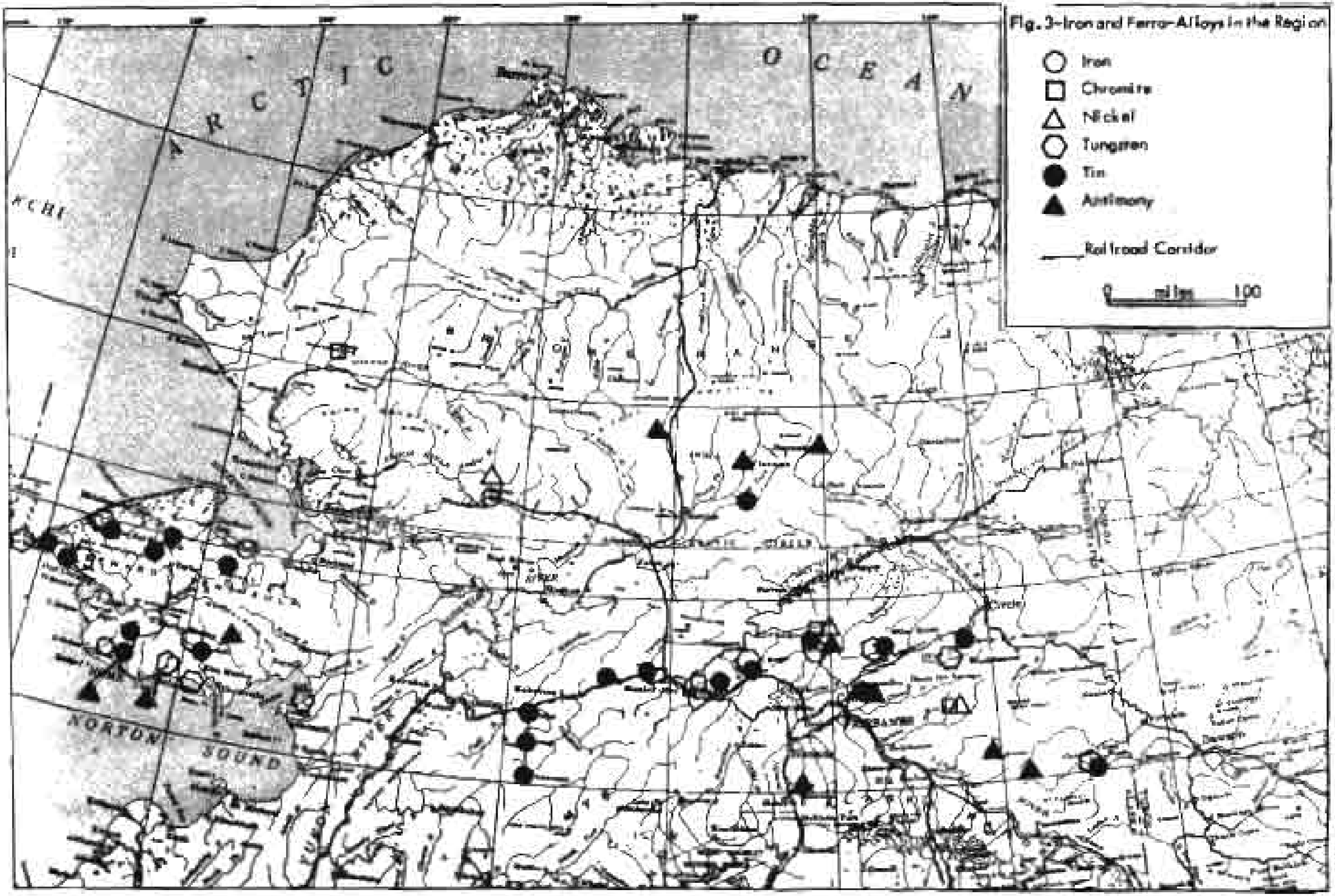


Fig. 3-Iron and Ferro-Alloys in the Region
Iron
Chromite
Nickel
Tungsten
Tin
Antimony
Railroad Corridor
0 miles 100
ARCTIC OCEAN
NORTON SOUND
Circle

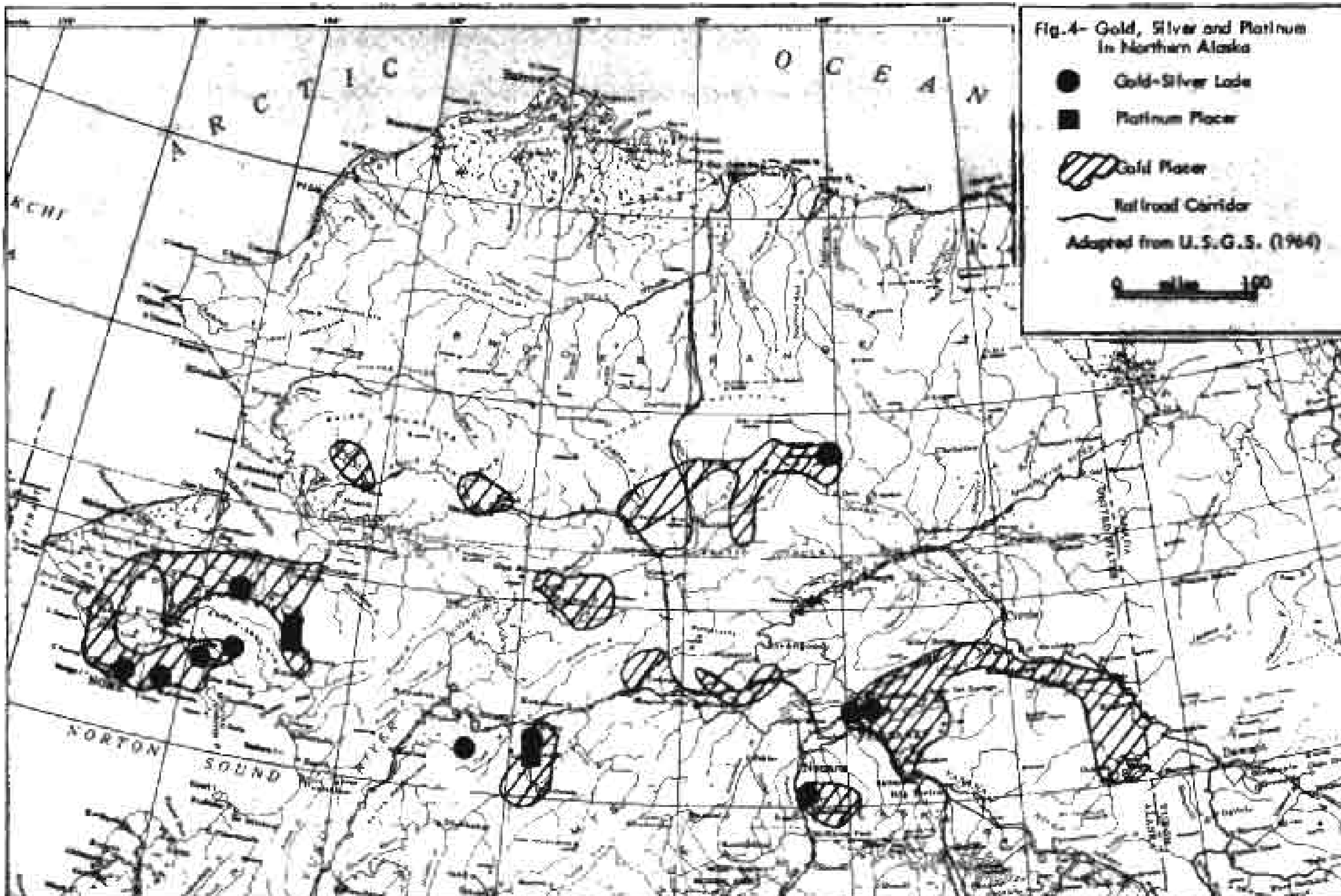


Fig.4- Gold, Silver and Platinum In Northern Alaska

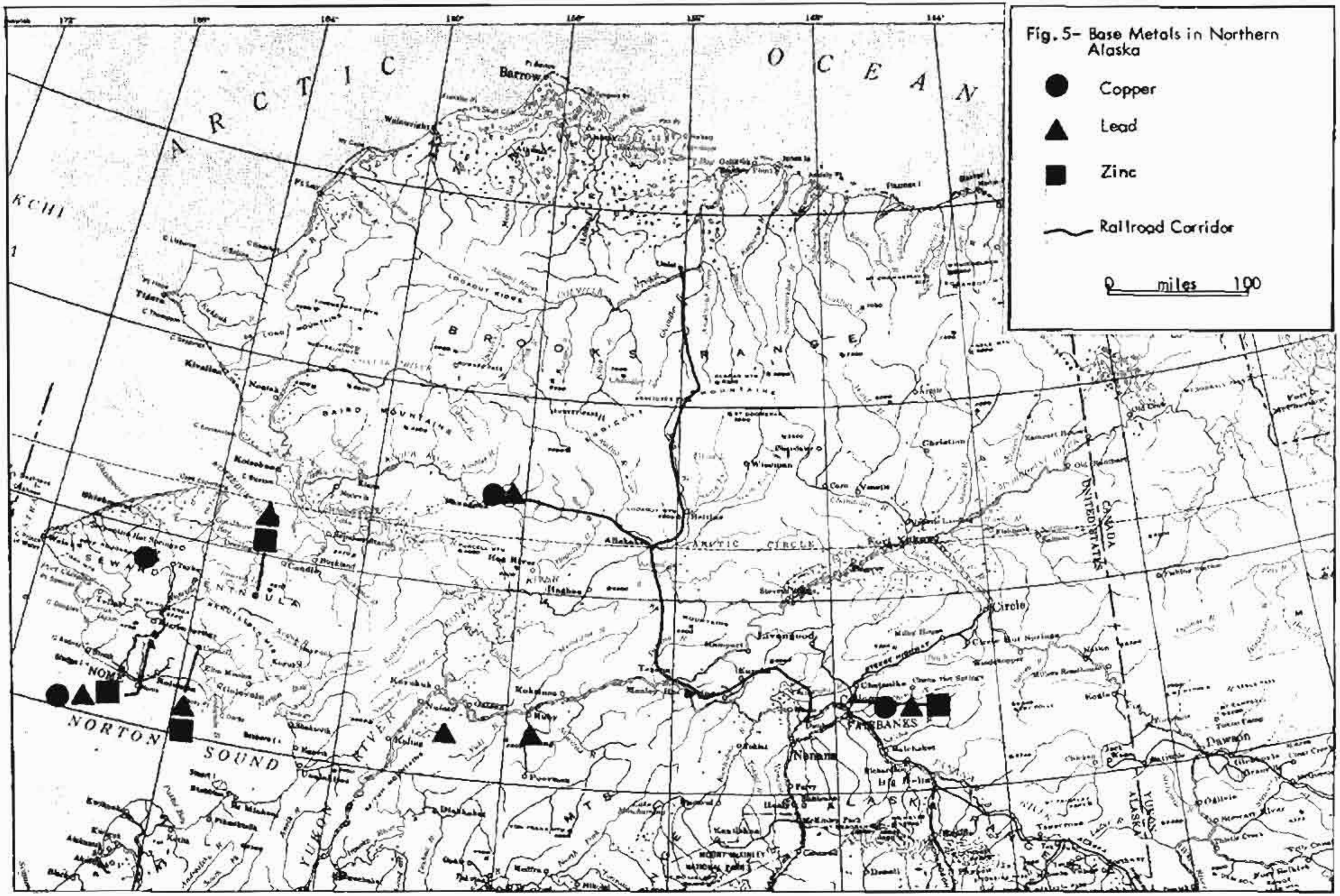


Fig. 5– Base Metals in Northern Alaska
Copper
Lead
Zinc
Railroad Corridor
0 miles 100
ARCTIC OCEAN
Barrow
Wainwright
BROOKS RANGE
BAIRD MOUNTAINS
ARCTIC CIRCLE
SEWARD PENINSULA
NOME
NORTON SOUND
YUKON RIVER
Circle
FAIRBANKS
Nenana
Fort Yukon
Dawson
CANADA
UNITED STATES
YUKON
ALASKA
Kotzebue
Kivalina
Tigara
Candle
Ruby
Livengood
Allakaket
Christian

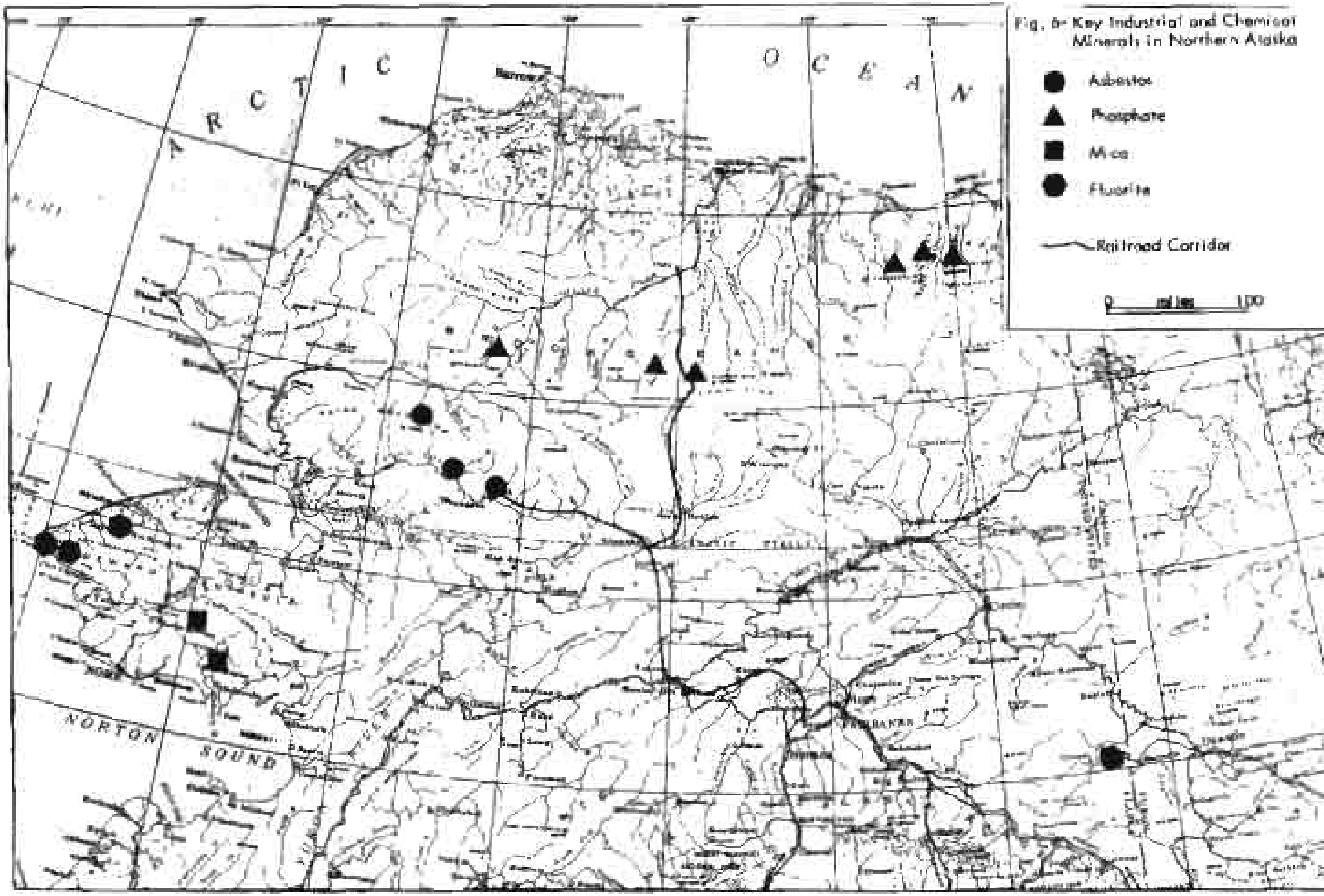


Fig. 6- Key Industrial and Chemical Minerals in Northern Alaska
Asbestos
Phosphate
Mica
Fluorite
Railroad Corridor
0 miles 100
ARCTIC OCEAN
NORTON SOUND
FAIRBANKS

Table 1 - Estimated Coal Resources of Northern Alaska
(millions of tons)

Bituminous		Subbituminous	
Indicated Resources		Indicated Resources	
14 - 28 in. thick	156.8	2 1/2 - 5 ft. thick	451.3
28 - 42 in. thick	237.7	5 - 10 ft. thick	540.9
>42 in. thick	443.5	>10 ft. thick	617.2
Total Indicated	838.0	Total Indicated	1,609.4
Inferred Resources		Inferred Resources	
14 - 28 in. thick	4,273.8	2 1/2 - 5 ft. thick	15,065.0
28 - 42 in. thick	4,402.8	5 - 10 ft. thick	31,312.1
>42 in. thick	9,777.6	>10 ft. thick	52,918.8
Total Inferred	18,454.2	Total Inferred	99,295.9
Total Bituminous Coal		Total Subbituminous Coal	
14 - 28 in. thick	4,430.6	2 1/2 - 5 ft. thick	15,516.3
28 - 42 in. thick	4,640.5	5 - 10 ft. thick	31,853.0
>42 in. thick	10,221.1	>10 ft. thick	53,536.0
Total	19,292.2	Total	100,905.3

Note that no beds were considered where thickness is less than 14 inches for bituminous coal and 2 1/2 feet for subbituminous coal. No coal with more than 3000 feet of overburden was included. There are no measured reserves of coal in Northern Alaska.

extreme eastern part of the region, is said to contain placer gold. Because of the isolation and other adverse conditions, virtually nothing is known of the area. Specimens of cinnabar said to have come from the Canning River area were sent to the Alaska Territorial Department of Mines (now State of Alaska Division of Mines and Minerals) sometime before 1947. It is unlikely, due to known geology, that these samples originated there. In the late 1880's pyrite said to contain $3.50 to $8.50 in gold per ton was reported on a tributary of the Pitmegea River. Recent work by the U. S. Geological Survey in neighboring areas indicates that geologic conditions are not favorable for gold lodes. Iron-sulfide nodules 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 (Berg and Cobb, 1967).

Northwestern Alaska Region

The region comprises the area drained by all streams flowing into the Arctic Ocean (Chukchi Sea and Kotzebue Sound) between and including the Noatak River on the north and the Kauk River on the south. The principal streams are the Noatak, Kobuk, Kugarak, Selawik and Kauk rivers.

The Northwestern Alaska region contains the Kiana, Shungnak, Noatak and Selawik districts (see Figure 1). Ore has not been shipped from metalliferous lodes in the region although there has been some jade and placer gold production. Occurrences of iron ore, coal and jade are known to exist in the region. At the present time no evaluation of these occurrences can be made.

Placer mining has been carried on at two different areas around Shungnak and near Kiana, 100 miles downstream, where a dredge was operated for several seasons.

The major interest in this mining region at the present time is the development of a copper deposit in the Ruby Creek area at the west end of the proposed railroad route. This is the largest known Alaskan copper reserve. After more than ten years of exploration and testing of this deposit, the Kennecott Copper Corporation has purchased the property and established a division to plan for production. Access roads and camp facilities have been built. Underground exploration is underway (Kennecott Ann. Rept., 1966).

The Kobuk region that contains the deposit at Bornite is the scene of much prospecting and exploration for copper. Reconnaissance and drilling over an east-west distance of more than 200 miles is currently in progress.

KIANA DISTRICT

In 1898, the Kobuk River was the scene of a stampede by two thousand men, most of whom were gone by the next year. There was little justification for that stampede; although there are gold placers on Squirrel River north of Kiana. They were not discovered, however, until 1909, and have been mined intermittently since then; and have supported a dredge. These placers have provided the only known mineral production from the district.

According to Berg and Cobb (1967) a copper lode, the Malfiotti claims, was discovered in 1912 near the headwaters of the Hunt River, and reports of gold, copper, lead and cassiterite lodes in the district have been made. Nothing is known however concerning their location or geologic setting. They also state that the occurrence of the nickel silicate, garnierite, has been reported in the Jade Hills about 70 miles east-northeast of Kiana.

NOATAK DISTRICT

A few ounces of placer gold have been produced from Lucky Six Creek near the head of the Noatak River. Chalcopyrite, stibnite, bornite and malachite specimens from the Lucky Six Creek area have been assayed by the U. S. Geological Survey; the richest contained less than $2 per ton in gold. Several claims have been staked by prospectors in this region and some of them have reported assays as high as $90 per ton. Samples from a reported lode on the Noatak side of Shishakshinovik Pass are said to assay 9.8% copper, 27.7% lead, with some gold and silver. Silver is also reported on the Noatak side of the divide near Angunelechak Pass (Berg and Cobb, 1967). The Noatak drainage has seen little prospecting. Lucky Six Creek was discovered in 1898, but due to the inaccessibility of the region, very little work has been done. The southern drainage of the Noatak north of the Shungnak area has been investigated in a cursory way; it no doubt will receive more attention because of the interest in the copper deposit on the Kobuk side.

SELAWIK DISTRICT

This district has one gold placer of little importance on a northward flowing tributary of the Selawik River near Purcell Mountain. No metalliferous lodes are known.

SHUNGNAK DISTRICT

The Shungnak area is the second one on the Kobuk that has produced placer gold. It was discovered during the Kobuk Stampede, before the Kiana district. Gold has been mined from Dahl Creek, Shungnak River, and the Kogoluktuk River. This is a well mineralized area; the district contains the Ruby Creek copper lode (Bornite) of the Kennecott Copper Corporation. No estimates of ore reserves or grade have been made public although the deposit is thought to be large, consisting of disseminated sulfides of chalcopyrite and bornite, with some galena, sphalerite, and gold.

There is also a copper lode on Aurora Mountain which may be similar to the Bornite deposit. Assays of bornite from this lode showed 0.04 ounce of gold and 1.4 ounces of silver per ton. Vein material from the south side of the Shishakshinovik Pass, supposedly from the continuation of a lode carrying copper and lead minerals on the Noatak side of the pass, assayed approximately $1.24 per ton in gold and silver. Copper, as chalcopyrite, occurs near Lake Selby. Galena in quartz veins on a hill west of Wesley Creek, auriferous quartz veins near the head of Riley Creek, some nickel in asbestiform minerals near the mouth of Stockley Creek, and magnetite in the form of float boulders on the slopes of Iron Mountain have also been found (Berg and Cobb, 1967).

Yukon River Region

The region embraces the area drained by the Yukon River and its tributaries from the Alaska-Yukon boundary on the east to the Bering Sea on the west; and includes the area drained by all streams flowing into Norton Sound and the Bering Sea from and including the Unalakleet River and its tributaries on the north to and including the Manopiknak River and its tributaries on the south. It contains 26 districts (see Figure 1), of which 13 are within the area of this report. It is the largest region in Alaska, and contains mining districts from the Alaska Range to the Arctic and from the Canadian border almost to the Bering Sea.

The most important area in the region, the Fairbanks district, has produced more than 240,000 fine ounces of gold and about 40,000 fine ounces of silver from lodes. Placer gold production has been about 7,500,000 fine ounces. Production in dollars is probably about $220,000,000.

Besides the precious metals, minor amounts of lead, antimony, and tungsten have been produced.

About 100 miles west of Fairbanks, two of the oldest placer districts in the Interior, the Rampart district and the Manley Hot Springs district, are still producing gold. The combined production of these districts is approximately 600,000 ounces of gold having a value of about $17,000,000. The western end of the Hot Springs district (Tofty) contains considerable placer tin.

Following the general practice of estimating reserves of gold as about equal to past production, the Rampart-Hot Springs area may contain about 600,000 ounces of gold in reserve.

On the north side of the Yukon, the Tozimoran district has been a small producer of placer gold. However, little prospecting has been done, and more gold might be found.

There is an area between the Yukon and Koyukuk rivers, approximately 10,000 square miles, known as the Kokrine Hills and the Ray Mountains, in which very little prospecting has been done and in which no settlements exist. Reconnaissance geologic mapping to date indicates that the area would be a favorable one to prospect (see Plate 3). All production has come from the edges of the area, close to the Yukon and Koyukuk rivers.

A placer area on the central Koyukuk River, known as the lower Koyukuk or Hughes district, is centered near the town of Hughes.

On the Hogatza River, a tributary of the Koyukuk, heading against the Kobuk drainage, the U. S. Smelting, Refining and Mining Co. operates one dredge. The operation embraces several creeks; it is unusual in that it did not have a history of hand mining, but was developed as virgin ground by the company in the late 1930's.

The upper Koyukuk district, centered at Wiseman, has produced about 360,000 ounces of placer gold or approximately $10,000,000. Because mining with machinery has not been so extensive there as elsewhere, reserves may be somewhat higher on a proportional basis than in other districts. A little antimony has been produced from small stringers, chiefly on

Nolan Creek and its tributaries. These areas are described more fully in the following pages (see Figure 1, for locations).

BLACK DISTRICT

Hematitic and siliceous red beds of the Precambrian Tinder Group are the only known lode-mineral occurrences in the district. These contain 5% to 27% Fe_2O_3, and occur along and near the Tatonduk River (Berg and Cobb, 1967). Estimates for the Corps of Engineers made in 1960 predicted that these beds would be utilized for iron, copper, and ferroalloys by 1995. The U. S. Bureau of Mines believes that this is a part of a seriously exaggerated estimation of the importance of known and undiscovered minerals (U. S. Dept. of Interior, 1967, p. 14). These red beds do, however, represent a source of low grade iron, but it would be unwise to anticipate their use for a very long time yet.

CHANDALAR DISTRICT

The Chandalar district was discovered in 1906, but because of its isolation (125 miles from Beaver, on the Yukon River), it supported only hand mining until 1950. The area contains some of the best gold lodes in the Interior. They consist of steeply dipping quartz veins from 1 to 15 feet wide, containing accessory amounts of antimony, lead, and zinc. The chief known lode deposits are concentrated in mountains drained by Big, Tobin, Big Squaw, Little Squaw, and Little McClellan creeks, an area of no more than 25 square miles. Placer production in the district is estimated at about 40,000 ounces of gold. Placer mining has been significant and probably will be again should the price of gold become favorable. The most important development in the Chandalar district is on the Mikado property, where a mill is presently being constructed to process auriferous ore having a tenor of $85 per ton. Proved reserves in this one deposit are estimated at $2,000,000.

Copper mineralization, consisting of small scattered pods and veinlets of malachite and azurite were reported by the U. S. Geological Survey in 1959 and 1960 (Berg and Cobb, 1967).

CIRCLE DISTRICT

Placer gold was discovered in the Circle district in 1893 (then called the Birch Creek district). Since that time the district has produced placer gold in excess of 730,000 ounces and there are still a few isolated placer workings still in operation. The placer mines are distributed over an east-west distance of more than 30 miles. Some 40 miles east of Circle Hot Springs, a smaller placer area in the Charley River subdistrict consists of two creeks, Woodchopper and Coal. The region along the south side of the Yukon contains Tertiary conglomerates , which it has been suggested, are the source of the placer gold, although it is doubted by some.

No production from metalliferous lodes has been recorded, and even the number of known deposits is smalll. Gold Quartz veins have been discovered on Porcupine Dome, and faults containing quartz, pyrite and galena have been observed on Deadwood Creek (Berg and Cobb, 1967). Minor amounts of lead, copper, scheelite, sphalerite and wolframite occur in the district. On none of these has enough work been done to determine if they are of economic value at present. The only lode on which any work has been done is on Copper Creek, about six miles above its confluence with Charley River. This deposit is in a metamorphosed roof pendant in the Charley River batholith. It contains chalcopyrite, bornite, malachite, azurite and minor amounts of galena in calc silicate rock near an amphibolite contact. This has been examined by the Territorial Dept. of Mines (now the Division of Mines and Minerals) and the U. S. Geological Survey.

FAIRBANKS DISTRICT

This district, discovered in 1902, has been the largest producer in Alaska. After a slow start, production from deep placers worked by underground methods climbed to $9,650,000 in 1909, then declined to $400,000 (counting lode gold) in 1927. With the advent of the Alaska Railroad, the large dredging operations, and the increased price of gold, production climbed to about $7,000,000 in 1940; production now is very small. The district contains numerous mines and prospects, chiefly centered in two areas, Pedro Dome and Ester Dome. The reader is referred to publications listed in the bibliography, especially U. S. Geological Survey Bulletin 849-b (Hill, 1933; Chapman, 1967). The total placer gold production has been 7,500,000 ounces; lode gold production has been much smaller, perhaps about 500,000 ounces. The lodes are steeply dipping veins, from six inches to three feet wide. The great amount of placer gold in the district has led many to conclude that only the roots of the veins are left, and at present there is not enough economic incentive to test this theory by exploration at depth. Minor amounts of lead, silver, antimony, and tungsten have also been recovered.

HOT SPRINGS DISTRICT

The Hot Springs district, about 100 miles west of Fairbanks, consists of two areas: Eureka and Tofty. Placer gold was discovered in these areas in 1898 and 1906 respectively. The Hot Springs area is served by gravel road 160 miles from Fairbanks and by river via Manley Hot Springs.

The district has been a steady producer, and more than 450,000 ounces of placer gold have been recovered. Placer tin as cassiterite has been produced in the Tofty area as a by-product; production to date has been something less than 500,000 pounds of tin. Extensive drilling by the U. S. Bureau of Mines has outlined the extent of this tin, but estimates of reserves have not been made other than in tailing piles, which contain approximately 733,000 pounds of tin in 1,259,000 cubic yards (Thomas, 1957). Much energy has been expended in attempts to locate a lode source for the placer tin; so far without success. Should lode tin of commercial grade be discovered, the district would take on new importance.

Placer gold mining is still in progress. No lode production is recorded, although about six gold-silver lodes occur along a mineralized belt on Hot Springs Dome. These are believed to be too low grade or too small to be economically significant at the present time. Low grade hematite, chalcopyrite, chalcocite, pyrrhotite, pyrite, secondary copper minerals, cobalt, chromite, silver-lead, and nickel mineralization also occur in the area. None of these is commercial, so far as is now known.

HUGHES DISTRICT

The Hughes, or lower Koyukuk district, lies near Hughes on Indian River. Exact production figures are not available, the district must have produced several hundred thousand dollars in placer gold, mostly from one continuing operation. The district is now inactive.

A deposit of molybdenite is the only lode known to have been prospected in this district. it is near the Indian River and is said to contain mineralized rock of fairly high grade (Berg and Cobb, 1967); traces of zinc, gold and other metals are found in a pyritic latite porphyry near the mouth of Red Mountain Creek.

KOYUKUK DISTRICT

The Upper Koyukuk district was discovered in 1898, and attracted men from Dawson, Nome, and other parts of Alaska. The main producing area is around Wiseman, but placer gold is distributed all the way from north of Big Lake to the South Fork of the Koyukuk and west of Wild Lake. The district is reached by air from Fairbanks or Bettles, or by boat to Bettles and thence by tractor.

Placer gold production from the district has amounted to 360,000 ounces or about \$10,000,000. Although there are numerous occurrences of lodes containing gold, silver, copper, lead, and manganese, there has been almost no production. Approximately six tons of antimony have been shipped from a deposit near Nolan Creek about four and a half miles northwest of Wiseman; an antimony deposit said to contain 42% antimony has been reported on the John River near Hunt Fork (Berg and Cobb, 1967). There are chalcopyrite occurrences in limestone along the middle reaches of the John River, and a galena-bearing vein in limestone is also reported on Michigan Creek, tributary of the Wild River. It is believed to be of considerable size, and to carry gold (Berg and Cobb, 1967).

Traces of copper and lead in scattered sulfide-bearing veinlets in Devonian phyllite, limestone and schist near Wild Lake, the middle and upper reaches of the John River, and near the Middle and North forks of the Koyukuk River were discovered by the U. S. Geological Survey in 1960. The Survey also detected traces of copper, zinc, paladium, and nickel north of Big Lake, and sparse copper minerals near the South and Mosquito forks of the Koyukuk River (Berg and Cobb, 1967). These writers also note that high trace amounts of nickel were found in phyllite in the western parts of the district.

MELOZITNA DISTRICT

This district lies between the Yukon and Koyukuk rivers, in the Yukon drainage. There has been some small placer gold production, chiefly from Grant, Morelock, and Lynx creeks. In addition a few lodes of gold and argentiferous galena were worked early in the century. Silver-bearing galena veins occur in a ten foot stockwork in limestone on Quartz Creek, about 25 miles above Tanana. This property, on which some drilling was done, has since been abandoned. Tozimoran Creek has several small galena veins. The Gold Hill quartz vein on the north bank of the Yukon River about 20 miles below Tanana, has the distinction of being the first attempt to develop a lode mine in the Interior of Alaska. It was abandoned before 1910 (Berg and Cobb, 1967).

The Yukon-Koyukuk region has been little explored, away from the rivers. This large area has favorable geology, and may contain deposits unknown at present.

RAMPART DISTRICT

This district lies just north and east of the Eureka area of the Hot Springs district. It was discovered in 1893, and is still best reached by boat on the Tanana and Yukon rivers. Some of the placérs are still being mined. Production data are incomplete, but based on records to 1930 (Smith, 1933), it has probably produced something like $2,000,000. The district's placers also contain cassiterite, scheelite, cinnabar, and chromite in the concentrates. A few lodes, none of which have been productive, have been reported. Stibnite occurs on Wolverine Mountain and on the ridge between upper Minook Creek and Granite Creek, and a strong antimony anomaly was discovered by the U. S. Geological Survey near Elephant Mountain, about 15 miles south-southeast of Rampart. Manganese float occurs at the Avnet prospect about 19 miles northeast of Tofty. The fragments are sparsely scattered over an area 3,000 feet long and 600 feet wide. Samples assayed by the U. S. Bureau of Mines contained 15% to 20% manganese and up to 0.28 ounce of silver per ton (Berg and Cobb, 1967). The U. S. Bureau of Mines has investigated limestone and quartzite south of the Yukon near Rampart. Since use of these rocks would depend on the construction of the "Rampart Dam", they have little value at present. High grade silica rock does occur in the area.

RUBY DISTRICT

The Ruby district actually centers on creeks several miles south of Ruby, at Long and Poorman, where placer gold was found in 1907 to 1910. The placers have produced approximately 390,000 ounces. The only lode that has been described in the district is a silver-lead deposit in schist, slate, and chert on Beaver Creek, about 14 miles south of Ruby. Attempts to ship the ore were unprofitable and the property was abandoned. Several assays of the ore gave values of 8 to 82 ounces of silver per ton (Berg and Cobb, 1967).

SHEENJEK DISTRICT

There is little known about mineral deposits in this district. There are reports of sulfides containing copper, lead, zinc, and silver in the headwaters of the Coleen River and a nickel-bearing alum collected from a seep on the Porcupine River near Old Rampart (Berg and Cobb, 1967).

TOLOVANA DISTRICT

The Tolovana (Livengood) district has produced about 380,000 ounces of placer gold, and a few creeks are still in production. There are still fair reserves of placer ground too low grade to mine at present. There are numerous lode occurrences of gold, silver, antimony, mercury, chromium, nickel and iron, but, with the exception of one lode that yielded a little antimony ore, and another from which a small amount of mercury was recovered, the deposits explored are of too low tenor, or the reserves are too small to mine. Gold lode claims were staked at the heads of Ruth, Lillian, and Olive creeks in the early 1900's. Some of the veinlets assayed $12 per ton gold and $2 per ton silver in 1917.

Stibnite has been shipped from two properties, one on Livengood Creek and the other on Sawtooth Mountain near the head of Chocolate Creek. Stibnite also occurs on Lillian Creek. Low grade cinnabar occurs on Olive Creek; sparsely disseminated chromite on Ruth Creek, and small amounts of nickel occur in the serpentine near Livengood (Berg and Cobb, 1967).

YUKON FLATS

Most of this district, of course, is in the flats, and is covered by deep alluvium. The area in the northern part, however, including the country lying across the divide along the west Fork of the Chandalar, is accessible.

A little placer gold which is noteworthy for its low fineness, has been recovered from Trout Creek near the headwaters of the Hodzana River. Placer gold prospects are also reported from Trail Creek and Monarch Creek on the Chandalar side. The only recorded evidence of lode mineralization in the district consists of some quartz-, pyrite-, sphalerite-, and molybdenite-bearing rock specimens from Trout Creek.

Seward Peninsula Region

The region comprises all of the Seward Peninsula including the Buckland River and its tributaries to the northeast, and the Ungalik and Shaktolik rivers, Egavik Creek and their tributaries to the southeast. The use of large scale dredging equipment was much more widespread on Seward Peninsula than in Fairbanks in the days before the U. S. Smelting, Refining, and Mining Co. began work in both places. Nor did Seward Peninsula experience the severe cutbacks in gold production in the twenties that Fairbanks felt. In 1913 there were 40 dredges working (Chapin, 1914), and in 1919, 22 dredges (Harrington, 1921), neither place now, however, has much placer mining.

The Seward Peninsula is generally regarded as being one of the best mineralized areas in Alaska. In placer gold production the region ranks only after Fairbanks, having produced about 6,230,000 ounces or $175,000,000. The placers are more widespread than at Fairbanks; all parts of the peninsula are represented. The region is divided into the following districts: Council, Fairhaven, Kougarok, Koyuk, Nome, Port Clarence and Serpentine. The chief placers of Seward Peninsula, those at Nome, discovered in 1898, are mostly marine deposits, and although placer mining is almost shut down, there is much interest in offshore equivalents of these. It is probable that fair reserves of placer gold remain on Seward Peninsula, although of lower grade than those that have been mined in the past.

Tin deposits on the peninsula probably represent the best known tin occurrences in North America, but known reserves are limited in size. Past production has been about 2,000 tons of metal from placers and 350 tons from lode sources. It is estimated that, from known occurrences this region might produce approximately 500 tons of tin per year for ten years or more at approximately current prices (Lund, R. J., 1961). Reserves are estimated at 36,750 tons of metal at 0.2% to 1.3% at Lost River and only a few thousand tons at

Ear Mountain, Cape Mountain, and Potato Mountain. If mining is resumed and continued, there should be a good chance of extending the reserves.

At the Lost River tin mine, significant amounts of commercial fluorite and beryllium were discovered. Total estimated resources are about two million tons of 50% fluorite, most, if not all of which could be economically recovered as byproducts of the tin mining. Indicated and inferred reserves are estimated at about 2,000,000 short tons at 0.18% to 0.29% beryllium with additional "large indicated and inferred resources containing 0.04% to 0.07% beryllium and up to 0.3% tin" (U. S. Senate Comm. Print, 1964). This represents significant potential reserves of beryllium and tin. However, both are low grade, and there are serious problems of concentration and recovery to be worked out for beryllium. Therefore, at present they are not economical.

Tungsten occurs with the tin at Lost River. Although there has been no recorded production, reserves are estimated at 63,350 units (20 lbs.) of WO_3 plus indicated ore containing 0.60% WO_3. Lower grade reserves are 193,000 units of inferred ore at 0.5% WO_3(containing up to 1% tin) and 130,000 units of inferred ore at 0.2% WO_3 with up to 0.4% tin.

Lead is another commodity for which there is no record of production although occurrences are known near Nome, and the Bunker Hill Mining Co. of Kellogg, Idaho is drilling a group of claims in the northeast part of the peninsula.

Known resources of lode gold occur in the region with estimated ore reserves of a few hundred thousand tons (U. S. Senate Comm. Print, 1964, p. 97-105).

At Imuruk Basin, in the Kigluaik Mountains, graphite and graphitic rocks are known to exist. Production from this area has been 270 tons. Fifty tons of sorted material has been stockpiled. Sixty five thousand tons of 52% material, or 300,000 tons of 10% ore are estimated in reserve. At present there is probably no likelihood that this deposit can be exploited, but opinion is divided as to the chance of finding more graphite. Since the graphite region is relatively unprospected, it appears that there is a chance that commercial deposits could be developed.

Other potential mineral resources, at present little known, are iron ore, ferro-alloy metals, mica, graphite, uranium, and coal.

POSSIBLE IMMEDIATE TONNAGES

Placer Gold

It is apparent that placer gold mining has accounted for most of the mining activity in Alaska.

Gold, being a high value commodity, does not generate a need for transportation out of the mining regions. However, there is a need for freight moving to the mines. It is difficult to state a rule as to how much freight is needed by a placer mine but assuming that large tractors and pumps are in operation, one drum of fuel per shift per machine might be used. An "average" placer mine working one shift might thus require 1,200 pounds of fuel. Other requirements could boost the consumption to 1,500 to 2,000 pounds per day. A placer mine, after the initial move to an area, could therefore require 80 to 100 tons of freight per season.

There are only three apparent sources for southbound freight in the relatively near future. These are copper from Bornite, and oil and coal from the north slope.

Copper at Bornite, Alaska

At the Bornite deposit, the Kennecott Copper Corporation originally planned an operation of 500 tons per day, producing ore containing 10% copper. This would have resulted in approximately 45,000 tons per year of concentrate. It now appears that the mine, if Kennecott decides to put it into operation would produce about 5,000 tons per day at the start. Assuming that the grade would be 2.5% copper, yearly tonnage would be about 115,000 tons of concentrate.

It is possible to make rough calculations of the annual production of concentrates using different mining rates and assuming a work year of 320 days and a concentrate containing about 35% copper. These are tabulated below.

Mining Rate per Day	Mining Rate per Year	Tenor of Ore	Pounds Copper/Year	Tenor of Concentrate	Tons of Conc./Year	Tons Concentrate shipped/Day
500 T	160,000 T	10%Cu	3.2×10^7	35%Cu	45,700	125
5,000 T	1,600,000 T	2.5%Cu	8.0×10^7	35%Cu	114,000	313
10,000 T	3,200,000 T	1.5%Cu	9.6×10^7	35%Cu	137,000	376
20,000 T	6,400,000 T	1.0%Cu	12.8×10^7	35%Cu	183,000	502

$$\text{Tons Concentrate per Year} = \frac{(\text{Tons per Day})\,(320)\,(\%\text{Cu})}{(100)\,(0.35)}$$

It should be understood that estimates of production and tenor of ore are speculations based upon what is known of the geology of the deposit and of Alaskan economics. No representative of the Kennecott Corporation has made definite statements regarding proposed production, nor is it probable that any firm estimate can be made at present. The above table is simply to illustrate the relationship between mining rate, tenor and tonnages generated therefrom.

Coal

In a recent interview, a group of Japanese stated that they are in need of one million tons per year of low volatile coking coal or medium volatile coking coal. Specifications for these coals are:

	Low Volatile Coking Coal	Medium Volatile Coking Coal
Moisture	2-4%	2-4%
Ash	5-6%	5-6%
Volatile matter	16-19%	20-24%
Sulfur	0.8% maximum	0.8% maximum
Free swelling index	7-9%	7-9%

Barnes (1967, p. 14) gives some ranges in composition and heating value for coals from several areas in Northern Alaska. These are reproduced below.

TABLE 2

Location	Rank	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heat Value B.T.U.
			Percent				
Corwin Bluff-Cape Beaufort	Bitum.	3.0-5.9	28.8-40.1	47.8-58.0	4.1-11.6		
Kukpowruk River	Bitum.	0.8-9.9	31.4-35.6	52.6-56.1	2.5-15.0	0.2-.3	11,910-12,880
Kokolik and Utokok rivers	Bitum.	1.7-6.2	33.1-37.4	46.8-57.9	2.3-17.4	.2-.6	11,630-13,640
Kuk and Kugrua rivers	Subbitum.	17.8-26.7	29.1-31.9	40.5-42.5	2.3-9.8	.2-.3	8,780-9,510
Meade and Ikpikpuk rivers	Subbitum.	14.4	33.5	47.3	4.8	.6	10,330
	Subbitum.	8.3-9.9	32.4-35.5	37.7-49.9	6.4-20.0	.2-.8	7,700-10,720
	Bitum.	3.4	36.5	46.8	13.3	.7	11,660
Colville River	Bitum.	2.5-6.6	30.1-43.7	39.3-62.8	2.6-24.3	.3-.7	10,430-13,450
	Subbitum.	5.2-16.4	28.3-31.6	41.9-49.2	11.8-23.4	.3-.7	8,450-9,390

A recent analysis by P. D. Rao of the Mineral Industry Research Laboratory, however, indicates the presence of certain coals in the Kukpowruk River region with a high free swelling index. Should sufficient tonnages of this type of coal be found and developed at competitive prices, a market exists. The coal sampled (sample #1-c) has the following analysis:

Moisture	1.60%	Sulfur	0.18%
Ash	2.54%	B.T.U.	14,133
Volatile matter	38.85%	Free swelling index 6(CF)	
Fixed carbon	57.01%		

The need for subbituminous steaming coal will drop steadily. Until new uses for such coal is found, it probably will not be brought south.

Oil and Gas

Drilling in Petroleum Reserve No.4 indicates the following:

1. A medium size oil field at Umiat, with an estimated reserve of 70,000,000 barrels
2. A small oil field at Simpson with perhaps 12,000,000 barrels reserve
3. A prospective oil field at Fish Creek
4. A medium size gas field at Gubik with probably as much as 300 billion cubic feet of reserve
5. A small gas field at Barrow, with 5 to 7 billion cubic feet of reserve
6. Prospective gas fields at Meade and Square lakes.

Recently oil was struck in a well being drilled by Atlantic-Richfield at Prudhoe Bay near the Arctic Coast in the Beechey Point quadrangle. This well is producing at the rate of 1,150 barrels per day, and has raised the hope that Arctic Alaska may become a large oil producer.

It should be noted that all three commodities mentioned above, the copper, coal, and oil, are much closer to the Bering Sea or Arctic Ocean than to the Gulf of Alaska. Balanced against this is the short shipping season in the north.

DISTRIBUTION OF MINERALS AND MINING CLAIMS

The Division of Mines and Minerals Kardex files were screened in an attempt to ascertain the location and number of active and patented mineral claims in Northern Alaska. This makes for some uncertainty, as the only criterion easily used to determine whether or not a mineral claim is current is the presence of an annual assessment work document. The State of Alaska requires claim holders to file annual assessment work affidavits, but the Federal Mining laws do not require this, therefore some claims that have been counted in the inactive category may actually be active claims under Federal rules. For the purpose of this study, claims were considered current if the 1966 assessment work affidavit had been filed.

Table 3 lists groups of patented claims by quadrangle, giving the area covered by claims in each quadrangle, as well as the commodity. Figure 7 depicts the distribution of these patented claims.

Table 4 shows the active mineral claims in Northern Alaska by quadrangle. The number of claims, commodity, and type (lode or placer) is given as well as the total numbers of each type. Figure 8 shows the overall distribution of these claims.

Tabulation of Mineral Occurrences

The records of the Division of Mines and Minerals and U. S. Geological Survey literature were examined in order to compile a comprehensive list of mineral deposits (Table 5). When possible, informed persons have been consulted to make the list more complete and bring it more nearly to date. Even so, it can be only approximate, and undoubtedly anyone familiar with a particular region can find shortcomings. The two most comprehensive sources for information on mineral deposits are the Division of Mines and Minerals Kardex files and U. S. Geological Survey Bulletin 1139 (Cobb and Kachadoorian, 1961). In the tabulations beginning on page 32, the reader is referred whenever possible to the appropriate page in Bulletin 1139 for a comprehensive listing of references concerning the property in question. The prospects and mineral deposits are listed by quadrangle (the U. S. Geological Survey has subdivided Alaska into such quadrangles for topographic mapping at a scale of 1: 250,000; Figure 9 shows the location of the quadrangles in Northern Alaska.) Names of prospects and mines are then arranged alphabetically by quadrangle.

A binominal coordinate system, used by the U. S. Geological Survey and by the Alaska Division of Mines and Minerals is used to locate mineral occurrences on maps of the Alaska Reconnaissance Topographic Series. The first number is the perpendicular distance from the west boundary of the quadrangle map; the second number is the distance from the southwest corner of the map northerly until its intersection with a perpendicular from the occurrence. Therefore an occurrence with coordinates (7.6, 10.1) would be 7.6 inches from the west boundary along a line extending east, normal to the west boundary, and 10.1 inches above the southwest corner of the map. Coordinates such as 2.1-2.3,3.2-3.3 are used to

TABLE 3

PATENTED CLAIMS NORTH OF 65° NORTH LATITUDE
(Data compiled from DMM records)

Quadrangle	Area in Acres	Number of Groups of Claims	Commodity *	Lode or Placer
Bendeleben	1,899.49	1	Ag, Pb, Sb, Au, Sn	Lode
		8	Au	Placer
		5	Sn	Lode
		1	Cu	Lode
Teller	1,821.74	1	Sn	Placer
Candle	733.41	1	Au	Placer
Point Hope	160.00	1	Coal	
Hughes	2,069.17	1	Au	Placer
Tanana	50.54	1	Cu, Pb, Co	Lode
Livengood	9,631.87	33	Au	Placer
		9	Au	Lode
		1	Ni	Lode
Circle	867.06	6	Au	Placer
Chandalar	489.62	3	Au	Lode
		1	Au	Placer
TOTAL	17,722.90 acres			

* Symbols: Au-gold, Ag-silver, Sb-antimony, Sn-tin, Cu-copper, Co-cobalt, Ni-nickel

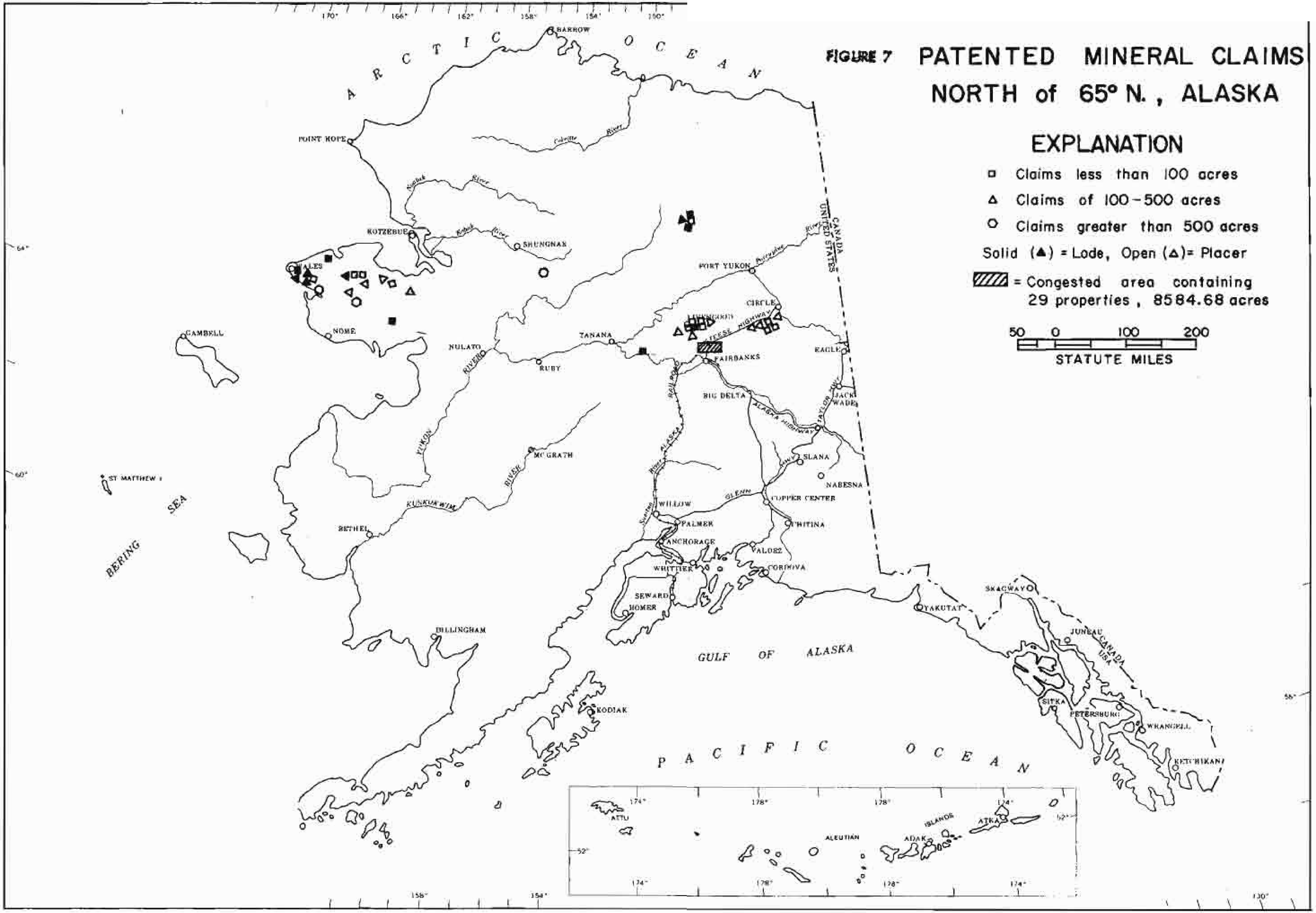


FIGURE 7 PATENTED MINERAL CLAIMS NORTH of 65° N., ALASKA

TABLE 4

ACTIVE MINERAL CLAIMS IN NORTHERN ALASKA

	Lode		Placer	
Quadrangle	Number	Commodity	Number	Commodity
Baird Mountains	40	Cu, Au	-	-
Ambler River	283	Cu, Pb, Zn, Ag	2	Jade
Wiseman	2	Au	106	Au
Chandalar	50	Au, Zn, Hg, Pb, Sb	61	Au
Kotzebue	-	-	9	Au
Shungnak	-	-	6	Jade
Hughes	-	-	15	Au
Teller	162	Sn, Be, Au, W, Mo, Pb, Zn	114	Sn, Au, W
Bendeleben	85	Au, Pb, Sb, Sn, Cu, U, Hg	294	Au, Sn, Radioactives
Candle	-	-	104	Au, Pt
Tanana	3	Limestone	389	Au, Sn, Radioactives
Livengood	339	Ag, Sb, Pb, Hg, W, Zn, Cr, Ni, Radioactives	313	Au, Sn, W
Circle	3	Au	194	Au, W, Sn
Charley River	-	-	162	Au, Sn, W, Pt
TOTALS	964		1769	

Data compiled from DMM Kardex Files. Claims considered current if 1966 assessment work was filed. Patented claims included only if actually active. Placer counts for Livengood, and Tanana are approximate.

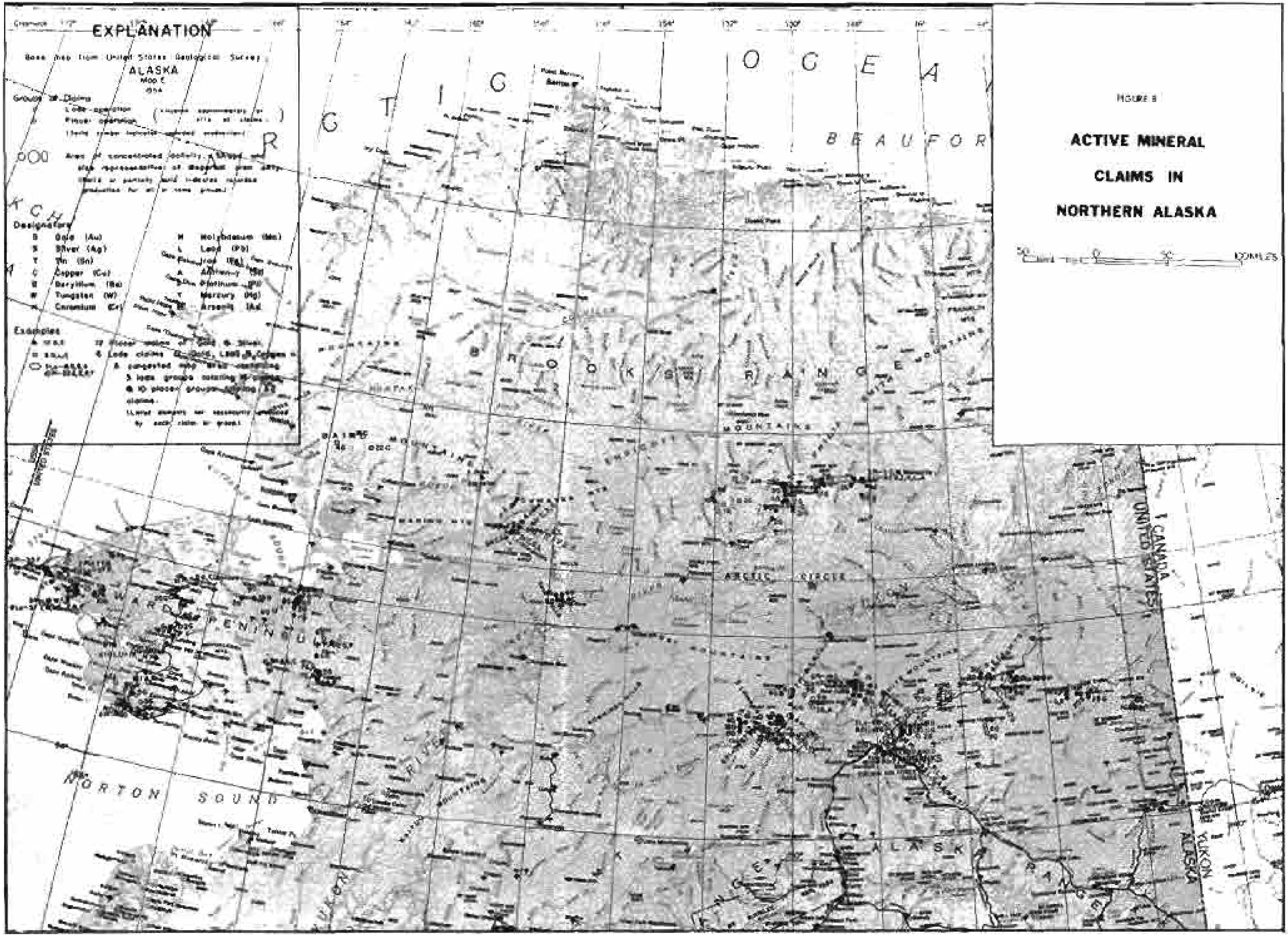


FIGURE 8
ACTIVE MINERAL CLAIMS IN NORTHERN ALASKA

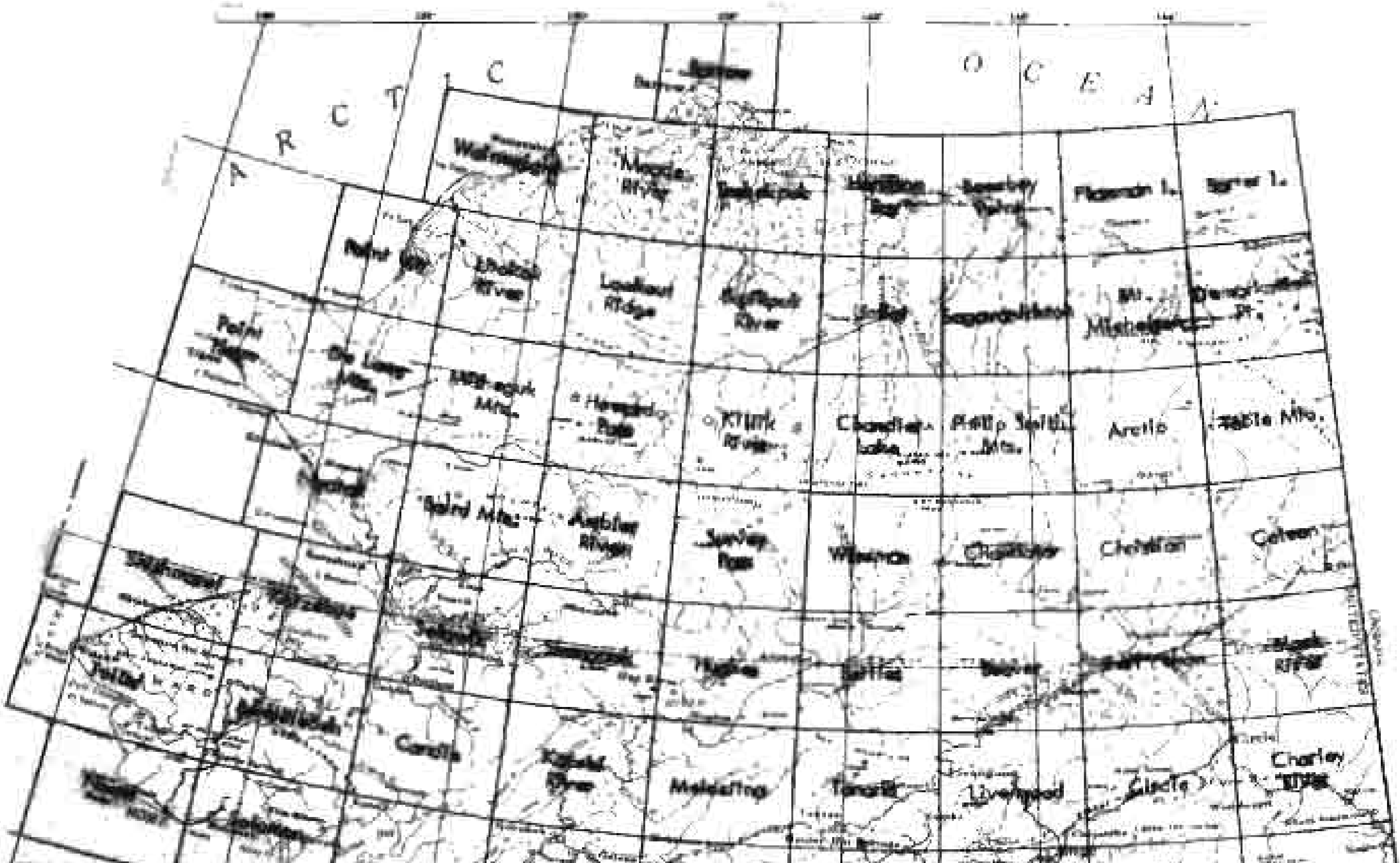


Figure 9 — Quadrangle Index of Northern Alaska

delineate extreme limits of an area; this would be interpreted as 2.1 to 2.3 inches east of the southwest corner of the map and 3.2 to 3.3 inches north of the southwest corner.

Figure 10 shows the distribution of inactive mining claims which corresponds approximately with the distribution of these mineral deposits.

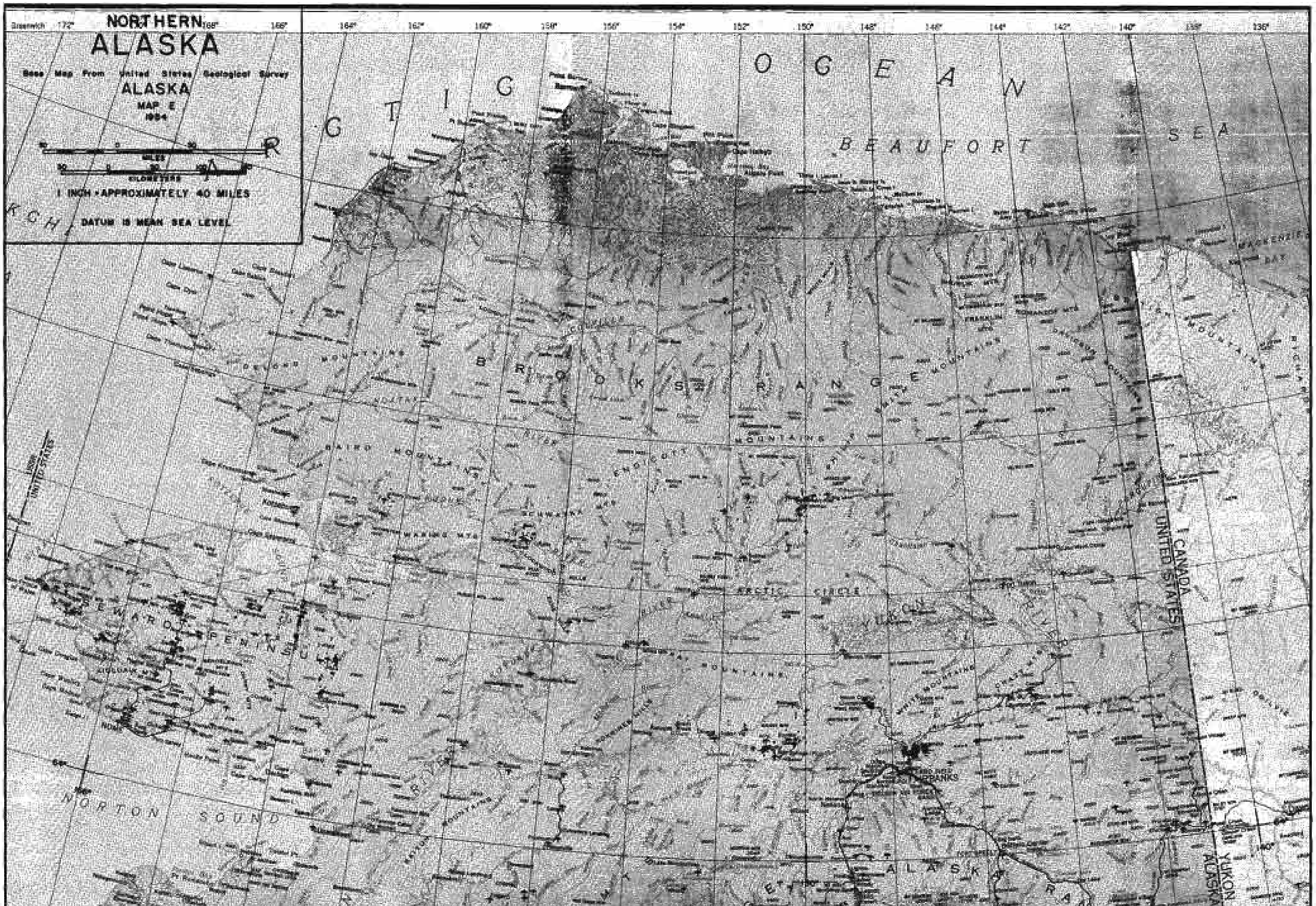


FIGURE 10 SPATIAL DISTRIBUTION OF INACTIVE MINERAL CLAIMS

TABLE 5

Tabulation of Mineral Occurrences
(106 pages following)

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Agnes Creek (10.7-11.6) (3.1-6.8)	B. 1139, p. 6	Au Placer		Some prospecting has been done on this creek.
Asbestos Mountain (14.85, 0.95)	B. 1139, p. 6	Asbestos, Jade, Quartz, Talc Lode	Arctic Circle Exp. Co., Inc.; Ing-Ihk; Ing-hik; Ingik	Trenching, shallow pits, some production.
Aurora Mountain (12.9, 1.3)	B. 1139, p. 6	Cu, Ag, Au, Pb Lode		Three miles west of Ruby Creek. Some shaft sinking and drifting. Encouraging reports. Bornite assays show 0.04 oz. gold and 1.4 oz. silver per ton. No tonnage estimate.
Bismark Mountain (11.95, 1.35)	B. 1139, p. 6	Asbestos, Jade Lode		Some trenching.
Boulder Creek (SE 1/16 quad.)	B. 1139, p. 6	Au Placer		Tributary Kogoluktuk River. Some prospecting.
Cosmos Creek (12.85, 0.45)	B. 1139, p. 6	Asbestos, Jade Lode	Arctic Circle Exp. Co., Inc.; Garland	Chrysotile float and exposures. Some mining.
Cosmos Hills (14.5, 0.95)	B. 1139, p. 7	Au Lode		North of Shungnak. Numerous veins intricately intersect the black slate and schist. No production.
Dahl Creek (14.45-14.50) (0.2-0.5)	B. 1139, p. 6	Asbestos, Cd, Ag, Chromite, Cu, Au, Jade, Ni, Quartz, Placer	Arctic Circle Exp. Co., Inc.; Garland	Some placer mining. Chromite float, native silver in gravels. Some mining of tremolite and placer gold. Chrysotile of the slip-fiber variety of good quality, often up to 12 inches in length. No areas of large tonnage yet observed.
Hunt River (SW 1/4 quad.)	B. 1139, p. 6	Au, Asbestos		Asbestos float, mountain leather variety.
Iron Mountain (S 1/2 13, 1)	B. 1139, p. 7	Fe		Masses of magnetite float. No large ore bodies known.
Jade Mountain (6.0-6.7) (3.25-4.2)	B. 1139, p. 7	Asbestos, Jade		Chrysotile float. No ore in place found.
Jade Mountain (6.35, 3.85) approx.	B. 1139, p. 7	Asbestos, Jade Lode-Placer		No large reserves known.

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Malfiatti (0.0, 9.8)?	B. 1139, p. 7	Cu Lode		Copper claim in Hunt River Valley, discovered in 1912. Some encouraging work said to have been done in 1913. No tonnage estimate.
Midas Creek (16.5-19.8) (15.0-17.0)	B. 1139, p. 7	Au Placer	Jim Cross?	Discovered in 1904. Some mining.
Pearl Creek (14-15, 1-2)?	B. 1139, p. 7	Au		
Riley Creek (14.7-14.8) (1.05-1.15)	B. 1139, p. 7	Au Placer		Prospecting. Some mining.
Ruby Creek (13.95, 1.5)	B. 1139, p. 7	Cu, Au, Pb Lode	Kennecott Copper; Berg	Exploration and development by Kennecott Copper Corp. Diamond drilling, shaft sinking, trenching and test pitting. Good prospect. Large reserves indicated.
Shungnak River (12.0-12.3) (0.75-1.2)	B. 1139, p. 7	Au, Ag, Cu, Asbestos Placer	Kobuk Alaska Mines	Prospecting. Some mining.
Stockley Creek (14.6, 0.75)	B. 1139, p. 7	Asbestos, Ni		A little nickel found in asbestiform minerals near mouth. Asbestos float.
Wesley Creek (13, 0)	B. 1139, p. 7	Pb, Jade, Asbestos Lode		Small amounts of galena on a high hill west of Wesley Creek.
--- (17-18, 8)?	B. 1139, p. 8	Pb, Cu, Au, Ag		Associated lead with copper sulfides on Aurora Mountain and on Ruby Creek.

BAIRD MOUNTAINS QUADRANGLE

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bear Creek (11.4-11.5)	B. 1139, p. 21	Au Placer		Considerable tract of prospective placer ground work in 1934-35.
Central Creek (11.05-11.1) (2.15-2.25)	B. 1139, p.,21	Au Placer		Dragline scraper used successfully to recover gold.

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Klery Creek (10.5-10.9) (2.55-4.75)	B. 1139, p. 21	Au Placer	Klery Placers, Inc.; Kiana Placer District; Squirrel River; Doug Colp; Colp Mining Co.; Lammers;	Gold dredging. Still active off and on.

BEAVER QUADRANGLE

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Mason Hyde (NW 1/4 quad.)	Kardex 40-6	Au? Placer	Mason Hyde	In 1931 Hyde prospected Lansing Fork, Granite Fork and Mud Fork, all tributaries of the Hodzana River.
Slate Creek (6-7, 14-16)	Kardex 40-3	Au Placer		Placer gold claims staked in 1954 and 1955.
Trout Creek (NE 1/4 NW 1/4 quad.)	B. 1139, p. 21	Zn, Mo, Au Placer	T. Sturrock	Specimens sent to the USGS in 1923 by T. Sturrock of Beaver, contained quartz, pyrite, sphalerite and molybdenite. Trout Creek is probably one of the small streams forming the extreme headwater part of the Hodzana Valley, possibly flowing into the Pitka Fork of that river. Claims staked for placer gold in 1955. Not now active.

BENDELEBEN QUADRANGLE

Coordinates	Reference	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Albion Gulch or Creek (9.5-9.6) (0.5-0.55)	B. 1139, p. 21	Au Placer		Gold gravels throughout channel.
American Creek (13.0-13.35) (14.45-15.1)	B. 1139, p. 21	Au, Sn Placer		Brighter gold than rest of area but in small quantities. Placer cassiterite.
Anderson Gulch (2.0, 8.0) approx.	B. 1139, p. 22	Au Placer		Bedrock composed of a silvery mica schist with iron stained quartz. Placers traced 1600 feet along the valley slope.
Angeles Creek (3.65-3.75) (7.9-8.15)	B. 1139, p. 22	Au Placer		Gold reported in area. Little history of prospecting or mining.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Arizona Creek (0.8-1.55) (10.5-10.85)	B. 1139, p. 22	Au Placer		Mineable gravels reportedly uncovered in 1908 on bench near mouth. Gravels 70 feet above stream elevation.
Balm of Gilead Gulch (9.7, 0.4)	B. 1139, p. 22	Au Lode	Balmot Gulch	Richest gold occurs in limestone crevices. Gold is rough and angular and of local origin.
Bella Creek (0.9-1.1) (14.3-14.8)	B. 1139, p. 22	Au Placer		No gold taken in commercial quantities.
Big Bar Creek (19.5-20.4) (8.4-9.7)	B. 1139, p. 22	Au (?) Placer		Prospecting reported but apparently too low for profit.
Birch Creek (7-8, 4)	B. 1139, p. 22	Mica Lode		Pegmatite dikes with mica flakes of exceptional size.
Black Creek or Gulch (5.95-6.0) (9.2-9.5)	B. 1139, p. 22	Au Placer		Small camps reported but recovery amounts not listed.
Boulder Creek (4.9-5.25) (9.1-10.2)	B. 1139, p. 22	Au Lode	Midnight Sun Mining Co.	One open cut operation in 1915.
Bryan Creek (0.15-0.25) (14.8-15.1)	B. 1139, p. 22	Au (?) Placer		No gold of commercial quantity taken.
Buzzard Gulch (6.0-6.3) (9.45-9.7)	B. 1139, p. 22	Au Placer	Lammers Fitzpatrick Mining & Exploration Co.	Dragline and hydraulic plant used.
California Creek (0.95-1.45) (11.0-11.2)	B. 1139, p. 22	Au Placer		Both flood and bench gravels yield gold. Considerable mining done on bench near creek mouth.
Camp Creek (trib. of Coffee Creek) (1.5-3.0) (5.1-5.7)	B. 1139, p. 22	Au Placer (?)		Some surveying done but no definite reports.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Camp Creek (trib. of Tubutulik River) (21.35, 0.95)	B. 1139, p. 22	Au Placer	Admiral Creek; Coffee Creek Mining Co.; Fred Durocher	Placer mining by horse scrapers gave unsatisfactory returns. Complex geology. Gold from older schists.
Candle Creek (20.9-21.6) (13.75-15.1)	B. 1139, p. 22	Au Placer	Alaska Dredge Assn.; Arctic Circle Exploration Co.; Candle Creek Dredge Co.; Candle Mining Co.; Candle Ditch Co.; Fairhaven Gold Dredge Co.; Golden Center Mines, Inc.; Johnson	Wide distribution of values. Gold occurs on benches and creek. Most values on second tier near creek mouth. Water supply is a problem. Hydraulic methods and dredging used to mine the creek.
Chicago Creek (18.55-19.7) (16.1-17.25)	B. 1139, p. 23	Au Placer		Rich placer ground mined in 1906. Largest producer for the season. General prospecting done. No other workable ground (?). Coal bed in area. Water supply a problem.
Coarse Gold Creek (0.6-1.75) (9.4-10.5)	B. 1139, p. 23	Au Placer		Alluvium gold bearing. Part of creek bedrock is diorite and unworkable but the lower part is schist. Good potential. One mine worked but water is a problem.
Coffee Creek (1.55-3.0) (5.15-5.5)	B. 1139, p. 23	Au, Hg Placer	Coffee Creek Mining Co.; Grant Mining Co.	Good producer using dragline and hydraulic plants. Small amount of placer cinnabar found in concentrates.
Collins Creek (13.0-15.85)	B. 1139, p. 23	Au, Pb Placer		Little prospecting in 1905. Lead carbonates and galena present.
Crooked Creek (9.55-9.9) (0.35-0.6)	B. 1139, p. 23	Au, Hg Placer	Crooked Creek Dredge Co.; Flume Dredge Co.; Fernegal & Hanson; Ost	Quartz heavily mineralized with pyrite. In 1903, more mining was done here than on any other creek. Gold is coarse. Lack of water is major mining problem. Gold lode near head of creek.
Cunningham Creek or Gulch (11.7-12.15) (16.2-16.45)	B. 1139, p. 24	Au, Pb, Ag Placer	Johnston	1927, one prospector reported. 1942, concentrates assayed - 50% lead and 5.7 oz. gold. Lead carbonates and pyromorphite are common minerals.
Dahl Creek (1.65-2.3) (5.95-6.3)	B. 1139, p. 24	Au Placer	Dahl Creek Mining Co.; Al Carey, Emile Milak (?); Waldhelm; Nashenweng	Some gold produced yearly. Remoteness is major problem. 1908, one hydraulic plant operated on a bench claim. Considerable work done on four claims by sluice boxes.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Dick Creek (0.2-0.35) (13.65-14.8)	B. 1139, p. 24	Au, Sn, W Placer	Dick Creek Mining Co.; Flodin & Hutton; George Bodis	Small amount of gold taken out in 1908. Placer tin and placer scheelite in fairly large amounts. Mined with cat and hydraulic methods in the 1950s.
Discovery Gulch (11-14, 15-17)	B. 1139, p. 24	Au Placer	Hoogandorn	Five-man hydraulic plant operated in 1935.
Dixie Creek (19.0-19.2) (9.1-9.6)	B. 1139, p. 24	Au Placer		1903, two men worked one season. Reported good wages.
Dome Creek (20.75-21.75) (11.8-12.4)?	B. 1139, p. 24	Au (?) Placer	Pete & Andy Wirum	Prospected in 1902. Mined with hydraulic methods for several years.
Dreamy Gulch (1.4-1.45) (11.65-11.7)	B. 1139, p. 24	Au Placer		Coarse, rusty, well-rounded gold. Water main problem.
Eagle Gulch (1.5-3.0) (5.1-5.7)	B. 1139, p. 24	Au Placer		1921, small hydraulic plant in operation.
Esperanza Creek (8.15-9.0) (14.39-14.42)	B. 1139, p. 24	Au Placer		Gold discovered in 1908. Pay streak in 1909 occurred in a narrow, shallow strip in the creek bed. Six claims near lower end. Water problems.
Eureka Creek (2.2-2.6) (10.5-10.6)	B. 1139, p. 24	Au Placer		Schist and vein quartz gravels. Fine gold. Small amount mined.
Foster Lode (17.2, 1.4)	B. 1246, p. 109	Pb, Zn, Sn, Sb, Cu, Ag, As Lode		Discovered prior to 1900. Trenched by prospectors in 1949. Drilled by USBM in 1953 and 1954.
Frost Creek (6.2-6.5) (10.15-10.35)	B. 1139, p. 25	Au Placer		Gold bearing gravels reported. Mining hampered by remoteness and water scarcity.
Garfield Creek (3.3-4.6) (7.3-8.65)	B. 1139, p. 25	Au Placer		Gold discovered in 1900. Considerable gold taken out of shallow placers. Lacked rich ground. Gold bearing creeks cross contact of limestone and schist.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Glacier Creek (20.95-21.2) (10.75-11.0)	B. 1139, p. 25	Au Placer		Interbedded schist and limestone. Good pay streak in 1908.
Gold Bottom Creek (8.75-8.9) (0.5-0.6)	B. 1139, p. 25	Au Placer		Some gold produced. Placer confined to creek bed and flood plain.
Gold Run Creek (21.1-21.8) (9.7-10.35)	B. 1139, p. 25	Au, W, Kyanite Placer	Xavier	1940, prospecting done. Scheelite is a common mineral in concentrates. Lode occurrence of kyanite found.
Goose Creek (6.2-6.35) (9.8-9.9)	B. 1139, p. 25	Au Placer	Harry Nelson; Whaley	1900, gold found. Little mining done as lack of water and transportation to this remote area make mining costs high.
Grouse Creek (trib. of Noxapaga River) (5.5-5.7) (9.0-9.4)	B. 1139, p. 25	Au Placer		Gold found in gravels. Lack of water and transportation are major mining problems.
Grouse Creek (trib. of Tubutulik River) (20.6-20.7) (1.1-1.5)	B. 1139, p. 25	Au Placer		Outcrop of vesicular basalt. Old gold placer operation near.
Hannum Creek (11.9-13.2) (15.55-16.3)	B. 1139, p. 25	Au, Pb, Sn Placer, Lode	Neal W. Foster; Bear Creek; Bunker Hill	Lead and placer cassiterite found. Poor water supply. Prospecting in 1968.
Harris Creek (2.95-3.8) (10.7-12.0)	B. 1139, p. 25	Au, Pb, Ag Placer	North Fork Dredge Co.	Lead occurs in concentrates and in a galena lode occurrence. Placers are confined to area of limestone bedrock. Richest where rock is broken up by fissures and crevices. No distinct gold veins in the limestone. Economically important.
Harry Creek (11.95, 16.25)	B. 1139, p. 26	Pb Lode		Vein of galena in limestone. Could be galena source for Hannum Creek.
Henry Creek (0.3-1.4)	B. 1139, p. 26	Au Placer	Continental Gold Mining Co.; Well Bros.; Sam Godfrey	Low grade placer deposits. Flat, coarse gold which is well-rounded and iron stained. Dredge operated on creek for several years.

Coordinates	References	Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Homestake Creek (0.65-1.3) (12.0-12.15)	B. 1139, p. 26	Au, W Placer		1902, active mining efforts produced little more than wages. Pay streak in general is 8-40 feet wide and confined to the valley floor. Scheelite reported.
Hotsprings Creek (1-2, 14-15)	B. 1139, p. 26	Hg ?		Mercury reported. Little mining done.
Humboldt Creek (4.9-5.5) (15.25-16.95)	B. 1139, p. 26	Au, Sn Placer	Laurin; Pearse M. Walsh	Cassiterite most common mineral in placer concentrates. Lot of gold taken off of this creek.
Imuruk Lake (11-13, 8-9)	B. 1139, p. 26	Au (?) ?		Reported claims staked near Lava flow margin adjacent to lake in hopes of finding ancient placers.
Imachuk River (12,15)	B. 1139, p. 26	Ag, Pb, Fe Lode		Galena and gold lode with limonite capping occurs on left limit of river between its head and Collins Creek. Magnetite present in ore from this deposit.
Imachuk River (12.95-14.75)	B. 1139, p. 26	Au, Hg Placer	Bellview Boys; Dashley; Dry Creek Dredge or Mining Co.; Deering Dredge & Mining Co.; Fairhaven Ditch & Hydraulic (and/or) Water Co.; Forsgren & Vollmer Dredge Co.; Homestake; Fries Dredge Co.; Hoogendorn; Imachuk Gold Dredge Co.; Utica; North American Mines, Inc.; Polar Bear; Ipnichuk River; Casa De Paga; Fred Parker	Cinnabar pebbles in concentrates. Dredge idle in 1915. 1940, dragline and dredge both in use. Benches currently being mined with D-9 cats.
Joe Creek (1.1, 6.4)	B. 1139, p. 27	Au Placer		Gold gravels of this creek, Dahl Creek and Lane Creek belong to the same horizon.
Joseph Creek (NE 1/4 quad.)?	B. 1139, p. 27	Au Placer		Deep placer mine worked in 1916.
Jump Creek (21.25-21.5) (15.6-15.85)	B. 1139, p. 27	Au Placer	French; Smith & Shane; Otto Weinert & Son	Gold discovered in 1901, two miles above mouth. Bench worked in 1903. Bedrock is composed of decomposed mica schist.
Kougarok River (0.0-3.55) (4.45-13.0)	B. 1139, p. 27	Au, Hg, Sn, Cu Placer	J. Sullivan; Alaska Kougarok Dredge Co.; Alaska Taylor Mining Co.; Carroll; Be(h)ring Dredge Co.; Coal Creek Dredge Co.;	Benches indicated tranquil periods between uplifts. Gold gravels occur in two zones that converge at the lower part of the river. The best gold gravel is found in the main river on stream beds and benches.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Kougarok River, cont.			Dearborn Investment Co.; Fox Bar Dredge Co.; Godfrey; Henry Creek Gold Dredge Co.; Johnson; Kanari; Keenan & Castleton; Kelliker Dredge Co.; Kourgaruk Consolidated Placers, Inc.; Mascot Mining Co.; Kourgaruk Mining Co.; Taylor Creek Ditch Co.; Tweet Bros.; N.B. Tweet	Dredge and hydraulic mining. Copper prospect on Taylor Creek tributary. A fortune made here. Dredged from 1959-1962. Currently active.
Kourgarok River, North Fork (2.05-3.75) (10.35-10.8)	B. 1139, p. 28	Au Placer	Reader & McLean	Economically important tributaries are Harris and Eureka Creeks. Some placers have considerable yield. Benches are prominent features and have gold.
Kugruk River (18.2-18.75) (15.0-16.3)	B. 1139, p. 28	Au Placer	Kugruk Mines, Inc.	The discovery claim was the only one to produce amount of gold. Pay streak crescent shaped. Some coal in the area. A small diesel unit worked on the main stream in 1940.
Macklin Creek (1.25-2.05) (12.95-13.3)	B. 1139, p. 28	Au Placer	Anderson; Laurin Bros.	Mineable gravels but sluice water lacking. A lot of gold taken off of this creek.
Mascot Creek or Gulch (0.4-0.45) (12.65-12.85)	B. 1139, p. 28	Au, Sn Placer		Bedrock is mica slate or phyllite with quartz stringers. Manganese stained talus on top. Gold is in irregular patches on bedrock near source. Cassiterite also occurs. Considerable mining done here.
Merritt Gulch (SW 1/4, 0, 11)?	B. 1139, p. 28	Au ?	Continental Gold Mining Co.; Well Bros.	Active mining apparent, 1935.
Milroy Creek (12.1-12.3) (16.35-16.85)	B. 1139, p. 28	Pb Placer	Ray Mendenhall	Lead carbonates and pyromorphite are the most common minerals. Concentrates assay approximately 50% lead.
Mina Creek (18.7-19.2) (13.0-13.45)	B. 1139, p. 28	Au Placer		Workable prospects found in 1909 but lack of water is a problem.
Minnehaha Creek (20.7-21.5) (15.9-16.4)	B. 1139, p. 28	Au Placer		Prospected and gave good indications, 1902.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Nelson Gulch (12.85, 14.95) approx.	B. 1139, p. 28	Au Placer		Some hydraulicing done, 1909. Water problems.
Neva Creek (2.3-2.4) (8.35-8.45)	B. 1139, p. 28	Au Placer		Prospecting done in shallow gravels but production small.
Old Glory Creek (12.7-13.35) (14.8-15.1)	B. 1139, p. 29	Au, Sn Placer		Placer cassiterite occurs but none of commercial value. Gold found in 1900. Working abandoned in 1908.
Omilak (17.15, 1.35)	B. 1139, p. 29	Ag, Pb, Sb, Au Lode	Golovin Bay Mining Co.; Omilak Gold & Silver Mining Co.; Russian-American Mining & Exploration Co.; (Omalik, Oonilak)	First attempt at mining in peninsula at the lead silver mine here. Operated 1881-1890. Stibnite ore occurs in thin bands in limestone shatter zone. 300-400 tons of lead have been produced. Ore in irregular discontinuous pockets formed by limestone replacement processes. Sporadic attempts at mining from 1890-1920.
Ophir Creek (9.4-10.0) (0.1-1.25)	B. 1139, p. 29	Au Placer	Blue Goose; Wild Goose Mining Co.; Flume Dredge Co.; Kimball & Saupe; Northern Light Mining Co.; Ophir Gold Dredge Co.; (Oxide Creek); Pederson	Paying quantities taken in 1899. Placer of creek and bench type. Small veins and stringers of quartz appear to be source. Most bonanzas at junctions with side streams. Still active; Pederson family operated dredge 1967.
Pargon Mountain (N 1/2, 10, 2)?	B. 1139, p. 29	Mica Lode	Ost	Muscovite deposit. Large sheets not uncommon.
Patterson Creek (21.15-21.6) (15.25-15.3)	B. 1139, p. 29	Au, Pb, Ag Lode		Considerable mining done. Arsenopyrite makes up large part of claim. Galena veins exposed.
Perkeypile-Ford (ref. Independence Creek) (18.5-11.95)	B. 1139, p. 30	Ag, Pb, Au, Zn Lode	Independence; Independence Creek; Kugruk River; Rheinhard & Berg	Lead lode. Several hundred feet of drifts and shafts in area. Ore is wider than the drifts, which are 10-12 feet wide.
Perry Creek (13.3-13.85) (14.45-14.6)	B. 1139, p. 30	Au Placer		Gold operations active in 1901. Bright, fine gold in wash gravel, chiefly quartz pebbles. Lack of water and difficulty in transporting supplies make work difficult.
Pinnell River (13.8-13.85) (15.4-15.64)	B. 1139, p. 30	Au Placer	Cordovado Mining Co.; Dry Creek Dredge (or) Mining Co.	Small amount of gold taken out below the mouth of Old Glory in 1938. Plans made to use a dredge.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Pish River (2-3, 15)	B. 1139, p. 30	Sn Placer		Quantities of placer tin recovered.
Quartz Creek (2.2-3.0) (5.25-6.4)	B. 1139, p. 30	Au, W Placer	Nashenwing	Scheelite is a common placer constituent but is not of economic importance. Drilling done and dredge plans made in 1915.
Schlite Creek (1.05-1.35) (14.3-14.95)	B. 1139, p. 30	Au (?) Placer		Preparatory work being done in 1901.
Serpentine Hot Springs (2.35, 15) approx.	B. 1139, p. 30	Sn (?) Lode	Hotsprings	Graphitic mica schist intruded by granite. Trace amounts of tin in granite.
Solomon Creek (now called Salmon Creek) (2.9-3.0) (12.45-12.55)	B. 1139, p. 30	Au Placer	Salmon Creek	Ground sluicing done, also dredging. Paid $1000-2000, but no more.
Taylor Creek (1.5-3.9) (12.0-13.1)	B. 1139, p. 30	Au, Cu Placer	Alaska Kougarok Dredge Co.; Be(h)ring Dredge Co.; N.B. Tweet & Sons	Gold colors found but little mining done. Creek cuts strike of schists and limestone. Copper lode reported near mouth.
Timber Creek (19.35, 5.1) approx.	B. 1139, p. 30	Cu, Ag, Au Lode		Prospect pits sunk 1906-07 on copper stained greenstones near a limestone contact. Mineralization appears to be local. Copper occurs as malachite.
Trinity Creek (0.8, 12.9)	B. 1139, p. 30	Au Placer		No extensive deposits but has workable gravels with wide gold distribution.
Tubutulik River (Camp Creek) (20.5-21.7) (0.4-1.1)	B. 1139, p. 31	Au Placer		Colors found but not of sufficient quantity to mine. One open cut operation.
Turner Creek (4.9-5.36) (8.55-10.21)	B. 1139, p. 31	Au Placer		No mining done but good gold prospect reported. Little bedrock exposure. In 1938 the tundra was bulldozed and slucing done, which paid well.
Windy Creek (1.35-2.3) (8.0-8.15)	B. 1139, p. 31	Au Placer	Otto Worm	Ground sluicing done. Bedrock a silvery mica schist with iron stained quartz. Placers traced for 1600 feet along the valley slope.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Wonder Gulch (1.95-2.0) (5.45-5.6)	B. 1139, p. 31	Au, Pb, Hg Placer		Open cut operation. Hydraulic plant in use.
--- (8.0, 3.0) approx.	B. 1139, p. 31	Cu, Au Lode		Copper ore occurs near contact of limestone and schist; consists of chalcopyrite and is of low grade, with associated trace gold. No main body found.

BETTLES QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Davis Creek (17.65, 17.8)	B. 1139, p. 33	Au Placer		Had produced $5000 by 1909. Creek is about five miles long and has thick deposits of washed gravel containing some gold.
Dome Creek (S 1/2 quad.)?	B. 1139, p. 33	Au (?) Placer		Placer gold prospects are said to have been found on this creek.
Koyukuk River (9.7, 16.3)	Kardex 39-5	Au Placer		A claim staked on river at bedrock riffle, about a mile below Bettles Field. Not currently active.

CANDLE QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alameda Creek (7.25-7.4) (0.95-1.1)	B. 1139, p. 42	Au Placer		Various prospect hole sunk. Not sufficient gold to mine in 1909.
Bear Creek (6.8-7.1) (9.5-9.75)	B. 1139, p. 42	Au, Pt Lode	Hoxie; Tendness & Barr; Porter	The lodes consist of pyrite, sphalerite and galena disseminated in greenstone adjacent to quartz-pyrite bearing calcite veinlets; and disseminated pyrite and galena in greenstone breccia zones as much as 2 1/2 feet wide. The deposit is marked by a thin oxidized zone from which a little gold can be panned.
Bear Gulch (4.9-5.0) (6.0-6.1)	B. 1139, p. 42	Au, Pt Placer		Pannings in area carry considerable platinum and gold. Creek and bench claims are staked.
Beltz (6.4, 9.5)	B. 1139, p. 42	Cu, Au (?) Lode		Sparse chalcopyrite and secondary copper minerals are found in a quartz vein in andesite. Gold bearing quartz veins reportedly occur in the area. Explored by several open cuts in the early 1900s.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Boulder Creek (6.4-6.9) (6.95-7.25)	B. 1139, p. 42	Au Placer		Stream and bench gravels have been prospected. Uranothorianite is present in placer concentrates.
Candle Creek (0.0-0.6) (14.65-16.1)	B. 1139, p. 42	Au, Pb, Cu Lode		Small veins of galena in bedrock were exposed during placer operations.
Candle Creek (0.0-0.6) (14.65-16.1)	B. 1139, p. 42	Au, Fissionable Materials, Cu, Pb Placer	Alaska Dredge Assn.; Arctic Circle Exploration Co.; Candle Creek Dredge Co.; Candle Creek Mining Co.; Candle Ditch Co.; Fairhaven Gold Dredge Co.; I. Johnson; Golden Center Mines, Inc.; Keewalik Mining Co.; New York-Alaska Gold Dredge Co.	Gold bearing gravels mined along lower five miles of creek. Placer mining since 1901. Gold on creek is flattened and dark while gold on bench claims is bright.
Canoe Creek (0.0-1.4) (8.75-10.0)	B. 1139, p. 42	Ag, Pb Lode		A specimen of argentiferous galena reportedly was taken from a vein 1 1/2 feet thick.
Cub Creek (7.1-7.3) (8.9-9.1)	B. 1139, p. 43	Au, Radioactive Placer		Small amounts of uranium found in syenites of the area. Uranothorianite was present in placer concentrates in 1947.
Dime Creek (6.25-6.4) (2.9-3.9)	B. 1139, p. 43	Au, Pt, Cr (?) Placer	Dime Creek Dredge Co.; Dime Creek Mining Co.; Haycock; Haycock Mining Co.; Moon & Ryan; Smith	Platinum recovered with gold. Chromite and chrome spinels in placer concentrates from streams. Rich claims on first and second tier bench claims. A one oz. platinum nugget was mined and $5000 gold was recovered in 1917.
Dome Creek (0.0-1.05) (11.85-12.05)?	B. 1139, p. 43	Au (?) Placer		Prospected for gold and gave good indications.
Eldorado Creek (6.1-6.35) (3.7-4.35)	B. 1139, p. 43	Au Placer	Little Eldorado Creek	Gold discovered near the mouth. Claims proved to be poor.
Farmer Creek (6.3-6.7) (6.6-6.75)	B. 1139, p. 43	Au Placer		Panning showed a few fine colors.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Gold Run Creek (0.0-1.1) (9.95-11.5) ?	B. 1139, p. 43	Au Placer		Some prospecting done. No reported production.
Greenstone Creek (6.3-6.6) (3.0-3.5)	B. 1139, p. 44	Pt Placer		Platinum reported in the gravels.
Hunter Creek (2.5-3.8) (12.65-13.65)	B. 1139, p. 44	Au Placer		Prospected for placer gold.
Hunter Creek, Right Fork (3.8-5.5) (12.6-13.4)	B. 1139, p. 44	Au (?) Placer		Prospecting done by one man in 1947.
John Bull Hill (0.5, 15.9) approx.	B. 1139, p. 44	Au Placer	Keewalik Minging Co.	Hydraulic operation, 1918. Various minerals found in the sluicings, with iron oxides predominating.
Jump Creek (0.0-0.25) (15.4-15.6)	B. 1139, p. 44	Au Placer	French; Smith & Shane	Placer gold discovered in 1901. Gold bearing gravels have been mined.
Kiwalik River (0, 16)	B. 1139, p. 44	Au Placer		
Koopuk River (N Central 1/8 quad.)	B. 1139, p. 44	Au Placer		Small camp with recovery variable.
Meinzer Creek (5.0-5.9) (13.5-15.3)	B. 1139, p. 44	Au Placer		Prospected for gold.
Mud Creek (0.1-0.7) (16.1-17.2)	B. 1139, p. 44	Pb, Hg Placer	Weinard	Small amounts of galena and cinnabar found in concentrates from drift operations.
Peace River (7.2, 8.4)	B. 1139, p. 44	Cu Lode		Copper sulfides in granite are found about 17 1/2 miles north of Haycock. Quantity of mineralization slight.
Peace River (6.35-7.0) (5.8-7.85)	B. 1139, p. 44	Au, Pb, W, Cu, Zn, Radioactives Placer		Most promising locality in the area for high grade uranium ore. Trace amounts of gold, lead, tungston, zinc and copper were found in three concentrate samples.

CANDLE QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Placer Creek (SW 1/4, 1/4 quad.)	B. 1139, p. 44	Au Placer		Some mining done in 1912.
Quartz Creek (4.8-5.55) (8.55-8.8)	B. 1139, p. 45	Au, Pt, Radioactives Placer	Jack	Prospected. Uranium bearing minerals found on South Fork.
Rock Creek (6.3-6.95) (6.95-7.5)	B. 1139, p. 45	Au (?) Placer		Prospected in stream and bench gravels.
Rube Creek (6.25-6.8) (6.5-6.6)	B. 1139, p. 45	Au, Pt (?), Cr (?) Placer	Diamond Creek	Small amounts of platinum reported. Prospected for gold. Little mining done since Stampede days. Trace of chrome.
Sheridan Creek (6.4-6.65) (10.3-10.35)	B. 1139, p. 45	Au, Pt Placer	Sheridon Creek	Gold mined and open cutting done. Chrome spinel occurs with platinum.
Spring Creek (5.4-5.9) (6.3-7.4)	B. 1139, p. 45	Au Placer		Ten feet of gravel. Ground of main creek only claim held.
Spruce Creek (3.9-4.3) (11.7-12.1)	B. 1139, p. 45	Au (?) Placer		Stream and bench gravels prospected. Trace amounts of gold found.
Sugarloaf Creek (5.7-6.4) (12.9-13.0)	B. 1139, p. 45	Au (?) Placer		Stream and bench gravels prospected. Trace amounts of gold found.
Sweepstakes Creek (4.95-5.2) (5.9-7.05)	B. 1139, p. 45	Au, Pt, Fissionable Materials Placer	Circle; Eagle; Fairbanks; A. Johnson; Moon; Porter; Winder; Rampart	Platinum recovered with gold. Open cutting practiced. Platinum only recovered in lower claims. Chrome spinel also is present in the bedrock. Metamorphosed andesite series of uranium-thorium present.
Trio Creek (0, 10)?	B. 1139, p. 45	Au Placer		Ground 6-12 feet deep, with considerable fall and bed-rock drained by cuts. 250 foot cuts worked in 1909.
Willow Creek (6.4, 9.9)	B. 1139, p. 45	Au Lode		Only known gold in the area occurs in a gold-quartz vein on the hillside.
--- (6.4, 9.9)	B. 1139, p. 46	Au Lode		Occurs between Polar and Split Creeks.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bettles River (4-7, 9-12) approx.	B. 113 , p. 46	Au Placer		Prospects on tributaries: Emory Creek, Garnet Creek, Mule Creek, Eightmile, Phoebe, Spruce and Sheep Creek.
Big Creek (SW 1/4 12, 9)	B. 113 , p. 46	Au, W, Ag, Pb, Zn, Sb Placer	Newton and Yasuda	Body of gold bearing quartz in bed of creek. It is thought that this mineralized zone continues from the valley of Big Creek to the upper basin of Tobin Creek, a linear extent of approximately three miles. Associated minerals include arsenical pyrite, sphalerite, galena, stibnite, pyrite and chalcopyrite. Large placer creek. Mined until 1960. Higher prices necessary before mining could begin again. Production over $500,000.
Big Squaw Creek (12.25, 10.0) approx.	B. 113 , p. 46	Au, Sb, Pb, Mo Placer		Coarse gold in placer. Heavy minerals include pyrite and arsenopyrite. Uranothorianite is present in trace amounts, along with a few grains of monazite and zircon. No production reported.
Boer Gulch or Creek (2.5-3.4) (0-8.4)?	B. 113 , p. 46	Au Placer		Gold placer capable of supporting two men. Has not proved attractive.
California Creek (3.35-3.5) (7.8-8.7)	B. 113 , p. 46	Au Placer		$3000 production by 1909. Worked intermittently for several years.
Carter (SW 1/4 12, 9)?	B. 113 , p.	Au Lode	Mikado; Little Squaw Mining Co.; Frank Birch	A 400 foot crosscut driven 400 feet to interesect ore 200 feet below the surface (done in 1913).
Crystal (NW 1/4 12, 9)?	B. 113 , p. 47	Au? Lode	Little Squaw Mining Co.	Gold quartz claim. Extent of work done or tenor unknown.
Denny's Gulch (6.7, 8.8) approx.	Kardex 31-11	Au Placer, Lode	Denny O'Keefe; Shamrock Bench; Highjacket Association; Sprucehen Bench	Gold placer prospect. $100 coarse nuggets found. No paystreak delineated. 6-70 feet deep. Six gold lode claims staked in 1955.
Dictator Creek (W 1/2 12, 6) approx.	B. 113 , p. 47	Au Placer	Chris Olson	Gold placer production, 1928-30.
Eclipse (NW 1/4 12, 9) ?	B. 113 , p. 47	Au (?) Lode		Gold quartz claim. Little is known concerning the property.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Eight Mile Creek (4.25-5.0) (9.5-10.1)	B. 1139, p. 47	Au, Hg Placer	Botts Brothers	Prospect only. Two claims staked in 1967. Worked in the 1950's.
Emory Creek (2.7-3.1) (9.1-10.0)	B. 1139, p. 47	Au	S. Richlew	$10,000 production by 1913. Gold on bedrock with boulders.
Eneveloe (NW 1/4 12, 9)	B. 1139, p. 47	Au, Zn, Ag, Pb, Sb, Cr Lode	Woodchuck; Little Squaw Mining Co.; First Chance; Last Chance	A body of quartz about six feet wide which carries considerable free gold. Prospected by three open pits.
Engineers' Exploration Syndicate (11-12, 9-10)?	B. 1139, p. 47	Au (?) ---		Turned over leases and options to the Idaho-Alaska Corp. in 1932.
Garnet Creek (4.05-4.7) (9.3-9.95)	B. 1139, p. 47	Au Placer		South side tributary of the Bettles River about five miles long. Reported to have yielded $7 to $9 per man per day in the early 1900's. Produced $1000 by 1909. Claims staked in 1959.
Gold Creek (1.5-2.5) (8.55-9.05)	B. 1139, p. 47	Au Placer	Creecy; Kellihər; Leonard; Neck; Christenson; Wilcox	Produced $232,000 by 1909. There was placer activity reported on the creek as late as 1938. Heavy equipment was used in the late 1940's. Small production then.
Gold King (SW 1/4 12, 9)?	B. 1139, p. 47	Au Lode	Haynes & Griffin	Gold quartz property. A three stamp mill was errected in 1910.
Golden Eagle (NW 1/4 12, 9)?	B. 1139, p. 47	Au (?) Lode		Gold quartz claim, fissure vein.
Grizzley Bear Creek	Kardex 31-4	Au (?) Placer		A tributary of the Bettles River. One claim was staked in 1953. DMM color code of violet indicates the prospect is not of any interest.
Idaho-Alaska Corp. (11-12, 9-10)?	B. 1139, p. 47	Au (?) ---		In 1932 the Idaho-Alaska Corp. took over the leases and options formerly held by the Engineers' Exploration Syndicate on various properties in the Chandalar district.
Jim Gulch, Creek or Pup (3.4-4.0) (8.0-8.6)?	B. 1139, p. 47	Au Placer	Christenson; Joe Blondel	Produced $3000 in placer gold by 1909. Gold discovered in 1901. Worked by hand until the 1940's. Blondel worked in the 1950's. Small production.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Kelty (NW 1/4 12, 9)?	B. 1139, p. 47	Au, Ag, Zn, Pb, Sb, Cr Lode		On a zone of crushed gold quartz. Other claims on this zone are the Eneveloe and Summit groups. Veins chiefly of the fissure type.
Lake Creek (3.8-3.9) (9.4-9.8)?	B. 1139, p. 47	Au Placer	Maglars; Fred Pitts	Some gold production noted in 1929. $2000 accumulative production by 1909. Small production until the 1940's from the creek. A little larger production from the bench in the 1940's and 50's.
Limestone Creek (4.2, 10.1) approx.	Kardex 31-3	Au Placer		One claim staked in 1954. Not presently active.
Linda Creek (3.8-3.9) (9.4-9.8)?	B. 1139 p. 48	Au Placer	H.O. Wilcox; Frank Miller	1901, discovery claim. $20,000 production by 1909. Stream about four miles long on east side of Middle Fork, approximately one mile north of Gold Creek. Stream washed gravel. Probable source of placer gold is Gold Creek. Mining in the winter as well as the summer in 1915. In 1938 the mining done by simple hydraulic or hand methods. Claims were staked here in 1957 and 1962.
Little Squaw (12.4, 9.9)	B. 1139, p. 48	Au, Zn, Ag, Pb, Sb, Cu, As Lode	Alaska-Chandalar Mining Co.; Buckley; Carlson (Amero) & Buckley; Chandalar Mining Co.; Mello; Smith; Squaw Creek; Little Squaw Mining Co.	Discovery claim about 1908. In 1913 a tunnel 87 feet along vein, ore run through a stamp mill, assay showed $60 per ton; $38 per ton of free gold recovered from the stamp mill plates. Most abundant sulfides: sphalerite, arsenopyrite, galena. Free gold (flakes and specks) mixed with sulfides and scattered in quartz. Crushed and apparently recrystallized quartz. In 1923 a tunnel 150 feet, quartz four feet thick at portal, varies considerably elsewhere. A 10,000 ton per season mill currently being constructed.
Little Squaw Creek (12.4-12.65) (9.9-10.4)	B. 1139, p. 48	Au, W Placer	Little Squaw Mining Co.	1923, in operation "for a number of years". Depth from surface to glacial deposits (false bedrock) is 55-100 feet. Gold occurs in upper 6-8 feet of rounded gravel of preglacial deposits. Nuggets as large as $180 in value found in preglacial deposits, $10 in postglacial. Average value of gold recovered: $17.26 per oz. Largest producer in 1936. 1940, drift mining. Activity in area in 1968.
Marion Creek (0.5-6.0) approx.	B. 1139, p. 48	Au (?) Placer		Discovery claim, 1900. $1000 production by 1909. Tributary of Middle Fork. 26 feet to bedrock. Prospects only.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Mikado (SE 1/4 11, 9)	B. 1139, p. 48	Au, Ag, Zn, Pb, Sb, Cu Lode	Little Mikado; Tobin; Little Squaw Mining Co.	Discovery claim, 1923. Located at head of Tobin Creek. Old 100 foot shaft now caved. Quartz is massive and close textured, contains more pyrite than arsenopyrite. 1200 feet of underground work. Interest in area in 1968.
Minnie Creek (0.0-2.5) (7.0-7.45)	B. 1139, p. 48	Au Placer		Claimed a production of $1000 by 1909. Valley about nine miles long. Wet bedrock. First hole to bedrock dug in 1904 and $500 of heavy shot gold was taken from a short drift before water came in.
Mike Creek (4.75, 10.3-11.0)	B. 1139, p. 48	Au, Ag, Cu Placer		$1000 production by 1909. Tributary of Bettles River. Gold is found on lower courses where creek has cut down into schists beneath massive limestones. Prospects only.
Mule Creek (4.7-4.8) (10.3-11.0)	Kardex 31-35	Au , Ag, Cu Placer		Native silver and copper nuggets up to seven lbs. reported. Some production of placer gold on creek.
Myrtle Creek (0.05-0.3) (3.9-4.7)	B. 1139, p. 48	Au Placer	Gold Myrtle Creek; Haslem & Assoc.; Marr, Repo & Schwaesdall; Colp; Hall, Thompson; Beistline	Discovery claim in March, 1899. One of the biggest producers. Principal tributary of Slate Creek. $182,000 production by 1909. Washed gravels 10-30 feet thick, gold discovered in present stream bed gravels 2-4 feet deep, 100-300 feet wide, well scattered. Average $5 to $15 per day per man. Many claims are worked out. Gold is shot, or wheat, size, coarse, clean and flat (like melon seeds) with $20 nuggets occasionally found. Dragline was to be installed in 1939. Claims staked in 1953 and 1956.
Overlook (NW 1/4 12, 9)?	B. 1139, p. 49	Au Lode		Gold quartz fissure vein.
Phoebe Creek (5.0-6.3) (10.0-10.45)	B. 1139, p. 49	Au Placer		Tributary of Bettles River. Prospects only in 1909.
Robert Creek (5.0-7.0) (10.5-13.)	B. 1139, p. 49	Au Placer		Tributary of Bettles River. Prospecting only in 1909.
Sawlog Creek (5.3-5.7, 7.0-7.4)	Kardex 31-47	Au Placer		One claim staked in 1960.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
St. Mary's Creek or Gulch (SW 1/4 12,9)	B. 1139, p. 49	Au Lode & Placer		With Big Creek the estimated production by 1906 was $50,000. Local alluvial concentration derived from nearby quartz veins. In 1915, no lode mining but deep mining during the winter.
Sheep Creek or Gulch (trib. of Middle Fork of the Koyukuk River) (1.1-1.5, 8.8-8.95)	B. 1139, p. 49	Au Placer	Miller & Assoc.	$2000 production by 1909. Steep short gulch. 200 square feet of bedrock reported to yield $800 in 1908.
Sheep Creek (trib. of Robert River) (6.35-7.0) (11.65-11.75)	B. 1139, p. 49	Au Placer		1909, discovery. Tributary of the Bettles River. Prospects only. Some activity in 1957.
Slate Creek (0.05-2.0) (3.85-5.6)	B. 1139, p. 49	Au Placer	Duane Hall	Discovery, 1899. One of the biggest producers. Largest eastern tributary of Middle Fork. 10-40 feet of washed gravel. Simple hydraulic or hand methods of mining used in 1938. Six association claims staked in 1960-61.
Spruce Creek (5.25-5.35) (11.2-12.0)	B. 1139, p. 49	Au Placer	V. Neck & J. Kelly	Tributary of the Bettles River. Prospecting only. Claims staked in 1953.
Summit (NW 1/4 12, 9)	B. 1139, p. 49	Au, Zn, Ag, Pb, Sb, Cu Lode	Ed Toussint	Discovery, 1913. Extends along divide between Big Creek and Little Squaw Creek. Veins dip about 65° south. Shaft sunk 54 feet and a tunnel runs along vein; at 34 foot depth in the tunnel, ore assayed at $54 per ton. Vein is 1 1/2 to 2 feet wide. One rich lens found. Some development work in the 1950's. Small mill installed on Big Creek.
Tobin Creek (11, 9)	B. 1139, p. 49	Au, W, Pb Placer	Anderson (Ellis?); Carlson & Freshman; Frank Birch & Co.	Encouraging prospects in 1930. Placer activity reported in 1940. Monazite in trace amounts. Sluicing in 1952. Bulldozer and hydraulic operation. Moderate production from 1957 to the present.
Tonopah (NW 1/4 12, 9)?	B. 1139, p. 49	Au (?) Lode	Little Squaw Mining Co.	Gold quartz fissure vein. Prospect.
Trail Creek (8.5, 2.5) approx.		Placer		Some prospecting in the 1950's. Results unknown.

CHANDALAR QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Trembley Creek (0.7-0.8) (16.3-16.4)	Kardex 31-51	Au Placer	G.W. Herbert	Claims staked in 1963 at the mouth of Trembley Creek, which is a tributary of the Dietrich River.
Wake Up Creek (3.85-4.0) (8.65-9.05)	B. 1139, p. 49	Au Placer		A tributary of the Bettles River. Mining here in 1936. Simple hydraulic or hand methods of mining were in use in 1938.

CHANDLER LAKE QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Anaktuvuk River (9.2-10.4, 5.8) approx.	B. 1139, p. 49	Phosphate		
Chandler Lake (3.4, 6.2) approx.	B. 1139, p. 49	Phosphate		
Kiruktagiak River (0.7-0.8) (6.7-6.8) approx.	B. 1139, p. 49	Phosphate		"Nearly all the phosphatic rock is low or medium grade. Furnace grade phosphate rock (25% or more P_2O_5) was found in thicknesses of as much as 37 inches, but no thickness of acid-grade phosphate rock (31% or more P_2O_5) exceed 16 inches."
Natuakruak River (8.9, 6.4) approx.	B. 1139, p. 50	Phosphate		Patton, Jr. & Mateko (1959)
Tiglukpuk Creek (6.9-7.2) (5.2-5.3) approx.	B. 1139, p. 50	Phosphate		

CHARLEY RIVER QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alder Creek (E 1/2 2, 5)?	B. 1139, p. 50	Au Placer		East tributary of Webber Creek. No commercial placers found as of 1938.
Alice Gulch (4.15, 5.5)	B. 1139, p. 50	Au Placer		Discovery: 1906. Tributary of Mineral Creek. Muck up to 30 feet, gravel 2 to 5 feet. Pay streak in parallel channels 12 to 14 feet wide and 1 1/2 to 4 feet thick. Mostly prospecting rather than mining in area.
Ben Creek (7.4)?	B. 1139, p. 50	Au Placer		East of Coal Creek on Sam Creek. Small placer deposits noted in 1938.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Boulder Creek (5.65, 5.25) approx.	B. 1139, p. 50	Au Placer		A tributary of Coal Creek. Prospecting only reported as of 1912. Tertiary deposits with gold apparently from the southeast side of the valley. Four claims staked in 1960 and five claims staked in 1964. Currently active.
Coal Creek (5.15-6.25) (5.0-6.4)	B. 1139, p. 50	Au Placer	Adamic; Coal Creek Hydraulic Mining Assoc.; Forrest Assn.; Gold Placers, Inc.; Golden Eagle; McDonald; Malstrom; Slaven Assn.	Twenty mile long creek. Placers probably derived from Tertiary conglomerates and were discovered in 1910. Depth approximately seven feet at discovery. Productive gravels 100 feet wide. Mined by dredge. Currently active.
Colorado Creek (5.2, 5.0) approx.	B. 1139, p. 50	Au Placer		A tributary of Coal Creek. Small scale mining in the past.
Dome Creek (trib. of Washington Creek) (11.0)?	B. 1139, p. 50	Au Placer		Some past mining reported.
Dome Creek (trib. of Woodchopper Creek) (4.5-4.65) (5.75-5.95)	B. 1139, p. 50	Au Placer		Small gold placer, the result of tertiary rocks.
Drayham Creek (8.9, 2.3)?	B. 1139, p. 50	Au Placer		Tributary of Charley River. Some gold reported.
Eagle Creek (12.25-12.5) (2.3-3.0)	B. 1139, p. 51	Au Placer		Gold placer prospect, probably small.
Flat Creek (8.6-9.8) (2.4-3.1)?	B. 1139, p. 51	Au (?) Placer	McCarthy	Tributary of Charley River. As of 1914, prospects only.
Fourth of July Creek (14.2-15.2) (2.15-2.6)	B. 1139, p. 51	Au, Ag, Pt, Hg Placer	Bauer; Ellington; Fourth of July Placers Co.; July Creek Mining Co.; July Creek Placer Co.	1911, placer mining. Bedrock predominately conglomerate. Depth to bedrock is 12-15 feet with 5-6 feet of comparatively fine gravel being mined. Gold lies in lowest 12 to 20 inches of gravel over an undetermined width. The gold is in flat, rather thick flakes, up to 1/4 inch diameter. Assay value $18.89

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Fourth of July Creek, cont.				per oz. to $18.91 per oz. The average 12x12 box yields $25. Large part of the gold is believed to have come from Union Creek. The gold is fine grained and the largest nugget recovered weighed 1/2 oz. Mercury is also present. In 1940 was the largest mining enterprise in the Eagle district. Two claims staked in 1961, one claim staked in 1962 and four claims staked in 1964.
Grouse Creek (E 1/2 3, 5)?	B. 1139, p. 51	Au (?) Placer		1906 and 1911 - prospects only reported.
Irish Gulch (8-9, 2-3)?	B. 1139, p. 51	Au		Some gold found here although the rest of the Charley River tertiary belt has produced very little.
Iron Creek (3.95, 5.55)	B. 1139, p. 51	Au Placer		A past placer producer.
Mineral Creek (4.15-4.2) (5.45-5.55)	B. 1139, p. 52	Au Placer		Alluvial floor of the valley is about 75 feet wide at the mouth, but narrows upstream. Three benches; 30, 150 and 250 feet above the creek. Muck on some claims to a depth of 30 feet, gravels 2-5 feet thick. Pay in channels 12-14 feet wide. Has been mined.
Nugget Creek or Gulch (12.2-12.4) (4.0-4.6) approx.	B. 1139, p. 52	Au Placer		Irregularly distributed values consisting of coarse gold on bedrock. Source of gold is Cretaceous slates.
Rose Creek (5.5) ?	B. 1139, p. 52	Au Placer		Some placer activity in 1912.
Ruby Creek (14, 2)?	B. 1139, p. 52	Au Placer		Open cut, 12 to 15 feet deep, in 1911. Gold is confined to 20 inches above bedrock. Values of $50 to $75 per 144 square feet have been reported. Poor water supply.
Sam Creek (7, 4)?	B. 1139, p. 52	Au Placer		Small placer. Over 20 claims staked during the period 1953-62. Has produced and is still active.
Sawyer Creek (7, 4)	B. 1139, p. 52	Au Placer		Small placer deposit.
Surprise Creek (12.25-12.5) approx.	B. 1139, p. 52	Au Placer	Dr. Pratt	Discovered in 1907. Worked intermittently.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Tatonduk River (21.6-21.7) (0.5-0.6) approx.	Kardex 51-27	Fe Lode		Forty claims staked in 1961 and 1962 on the Tatonduk River, nine miles from the Yukon River on the north shore.
Washington Creek (12.2-12.5) (2.3-4.6) approx.	B. 1139, p. 52	Au		
Webber Creek (E 1/2 2, 5)?	B. 1139, p. 52	Au Placer		Small placer deposits.
Willow Creek (0.0-0.4) (0.9-1.0)	Kardex 51-28	Au, Ag Placer		Seven claims staked in 1962.
Woodchopper Creek (3.5-4.3)	B. 1139, p.	Au Placer	Alluvial Gold, Inc.; Alluvial Placers; Anna May; Aztec; Joe; Bennett; Bodacious; Charles; Comet; Cordova; Florence; Gold Medal; Gladys; Gold Star; Kelly; Herbert; Holstrom; Hunky Dory; Woodchopper Creek; Seward Assn.; Sioux; Snowbird; Sunshine; Valdez	Creek is 12 miles long, 8 to 15 feet deep, alluvium 1/2 mile wide. Gradient of 100 feet per mile. Many benches, creek floor 100 to 150 feet wide. Values of 5¢ to 50¢ per pan reported. Creek dredged. 255.9 acres patented as of 1955.

CIRCLE QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bachelor Creek (6.5, 8.6-8.9)	B. 1139, p. 121	Au Placer		Gravels average 7-8 feet thick and are unfrozen in the bed of the stream. A low bench with gravels 20 feet thick lies on the east side of the valley.
Birch Creek (16-18, 5-6)?	B. 1139, p. 121	Au Placer		Prospected in 1912 by ditch, producing a large open cut on the bench. Gold in paying quantities not found.
Bonanza Creek (11.95-12.45) (9.45-9.75)	B. 1139, p. 121	Au Placer	LaCross; Westwick; Au Limited	Has a length of about 7 miles and a gradient of as much as 3%. Some mining. Pay ranged in width from 75-150 feet. Average pay about 15-20¢ per bedrock foot. Gravels 3-6 feet, muck 2-8 feet. Gold course. Two nuggets, 10 1/2 oz. and 8 1/2 oz., recovered. Creek below the old ditch is still active, 8 claims currently being held by Au, Limited.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bottom Dollar Creek (16.05-16.15) (7.3-7.55)	B. 1139, p. 121	Au Placer		Some mining done in 1912.
Boulder Creek (13.85, 8.15) approx.	B. 1139, p. 121	Au Placer		Large stream about 13 miles long; site of small scale mining for many years.
Buckley Bar (17.85, 5.95) approx.	B. 1139, p. 121	Au Placer		Prospected in 1910. No other information available.
Butte Creek (10.3-10.8) (6.45-7.25)	B. 1139, p. 121	Au Placer		Mined by dragline excavator plant. Gold 900 fine.
Charity Creek (5.45-5.5) (6.9-7.3)	B. 1139, p. 121	Au (?) Placer	Vogler	No high values found. Some gold produced.
Chena River (11-14, 0-1)?	B. 1139, p. 121	Au Placer	Fred Parker	Prospected for gold. Ground averaging $1 per square foot is reported to have been found on the South Fork.
Chena River, Middle Fork (11-14, 0-1)?	B. 1139, p. 54	Au Placer		Known to contain coarse gold. Economic amounts found only near Shamrock Creek.
Crazy Mountains (NE 1/4 quad.)	B. 1139, p. 54	Au Placer		Reported as a promising placer discovery in 1922.
Deadwood Creek (14.5-16.05) (7.5-9.35)	B. 1139, p. 54	Au, Hg, Sn, W, Pb, Flourite, Hg Placer	Deadwood Mining Co.; Discovery Gulch or Creek; Eaton; Knudson & Larson	Length about 15 miles. Shallow deposits of gravel in part of creek and very deep in other parts. Discovered in 1894. Over 45 years of mining on this creek and is still active at the present time.
Dempsey Pup (3.9, 6.5)	B. 1139, p. 54	Sb Lode		
Dome Creek (10.5-10.65) (9.2-9.65)?	B. 1139, p. 54	Au Placer	Lee & McGregor; Au, Limited	Reported as a promising placer discovery in 1922. Still active.
Eagle Creek (10.6-11.7) (7.65-7.95)	B. 1139, p. 54, 55	Au Placer	Berry Holding Co.; Mastadon Fork; Fransca & Hering	Gold discovered about 1895. Berry Holding Co. worked this creek for more than 29 years. 5-20 feet gravel overlain by 2-15 feet muck. Currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Faith Creek (4-5, 6-7)	B. 1139, p. 55	Au Placer	Peterson & Co.; Vogler Bros.; McIntosh; USSR&M	No high values found in this placer but some gold has been produced. Active at the present time.
Frying Pan Creek (10.1-10.6) (5.05-6.2)	B. 1139, p. 55	Au Placer		During the summer of 1910, three prospectors located good values in a hole to bedrock. Ground 20 feet deep, comprising 15 feet of overburden and 4 or 5 feet of pay.
Golddust Creek (10.45-12.0) (7.15-7.6)	B. 1139, p. 55	Au (?) Placer		Gravel prospected by drilling in 1936. No known mining here as a result of this.
Greenhorn Creek (13.9-14.0) (7.95-8.1)	B. 1139, p. 55			Some work done here in earlier years.
Half Dollar Creek (15-16, 7)	B. 1139, p. 55	Au, W, Sn Placer		Some mining done on this creek.
Harrison Creek (13.65-14.5) (6.35-6.4)	B. 1139, p. 55	Au Placer		Prospected and mining contemplated. Reported that the pay streak was found to be narrow and the gold irregularly distributed.
Harrison Creek, North Fork (12.65-13.8) (6.45-7.5)	B.1139, p. 55	Au, Sn Placer	Clayworth Assn.; Speaker; Pitka Bar; Hamilton	Creek about 20 miles long. Gravels range in thickness from 4-12 feet with little or no muck. Mined in part by hydraulic methods. Currently active.
Harrison Creek, South Fork (13.2-13.65) (6.4-6.45)	B. 1139, p. 56	Au Placer	Fred Johnson Estate	Some production by hydraulic means.
Holdem Creek (15.9-16.45) (8.25-8.6)	B. 1139, p. 56	Au Placer	Vogler	Small producers have mined on this creek. Active at the present time.
Homestake Creek (5.5-5.65, 6.95)	B. 1139, p. 56	Au Placer		Small production.
Hope Creek (4.55-5.1) (6.95-7.1)	B. 1139, p. 56	Au, Pb, Mo, Sb (?) Placer	Swanson	No high values have been found although some gold has been produced.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Independence Creek (12.6-13.0) (7.95-8.95)	B. 1139, p. 56	Au, Sn, Pb, W Placer	Berry C.J. Dredge Co.; Berry Holding Co.; Independence Mining Co.	Worked for about 40 years. Ground being worked in 1936 averaged 30-50¢ per bedrock foot. About 8 feet of poorly rounded gravel with little or no muck.
Ketchem Creek (16.25-16.65) (7.05-8.85)	B. 1139, p. 56	Au, W, Sn Placer	Zimmerman; Vogler	Depth varies, being about 11 feet deep on Claim #2 above and 17 feet deep on #5 below discovery. Mined for many years. Gold found to occur in the lower 2-3 1/2 feet of bedrock and the fine sand which covers bedrock. Currently active.
Lawson Creek (10.1-11.2) (1.1-2.5)	B. 1139, p. 56	Au Placer		In 1912 rich placers were reported here but sufficient work was not done to prove their extent.
Loper Creek (9.0-9.9) (8.7-13.3)	B. 1139, p. 56	Au Placer		Known to carry gold and has been prospected for several years in a small way.
McLain Creek (13.6-13.7) (4.7-4.9)?	B. 1139, p. 56	Au (?) Placer		Literature sites this creek only as an automatic dam site.
Mammoth Creek (12.9-13.9) (8.95-9.7)	B. 1139, p. 57	Au, Pb, Mo, W Placer	Berry C.J. Dredge Co.; Berry Holding Co.	Dredged by Berry Holding Co. for 12 years. A very large producer of placer gold.
Mastodon Creek (12.35-12.9) (7.95-8.95)	B. 1139, p. 57	Au, Sn Placer	Anderson; Berry Holding Co.; Roman Clark; Elmer; Berry & Lamp; Erickson; Mastodon Mining Co.; Berry C.J. Dredge Co.	Produced between $2-3 million by 1936. Dredged by Berry Holding Co. Patented.
Miller Creek (12.15-13.05) (8.85-9.3)	B. 1139, p. 57, 58	Au Placer	Kelley; Carr	About 7 miles long, discharging into Mammoth Creek. Gravel 4 or 5 feet thick in upper valley. Not a large producer but worked intermittently from 1895 to the present time.
Miller House (13.1, 9.3)	B. 1139, p. 58	Cu, Pb Lode		Incorrect reference.
Nome Creek (0.25-2.8) (5.95-6.35)	B. 1139, p. 58	Au, Sn Placer	Beaver Dredge Co.; Nome Creek Dredge Co.; Nome Creek Mining Co.	Creek probably in Beaver Creek basin.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Palmer Creek (11.3-11.4) (0.1-0.5)	B. 1139, p. 58	Au, W Placer	Jack Raymond; Fred Parker	Some placer production.
Porcupine Creek (10.7-11.4) (9.75-9.95)	B. 1139, p. 58	Au, Sn Placer	Park-Reed; Al Martin; McGee; Au, Limited	Creek about 15 miles long with gradient of 60 feet to the mile for the lower 11 miles. Not a large producer but still active in the vicinity of Yankee Creek. Approximately 100 holes drilled on creek. Values: 25¢ per bedrock foot.
Porcupine Dome (10.5-9.05)	B. 1139, p. 58	Au Lode		Gold lode found along ridge west of Porcupine Dome at the head of Dome Creek. No production.
Portage Creek (17.4-17.55) (8.0-8.4) approx.	B. 1139, p. 58	Au, Sn, Cu, W, Zn, Bi, Flourite Placer	Carstens	Site of small scale mining for many years. One area of 20x300 feet reported to have a tenor of 30¢ per bedrock foot.
Preacher Creek (4-7, 7-9)?	B. 1139, p. 58	Au (?) Placer		It is reported that large bodies of low grade gravel exist in the Preacher Creek valley.
Shamrock Creek (11.35-11.75) (0.1-0.65)?	B. 1139, p. 58	Au Placer		Some placer mining.
Sourdough Creek (3.75-3.8) (6.05-6.4)	B. 1139, p. 58	Au, W, Sb, Sn Placer	Zimmerman; Carlson	Successful mining on this creek in the past and still active at the present time.
Squaw Creek (15.25-15.4) (6.7-7.35)	B. 1139, p. 59	Au Placer		Some prospecting and mining accomplished. This creek is a tributary of Harrison Creek.
Switch Creek (15.5-15.65) (8.4-8.75)	B. 1139, p. 59	Au, Pb, W Placer	Langlow & Larson; Col. Parker	Small creek about 3 miles long which flows into Deadwood Creek. Gradient said to be 5 1/2%. Pay contained in both stream and bench gravels. Was mined for several years. Gold is generally coarse; a 4 oz. nugget is the largest reported. Currently active.
Traverse Creek (16.5-16.7) (6.4-7.5)	B. 1139, p. 59	Au Placr	Traversey Creek	Some prospecting and mining has been done on this creek.
Two Bit Gulch (15-16, 17)	B. 1139, p. 59	Au Placer		Some prospecting and mining. Pay reported to be narrow and irregularly distributed.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Yankee Creek (11.3-11.4) (9.8-9.95)	B. 1139, p. 59	Au Placer	T. Anderson; McGee; Au, Limited	Presently held by a Fairbanks group. High values reported in a narrow pay zone. Mouth of Yankee mined several years ago. Drilled. Currently active.

COLEEN QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Porcupine River (15.85, 3.15)	B. 1139, p. 59	Ni		Nickeliferous alum
Procrastination Creek (9.5-9.7) (12.6-12.8) approx.	Kardex 33-1	Au		Placer claims staked in 1958 and 1959. No known information.

DeLONG MOUNTAINS QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Mount Kelley (8, 8)	B. 1139, p. 83	Au Lode		Gold contained in sulphides of iron.

FORT YUKON QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Yukon River (15-16, 5-6)	Kardex 41-2	Au Placer	Gilbert Lord & Assn.	Located on the Yukon River about 22 miles upstream from Fort Yukon. Claims staked in 1949.
Yukon River, Upper (SE 1/4 quad.)	Kardex 41-3	Au, Ag Lode	Sansome & Hughes	Claims staked in 1929.
--- (N 1/2 quad.)	B. 1139, p. 110	Potash		Potash salts occur in several lakes in this region. Analysis of lake water gives potassium oxide (K_2O) results too low to be of economic value.

HOWARD PASS QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Mount Burpto (9.5-, 8.8)	B. 1139, p. 121	Phosphate Lode		Phosphatic calcareous mudstone from sequence of black shale and chert. Low or medium grade of phosphate.

HOWARD PASS QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
--- (14.5, 11.0)	B. 1139, p. 121	Phosphate Lode		Phosphate of low or medium grade occurs in black shale or chert.

HUGHES QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alatna River (17.5-18.0) (16.8-17.9)	B. 1139, p. 121	Au Placer		Gold is found in very small pieces of reddish brown color placer deposits. No rich gravels had been located as of 1930.
Bear Creek (2.0, 4.0)?	B. 1139, p. 121	Au Placer		Gravel worth $3.20 per cubic yard in 1921. Not much mining has been done in the area because of difficult access.
Black Creek (15.35, 1.6)	B. 1139, p. 121	Au Placer		Depth to bedrock about 20 feet. Easily mineable deposits.
Felix Creek or Ford (15, 1)?	B. 1139, p. 121	Au Placer		Not much information available.
Helpmejack Creek (16.75-17.5) (16.8-17.9)	B. 1139, p. 121	Au Placer		Not much information available.
Hughes Bar (12, 0-1)?	B. 1139, p. 121	Au Placer		Not much information available.
Indian River (15.7-15.9) (1.05-1.35)	B. 1139, p. 121	Au, Mo, Ag Placer		$14,000 gold production in 1911; $24,000 in 1912; $13,952 in 1913 plus $373 in silver that same year; $4000 in gold in 1917. Gravel is 2 to 6 feet thick and the gold bearing gravel is located mostly on the headwaters to 5 miles downstream.
Pocahontas Creek (14.25, 0.3)	B. 1139, p. 121	Au Placer		Gold prospects indicated in 1916.
Red Mountain (S 1/2 14, 5)	B. 1139, p. 121	Au Placer		Not much information available.
Reed River (7-8, 14-17)	B. 1139, p. 121	Au Placer		Some prospecting but no report on the findings.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Rocky Bottom Creek (17.3-17.55) (17.6-17.9)	B. 1139, p. 121	? Placer		Mostly prospects.
Snyder Creek (15, 1)?	B. 1139, p. 121	Au Placer		Discovery in 1910. Very little information available.
Utopia Creek	B. 1139, p. 121	Au	McGee	Not much information available but was mined for several years.

KOTZEBUE QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alder Creek (19.8-20.0)	B. 1139, p. 153	Au Placer		Production of placer gold of varying amounts. Fine gold recovered by beach diggings.
Sullivan Creek (13.2-13.95) (0.15-1.35)	B. 1139, p. 153	Au Placer		Prospecting reported in 1900.

LIVINGOOD QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alabam Creek (11.65-12.0) (10.25-10.5)	B. 1139, p. 155	Au		Fine gold reported on this creek.
Alaska (Jupiter-Mars) (19.25, 1.65) approx.	B. 1139, p. 155	Au Lode	Foster & Hungerford; Gladstone; Goldstone; Jupiter-Goldstone; Jupiter-Mars (Consolidated Mining Co.); Mars-Emerald; F.M. Wackwitz	Ore tenor from several veins from the mine showed $30 per ton.
Alaska Flyer (17.95, 0.85)	B. 1139, p. 155	Au (?) Lode		Gold bearing quartz found in 1913. More work to be done.
Alder Creek (20.4-20.6) (1.7-2.0)	B. 1139, p. 155	Au Placer		Not much information available.
Alpha Creek (18.1, 0.95)	B. 1139, p. 155	Au Lode	M.E. Stevens	Gold lode property, a part of the old Soo group. Some development.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Amy Creek (11.2-11.4) (9.45-9.6)	B. 1139, p. 155	Sb, Cr, Au Placer	Fiske Bros. & Wickstrom; Wall; Luckman & Co.; Luckman & West; Stadelman	Gravel about three feet thick. Placer production. (Misprinted as "Army" Creek).
Anna (19.15, 1.5)	B. 1139, p. 155	Au (?) Lode	Warren	Lode prospect 100 feet south of the Mary. Not much other information available.
Banner (19.45, 1.65)	B. 1139, p. 155	Au Lode		Abandoned by 1912. Not much other information available.
Bear Creek (19.1-21.0) (1.1-1.2)	B. 1139, p. 156	Au (?)		Prospected in 1909. Some activity in the area in 1954 and claims staked in 1959.
Beaver Creek (15-21, 5-15)?	B. 1139, p. 156	Au (?) Placer		Placer gold found in Beaver Creek basin in 1919.
Bedrock Creek (18.85-18.9) (1.4-1.6)	B. 1139, p. 156	Au, W, Ag, Sn Placer		Not much information available.
Billy (SE 1/4 21, 2)	B. 1139, p. 156	Au (?) Lode		Group of these claims in the Kokomo Creek basin. Highest assays 29¢ per ton.
Blue Moon (17-20, 0.1)	B. 1139, p. 156	Au (?) Lode		An old lode claim, or mine.
Bob (18.65, 1.4)	B. 1139, p. 156	Au Lode		No information available. Listed under lode claims in Fairbanks district, B. 849-B, p. 75.
Bobbie (19.05, 1.5)	B. 1139, p. 156	Ag, Pb, Sb Lode		Not much information available.
Branholm-Jenkins (19.7, 1.75)	B. 1139, p. 156	Sb, Pb Lode	Leindecker; McNeil	Not much information available.
Burnet (18.65-18.85) (0.8-1.05)	B. 1139, p. 156	Au, Ag, Pb Lode		Not much information available.
Burnet Galena (18.65, 0.9)	B. 1139, p. 156	Pb, Sb, Au Lode		Not much information available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Cleary Hill (18.85-19.1) (1.4-1.55)	B. 1139, p. 158	Au, Sb, W, Zn, Sn, Pb, Cu Lode	Alabama; California; Carlisle; Cleary; Cleary Hill Alaska Gold Mines; Cleary Hill Alaska Mining Co.; Colorado; Free Gold; Goessmann; Gustafson Bros.; Idaho; Keystone Mines; New York; Pauper's Dream; Rhoades & Hall; Snowdrift; Texas	Discovery date, 1908. 147 tons of ore in 1911 yielded $17,645 - average of $120 per ton. Reported to have produced over $1,000,000 by 1933. Gold assays of 0.793, 0.820 and 0.830 fine. Samples taken from the mine in 1933 indicated values of $33.40 per ton with mill heads worth $40 per ton. Largest gold lode mine in Fairbanks district. Mill converted to ball mill floatation. Currently active milling ores from other properties.
Coffee Dome (21.5, 1.9) approx.	Kardex 49-296	Au (?) Lode	Egan	Currently active. Claims staked on south slope of Dome.
Coffee Dome (21.9, 1.8) approx.	Kardex	Au, Pb, Ag Lode		Mineral claims. No other information available. Currently active.
Cornell (18.75, 1.3)	B. 1139, p. 159	Au (?) Placer		Abandoned tunnel and several shallow shafts and pits.
Crane Gulch or Creek (20.2-20.4) (1.65-2.0)	B. 1139, p. 159	Au Placer	Martin Sather	$30,000 production by 1910. Average value of gold that year was $17 per oz. Currently active.
Crooked Creek (20.0-20.1) (4.0-4.01)	Kardex 49-333	Au Placer		Currently active. Claims staked in 1966.
Cunningham (18.95, 1.65)	B. 1139, p. 159	Au, Sb		Not much information available.
David (18.8, 0.95)	B. 1139, p. 159	Au, As Lode	Apex; Northern Commercial Co.; Robinson & Drouin; Roth & Maddocks	480 tons of ore shipped by 1913. Assays from mine in 1933, which was not being worked at the time, showed $22.92 per ton and from one of the better veins, $212.14 per ton.
Dawson Creek (0.05-0.2) (7.75-8.4)	B. 1139, p. 159	Au, Hg, Pb, Sn, Cu Placer		Gravel 8-10 feet thick with 20-30 feet of muck overburden. Gold present as much as four feet into bedrock. Gold assayed at $18.40 to $18.60 per oz.
Deep Creek (21.1, 1.5) approx.	B. 1139, p. 159	Au Placer		Not much information available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Busty Belle (17.7, 0.4)	Kardex 49-151	Au, Pb, Mo (?), Ag W Lode	Tury Anderson; Mel Anderson; Freeman & Scharf; Silvertone; Warren Taylor	Obtained an OME loan 1966-67. Explored by an underground adit. Status uncertain. Visited by USGS, USBM and University of Alaska.
Charles (20.85, 2.05)	B. 1139, p. 157	Au Lode		Not much information available.
Chatanika River (16.7-18.5)	B. 1139, p. 157	Au Placer	Hard Scramble; Hope; Steir; USSR&M	$1,245,000 production by 1910. $17.62 per oz. average value of gold. Gravel 30-100 feet thick.
Chatham (19.3, 1.55)	B. 1139, p. 157	Au, Sb Lode	Burns, Chatham Mining Co.; Colby; Fay; Tanana Quartz & Hydraulic Mining Co.	Estimated free milling content of ore was $25 to $40 per ton. Mine was inactive in 1933.
Chatham Creek (18.95-19.15) (1.5-1.65)	B. 1139, p. 157	Au, Sb, Sn, W, Zn Placer	Chatham Creek Dredge Co.; Chatham Gold Dredge Co.; Oscar Tweten	$300,000 production by 1910. $16.90 per oz. average value of gold. Not much other information available.
Chechako No. 1 (18.75, 1.5)	B. 1139, p. 157	Ag, Pb, Sb, Au, Zn, Cu (?) Lode	Anchor; Eldorado; Eldorado Creek Mining Co.; Franklin; Eldorado Mining & Milling Co.; Westonvich	Not much information available.
Cheyenne (18.85, 1.2)	B. 1139, p. 157	Au, Pb Lode		Not mentioned by name, but description in the literature fits this location. Lead lode assays for gold show about $10 per ton in 1913.
Chocolate Creek (3.8-4.8) (6.4-6.6)	Kardex 49-92	Au, Sb Lode		A lode claim staked in 1965.
Cleary Creek (18.2-19.05) (1.5-2.3)	B. 1139, p. 158	Au, W, Sb, Sn Placer	Chatham Gold Dredge Co.; Diamond, USSR&M	About $4,500,000 of gold production in 1905. Total production by 1910 $17,500,00; by 1921, $23,142,000. Best producer of the region by 1906. Gravel averaged five feet thick. Average value of gravel was $10 per square yard in 1906. $17.06 per oz. average value of gold in 1910. Small amount of placer mining currently being done.
Clear Creek (11.85-12.05) (8.25-8.85)	B. 1139, p. 158	Au (?) Placer		Prospect found in 1915.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Dome Creek (17.05-18.0) (0.8-1.6)	B. 1139, p. 159	Au, Sn, W Placer	Christmas, Day Dawn; Recorder; Niggerhead; Shakespeare; USSR&M	$5,050,000 production by 1910. Gravel 1 to 8 feet thick. Values as high as $6 per bedrock foot found by 1913. $17.43 per oz. average value of gold.
Dome View (18.55-18.65)	B. 1139, p. 159	Au Lode	Rock Run; Wackwitz Bros.	Discovery, 1917. $6500 production by 1933. Samples from vein taken in 1933 showed from $.38 to $3.26 per ton. These, however, "are probably not the best areas of the vein".
Dominion Creek (18-24, 4-7)?	B. 1139, p. 160	Au (?) Placer		Placer prospect found in 1910. May be in Circle Quadrangle.
Egan (18.65, 0.75)	B. 1139, p. 160	W Lode	Eagen and Assoc.	Sparsely distributed scheelite of low grade.
Egan and Egan (20.85, 2.35)	B. 1139, p. 160	Au Lode		Assay of samples cut across one of several veins showed $7.38 per ton in 1933.
Emma (18.85, 1.3)	B. 1139, p. 160	Au Lode	Katherine; Newsboy Mining Co.; Overgard	Under development in 1912. Selected ore yielded $38 per ton.
Empire (19.1-19.25) (1.45-1.65)?	B. 1139, p. 160	Au Lode	Foster & Hungerford	14 tons of ore removed by 1913. Not much other information available.
Ester Creek (11.05, 8.65)	B. 1139, p. 160	Au, Hg Placer		Gold assayed at $18.85 per oz. after melting. Currently active.
Eureka (20.7, 2.05)	B. 1139, p. 160	Au Lode		Not much information available.
Excelsior (19.8, 1.7)	B. 1139, p. 160	Ag, Au, Sb, Pb Lode		Not much information available.
Fairbanks Creek (19.9, 1.55) approx.	B. 1139, p. 160	Ag, Au Lode	USSR&M; Sather	Values of $4 per ton of gold and 60 oz. per ton of silver were reported. No ore reported by USGS in 1913.
Fairbanks Creek (20.0-21.2) (1.35-1.7)	B. 1139, p. 160	Au, W, Sn, Sb Placer	Alaska Express Co.; Murphy; Fairbanks Gold Dredge Co.; Fairbanks Gold Mining Co.; USSR&M	$5,250,000 production by 1910. Average value of gold in that year was $17.26 per oz. Gravel averages six feet thick. Currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Fish Creek (19.7-20.1) (0.4-1.05)	B. 1139, p. 161	Au, W, Bi, Sb, Sn Placer	Fish Creek Mining Co.; Walt Roman; Tanana Valley Gold Dredge Co.; USSR&M	Production $200,000 by 1910. Nuggets worth $2 to $3 have been found, and two large nuggets, one worth $43 and the other $84.25, have been found. Average value of gold in 1910 was $18.48 per oz. Currently being mined by dragline and elevated sluicebox. Production figures are confidential.
Flume Creek (18.2, 0.35)	B. 1139, p. 161	Au Placer		Mined for placer gold. Currently of interest.
Flume Creek (18.2, 0.3)	Kardex 49-20	Ag, Pb Lode		Lode claims staked on the ridge between Flume Creek and Fox Gulch in 1956. (Busty Belle?) Currently of interest.
Franklin Creek (10.95, 9.6)	B. 1139, p. 162	Au Placer		Shallow placers.
Fredericks (17.25-17.3, 0.65)	B. 1139, p. 162	Au, Sb	Friederich	Some stibnite. As of 1933, no work had been done since 1912, although samples from the dump showed $1.46 and $2.83 per ton. Has produced gold.
Fursteneau (19.25, 1.65) approx.	B. 1139, p. 162	Au (?) Lode		Lode prospect shown on map B. 525, p.169. No information available.
Genki (19.25, 1.65) approx.	B. 1139, p. 162	Au (?) Lode	Jupiter-Mars Consolidated	Lode claim covering part of the north end of old Jupiter-Mars ground. Twelve foot wide gold quartz vein. No assays known.
Gertrude Creek (10.8-10.95) (9.2-9.5)	B. 1139, p. 162	Au Placer	Dahl & Co.; Glen Gulch Mining Co.	Discovered in 1916. Gravel 2 to 14 feet thick. Only the lower few feet were worked in 1918. Gold is fine and angular.
Gilmer (17.3, 0.55)	B. 1139, p. 162	Sb, Au, Ag Lode	Frederichs; Helen W.; Muchano; Wilcox	On Willow Creek
Gilmore (19.9, 1.55)	B. 1139, p. 162	Au Lode	Connor & Stevens; Gilmore & Stevens; Gilmore & Stevenson	Not much information available.
Glen Gulch (10.95, 9.2)	B. 1139, p. 162	Au Placer		Two to four feet of gravel with 10 to 25 feet of overburden. Gold is fine, angular and shot size.
Goepfert (18.7-18.75) (0.95-1.0)	B. 1139, p. 162	Au, Pb Lode		According to USGS, the vein looks barren. Some work has been done, but not much information is available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Gold Mountain Creek (18-21, 4-7) ?	B. 1139, p. 162	Au (?) Placer		Prospect only. No information available.
Goodluck Creek (11.45-11.65) (9.5-9.8)	B. 1139, p. 163	Au, Cr, Hg, Sn Placer	Healy, Le Boyteau; Lucky Creek	Claims currently active. Mining and prospecting on creek from 1925 to 1931.
Govenor (19.95, 1.65)	B. 1139, p. 163	Au Lode		Values reported at $10 to $15 per ton. No work had been done for some time in 1913.
Grismoe (19.1, 1.5) approx.	B. 1139, p. 163	Au (?)		Property or claim. No information available. Spelled "Grimsoe" in B. 1139.
Grouse Creek (14.05-16.0) (12.8-14.85)	B. 1139, p. 163	Au (?)		Prospect reported in 1913.
Gunnison Creek (2.25-3.4) (6.65-8.0)	B. 1139, p. 163	W, Au Placer		Not much information available.
Harris & Brown (19.3, 1.6)	B. 1139, p. 163	Sb, Au Lode		Not much information available.
Hershberger, Beall & Phipps (18.8, 1.45) approx.	B. 1139, p. 163	Au		Rich ore removed by 1910. Not much information available.
Hess Creek (N 1/2 quad.)	B. 1139, p. 163	Au (?)	Mike Hess Creek	Not much information available.
Hess Creek, South Fork (11.3-11.6) (10.4-11.2)	B. 1139, p. 163	Au	Gold Stream Creek	Not much information available.
Hidden Treasure (18.5, 1.3)	B. 1139, p. 164	Au Lode	Goyett	Discovery date, 1909. Value of deposit not known.
Hirshberger & Zimmer-man (18.7, 1.0) approx.	B. 1139, p. 164	Au Lode		Not much information available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Hi-Yu (19.85-20.05) (1.7-1.75)	B. 1139, p. 164	Au, Ag, Sb, Pb, Zn Lode	Crites & Feldman; Dorando; Feldman; Gibbs; Helen S.; Insurgent; Nars, Anderson & Gibbs; Summit; Sunnyside; Teddy R; Yankee Doodle (Fraction)	$252,000 worth of gold recovered by 1931 with estimated reserves of $426,000 to $455,000 still unmined. Ore averaged $32 per ton in that year but an ore sample taken from the mine assayed at about $29 per ton. Some recent activity.
Hoel Bros.; Johnson & Witmer (17.0, 0.7)	B. 1139, p. 164	Au Lode		30 foot ledge carrying low gold values and a richer vein eight inches to two feet wide were reported in 1912.
Homestake (19.45, 1.65)	B. 1139, p. 164	Au, Ag, Sb, Cu Lode	Balzimer; Fairbanks; Hope; Horton & Solomon; Kawilita; Keystone; G. Nightingale; Wolf; Nordale; Rexall; Wolf Creek	Discovery date, 1908. Production $60,000 by 1931. Assays: 25 tons from the mine, $112 per ton; 10 tons, $166 per ton.
Hoosier Creek (18-21, 4-7)?	B. 1139, p. 164	Au (?)		Prospects only. Not much information available. May be in Circle Quadrangle.
Hoover (18.5, 0.7)	B. 1139, p. 164	Au, Sb, As Lode	Anderson & Birch; Birch & Anderson; Busch & Anderson; Robinson & Lieman	Grab sample from dump assayed at $1.23 per ton in 1933. Ore yielded $8 per ton.
Hosiana Creek (SW 1/8 quad.) ?	B. 1139, p. 165	Au (?)		In 1910, 50 men were prospecting on this creek. May be in Tanana Quadrangle.
Hunter Creek (0.0-0.2) (8.3-8.4)	B. 1139, p. 165	Au, Hg, Sn, Cu Placer		Discovered in 1896. Five to six feet of gravel. Gold was found in the upper 18 inches of bedrock and was mostly fine (pumpkin seed size) with a few nuggets worth $20. One area had gold valued at $19 per oz. with at least one nugget worth $190.
Idaho Bar (17.85-18.2) (1.55-1.9)?	B. 1139, p. 165	Au Placer	Little Eldorado Creek; Idaho Mining & Leasing Co.	Gold found in the lower foot or two of gravel and along the upper surface of bedrock. In most favorable areas, gravel carried $1 per square foot of bedrock. Gold assays at $18 per oz. Shot-size, coarse, rather uniform in size with no large nuggets.
Independence (18.8, 0.85)	B. 1139, p. 165	Au, Pb Lode	Harrais; Harris	Seems to be low grade. In 1933, assays showed $6.36 per ton. Claims staked in 1953 and 1963.
IXL (19.1, 1.45)	B. 1139, p. 165	Au (?)		Property or claim. No information available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Jack (18.65, 1.4)	B. 1139, p. 165	Au (?) Lode		Lode claim. No information available.
Jackson (18.9-19.0)	B. 1139, p. 165	Au, Sb, Ag, Pb Lode	Big Jim; Hess & Barnet; Little Jim; Our Jim; Silver King; Your Jim; Vergil; Wolverine	Gold deposit valued at $6 to $7 per ton.
Jackson & Assoc. (19.05, 1.1)	B. 1139, p. 165	Au (?)		Hole sunk at extreme head of Twin Creek. Values probably low.
Johnson (18.8, 1.55)	B. 1139, p. 166	Sb, W, Sn, Au (?) Lode	Martin	Scheelite in minor amounts.
Kellen (19.75, 1.55)	B. 1139, p. 166	Au, Sb Lode		No ore removed by 1913.
Keystone Mines (19.8-20.1, 1.7)	Kardex 49-96	Au, Ag, Sb, Pb, Zn Lode		Properties between Moose Creek and Too Much Gold Creek, tributaries of Fairbanks Creek.
Kokomo Creek (20.0-21.3) (2.4-3.7)	B. 1139, p. 166	Au Placer	Zimmerman	Not much information available.
Lillian Creek (10.4-10.55, 9.0)	B. 1139, p. 166	Au, Hg, W, Sb, Cr, Ni, Ba Lode & Placer	Fall; Falls & Barker; Jurich; Livengood & Hudson; Mandich & Jurich	Gravel 18 inches thick with four to five feet of overburden. Other areas of the creek show 15 feet of overburden. Gold worth $17.50 to $18 per oz. Lode and placer claims currently active.
Little Eldorado Creek (17.85-18.2) (1.55-1.9)	B. 1139, p. 166	Au, Sn, W Lode & Placer	Eldorado; Eldorado Creek; Idaho; Idaho Mining & Leasing Co.; USSR&M	$1,100,000 production by 1910 with total production by 1921 valued at $2,302,000. Gravel about 70 feet thick. Average value of gold in 1921 was $17 per oz. Various lode prospects along the stream.
Livengood Creek (10.45-11.35) (9.45-9.75)	B. 1139, p. 167	Au, Sb, Cr, Sn, W Lode & Placer	Baltic; Barry; Deep Channel; Duncan; Eagle; Eldorado; Carl Heflinger; Etna; Fish; Franklin No. 2; Gan; Callahan Mining Co.; Cascade; Gold Dollar; Mahan; Hidden Treasure; Italy; Lietrim; Livengood & Hudson; Livengood Placers, Inc.; Red; Marrietta; Mines Development Syndicate; Nelson; Ready Bullion;	Discovery date in 1914. At that time, the assayed fineness of gold was 0.915 and silver, 0.076, with a value of $18.90 per oz. after melting (placer deposits). By 1915 the ranges in fineness were from 0.907 to 0.914 with a value of $18.75 to $18.90 per oz. A few nuggets worth $20 have been found, mainly in the upper six miles of the creek. Average depth to bedrock was 80 feet with about 14 feet of gravel. Value of the gravel averaged $5.40 per square yard in 1918. A few pieces worth up to $50 had been

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Livengood Creek, cont.			Silva & Co.; Somerville; Sunny; Spall & Livengood; Sunnyside; Triangle; Virginia;	found by 1918. Currently active.
McCarty (Pioneer) (19.5-19.65) (1.6-1.65)	B. 1139, p. 168	Au, Sb, Pb, Zn Lode	Black Warrior; Dorothy; Free Gold; Harrietta; Henry Clay; Hinton; I.B.; Iron Mask; Laughing Water; Leroy; McCarty & Lawson; McDougall; War Eagle; Marigold; Minnie Ha-Ha; Pioneer (Fairbanks Creek); Pennsylvania; Russian Kid; Willie	
McCord Creek (12.6, 8.4) approx.	Kardex 49-40	Au Placer		A claim staked in 1953.
McNeil & Huddleson (19.7, 1.75)?	B. 1139, p. 168	Au (?)		
Mizpah (19.85, 1.61)	B. 1139, p. 169	Au, Sb, W, Pb, Mn Lode	Black Joe; Ott & McGowan; C. Thompson	Discovered in 1910. Selected gold ore produced $92 per ton from three tons.
Mohawk (18.65, 1.2)	B. 1139, p. 169	Au, Sb, As Lode	Creighton & Heilig; Franklin; Goyett; Heilig & Creighton; Robinson (Little Eldorado Creek); Rose Claim	Discovered in 1909. Osmiridium in ore reported by owner. Free gold in vein. 48 tons of ore removed in 1916. Development work currently being done.
Moonlight (18.8-18.9, 0.9)	B. 1139, p. 169	Au Lode	Harrais; Moonshine; Sunlight; Sunshine; Twilight	Grab sample of ore assayed at $3.26 per ton.
Moore Sheldon	Kardex 49-222	Sb Lode		
Moose Creek (11.9-13.15) (10.35-11.95)	B. 1139, p. 169	Au		Prospect reported in 1915.
Mother Lode (Dome Creek) (17.6, 1.0)	B. 1139, p. 169	Au, Cu, As Lode		Evidence of "copper pyrite" in dumps.
Mother Lode (Willow Creek) (18.8, 1.25) approx.	B. 1139, p. 169	Sb, Au Lode		Gold assayed at less than $1 per ton.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Myrtle (10.45, 9.5)?	B. 1139, p. 169	Au Placer		Not much information available.
Newsboy (18.65, 1.4)	B. 1139, p. 169	Au, Sb, Zn, Cu Lode	Cleary Hill Extension; Lucky Lad; Newsboy Extension; Newsboy Mining Co.; Pilgrim	Grab sample assayed at $53.98 per ton for concentrate. Vein sample from mine assayed at $5.24 per ton, another at $8.46 per ton. Sixty tons of ore treated in 1911 gave an average gold content of $81.50. Seven and a half tons yielded $104 per ton but the average sent to the mills was probably about $40 per ton.
Nightingale, J. (18.3, 0.55)	B. 1139, p. 170	Pb, Sb		A claim carrying galena and stibnite in the Steamboat Creek valley.
Nome Creek (20.9-21.9) (6.0-7.25)	B. 1139, p. 170	Au Placer	John Clark	Discovered in 1910. Gravel two to four feet thick. Gold worth $17 per oz. and $1.25 to $1.75 per square foot. Considerable low grade reserves reported. Claims currently active.
North Star (Skoogy Gulch) (18.75, 0.95)	B. 1139, p. 170	Au, Sb Lode	Big Lead; Faulkner	$5000 in gold recovered. In 1933 samples taken from the tunnel had a value of $1.72 per ton or less. One ton of $35 ore was removed from open pits on the claim. Area was restaked in 1967 and extensive development work is currently being done.
North Star Extension (18.16-18.7) (0.95-1.0)	B. 1139, p. 170	Au Lode	Center Star; Central Star; Faulkner	Estimated value of the entire ore body was $4 per ton prior to 1933.
Ohio (19.85, 1.65)	B. 1139, p. 170	Au, Sb, Pb, Ag Lode	Gilmore & Stevens; Gilmore & Stevenson; Gray Eagle; Mayflower	Gold bearing quartz showed $4 to $5 per ton. Property had not been active for some years in 1931.
Old Glory (17.9, 0.75)	B. 1139, p. 170	W Lode	Leslie & Hunter	Scheelite bearing rock. Assay showed 0.48% WO_3 and 0.005% MoO.
Olive Creek (10.8, 8.55-8.65)	B. 1139, p. 170	Au, Hg, W, Cr, Sb Lode & Placer	Fred Crane; Livengood & Hudson; Hudson; Carl Parker	Gravel 10 to 15 feet thick with two feet of muck overburden to ten or more feet of muck. Gold is in lower seven feet of gravel and was worth $18 per oz. in 1918. Cinnabar is plentiful. Gold very fine. Claims were staked in 1966. Placer gold claims are currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Omega (18.1, 0.95)	B. 1139, p. 170	Au (?)	M.E. Stevens	Some development work done on one claim. Part of the old Soo group.
Ophir Creek (20.15-21.2) (5.6-6.9)	B. 1139, p. 170	Au Placer	Miscovich Bros.	Discovered in 1910. Gravel 2-4 feet thick in bench deposits. Gold worth $17 per oz. Claims were staked on the creek in 1956 and 1957.
Oro Fino (18.65, 1.4)	B. 1139, p. 171	Au (?) Lode		An old claim. No information available.
Oro Grande (18.65, 1.4)	B. 1139, p. 171	Au (?) Lode		An old claim; no other information available.
Our Creek (15.5-15.8) (0.35-0.5)	B. 1139, p. 171	Au Placer	Georgia; Washington	Discovered in 1906. Gravel about 12 feet thick. One nugget worth $12 was found in 1908.
Pedro Creek (18.3-18.65) (0.35-0.65)	B. 1139, p. 171	Au, Sn Placer	Hanot Bros.; USSR&M	Gravel 8-30 feet thick. In some places gold was found in eight feet of the gravel and four feet of the bedrock, in others it was found only in the bedrock. In 1910 the average value of gold was $17.68 per oz. Currently of interest.
Robinson (Pedro Dome) (18.3, 0.9) approx.	B. 1139, p. 172	Au		No orebody of workable value has been discovered on this group of claims.
Rowley-Schummeff (Nightingale) (18.3, 0.55)	B. 1139, p. 170	Pb, Sb Lode		Galena and stibnite found on site. Listed as "Nightingale" in B. 1139.
Ruth Creek (10.6-10.7) (9.0-9.35)	B. 1139, p. 173	Au, Cr, W, Hg, Ni, Sb Lode & Placer	Estorffe & Radak; Fall; Radak; Livengood & Hudson; Ruby Creek	As much as $12 per ton of gold and $2 per ton of silver have been found. Cinnabar identified in the vicinity. Five feet of gravel with 12 feet of overburden. Gold is found in the gravel and upper two feet of bedrock and was worth $18 per oz. in 1918. The largest piece found by 1918 was worth $3. Placer claims are currently active.
Saucy (19.8, 1.8)	B. 1139, p. 173	Au, Sb Lode		Not much information available.
Sawtooth Mountain (3.45, 6.6)	B. 1139, p. 173	Sb Lode	Sparks; Vogeler; Wackwitz	Has been productive. Some development work. Antimony ore was hand picked and put in drums for ship-

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Sawtooth Mountain, cont.				ment. Discovered by Fred Wackwitz. Claims staked in 1953.
Seattle Creek (18.0, 0.7)	B. 1139, p. 173	W, Au Lode	Franklin & Assoc.	Has produced a minor amount of gold. Some development work is currently being done.
Silver Dollar (18.35, 0.55)	B. 1139, p. 173	Au (?)		No gold or sulfides visible.
Silver Ridge Mining Co. (18.2-18.4) (0.4-0.5)	Kardex 49-327	Sb Lode		Exploratory work conducted by shaft sinking in 1964 and 1965. About $50,000 worth of antimony is said to be contained in the old dump.
Sky High (19.2, 1.7)	B. 1139, p. 173	Au Lode		As of 1913, nothing promising - a very poor showing.
Solomon (19.4, 1.7)	B. 1139, p. 173	Sb Lode		
Soo Mining Co. (18.1-18.3) (0.95-1.05)	B. 1139, p. 173	Au, Ag, Sb, Cu Lode	Carnation; Chief; Equity Assoc.; H&K; Hawkins & Assoc.; Heath & Kearns; Inspiration; La Rose; Wild Rose; McGillvray & Ellis; Reliance Mining Co.; Waterbury; Spaulding-Roman-Cunningham; Spaulding & Brumbaugh; Stevens & Martin; Waverly	Assays showed fineness ranging from 0.823 to 0.843 for gold and 0.149 for silver. Stibnite has been reported, as has tetrahedrite. Average mill runs for gold in 1912 were $50 to $60 per ton with some as high as $250 per ton.
Spruce Creek (17.7, 1.3)?	B. 1139, p. 174	Au Lode	S. Dale	$12 per ton of gold. Not much information available.
Steamboat Pup or Creek (18.4, 0.5)	B. 1139, p. 174	Au, W, Ag, Pb Lode & Placer	Rowley; Pete Smith; Lindgrum	Limited amounts of low grade gravel with $18 per oz. the average value for gold. Small scale mining in 1966 and 1967. Lead-silver lode prospect near head of creek. Extensive trenching and approximately 100 feet of drilling done in 1966-67.
Steel Creek (11.0-11.45) (7.8-8.2)	B. 1139, p. 174	W Placer		

LIVENGOOD QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Steil (18.75, 1.5)	B. 1139, p. 174	Au, Sb Lode	Steel	Report of 1912 indicated this property was not in production.
Sunrise (Cleary Creek) (18.95, 1.65)	B. 1139, p. 174	Sb, Au (?) Lode		Not much information available.
Sunrise (Last Chance Creek) (18.6, 1.35)	B. 1139, p. 174	Au (?) Lode		Claim prospected for lode gold. Located near the Newsboy at an elevation of 1975 feet.
S.S. (18.7, 1.0)	B. 1139, p. 174	Au Lode		Not much information available.
Tamarack Creek (19.1-19.2) (1.3-1.4)	Kardex 49-290	Au Placer		Claims currently active.
Tanana Quartz Mining Co. (19.3, 1.55)?	B. 1139, p. 174	Au Lode		Property did produce. A five stamp mill was operated here.
Thompson (18.55, 1.2)	B. 1139, p. 174	Au Lode		Showed gold. Not much other information available.
Thompson & Burns (18.6, 1.0)	B. 1139, p. 174	Au (?) Lode	Million Dollar Corp.	Assays of grab samples showed $.83 and $.00 per ton from dump in 1933.
Thrift (17.3, 0.9)	B. 1139, p. 174	Au Lode		Reported $11 per ton for gold.
Tolovana (Mining & Milling Co.) (18.75-18.85) (1.5-1.55)	B. 1139, p. 175	Au, Sb, W, Ag Lode	Scheuyemere; Scheuyemeress; Tolovana Stibnite	"Several thousands dollars" gold fineness 0.824, 0.8215, 0.814, 0.792; sample with 0.792 fineness had 180 parts per thousand in silver. Gold is in free form. Scheelite occurs in minor amounts.
Tolovana River (10-11, 8-9)	B. 1139, p. 175	Au Placer	Dougal & Braun	Most of the production was from tributaries; Ester, Livengood, Olive and Wilber Creeks being the most important. In 1925, an 80 foot prospect shaft was sunk.
Trail Creek (17.9-19.5) (4.5-7.15)	B. 1139, p. 175	Au Placer		Encouraging prospects found in 1909.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Treasure Creek (16.6-0.45)	B. 1139, p. 175	Au Lode	Tonaskate; Victoria	Not much lode information available. Stibnite and silver were reported but not verified in 1913 by the USGS. By 1910 placer gold production had reached $250,000. Gravel as much as seven feet thick. Gold values ran $.50 to $7 per square foot of bedrock with the average value in 1908 about $1.50 per square foot. Claims were staked in 1953 and 1963. Currently, placer activity on creek.
Treasure Creek (16.8-16.9) (0.6-0.8)	Kardex 49-4	Sb, Ag Placer		
Trojan (17-20, 0-1)?	B. 1139, p. 175	Au (?) Lode		A gold (?) lode prospect in the Pedro Dome area. Ownership unknown.
Troublesome Creek (1.8-2.9) (6.3-8.9)	B. 1139, p. 175	Au, Hg, Sn, Ba, Pb Placer		Not much information available, but currently active.
Twin Creek (18.6-18.75) (0.6-0.9)	B. 1139, p. 175	Au, Sn Placer	Fairbanks Gold Mining Co.	Four feet of gravel. Average value of gold $17.66 per oz. Currently active.
Vault Creek (16.8-17.15) (0.65-1.35)	B. 1139, p. 176	Au Placer	Alabama; Hard Luck; Homestead; Isabel; Isabella; Nevada; Oregon; Sierra; Victor	One nugget worth $60 found plus 1/3 oz. gold in $1 pieces. Gravel 3-6 feet thick. Average value of gold $17.75 per oz. $1,250,000 recovered by 1910. Claims staked in 1953 and 1963. Currently active.
Vault Creek (17.3, 0.6)	Kardex 49-47	Sb Lode		Claims staked on right limit of creek at a point near Tanana Valley railroad grade.
Vetter (19.5, 1.7-1.8)	Kardex 49-291	Au Lode		Claims staked on the divide between Wolf and Cleary Creeks and directly north of the Nordale group. Currently active.
Vetter (19.7, 1.2) approx.	Kardex 49-157	Sb, Cu, Au, Pb, Ag, Zn Lode		Auriferous gold quartz vein containing jamesonite and other lead-antimony sulfides. Some production from an opencut.
Wackwitz (Cleary Summit) (17.75, 0.45) approx.	Kardex 49-297	Sb, Au, Pb, Ag, Zn Lode	Fred Wackwitz	Ships a little ore to a smelter - all hand picked.
Wackwitz (Wyoming) (18.9, 1.5)	B. 1139, p. 176	Au, Sb, W, Zn, Mo Lode	Alaska Mining & Development Co.; Cleary Hill Alaska Gold	Possibility of large amounts of ore being present in this area. Looked good in 1933. Ore has been

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Wackwitz (Wyoming) cont.			Mines; Goessmann; Gustafson Bros.; Oklahoma; Tanana Quartz & Hydraulic Mining Co.; Wackwitz Bros. (& Nelson); Wackwitz Bros.; Wyoming (Quartz Mining Co.)	milled at $6 per ton. Another area of the mine indicated ore valued at $12.86 per ton in 1933.
Walnut Creek (20.7-20.8) (1.7-1.95)	B. 1139, p. 176	Au Placer		Discovered in 1912. Production $8700 by 1910, with the average value of gold being $17 per oz. Gravel was worth $2 to $2.50 per square foot. Claims staked on creek in 1953.
Washington Creek (10.0-17.5) (1.25-4.1)	B. 1139, p. 177	Au (?)		Creek was being prospected in 1907. Some pay reported.
White Elephant (18.95, 1.1)	B. 1139, p. 177	Pb, Ag Lode	Faulkner; Nerick, Jackson & Faulkner	Galena in lenses which also contain "considerable" silver.
Whitehorse (Too Much Gold Creek) (19.9, 1.6)	B. 1139, p. 177	Au, Sb, Pb Lode	Bishop	Not much information available.
Whitman & Murray (18.85, 0.95)	B. 1139, p. 177	Au Lode		Very little information available.
Wickersham Dome (14.2-14.6) (3.6-3.8)	Kardex 49-292	Au, Ag Lode		Currently active claims staked on the south slope of Wickersham Dome near the head of Eureka Creek.
Wilbur Creek (11.0-11.85) (7.1-8.25)	B. 1139, p. 177	Au Placer	Bostrum & Wickstrom; Fall; Haley & Magnussen; Wilber Creek	Many claims on this creek are currently active.
Wildcat Creek (16.85-16.9) (0.55-0.65)	B. 1139, p. 177	Au Placer		Gravel low grade. Active from 1958-1962.
Willow Creek (11.3, 11.2) approx.	B. 1139, p. 177	Au Placer		Active in 1959 and still being worked.
Wilson Gulch (19.7-21.0) (0.4-1.1)	Kardex 49-283	Au Placer		Claims staked on Wilson Gulch, a tributary of Fish Creek, in 1958. More claims staked in 1967.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Wolf (Too Much Gold Creek) (19.8, 1.8) approx.	B. 1139, p. 177	Au, Sb Lode		
Wolf Creek (19.05-19.45) (1.75-1.9)	B. 1139, p. 177	Au		$33,000 production by 1910. Considerable work done in 1903 but not much done from 1904-1908. Average value of gold in 1910 was $17.85 per oz. Claims staked in 1956.
Woods	Kardex	Sb, Au, Pb Lode		
Yellowjacket (19.9, 1.7)?	B. 1139, p. 178	Au		
Zimmerman (near Twin Creek) (18.9, 1.0)	B. 1139, p. 178	Ag, Au Lode		Values up to $1.66 per ton, but generally ran only a trace of gold and silver, according to assays of 1933.
Zimmerman (Twin Creek) (18.7, 0.7)	B. 1139, p. 178	Au Lode		
--- (17.8, 0.5) approx.	Kardex 49-85	Ag, Pb Lode		Claims staked on the divide between Flume Creek and Fox Gulch in 1956.
--- (---)	Kardex 49-201	Au Lode		Claims staked at the head of the West Fork of Lost Chance Creek in 1957. Currently active.
--- (18.4-19.2) (1.6-1.8)	Kardex 49-340	Au Lode		Claims staked on the easterly slope of Cleary Creek and the head of Marshal Gulch, a tributary of Little Eldorado Creek.
--- (17.9, 0.9)	Kardex 49-339	Au Lode		Claims staked on the westerly half mile from Pedro Dome along a well marked survey line in 1967.
--- (17.8-18.3) (1.1-1.3)	Kardex 49-312	Au (?), Sb Lode		Many currently active claims staked on a ridge between Spruce and Louise Creeks.
--- (7.8-8.2) (8.4-8.7) approx.	Kardex 49-317	Cr, Ni Lode		Claims staked 11.6 to 7.6 miles south 70 west from Money Knob.

LIVENGOOD QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
--- (11.7-11.8) (8.6-8.7) approx.	Kardex 49-318	Ni Lode		Claims staked approximately one or two miles southeast from Amy Dome.
--- (19.4, 1.5)	Kardex 49-316	Pb, Ag, Au Lode		An active mineral claim 500 feet off the Fairbanks Creek road and near the head of Chatham Creek.
--- (16.3-17.3) (0.3-0.7)	Kardex 49-313	Sb Lode		Many currently active claims staked from the ridge between Treasure and Eagle Creeks to a ridge between Vault and Dome Creeks.
--- (10.5-12.0) (9.0-11.2)	Kardex 49-18	Au Placer		Many claims grouped on Livengood, Alabam, Alder, Franklin, Goldstream, South Fork Hess, Martin, Myrtle and Ruth Creeks currently active. Placer drill logs and maps on file at DMM.
--- (18.5-18.7) (0.7-0.9)	Kardex 49-330	Au, Ag, Hg Placer		Currently active mineral claims recorded in Sections 2 and 11, T.2N, R.1E.

MELOZITNA QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Florence Bar (10, 15-16)?	B. 1139, p. 192	Au Placer		Approximately $4000 worth of gold recovered from Florence and Hughes Bars.
Illinois Creek (21.0, 4.9) approx.	B. 1139, p. 192	Au Placer		Gold prospects reported but not demonstrated.
Mason Creek (20.05-20.3) (4.1-4.7)	B. 1139, p. 192	Au, Sn Placer		Some mining has been done on this creek.
Moraine Creek (19-22, 3-5)?	B. 1139, p. 192	Au Placer		Some prospecting on the creek in 1929.
Moran Creek (18-19, 6)?	B. 1139, p. 192	Au, Sn Placer	"Tuffy" Edgington	Creek said to contain 2 1/2 lbs. tin and $1.10 ($.10?) gold per cubic yard. Some gold recovered in 1935. Edgington worked here, on Golden Creek, and others in this area through the 1940's and 50's.

MISHEGUK MOUNTAIN QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Kugururok River (SW 1/4, SW 1/4 quad.)	B. 1139, p. 192	Chromite		A chromite specimen, assaying 20% chromium, was obtained from near the mouth of the river. Large amounts of float of similar material are reported to be in the area.

NOME QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Albion Creek (19.4, 11.1) approx.	B. 1139, p. 209	Au Lode & Placer	Crooked Creek Dredge Co.; Mebes & Hansen; Stick & Co.	A shaft of approximately 50 feet was sunk on a quartz vein. Trace amounts of gold found. Some hydraulic mining on the placer ground.
Alpha Creek (18.7, 11.3)	B. 1139, p. 209	Au Placer	Cochrane & Rodin; Dakota-Alaska Mining Co.	Considerable gold produced, probably of local bedrock derivation. Bedrock is well mineralized quartz-mica schist.
American (16.15, 13.8)	B. 1139, p. 209	Fe Lode		Several claims held in this iron bearing area. Four claims at the base of a limestone ridge. Deposit said to cover 50 acres.
American Creek		Au Placer	Barney Rolando	Dredge built on creek by Rolando, who mined here for a few years.
Anvil Creek (19.35-19.85) (10.1-10.75)	B. 1139, p. 209	Au, Sb, Ag, Cu, W, Pb Lode & Placer	Bangor Dredge Co.; Olsen; Wild Goose Co.; McIntosh; Jack Bullok & O'Leary; Christophosen; Winsted; Hendrixson; (Kotouik & Stipek); Widstedt	Great deal of prospecting and a small amount of work done on creek up to 1935. Stibnite veins up to 18 inches in width occur in a shear zone in schist. Small amounts of lead minerals. Claims staked in 1954 and 1961. Left limit currently active. 38 acres patented with 915 acres patented on Little Anvil Creek. Benches worked, some as recently as about 15 years ago.
Arctic Creek (16.4-17.0) (10.85-11.45)	B. 1139, p. 209	Au Placer	Arctic Creek Dredge Co.; Hall	Gold dredge operated here in 1922. Not of current interest. 304 acres patented.
Balto Creek (19.1-19.2) (11.45-11.55)	B. 1139, p. 210	Au, W Placer		Small amount of gold production in 1903. Hydraulic mining in 1913. Not of current interest.
Bangor Creek (18.85-19.0)	B. 1139, p. 210	Au, W Placer	Arctic Placer Mining & Milling Co.; Bangor Creek Dredge Co.	Dredge operated in 1908. One hydraulic operation. Claims staked in 1953 and 1955. Of current interest.

NOME QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Banner Creek (20.1-20.3) (11.7-11.8)	B. 1139, p. 210	Au Placer		Colors found but no paying placers. Little prospecting done due to lack of water.
Basin Creek (20.4-20.6) (12.4-12.45)	B. 1139, p. 210	Au, W Placer	Herb Engstrom & Son Dredging Co.	Gravel paystreak width of nearly 150 feet. Gold is coarse, bright, rough and associated with ilmenite, hematite and scheelite. Currently active.
Beaches, Old (8.5-10.0)	B. 1139, p. 210	Au Placer	Intermediate Beach; McCarthy & Panos; Monroeville Beach; Noble; Second Beach; Submarine Beach; Third Beach	Fifteen placer mines at third beach line, four at second beach line and two placer mines at Submarine Beach.
Beaches, Present (14.9-22.35) (8.25-10.0)	B. 1139, p. 210	Au Placer		One dredge operated in 1916. Ten open cut mines also that same year.
Bear Creek or Gulch (20.0, 10.3)	B. 1139, p. 210	Au Placer		Discovered in 1918. One open cut operation and hydraulic methods used in mining.
Boer Creek (20.15) (15.6-15.7)	B. 1139, p. 210	Au Placer		Pay streak narrow and confined to creek bed. Two grades of placer gold. An adequate water supply is a minor problem. Hydraulic plant operated on creek.
Bonanza Gulch (19.5, 10.8)	B. 1139, p. 210	Au Placer		The richest gravels were mined out by 1910. Gold bearing gravel overlain by 5-6 feet of clay and one foot of muck.
Bonita Creek (20, 12)	B. 1139, p. 210	Sb, Au Lode		Small lenses of gold bearing stibnite occur near the head of the creek. Mode of occurrence and work done unknown in 1947 (last date reported on).
Boulder (18.7, 11.7)	B. 1139, p. 210	Sb, Au, W Lode		Stibnite occurs in lode, which is highly iron stained. Several good paying quartz veins.
Boulder Creek (trib. Sinuk River) (14.75-15.05) (12.35-12.55)	B. 1139, p. 210	Au Placer		Reported to yield a small amount of gold.
Boulder Creek (trib. Snake River) (18.4-18.8) (11.6-11.9)	B. 1139, p. 211	Au, Sb, W, Bi Lode & Placer	Cochrane & Rodin; Dakota-Alaska Mining Co.	Gold-quartz strike of some importance made in 1915. Stibnite found in the lode. Placer scheelite occurs in quantities of commercial importance. Fluorite is a common mineral.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bourbon Creek (20.0, 10.0) approx.	B. 1139, p. 211	Au Placer	Nome Consolidated Dredge Co.; Pearse M. Walsh	Dredged. Powerhouse built on creek. Large operation.
Breen (19.9-20.2) (13.7-13.8)	B. 1139, p. 211	Sb Lode		Fourteen tons of float ore shipped in 1947. Ore, which was mined from pits and surface trenches, carried gold and 10% antimony. Occurs as quartz-stibnite veins in schist.
Buster Creek (20.7-21.15) (10.8-11.25)	B. 1139, p. 211	Au Placer	Towner & Straub	Two open cut operations in 1913. Productive since 1899 but most of creek worked over. Gold is of a coarse texture. Some of the creek has been dredged. Claims staked in 1967.
Butterfield Creek (18.7-18.95) (12.4-12.45)	B. 1139, p. 211	Au, W Placer		Has been worked but no further reports or information is available.
California (19.05, 13.9)?	B. 1139, p. 211	Au Placer Mo, W, Sb Lode	Connelly & Janssen; Connolly & Jensen; Jannsen; Mahon	Stibnite found in lodes. Small amounts of molybdenum found. Dredge operated on creek.
Canyon Creek (14.6-16.6) (16.1-17.75)?	B. 1139, p. 211	Au Placer		Prospected in 1927.
Cape Nome (22.65, 8.5)	B. 1139, p. 211	Cr Placer		Cromite and some radioactive minerals reported.
Center Creek (19.5-19.6) (9.55-9.8)	B. 1139, p. 211	Au Placer	Center Creek Dredge Co.; Wild Goose Mining Co. (?)	Reconcentrated stream. Magnetite, garnet and small amounts of scheelite reported. A deep placer and one dredge in operation in 1918. Considerable hydraulic mining.
Charley Creek (18.7-18.85) (15.2-15.4)	B. 1139, p. 212	Bi, Cr, Au Lode	Homburger & Shoemaker; Native Bismuth Co.; Margraf & Kawolski	Two parallel quartz veins 5-10 inches wide contain a little diseminated bismuth and bismuthinite. Development work done on creek in 1951
Christophosen (Last Chance Creek) (18.65, 13.1)	B. 1139, p. 211	Ag, Pb, Au, Sb Lode		Two arsenic-lead lode claims. 70 foot tunnel driven. Ore body four feet thick. Galena occurs with pyrite and quartz gangue. Ore carries gold.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Christophosen (Waterfall Creek) (18.55, 13.25)	B. 1139, p. 212	Sb, Au, Ag, Cu, Pb Lode	Bunker Hill; Waterfall Creek; Mabel; Monitor	Ore iron stained schist and quartz in which stibnite occurs as lenticular masses. 2 1/2 tons stibnite mined and sold. Gold in schist and stibnite. Chalcopyrite also occurs.
Christophosen (Zinc) (18.05, 12.7)	B. 1139, p. 212	Zn, Au Lode		Zinc occurs in narrow band of limestone country rock. No well-defined vein. Ore occurs in iron stained zone of mineralization and is sphalerite.
Coal Creek (15.4-15.65) (13.05-13.35)	B. 1139, p.	Au Placer	Lee	Gold found in gravels while working coal. Dredge operated on creek.
Cooper (17.0-18.0) (12.5-13.5)	Kardex	Hg Lode		On Oregon Creek (?). No information available.
Cooper or Copper Gulch (19.75-19.85) (10.1-10.3)	B. 1139, p.	Au Placer	Charles; Wild Goose Mining & Trading Co.	Unsuccessful attempts at mining gold in 1904. One deep placer mine worked in 1916.
Copper Mountain (20.8-21.05) (15.7-16.05)	B. 1139, p. 212	Cu, Pb, Ag, Au Lode	Cooper Creek; Dickens Creek	Small amount of development work done. Chalcopyrite, bornite and galena occur. Broad belt of schist with limestone lenses forms country rock. Sulphides associated with quartz. Ore bands usually found in limestone.
Cripple River (15.75-16.8) (9.7-12.05)	B. 1139, p. 212	Au Placer	Cripple River Dredge Co.; Nome Gold Gravel Dredge Co.	Dredge used in 1918. Prospected in 1967.
Cub Bear (16.9, 12.9)	B. 1139, p.	Fe, Pb Lode		No sulphides. Iron ore in zone 50-100 feet wide and extending several thousand feet along an anticlinal crest.
Dahl Creek (20.2, 14.3)		Sb, As Lode		40 acres patented in 1922. Some production.
Daisy Gulch (19-20, 10-11)	B. 1139, p.	Au Placer		Open cut operations in 1914.
Dakota (18.7, 11.7)	B. 1139, p.	Au Lode	Dakota-Alaska Mining Co.	Dakota lode includes 13 claims. Limestone bedrock. Iron staining and a few sulphides.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Darling Creek		Au Placer	Bob Herman	
David Creek (21.0-21.2) (15.2-15.3) approx.	Kardex	Au Lode		Discovered in 1959. Located approximately one mile northeast from the highway at or near the head of David Creek, a tributary of the Nome River.
Derby Creek (2.165, 8.65) approx.	B. 1139, p. 213	Au Placer		One open cut operation in 1916.
Dewey Creek (20.4-20.7) (11.5-11.9)	B. 1139, p. 213	Au, W Placer		Discovered in 1908. A little gold mined. Gold is associated with scheelite and garnet.
Dexter Creek (20.0-20.4) (10.3-10.65)	B. 1139, p. 213	Au, Cu, Sn (?) Lode & Placer	Dexter Creek Left Fork; Lane; Dexter Creek Dredge Co.; Chas. O Co.	Open cut and hydraulic mining in 1936. Mining done through entire creek length. None of the deposits frozen. Gold not confined to channel. 13 acres patented. Produced quite a bit of gold. Lode with small amount of copper minerals at head of creek.
Dexter Hill (19.7-20.15) (10.5-10.75)	B. 1139, p. 213	Au, Placer	Caribou; "Caribou Bill"; Deer Gulch; Dexter Station; Honey; Gambrinus & Gillette; Glass Gulch; Grouse Gulch; Miocene Ditch Co.; Lena; Madeline & Mattie; Nekula Gulch; Nicola Gulch; Snowflake; Specimen Gulch; Sugar; Summit	Placer gold in gravels made up of schist, quartz and limestone. Mining carried on since 1900.
Divide Creek (20.25, 15.1)	B. 1139, p. 213	Au Placer		Approximately one mile long. Gravel deposits contain quartz with free gold and are possibly a residual deposit. No mining attempts made by 1913.
Dorothy Creek (20.6-20.7) (14.85-14.9)	B. 1139, p. 213	Au, Sb Placer		Long bladed stibnite is common in placer concentrates. Washing and scraping done. Bedrock is of limestone schist and greenstone. Minerals in lower mile of creek. Little profit as of 1913.
Dry Creek (19.8-20.15) (9.35-10.3)	B. 1139, p. 213	Au, W Placer	Charles; Dry Creek Dredge Co.; USSR&M; Belleview Bros.	Dredge operated in 1938. Partly a primary and partly a secondary deposit. Pay gravel rests on clay and not elsewhere. Hematite, scheelite and pyrite

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Dry Creek, Cont.				accompany the gold. Old channel also contains gold. Claims staked in 1955. Mined by USSR&M's Dredge No. 5, one of the world's largest.
Duffy Mine (19.1-19.6) approx.		Au	Herk Edwards & Miller	Mined from 1960 to 1963. Located on the left limit tributary of Gold Bottom Creek, which is a tributary of the Snake River.
Extra Dry Creek (20.4-20.55) (10.3-10.4)	B. 1139, p. 214	Au Placer	Teddy Johansen	Productive part of creek in a narrow gulch cut in chloritic and feldspathic schists. Some limestone bedrock. Appeared exhausted in 1913.
Fairview Creek (12.95-14.0)	B. 1139, p. 214	Au Placer		Bedrock composed of graphic and feldspathic schist some massive limestone. Gold colors reported but no paystreak found as of 1908.
Flambeau River (21.5-23.55) (11.5-12.5)?	B. 1139, p. 214	Au Placer		Some prospecting and mining (?) done. Water supply problems.
Flat Creek (19.7-19.75) (10.0-10.1)	B. 1139, p. 214	Au Placer	Alaska Mines Corp.	One dredge operated in 1918. Alaska Mines Corp. operated a dredge in 1920 but it is not known for certain that they did any digging.
Fox Creek (21.5-22.45) (13.85-14.1)	B. 1139, p. 214	Au Placer		Some mining done but of little significance.
Fred Gulch (19.2-19.25) (14.15-14.25) approx.	B. 1139, p. 214	Au, Sn Placer		A small amount of gold recovered. Upper channel is composed of limestone and the lower channel, of schist and gravel. Some stream tin reported.
Galena (16.25, 12.95)	B. 1139, p. 214	Fe, Pb, Zn, Au Lode	Fox; Kentucky; Oso; Sunrise; Williams	Nine claims staked in 1914. Several open cuts and shafts on the property. Short drifts reveal small veins and small stock works of limonite and galena.
Glacier Creek (19.45-20.0) (10.85-11.15)	B. 1139, p. 214	Au, W, Sb, Sn Lode & Placer	Ames & Guinan; Guinan & Ames; Lynx; Miocene Ditch Co.; Louie Nashenwing; Ullrich	Stibnite found in lodes. Small amounts of cassiterite but not of economic importance. Placer scheelite, which occurs in quartz veins, approaches commercial quantities. Placer mining has been done on the creek.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Gold Bottom Creek (19.1-19.6) (13.05-13.65)	B. 1139, p. 214	Au, Sn Lode & Placer	Jensen	Claims not too encouraging. Some stream tin. Bedrock composed of schist and of limestone. One hydraulic plant in operation in 1918. Gold lode at head of creek.
Gold Hill (19.05, 10.95-11.05)	B. 1139, p. 214	Au Lode		Two openings made on quartz veins. Some gold reported.
Golden Cow (20.3, 9.5) approx.	B. 1139, p. 215	Au Placer		Very rich strike reported. Some mining done.
Grace Gulch (21.05-21.1) (11.1-11.15)	B. 1139, p. 215	Au Placer		Gold gravels similar to Buster Creek. An adequate water supply is a problem.
Grouse Creek (19.55-19.75) (13.1-13.6)	B. 1139, p. 215	Au, Pb, Sb Lode & Placer	Henry Breen (?); Pearse M. Walsh (?)	Lead minerals occur in small amounts in quartz veins. Does not appear commercially important. Poor gold appearance.
Grub Gulch (19.5-19.65, 13.0)	B. 1139, p. 215	Au Placer		Schist and quartz gravel with many granite boulders. Poor gold appearance.
Hastings Creek (21.85-21.95) (8.4-8.65)	B. 1139, p. 215	Au Placer	Hastings Creek Dredge Co.; Rube Cramer	Important placers belong to the second beach of Cape Nome with a small quantity of gold also taken from the head of the creek. Gold is reconcentrated from tundra gravels. Currently active and is considered a good property.
Hazel Creek or Gulch (21.65-21.8) (12.85-12.9)	B. 1139, p. 215	Au Placer		Gold gravels near a point where the creek leaves the surrounding hills.
Hed & Strand (20.15, 14.35)	B. 1139, p. 215	Sb Lode	Hed & Strom	Possibly 30-40 tons of antimony ore could be mined on this property. Average gold content is low.
Hobson Creek (20.35-20.4) (13.2-13.5)	B. 1139, p. 215	Au Placer	Arctic Gold Dredge Co.	One dredge operated in 1916. Bedrock is composed of massive limestone with greenstone schist near the head of the creek. Considerable prospecting done but little gold found.
Holyoke Creek (19.8, 9.6-9.8)	B. 1139, p. 215	Au Placer		Large dredge built in 1918. Gold from tundra gravels. Frozen ground is a problem. Shaft sunk 118 feet; beach sand and shells were encountered in it. (May be the same as Flat Creek.)

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Reported, Remarks
Hot Air Beach (19.5-19.6, 10.9)	B. 1139, p. 216	Au Placer		Gold gravels found on hill slopes. Two 30 foot open cuts made. Bedrock composed of mineralized schist. Gold not locally derived.
Hume (13.0, 16.15) approx.	B. 1139, p. 216	Au Placer		Two men worked rockers on the property in 1901 but abandoned them.
Hungary Creek (17.2-17.4) (11.9-12.1)	B. 1139, p. 216	Au, Bi Placer	Oscar Wilson	Bismuth found in placer concentrates. Three gold mines operated in 1903 but not much gold was recovered. Boulders of area composed of gneiss and granite.
Igloo Creek (12, 13)	B. 1139, p. 216	Au Placer		Gold colors reported but never in commercial amounts. Not of current interest.
Independence Creek (14.3-14.5)	B. 1139, p. 216	Au Placer		Some gold produced with evidence of prospecting and mining. Massive limestone bedrock in area.
Irene Creek (21.0-21.1) (9.0-9.05)	B. 1139, p. 216	Au Placer		Two deep placer mines worked in 1916. Not of current interest.
Jess Creek (17.0, 9.8) approx.	B. 1139, p. 216	Au Placer		One open cut operation in 1918.
Johnston Creek (13.7-15.5) (14.7-15.1)	B. 1139, p. 216	Au Placer		Gravels of granite and other glacially derived material. Gold colors found.
Jorgesen (19.5, 10.6)	B. 1139, p. 216	Au, W, Pb Lode	Borasco; Eureka	Several openings made on quartz veins in mineralized mica schists and limestone. Pyrite, arsenopyrite and galena found in cross-cutting veins.
King Mountain (20.05-20.15) (10.55-10.75)	B. 1139, p. 216	Au, Mo Lode	Hines & McLaughlin; Royal	Molybdenum is found in quartz stringers.
Lake Creek (19.03-19.85) (9.2-10.05)	B. 1139, p. 216	Au Placer		Two dredges operated on creek.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Last Chance Creek (18.65-18.95) (12.95-13.8)	B. 1139, p. 216	Au, Sb, W Placer		Bedrock is composed of chloritic schist with graphic and calcareous beds. A small amount of gold was found but mining was not profitable. Some iron minerals occur also.
Lillian Creek (20.7-20.8) (10.95-11.4)	B. 1139, p. 216	Au Placer	Tug Gulch; Towner & Straub	Small channel. Schist with some interstratified limestone in bedrock. Gravel 3-10 feet thick. Gold of uneven distribution. Poor production.
Lilly (18.9, 12.2)	B. 1139, p. 216	Au Lode		Trench at limestone-schist contact exposes limestone cut by quartz veinlets and some iron stained schist. No sulphides reported. No prospecting or mining reported.
Lindblom Creek (19.1-19.3) (11.2-11.3)	B. 1139, p. 216	Au, W Lode & Placer		Placer scheelite occurs in amounts approaching commercial quantities. Scheelite is also found in quartz veins. Shallow gravel with only a small amount of gold found. Not of current interest.
Little Creek (19.4-19.8) (9.75-10.0)	B. 1139, p. 217	Au Placer	USSR&M; Otto Hall; see also Anvil Creek	Most productive claims in area in 1905. Most of the deposits occurred at depth in the gravel with some old beach deposits resting on schist bedrock.
Livingston Creek (13.7-15.2) (13.7-14.8)	B. 1139, p. 217	Au Placer		Pebbles and boulders of granite. Gold colors found in 1908. No mining reports.
Manila Creek (20.1-20.3) (13.5-13.8)	B. 1139, p. 217	Au, Cu		Copper found on the ridge of the creek was reported in 1947.
Martin Creek (20.2, 9.0) approx.	Kardex	Au Placer		Property color coded by DMM as being of interest. Still active.
May Gulch (17.5, 11.8)	B. 1139, p. 217	Au Placer		Prospect holes sunk near the head of the creek went down 20 feet and did not hit bedrock. Colors were reported for all 20 feet.
McAllister (20, 15)?	B. 1139, p. 217	Au Lode		Work done on the lode gold of the area but no reports of findings are available.
McDougall Creek (20.65, 9.5)?	B. 1139, p. 217	Au Placer		One open cut operation in 1916.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
McDuffee (19.6, 13.6) approx.	B. 1139, p. 217	Sb Lode	Vern Miller; McDuffee	High grade stibnite lens to be found in sheared schist on limestone-schist contact. Little work done as of 1944. Currently active.
Monarch (16.8, 13.75)	B. 1139, p. 217	Fe, Mo Lode		15 claims on limestone ridge. Deposits of iron ore. Limestone mass too low grade to be classed as an ore. Manganese and gold also reported.
Mogul (17.1, 13.7)	B. 1139, p. 217	Fe Lode		Sulphides with ore may be merely gossan material capping sulphide veins. Four claims. A few acres of ore veins that cut limestone locally occur but their size and extent is unknown.
Monument Creek (18.65-19.05) (10.65-10.9)	B. 1139, p. 217	Au, Sn Placer	Casa de Paga Gold Co.; Connelly & Listen; Monument Creek Mining Co.; Poorman; Stewart	Small amount of placer cassiterite is found in the concentrates. Probably occurs with scheelite. Dredge operated in 1939.
Moss Gulch or Creek (21.1-21.9, 9.4)	B. 1139, p. 217	Au Placer	Sioux Alaska Mining Co.	One open cut operation in 1916. Dredged in 1913.
Mountain Creek (17.6, 12.6) approx.	B. 1139, p. 217	Au, Pb, W Placer		Scheelite occurs in quartz veins. Lead minerals also occur in small amounts. The lower part of the creek has extensive schist gravels carrying gold. Good prospects. No mining as of 1908.
Nekula Gulch (19.9-20.0, 10.7)	Kardex 52-25	Au Placer		One claim staked in 1953. A tributary of Anvil Creek. Coded by DMM as being of interest.
Nelson (19.55, 13.8)	B. 1139, p. 218	Pb, Zn Lode		Limestone country rock with small lead-zinc stringers. Pyrite is also present, along with galena and sphalerite.
Nelson Gulch (trib. Nome River) (20.8-21.0, 13.8)	Kardex 52-21	Au Placer		Claims staked in 1953-54. Coded by DMM as having little current interest.
New Era Mining Co. (19.65, 10.75)	B. 1139, p. 218	Au Lode		Seven lode claims. Bedrock of limestone and schist. Gold in quartz and sulphides with free gold in some veins.
Newton Gulch (20.1-20.2) (9.6-9.9)	B. 1139, p. 218	Au Placer	Al Carey; Dry Creek Dredge Co.; Homburger	Successful mining done in 1932 by dredge. Gold gravels lay on clay; probably a third beach deposit. Most of the gold appears to be worked out but in 1954-56 claims were staked and it is currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Nome River (20.4-21.15) (8.9-11.1)	B. 1139, p. 218	Au Placer		One open cut operation in 1918. Gold colors reported for 20 miles. 2013 acres on river are patented.
Nome River, North Fork (19.0, 13.5) approx.	B. 1139, p. 218	Cu Lode (?)		Copper reported near head in 1947.
Nugent (19.5, 11.25)	B. 1139, p. 218	Au Lode		Bedrock is composed of iron stained schist cut by gold bearing quartz stringers. No work reported.
Nuget Creek or Gulch (17.5-17.9) (12.25-12.35)	B. 1139, p. 218	Au, W, Bi Placer		Open cut mine. Limestone bedrock with greenstone dikes. Pay lays on yellow clay above limestone. Gold, garnet, scheelite, bismuth, rutile and hematite have been reported.
Oregon Creek (17.25-17.65) (12.2-12.65)	B. 1139, p. 218	Au, W, Bi Placer	Gustafson & Swedman; Wagner	Bismuth is found in placer concentrates. Mined by bulldozer in 1940. "Spotted" placers. Paying claims found in middle of gold belt.
Osborne Creek (21.4-21.85) (10.0-11.55)	B. 1139, p. 218	Au, Sb, Cu Placer	Nick Nolan; Gold Beach Dredge Co.; Greenstone Mines, Inc.; Julian; Julien Gold Mining & Dredge Co.; Lee & Swanberg; Moore; Osborne Mining Co.; Osborne Creek Dredge Co.; Osborne Dredge Co.	Dredge operated in 1940. Productive stream placers. Gold bearing gravels 5-6 feet deep. Claims staked in 1954 and 1956.
Otter Creek (20.5, 9.0)	B. 1139, p. 219	Au Placer	Plein Mining & Dredging Co.	Dredge operated in 1913. Appears to be a submarine beach. Thawing a problem. Claim staking in area in 1953.
Pajara Creek (---)	re. Al Doyle	Au Placer	Casa de Paga Mining Co.; Stewart	Dredged for several years.
Peluk Creek (20.05-20.1) (9.0-9.35)	B. 1139, p. 219	Au Placer	American Gold Dredge Co.; Gold Beach Placers, Inc.	Dragline and bulldozer used in 1940. Not much money taken off this creek.
Penny River (17.1-18.2) (9.7-12.6)	B. 1139, p. 219	Au, Pt (?) Placer		One open cut mine in 1918.
Peterson & Lamoreaux (19.45, 10.45)	B. 1139, p. 219	Au, Pb, Sb Lode		Tunnel cut uncovered heavy iron stained quartz body, which was probably formed prior to gold

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Peterson & Lamoreaux, cont.				mineralization. Some galena is found in quartz. Stibnite has been mined.
Pioneer Gulch (19.4-19.45, 12.6)	B. 1139, p. 219	Au Placer		Considerable placer gold mined. Source is nearby and gold is associated with quartz, pyrite and arsenopyrite.
Prospect Creek (19.1-19.3) (11.4-11.5)	B. 1139, p. 219	Au, W, Pb, Bi, Cu (?) Lode		Bismuth occurring in quartz veins and copper were reported in 1947. Lead, in small amounts, is also found in the quartz veins. Scheelite occurs in commercial quantities. Claim staking in 1953.
Quartz Creek (14.95, 10.25) approx.	B. 1139, p. 219	Au		Little more than wages made on creek in 1903. Beds are of chlorite and graphitic schist.
Quartz Gulch (19.65, 10.6)	B. 1139, p. 219	Sb Lode	Widstedt	Ten foot tunnel exposed schist and quartz containing pyrite and arsenopyrite.
Red (20.1, 10.25)	B. 1139, p. 219	Au Lode		Several claims staked. Limestone and schist are found on the property.
Reinisch (19.45, 11.15)	B. 1139, p. 219	Au Lode		Free gold occurs in quartz stringers that cut black schist.
Rex (20.0, 10.25)	B. 1139, p. 219	Au Lode		Iron stained calcite bears gold.
Rock Creek (19.35-19.5) (11.0-11.25)	B. 1139, p. 219	Au, W, Pb, Sb Lode & Placer	Warren	Commercial amounts of scheelite occur in small, irregular quartz stringers, with some also being found in schist.
Rocker Gulch (19.95, 9.05)	B. 1139, p. 219	Au Placer	Ernst Alaska Gold Dredge Co.	Dredge operated just below frozen tundra in 1913. As of 1915, 36 acres were patented. Not of current interest.
Rocky Mountain Creek (20.8-21.05) (13.8-14.1)	B. 1139, p. 219	W Lode Sn Placer	Hugo Lindfors	Small amounts of placer cassiterite in area. Mined for a number of years, with operations ceasing about 1960.
Rulby Creek (16.5-16.75) (13.9-13.95)	B. 1139, p. 220	Au Placer		A small amount of gold was produced in 1908.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
St. Michael Creek (21.45-21.6) (9.95-10.0)	B. 1139, p. 220	Au Placer	Greenstone Mines, Inc., Osborne Creek Dredge Co.	Prospected in 1938.
Samson (Sampson) (20.3-20.5) (13.0-13.2)	Kardex 52-7	Au Placer		Claims staked in 1954. Color coded by DMM as of little interest at this time.
Saturday Creek (19.7, 9.9) approx.	B. 1139, p. 220	Au, W Placer	O'Neal, Solomon & MacIver	An 80 foot hole sunk in 1928. Placer derived entirely from concentration of coastal plain gravels. Production small. Claims staked in 1956.
Sledge Creek (18.75, 11.5)	B. 1139, p. 220	Au, W Placer	Cochrane & Rodine; Dakota-Alaska Mining Co.	Two deep placer mines in 1916.
Sliscovich (20.1, 13.7)	B. 1139, p. 220	Sb, Au, Ag Lode	Slisco	Stibnite reported in 1920. Antimony-quartz lodes with some gold have been mined. Lode is of dull, opaque quartz and stibnite with antimony predominating on the surface. Analyses show consistant antimony, gold and arsenic. Drifts, shafts and stopes done.
Snake River (19, 9)	B. 1139, p. 220	Au Placer	Alaska Mines Corp.; Center Creek Dredge Co.; Rowe	Basin contains some of the richest claims in the area. A beach deposit with both coarse and fine gold.
Snow Gulch (19.55-19.65) (10.75-10.85)	B. 1139, p. 220	Au, W Placer	Miocene Ditch Co.	Productive stream placers. Schist bedrock. Numerous faulting quartz veins. Near source, schist contains pyrite.
Sonora Creek (15.5-15.65) (9.9-10.2)	B. 1139, p. 220	Au Placer		Colors found. A little work done in 1901 but none since then.
Sophie Gulch (19.45-19.5, 11.15)	B. 1139, p. 220	W, Pb Lode & Placer	Sophie	Sluiced for scheelite content. Schist contains small quartz veins, antimony and sulphides. One placer and two lode claims on property.
Steep Creek (19.5-19.55) (13.4-13.55)	B. 1139, p. 220	Au Placer		Small gold producer. In addition to schists and limestone, a trace of magnetite occurs also.

NOME QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Steiner (17.4, 10.45)	B. 1139, p. 220	Au Placer		A shaft was sunk but is now buried. Quartz-feldspar veins cut the schist. No definite pay streak encountered. Poor assay results.
Stewart River (17.1-20.0) (14.15-15.05)	B. 1139, p. 220	Au (?) Placer		Two or three claims staked in 1908 but only a small amount of work was done.
Stipek & Kotovic (19.4-19.5) (11.0-11.1)	B. 1139, p. 221	Au, W Lode		Quartz vein in schist bears gold. Concentrates contain pyrite and arsenopyrite. Contact zone has more gold than the quartz.
Sunset Creek (SE 1/4, 18, 10)	B. 1139, p. 221	Au Placer	Thomas Gaffney; Alaska Sunset Mines Co.; Sunset Mines Corp.; USSR&M	Dredge operated in 1939 on the coastal plain and had a fairly good season. About 80 acres of area are patented.
Tomboy Creek (13.0-13.35) (14.3-14.35)	B. 1139, p. 221	Au Placer		Gold bearing gravels occur one mile above the mouth of the creek. Some mining has been done.
Tribly Creek (17.3, 12.0) approx.	B. 1139, p. 221	Au Placer		Yielded $5000 in 1908. Gold is probably derived from concentrated beach gravels.
Tub Mountain (16.9, 13.9) approx.	B. 1139, p. 221	Fe Lode		Limonite iron reported.
Twin Mountain Creek (18.7-18.9) (11.7-12.2)	B. 1139, p. 221	Au, W, Cu Lode	Cochrane & Rodine; Dakota-Alaska Mining Co.; Colconda; Ruby	Localized copper minerals are found in scattered quartz veins. Two small lenses of scheelite have been reported. Not of current interest.
Union Gulch (20.95, 11.1)	B. 1139, p. 221	Au Placer		Gravel deposit is 10-15 wide. Coarse, iron stained gold is found in the gravel on the beaches.
USSR&M (18.7-20.0) (9.2-12.18)	B. 1139, p. 221	Au Placer	(United States Smelting, Refining and Mining Co.); Hammon Consolidated Gold Fields; Pioneer Mining Co.	Three dredges operated with good profits on ancient beaches.
Washington Creek (15.55-15.65) (12.3-12.4)	B. 1139, p. 221	Au Placer		High beach gravels. Good prospects reported.
Washington Gulch (21.05-21.15) (9.5-9.7)	B. 1139, p. 221	Au Placer		Gold found in fine sand that rests on bedrock.

NOME QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Waterfall Creek (18.75, 13.1)	B. 1139, p. 221	Au Lode & Placer	Christophosen; Isabelle	Quartz veins cut chloritic schist. Copper, antimony and a trace of gold have been reported.
West (19.5, 10.7)	B. 1139, p. 222	Au Placer	Gold Bug; Golden Eagle	Bedrock is composed of a quartz-mica-chlorite schist. Hematitic material pans gold.
Willow Creek (16.6-16.7) (12.4-12.6)	B. 1139, p. 222	Zn, Pb Lode		Claims staked at the head of the creek in 1966. Is a tributary of the Cripple River.
Willow Creek (17.3-17.6) (10.65-11.2)	B. 1139, p. 222	Au, Sn Placer		An open cut mine in operation in 1914. Cassiterite reported in the concentrates.
Windy Creek (19.55, 17.2)	B. 1139, p. 222	Graphite Lode	Grand Central River	Graphite deposits of considerable size reported at the head of this creek. Pegmatic and/or granitic dikes crosscut graphitic schists.
Wonder Creek (19.65-19.75) (9.8) approx.	B. 1139, p. 222	Au Placer	Nome Consolidated Dredge Co.	One deep placer mine in 1916. One open cut mine also reported that same year. Gold bearing gravels. Large dredge operated on creek. Water supply problems.

NORTON BAY QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bonanza Creek (9.3-9.4) (9.65-9.85)	B. 1139, p. 222	Au, Sb, W Placer	Moon & Partner; Nelson; Ungalik Syndicate	Placer mining was successful although adequate water supplies were a problem. Slate and shale bedrock. Various claims throughout the creek.
Christmas Creek (10-11, 11-12)?	B. 1139, p. 222	Au (?) Placer		Several placer claims were staked but no mining was done.
Christmas Mountain (10.6-11.2) (9.7-10.2)	B. 1139, p. 222	Au (?), Sb Lode		Stibnite float was reported in 1947. Various claims have been staked. Only a trace amount of sulfide mineralization.
Garryowen Creek (10-11, 14-15)?	B. 1139, p. 222	Au Placer		Yielded gold color's and a trace amount of gold gravels are to be found but not enough to make mining profitable.
Hopeful Gulch (9, 9)	B. 1139, p. 222	Bi, W Placer		Bismuthinite is a common mineral in placer concentrates. Scheelite and wolframite occur in placers.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
June Creek (0, 15)?	B. 1139, p. 222	Au (?) Placer		Trace amount of gold was found in 1928, but not in profitable quantities.
Kenwood Creek (3.5-5.0) (16.7-17.55)?	B. 1139, p. 222	Au (?) Placer		Prospecting reported. Lack of water may have prevented serious consideration of the property.
Moon (12, 12)	B. 1139, p. 222	Sb Lode		Stibnite lode occurs in small veinlets and lenses in quartz veins.
Negromoon Creek (10, 15-17)?	B. 1139, p. 222	Au Placer		Gold bearing gravels were found but were not profitable to extract.
Ungalik River (8.8-9.5) (9.15-9.66)	B. 1139, p. 222	Au Placer	Shaw & Assoc.; Shaw & Cook; Ungalik Syndicate; Pat Bliss	A dredge operated in 1940. Greatest amount of placer gold for area recovered here. Currently being mined by dredge.

SOLOMON QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Adams Creek (3.85-4.05) (12.35-12.4)	B. 1139, p. 280	Au Placer	Kimball	A dredge operated in 1914. Creek yielded good returns in the early 1900's.
Adventures' Creek (3.2-3.3) (15.1-15.15)	B. 1139, p. 280	Au Placer		Economic placer ground reported. Some exploration work has been done.
Aggie Creek (13.2-13.8)	B. 1139, p. 280	Au Placer	Swanberg; Council Dredge Co.; Inland Dredge Co.; Bill Munz	Placers mined by dredge in 1940. Mined again in the 1950's.
Allgold Creek (4.05-4.1) (15.1-15.2)	B. 1139, p. 281	Au Placer		Good prospect pits were dug in 1908.
American Creek (3.4-4.35) (15.6-16.55)	B. 1139, p. 281	Au Placer	American Creek Dredge Co.; C. Herbert	A dredge was operated in 1940. Eight claims were staked on the right limit in 1963.
Auburn Ravine (3.5-3.85) (15.8-16.2)	B. 1139, p. 281	Au, Hg Placer		Placer mining difficult due to water problem. Gravels carry good amounts of gold.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Banner Creek (5.1-5.3) (14.35-14.5)	B. 1139, p. 281	Au Placer		Creek had a little work done on it in 1907. An adequate water supply is a problem. Has limestone bedrock with schist.
Barney Creek (2.1-2.2, 16.3)	B. 1139, p. 281	Au Placer	Bunny Creek	Some mining was done here. Adequate water is a problem. Magnetite is found in the concentrates.
Basin Creek (10.05-10.65) (15.9-16.0)	B. 1139, p. 281	Au Placer	Plume Dredge Co.; Melsing Creek Dredge	Dredge operated in 1907.
Bear Gulch (4.9, 11.95)	B. 1139, p. 281	Au (?) Placer		A large portion of this creek was worked in 1910.
Beaton Creek (6.45, 10.45-10.55)	B. 1139, p. 281	Au Placer		Gravels of local origin with schist and greenstone pebbles. Gold in clay layer resting on bedrock. Only a small amount of gold was taken.
Beaver Creek (0.85-1.65)	B. 1139, p. 281	Au Placer	Casa de Paga Gold Co.; Stewart	A dredge, moved here from Monument Creek, operated in 1940.
Ben Gulch (6.05, 16.75)	B. 1139, p. 281	Au Placer		Staked and a little work done on the gravels; had water problems.
Benson Creek (2.3-2.7) (15.95-16.0)	B. 1139, p. 281	Au, Cu Placer	Lulu Creek	A complex bedrock geology; limestone series and feldspathic schist. Placers were worked from 1900 to 1908 - gold was near source. A small amount of work was done on the creek in 1938.
Benson Gulch (10, 16)	B. 1139, p. 281	Au Placer		Open cut mine operated in 1933.
Big Four Creek (6.15-6.9) (14.65-15.95)	B. 1139, p. 281	Au Placer	Al Doyle	Assessment work done in 1906. Gold usually found in clay. Two drill holes in 1949.
Big Hurrah (5.75, 11.45)	B. 1139, p. 281	Au, Ag, W Lode	Hurrah; Quiggley; Lane Investment Co.	Small amounts of scheelite reported in the quartz veins. The gold, in quartz, located on the bench. Country rock is hard schist with quartz crosscuts in it. Trace amounts of silver reported.
Big Hurrah Creek (5.15-6.05) (11.3-11.5)	B. 1139, p. 282	Au, Ag, W, Sb Lode & Placer	Burness-Iverson-Johnson; Flodin Gold Mining & Dredge Co.; Margraf & Kowalski; Haney Mining	Trace amounts of silver and gold from a mine upstream. Low dipping schists and limestone. Stibnite lens reported. Trenching, sampling and shaft

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Big Hurrah Creek, cont.			Co.; Iverson & Johnson; Ignacy Kawalski	sinking 1964-66.
Birch Creek (6.45, 14.6)	B. 1139, p. 282	Au Placer		Two camps worked gravels in 1907.
Bobs Creek (1.3-2.0, 16.1)	B. 1139, p. 282	Au Placer		Small amount of work done in 1906 and 1907. Frozen ground. Concentrates show large amounts of magnetite and garnet. Gold is fine.
Bonanza Creek (5.7-6.5) (16.5-16.85)	B. 1139, p. 282	Au Placer		Small amount of work done in 1906.
Boulder Creek (4.45-4.55) (15.05-15.2)	B. 1139, p. 282	Au Placer		Two feet of gravel on bedrock, of which the lower 18 inches carry gold. Some work was done in 1907. Schist bedrock.
Brookins (NE 1/4 7, 15)?	B. 1139, p. 282	Sb Lode		Small discontinuous stibnite lens in contorted mica schist. Some development work done in 1943.
Bunker Hill (9.4, 10.6)	B. 1139, p. 282	Au, Cu Lode		Copper reported. Small amount of work was done on the metalliferous quartz vein which lies at or close to the limestone-schist contact.
Butte Creek (4.95-5.1) (12.5-12.55)	B. 1139, p. 282	Au Placer		Creek placers mined. Schist is found in the lower portion of the well worked deposits, with limestone in the middle portion and schist again in the upper.
Butte Creek, South Fork (4.95-5.0) (12.4-12.5)	B. 1139, p. 282	Au Placer		Pronounced benches on property. Only a slight amount of gold taken from them; rest is in the creek.
Cashe Creek (6.2, 0.2)	Kardex S3-255	Au (?) Placer	J. Columbus & Casmir Cechowski	Sixteen claims staked on creek and west of Topkok head in 1967.
Cahill Creek (4.1, 14.35-14.45)	B. 1139, p. 282	Au Placer		Benches at the mouth contain a good amount of gold. Has a water supply problem.
California Creek (8.05-8.35) (10.9-11.1)	B. 1139, p. 283	Au Placer	Mahan & Slack	Dredge operated in 1940. Some gold was also recovered in 1938.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Camp Creek (7.5-8.0) (15.0-16.45)	B. 1139, p. 283	Au Placer	Al Doyle & Barney Crosby; Camp Creek Dredge Co.; Council Dredge Co.; Uplift Mining Co.; Niukluk Mining Co.	Productive placer in 1911. Several claims were worked in 1904. Dredged in 1949 and 1950.
Canyon Creek (trib. Casa de Paga River) (4.1-5.05) (15.0-15.05)	B. 1139, p. 283	Au Placer	Canyon Creek Gold Mining Co.; Flodin Gold Mining & Dredge Co.; Moody Mining Co.	Bench shows good colors but has been only slightly prospected. Lower portion not productive.
Canyon Creek (trib. Iron Creek) (1.3-2.15) (14.85-15.7)	B. 1139, p. 283	Au Placer		Top is schists, middle is slates and limestone. Gold is good in limestone. There were no workable deposits in 1908.
Cape Darby (16.7, 7.25)	B. 1139, p. 283	W		Allanite, hematite, monazite, sphene and zircon are present in the area.
Carson Creek (18.5, 9.4)	B. 1139, p. 283	Cu Lode		Small irregular, discontinuous copper bodies were found. The copper is mainly in carbonate form.
Casa de Paga River (3.55-6.4) (13.35-16.25)	B. 1139, p. 283	Au Placer	Casa de Paga Gold Co.; Casa Gold Mines Co.; Casa de Paga Mining Co.; Connor, Erichinger & Hanot; Peck; Ruby Dredge Co.	Some dredging was done but poor returns reported.
Chickamin Gulch (2.5-2.55) (15.35-15.45)	B. 1139, p. 283	Au Placer		A bench deposit. Gravels at end of a limestone cliff. Little prospecting had been done as of 1908.
Chukajak Creek (21.3-22.25) (16.5-17.9)	B. 1139, p. 283	Au Placer		Trace amounts of gold were reported in 1899-1900, but they were not profitable.
Clear Creek (20.7, 15.7)	B. 1139, p. 283	Sn, W Lode		
Coca Cola Creek (8, 11)?	B. 1139, p. 283	Au Placer		Small amount of placer gold was recovered. Little prospecting was done.
Consolidated (9.35-9.6) (10.0-10.3)?	B. 1139, p. 284	Au Lode		Some work was done on a group of claims.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Dane Creek (0.6-0.65) (15.75-15.95)	B. 1139, p. 284	Au Placer		Thin gravels. Little work has been done here.
Daniels Creek (9.35-9.6) (10.0-10.3)	B. 1139, p. 284	Au, Hg, W Placer	Alaska Homestake Gold Mine Co.; Black Chief Mining Co.; Bluff; Consolidated; Eskimo; Esquimeaut; Hunter & Walker; Idaho; Labay & Meegan; Sea Gull; Megan, Megan & Somerville; Sullivan Mining Co. (Crabtree et al); Sullivan, Ryan et al; Topkok Chief Mining Co.; Topkok Ditch Co.; Murane Associates; Martin Dredging Co.	Cinnabar in placer concentrates. Rich gold deposit exploited by Topkok Ditch Co. in 1904. Gold of local origin; alluvium bears much of the gold. Mined offshore by dragline in the winter. Under water mining in 1966.
Darby Mountains (17.18, 14-17)	B. 1139, p. 284	Sn (?)		
Dawson Creek or Gulch (6.05-6.15) (16.05-16.1)	B. 1139, p. 284	Au Placer		Fine gold in mica schist. Most of the gold derived from the beach gravels of the area.
Discovery Creek (2.2-2.25) (15.2-15.6)	B. 1139, p. 284	Au Placer		Gold found in small deposits only. Steam scraper used at one time in mining operations.
Dividend Creek (3.2-3.25 (14.9-15.05)	B. 1139, p. 284	Au Placer		Economically profitable placer. Ground discovered in 1908 and has had a good deal of work done on it.
Dixon Creek (5.75-5.85) (15.65-15.9)	B. 1139, p. 284	Au Placer		Some development work has been done.
Dome Creek, Left Fork (2.4-2.75) (15.5-15.65)	B. 1139, p. 284	Au, Cu Lode & Placer	Iron Creek, Left Fork; May Bale; Hugo Lindfors	Good placer ground is in the lower part of the valley. Pay streak is irregular. Two 20 foot cuts made in 1920 exposed a little quartz, malachite ore and some sulfide also. Two claims were staked in 1967.
Dry Creek (5.75-5.8) (15.55-15.6)	B. 1139, p. 284	Au Placer	Neal Foster	Gold is not in bedrock but on terrace gravels and is usually concentrated on clay seams. Two claims were staked here in 1966.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Dutch Creek or Gulch (10.05-10.7) (17.1-17.55)	B. 1139, p. 284	Au Placer	Wild Goose Mining & Trading Co.; Christenson	One open cut operation. Small amount of work done in 1905. Some drilling done in 1938 or 39.
Easy Creek (2.3-2.45, 16.15)	B. 1139, p. 284	Au Placer		Good values in the lower portion of the creek. Work was done in the summer of 1909.
El Patron Creek (1.7-1.8) (15.1-15.15)	B. 1139, p. 284	Au Placer		A little gold was produced here in 1906. Placer was located near contact of limestone and schist. Gold coarse, rounded and bright. Magnetite and ilmenite present in the concentrates.
Eldorado Creek (9.0-9.3) (10.1-10.4)	B. 1139, p. 285	Au, Hg Placer		Water is a problem. Sluicing done on half a dozen claims in 1908.
Eldorado River (0.5, 13.8)	B. 1139, p. 285	Au Placer		No profitable yield of gold although some work was done in 1908.
Elkhorn Creek (7.3-7.9) (16.15-16.45)	B. 1139, p. 285	Au Placer	Elkhorn; Doyle; G & O Dredge Co.; ORO Dredge Co.; Hugo Lindfors; Henry Cramer; May Bale	Patchy pay streak. Medium coarse gold; quartz is attached to gold. Some desultory work done. Two claims staked in 1967.
Etchepuk River (NE 1/4 quad.)	B. 1139, p. 285	Mica Lode		Pegmatitic dikes contain mica of exceptional size.
Fish River (12.6, 15.5)	B. 1139, p. 285	Ag, Pb, Hg Lode		Arsenic and lead lode which has been worked off and on. Cinnabar is also present.
Fish River (13.2, 16.0)	B. 1139, p. 285	Au Placer	Dent	Prospecting and drilling done in 1937. It is not workable placer ground.
Flynn (5.4, 11.65)	B. 1139, p. 285	Au Lode		Arsenopyrite occurs in green chloritic rock. Gold in quartz vein. Considerable work done in 1920.
Fox Creek (5.3, 12.85)	B. 1139, p. 285	Au Placer		Small amount of work done in 1907. Pay gravels upstream from limestone. Never a rich creek. Water is a problem. Most of the gold is found at the limestone-schist contact.
Fox River (8.9, 13.65)	B. 1139, p. 285	Au Placer		Bedrock primarily schist and greenstones with contacts of limestone. Small amount of work done in 1906.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Game Creek (4.35-4.4) (16.4-16.5)	B. 1139, p. 285	Au Placer	Gem Creek; Rolando; Bookwalter	Dredge operated in 1940. Claim staked and some work accomplished in 1964.
Gold Moon Gulch (5.15-5.3) (15.7-15.85)	B. 1139, p. 285	Au Placer		Most of the gold to be found at the limestone-schist contact. Mining difficult and production slight. Source veins in country rock nearby.
Goldbottom Creek (7.9-8.9) (16.5-17.3)	B. 1139, p. 286	Au, W Placer	Alaska Gold Dredge Co.	Dredge operated in 1911, below the confluence of Warm Creek and Goldbottom Creek.
Golovnin Bay (15.7, 9.55)	B. 1139, p. 286	W Placer		Some tungsten minerals are associated with granite in the area.
Goose Creek (4.75-5.45) (15.3-15.5)	B. 1139, p. 286	Au Placer	Goldbottom Dredge Co.; Nome Montana & New Mexico Consolidated Mining Co.; Adams & Edlin; Adams & WIK	One dredge operated in 1918. Yielded good returns. Creek has marked benches. Schist bedrock with some limestone. Water supply is a problem.
Guy Creek (9.55-9.9) (17.45-17.55)	B. 1139, p. 286	Au (?) Placer		Bedrock is primarily limestone with some schist. There was little production as of 1920.
Hardluck Creek (2.65-2.8) (15.4-15.5)	B. 1139, p. 286	Au Placer		Schists and greenstones were not profitable. Placers were developed in 1920.
Hilliard Creek (NW 1/4 2, 15)	B. 1139, p. 286	Au Placer		Limestone bedrock with greenstone. Deposits are irregular.
Independence Creek (2.55-2.65) (15.1-15.2)	B. 1139, p. 286	Au Placer		A little work was done in 1908, but developments did not warrant continuation of work.
Iron Creek (2.15-3.2) (15.05-17.05)	B. 1139, p. 286	Au, Cu, Hg Placer	Dome Creek; Scott; Telegram Creek; Telegraph Creek	Economically important stream in 1908. Colors plentiful near the surface along the lower part of the creek. Profit appears possible only by handling large amounts of ground at low cost. One dredge operated in 1940.
IXL Gulch (8.9, 13.75)	B. 1139, p. 286	Au Placer	Al Doyle	Some mining done in 1906. Considerable prospecting done. Water is a problem. Some drilling in 1938.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Jerome Creek (4.15-4.7) (10.55-10.95)	B. 1139, p. 286	Au Placer		Open cut mine in 1934. Some development work done in early 1900. Coastal plain placer gold not profitable.
John's Creek (4.5-5.1) (12.95-13.0)	B. 1139, p. 287	Au Placer		Water is a problem. Schist bedrock and little gold.
Kasson Creek (4.35-4.55) (12.1-12.2)	B. 1139, p. 287	Au Placer		Open cut mine in 1934. Limestone bedrock. Gold sediment on limestone. Pay streak in creek channel and is 16-100 feet wide. Water is a problem.
Koyana Creek (10.05-10.1) (10.0-10.05)	B. 1139, p. 287	Au, Hg Placer	Hanson; Hill; Lylles; Gene Farland	Cinnabar is a common constituent of placer concentrates. Gold reported in 1908. Shallow deposits which proved to be not very rich. Activity in area in 1963-65.
Kwiniuk River (SE 1/4, NE 1/4 quad.)	B. 1139, p. 287	Cu, W, Hg (?) Placer		Placer cinnabar reported in 1947.
Last Chance Creek (3.25-3.4) (15.4-15.6)	B. 1139, p. 287	Au, Cu (?) Lode		Shafts sunk on quartz outcrops in limestone and schist. Little sulphide mineralization adjacent to the vein. Trace amounts of copper.
Lightning Creek (5.76, 15.5)	B. 1139, p. 287	Au Placer		Some prospecting but no mining in 1907. Gold appears to be from old bench gravels.
Linda Vista Creek (5.5, 11.45)	B. 1139, p. 287	Au (?) Lode		Possible metallic mineralization in quartz vein. Quite a lot of limonite stain. Faulted twice. No reports of gold in area.
Lion Creek (6.05, 11.15-11.3)	B. 1139, p. 287	Au Placer		Gravels four feet thick. Prospect tunnels driven but no profitable pay streaks found.
Little Anvil Creek (8.55-8.7) (10.05-10.55)	B. 1139, p. 287	Au Placer	Jenks; Silver Bow Creek	Gold found in 1907. Some work done.
Lower Willow Creek (3.4-4.95) (14.2-14.65)	B. 1139, p. 287	Au Placer	Casa de Paga Gold Dredge Co.; Casa de Paga River, Left Fork; Alaska Gold Dredge Co.; Willow Creek (trib. of Casa de Paga River); Willow Dredge Co.	Two men workd all summer in 1906. Water was a problem. Bedrock is composed of limestone and graphic and chloritic schist. Gold derived from a nearby source. Mineralization occurs at contacts. Some sulphides present. Creek has been dredged.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Manila Creek (4.5, 10.25)	B. 1139, p. 287	Au Placer		Some development work in the early 1900's. Coastal plain placer gold. Not profitable.
Meddler Gulch (4.85, 11.9)	B. 1139, p. 287	Au (?) Placer		Exploited and a large part of the gravels worked. Water was a problem. Placer probably was not profitable.
Melsing Creek (10.0-10.5) (15.75-16.7)	B. 1139, p. 288	Au Placer	Flume Dredge Co.; Glass Dredging Co.; Kimball; Kimball & Saupe; Libby, Melsing, Mordaunt & Blake	Gold in paying quantities. Placers confined to the creek bed and lower terrace. Gold found in gravel near clay seams. Pay found in lower part of gravel. Dredged up to claim 27 above discovery.
Moonlight Creek (4.1-4.15) (13.65-13.7)	B. 1139, p. 288	Au Placer		One open cut mine in 1916.
Moonlight Divide (4.15, 14.0)	B. 1139, p. 288	Cu Lode		Copper prospects reported near the limestone-schist contact at the divide. A shallow prospect pit sunk and larger stringers staked.
Moran Gulch (4.7, 10.8)	B. 1139, p. 288	Au Placer		Open cut mine in 1933. Bench gravels hydrauliced in 1908.
Mount Dixon (5.7, 16.15)	B. 1139, p. 288	Cu Lode		Copper prospects located near the limestone-schist contact.
Mud Creek (NE 1/4 10, 15)	B. 1139, p. 288	Au Placer		One claim worked in 1903. Gold found in 3-4 feet gravel over mica schist. A poor paying property.
Mulligan Creek (0.75-1.35) (12.0-12.45)	B. 1139, p. 288	Au Placer		Some mining reported.
Mystery Creek (trib. Niukluk River) (10.65-11.0) (15.5-15.7)	B. 1139, p. 288	Au Placer	DeSoto Mining Co.	Dredge idle in 1915.
Mystery Creek (trib. Shovel Creek) (4.0-4.45) (11.3-11.5)	B. 1139, p. 288	Au Placer	Lubbe; Star Dredge Co.	Most of the gold comes from the benches. Can be worked in the winter.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Niukluk River (7.8-10.55) (15.1-16.45)	B. 1139, p. 288	Au Placer	Alaska Placer Co.; Council Dredge Co.; Elkhorn; North Star Dredge Co.; Northern Light Mining Co.; Uplift Mining Co.· Steve Pederson; Newbauer	Flood plain mined. Dredge operated in 1940. Producing placers in 1908. Gold to be found on both the river bars and gravel plains. Stripping, bulldozing and ditching in 1963.
No Man Creek (6.15, 16.05)	B. 1139, p. 288	Au Placer		One man worked here in 1907. Small production.
Nugget Creek (trib. American Creek) (3.1-3.4) (15.7-15.95)	B. 1139, p. 289	Au Placer		Some prospecting done in 1908.
Nugget Creek (trib. Solomon River) (5.3-5.4) (13.5-13.6)	B. 1139, p. 289	Au Placer		Poor yield.
Ophir Creek (9.35-10.05) (16.15-17.6)	B. 1139, p. 289	Au Placer	Boyd; Jack LaCross; Chester Milligan; Alaska Placer Co.; Blue Goose Mining Co.; Flume Dredge Co.; Kimball & Saupe; North Star Dredging Co.; Tom Shaw; Northern Light Mining Co.; Ophir Gold Dredge Co.; Sourdough Mining Co.; Steve Pederson	Most important gold paying stream in the precinct; said to be the longest unbroken paystreak in the world. The entire stream had been prospected by 1903. Much of it has been dredged, and some of it has been dredged several times. There is still some activity on Ophir. The quartz carries gold and arsenic. A very rich producer - in the early 1900's, a three-week period produced clean-ups worth approximately $25,000.
Oversight Creek (3.2-3.3) (15.0-15.05)	B. 1139, p. 289	Au Placer		Placer gold economically profitable but by 1908 the gravels had been fairly well worked out.
Penelope Creek (5.55-5.65) (14.9-15.35)	B. 1139, p. 289	Au Placer		A deep (57 feet) gravel deposit. Records indicate that only the lower part of the creek is productive.
Penny Creek (trib. Iron Creek) (3.1-3.25) (15.2-15.25)	B. 1139, p. 289	Au Placer		Gold placers were profitable but by 1908 had been fairly well worked out.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Penny Creek (trib. Solomon River) (4.7-4.85) (11.2-11.6)	B. 1139, p. 289	Au Placer	Herk Edwards	An open cut mine in 1934. Clay is usually found between the limestone bedrock and the pay streak. An adequate water supply presents mining problems. In 1958 dragline mining was in operation on creek.
Post Creek (S 1/2 7, 17)	B. 1139, p. 289	Au Lode		Lode was found in 1906. Quartz gangue occurs at the limestone-schist contact which is eight feet wide. There is considerable free gold.
Problem Gulch (4.0-4.1) (11.3-11.35)	B. 1139, p. 289	Au Placer		Gold is found in eight feet of gravel on decomposed schist bedrock. One open cut mine in 1916.
Puckmummie Creek (6.95-7.0) (16.7-16.75)	B. 1139, p. 289	Au Placer		Upper part of creek was prospected; no pay.
Puzzle Gulch (4.15-4.2) (11.35-11.5)	B. 1139, p. 290	Au Placer		Most of the gravel is from benches. The gold is coarse and associated with quartz.
Quartz Creek (trib. Casa de Paga River) (5.0-5.2) (15.5-15.85)	B. 1139, p. 290	Au Placer		There was some yield in 1899. Most of the gold is in clay material above bedrock.
Quartz Creek (trib. Solomon River) (5.1, 11.25-11.35)	B. 1139, p. 290	Au Placer		The east part is bedrock limestone and the west part is schist. The gravels are thin and most of the values are within the bedrock. Gold is from a nearby source. Mining is limited to the mouth and benches.
Quiggley (trib. Big Hurrah Creek) (5.4, 11.5)	B. 1139, p. 290	Sb Lode	Gray Eagle; Last Chance Creek	Stibnite lens was reported in 1947.
Rabbit Creek (east of Solomon) (4.95, 10.95)	B. 1139, p. 290	Au Placer		Two holes were sunk in 1910. Values occur in sand under gravels; some gold is iron stained.
Rabbit Creek (trib. Iron Creek) (2.15-2.2) (15.8-15.85)	B. 1139, p. 290	Au Placer		Ground staked but little mining done. Gold is fine, flaky and not abundant.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Rapid Creek (2.1-2.15, 15.75)	B. 1139, p. 290	Au Placer		Assessment work was done in 1906. Creek was completely staked.
Ready Bullion Creek (3.1, 5.1-5.2)	B. 1139, p. 290	Au Placer		There was economically profitable placer ground found. A great deal of work was done before 1908 and the creek appears to be worked out.
Righter Creek (Richter) (9.0-9.05) (16.15-16.3)	B. 1139, p. 290	Au Placer		Never mined. Reported that there was nothing on the creek but it may have been peddled as a promotion deal.
Ridgeway Creek (4.3-4.45) (14.1-14.3)	B. 1139, p. 290	Au Placer		Water supply presented problems. The creek was known to carry gold.
Rock Creek (trib. Aggie Creek) (13, 15)	B. 1139, p. 290	Au Placer	Fred Durosher; Bill Munz	Trace amount of gold was reported and worked on by one man in 1930. No money above Rock Creek on Aggie Creek.
Rock Creek (Iron Creek District) (0.9-1.1) (15.55-15.9)	B. 1139, p. 290	Au Placer		Placer mining had been carried on in 1908. Gold was found near the limestone-schist contact.
Rock Creek (trib. Solomon River) (4.65-4.8) (10.45-10.55)	B. 1139, p. 290	Au Placer		Some mining was done in 1903. The gold was probably from coastal plain gravels.
Rocky Creek (2.1-2.15) (15.75-15.8)	B. 1139, p. 290	Au Placer		Profitabel gravels worked by 1908.
Rover Creek (4.8, 13.3-13.95)	B. 1139, p. 290	Au Placer		Production was small. In the upper part of the creek the gravels are iron stained.
Ruby Creek (5.0-5.5) (14.0-14.3)	B. 1139, p. 290	Au Placer	Vern Dempsey; Ruby Dredge Co.	Prospecting and some work was done in 1934. The gold was fairly well distributed and was coarse and dark. Some mining by dredge was done in the late 1940's.
Ryan Creek (8.9, 10.1-10.2)	B. 1139, p. 290	Au Placer		There is a shallow deposit which is not too rich. Some water problems.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
San Jose Creek (0.3-0.8) (12.9-13.1)	B. 1139; p. 290	Au Placer		In 1900 some mining was reported but it appears to have been unprofitable.
Sapphire Gulch (4.8, 11.85)	B. 1139, p. 291	Au (?) Placer		Prospected and some gravels were worked but did not prove profitable.
Sherrette Creek (2.8, 15.85)	B. 1139, p. 291	Cu Lode		A pit and shaft were driven. Ore occurred in five foot wide mineralized zone in schist.
Sherrette Creek (3.0-3.2) (16.5-16.55)	B. 1139, p. 291	Au Placer		A dredge was planned in 1939. Some prospecting was done in the lower part of the creek in 1908.
Shoal Creek (3.0-3.15) (15.2-15.4)	B. 1139, p. 291	Au Placer		Economical gold gravels fairly well worked by 1908.
Shovel Creek (4.25-4.6) (11.2-12.2)	B. 1139, p. 291	Au Placer	Kimball; Nulen, Hultberg et al; Shovel Creek Dredge Co.; Lee; Shovel Creek Mining Co.	Flood plain deposits. Thin gold gravels with heavy overburden. Pay streak was 200 feet wide. Dredge was planned for 1939.
Sidney Creek (2.25-2.35) (15.8-15.85)	B. 1139, p. 291	Au Placer		Ground was staked in 1908 and some mining was done.
Silver (5.7, 12.0)?	B. 1139, p. 291	Au, W Lode		There was a small amount of scheelite in quartz veins reported.
Slate Creek (1.1-1.25) (15.6-16.05)	B. 1139, p. 291	Au Placer	OSMUN, Gunner Bowman	Small amounts of gold were obtained. Gravels were profitable but worked out fairly rapidly.
Snowball Creek (10.3-10.4) (17.45-17.6)	B. 1139, p. 291	Au Placer		Bench deposits reported but little was done as of 1908.
Solomon River (4.6-5.35) (10.3-13.55)	B. 1139, p. 291	Au, W Placer	Coal Creek Dredge; Eskimo Gold Dredge Co.; Eskimo Gold Mine Co.; Esquimo Dredge Co.; Flower; Esterbrook; Flodin Gold Mining & Dredge Co.; Goldsnif Dredge Co.; Kimball; Lee Bros. Dredge Co.;	Two dredges operated in 1905 and many dredges in operation by 1919.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Solomon River, cont.			Loman Reindeer & Trading Co.; Newburg & Flower; Nome Montana & New Mexico Consolidated Mining Co.; Scott-Newburg; Seward Dredge Co.; Sievertsen & Johnson; Sivertsen & Johnson Mining & Dredge Co.; Solomon Dredge Co.; Soloman River Dredge Co.; Nylan; Soloman Valley Dredge Co.; Three Friends Mining Co.	
Spruce Creek (east of Solomon) (6.4-6.55) (10.4-10.5)	B. 1139, p. 292	Au Placer	Cashe Creek; Talbert Scott; Fred & Billy Jones; Spruce Creek Dredge Co.	Three dredges were used and a large amount of gold was recovered. The majority of the gold was found at the mouth with a little being found upstream.
Spruce Creek (trib. Casa de Paga River) (5.85-5.9) (15.45-15.6)	B. 1139, p. 292	Au, Cu Lode		Copper prospects were reported in 1947. Ice was a problem in mining.
Sunshine Creek (4.75-4.8) (15.0-15.1)	B. 1139, p. 292	Au Placer		Prospecting and some mining was done in 1934. Gold found in rusty beach gravels which were overlain by tundra.
Swede Creek (9.8, 10.0)	B. 1139, p. 292	Au, Hg Lode & Placer	Alaska Mercury Corp.; Swede Creek Mining Co.	Cinnabar lode was prospected. Two tunnels and a few shafts were sunk. Cinnabar occurs in limestone beds. In 1947 the deposit had not been fully sampled. Gold was found but water was a problem in mining.
Sweetcake Creek (9.3-9.45) (16.3-16.8)	B. 1139, p. 292	Au Placer	Bill Brookins	Pay streak found in narrow strip along creek bed, with gold occurring in a layer of angular pebbles derived from the quartz and calcite bedrock. This is the discovery claim for Ophir Creek.
Thorpe Creek (5.85- 5.95) (15.6-15.65)	B. 1139, p. 292	Au Placer		Some mining was done in early 1900. Fine gold is associated with quartz and magnetite but the tenor of the ground is low.
Tubutulik River (21.4, 15.3)	B. 1139, p. 293	Au Placer		A little mining was done in the early 1900's. One dredged was operated in 1918.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Uncle Sam Mountains (5.5, 10.85-10.9)	B. 1139, p. 293	Au (?) Lode		A shaft was sunk on the quartz vein. No sulfides present but there is a trace of limonite. Veins cut black slaty schist.
Venetia Creek (1.1-1.5) (13.9-14.55)	B. 1139, p. 293	Au Placer	Charlie Jones	Gold was mined on creek from 1900 to 1908 but production was low. Bedrock is composed of limestone and schist. Placers are found on the broad flood plains.
Walla Walla Creek (19.0, 11.0)	B. 1139, p. 293	Au Lode		Small amount of prospecting in 1911. Lode occurs east of the contact of igneous rocks and black quartzitic slates. Not enough mineralization present to warrent further work.
Warm Creek (8.1-8.8) (16.7-17.1)	B. 1139, p. 293	Au, Ag, W Placer	Alaska Gold Dredge Co.; Garrot & Overbaugh; Garrot & Pfaffle; Warm Creek Dredge Co.	Placers on creek bed and flood plains.
West Creek (3.75-4.3) (11.8-12.0)	B. 1139, p. 293	Au Lode & Placer	Alden; Fred Cook	An open cut mine in 1934. It had sulfide veins of copper, iron, arsenic and antimony in chlorite schist. Gold was associated with sulphides with placer gold occurring on the creek also.
Wheeler (Iron Creek) (W 1/2 2, 16)	B. 1139, p. 293	Cu Lode		Copper claims with two tunnels, one 60 feet and the other 80 feet. Head of a group of tributaries. Chalcopyrite and bornite are both present in small quantities.
Wheeler (Kruzgampa River) (2.6-2.7) (17.15-17.2)	B. 1139, p. 293	Pb, Ag, Zn Lode	Pilgrim River	Galena is associated with gold minerals. Two galena kidneys are in schistose limestone. Shalerite and pyrite are also present.
Wheeler (Sherrette Creek) (2.7, 15.95)	B. 1139, p. 293	Cu, Au, Ag Lode		Copper lodes were prospected along limestone-schist contact.
Willow Creek (1.4-1.5) (15.8-16.15)	B. 1139, p. 293	Au Placer		Limestone and quartz schist bedrock. Gravels of benches and streams carried gold. Small amount of gold taken.
Wilson Creek (3.8-3.9) (14.3-14.55)	B. 1139, p. 293	Au Placer		Benches present at a low elevation. The pay streak is partially due to reconcentration of higher level deposits.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Winnebago Creek (5.15, 12.3)	B. 1139, p. 293	Au Placer		A two-horse scraper was used in 1907. Gravels on west bank and above stream level. Appear to be flood plain gravels.
--- (5.65, 11.6)	B. 1139, p. 293	Au, Cu Lode		Copper was reported and considerable prospecting was done on slate country rocks and quartz veins. Pyrite and phyrhotite are the main ore minerals.
SHUNGNAK QUADRANGLE				
California Creek (15.95-16.6) (17.25-17.75)	B. 1139, p. 267	Au, Asbestos, Jade, Quartz Placer	Ferguson & Son; Lammers & Assoc.	Dredging, construction of camp and airstrip.
Lynx Creek (15.7-16.2) (17.25-17.5)	B. 1139, p. 267	Au Placer		Small scale placer.
SURVEY PASS QUADRANGLE				
Alatna River (13.5-18.7) (0.4-9.2)	B. 1139, p. 296	Au Placer	Allen River; Arctic Prospecting & Development Co.; Sam Dubin; Al West; Frank Tyson; "Red" Cabelle	Prospecting activity in 1898. Small amounts of gold were found and boom camps of Beaver and Rapid City sprang up. By 1901 only a few prospectors were left on the river.
Copper King (7-8, 10)?	B. 1139, p. 297	Au, Cu Lode	Copper Queen; Gray Eagle; Iowa; Ground Hog; Lucky Six; Silver King; Mammoth	One of several veins. About half the gold veins in a six to seven mile belt have a width of approximately 75 feet with a minimum width of 10 feet. Ore is essentially iron pyrite and quartz with chalcopyrite and some traces of bornite and malachite. Three veins were reported to carry $40 to $90 per ton in gold. USGS assays on three specimens are less than 0.1 oz. per ton.
Helpmejack Creek (14.5-16.5) (0.3-2.3)	B. 1139, p. 297	Au		
Kugrak River (2.2, 8.8-8.9)	Kardex 29-1	Au Lode		North of Blacky Creek and ten miles south of the Noatak River. No published information available.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Lucky Six Creek (6.85-7.8) (9.6-10.9)	B. 1139, p. 297	Au, Ag, Graphite Placer		Gold discovered in 1898. Region is inaccessible and lacks timber. Coarse gold occurs in cracks and crevices of the creek bedrock. Only a few ounces of gold were produced. Specimens of quartz containing chalcopyrite, stibnite, bornite and malachite were collected in the early 1900's from this area. Reports of assays show from $2 to $90 of gold per ton. Little work was done on the claims staked.
Mauneluk River (SW 1/4 quad.)	B. 1139, p. 297	Ag		Silver ore is reported to have been found on the north side of the Kobuk-Noatak divide between the Reed and Manuneluk River portages.
Mecklenberg (19.8-20.5) (2.0-2.5)	B. 1139, p. 297	Au Placer	Mettenpherg Creek	Prospector reported fine colors in creek gravel lying on schist bedrock. Prospect not visited by the USGS.
Pingaluk River (14.7-17.5) (8.5-13.0)	B. 1139, p. 297	Au (?) Placer		Prospecting reported to have been done in this region.
Reed River (7-8, 0-3)	B. 1139, p. 297	Au (?) Placer		Three men reported to have prospected in this area in 1929-30. No results are available.
Walker Lake (9.5-12.01) (1.0-4.0)	B. 1139, p. 297	Au (?) Placer	Arctic Prospecting & Development Co.	Prospectors in the area in 1928. Five prospectors in the area in 1938. No results known.

TANANA QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
American Creek (13, 1)	B. 1139, p. 306	Au, Cr Placer	American Creek Dredge Co.; American Creek Mining Co.; American Creek Operating Co.; Hillside Assn.; Quam; Wild Goose Assn.	Discovery, 1911. Scraper plant was used. Gravel is 12 to 15 feet deep. A dredge operated in 1917. $700,000 in gold recovered by 1934. Currently, there is small scale activity on the creek.
American Gulch (0.55, 4.95)?	B. 1139, p. 306	Au Placer		Open cut made in 1917. Gravel 10 to 12 feet deep. Reported tenor as high as $1 per square foot of bedrock.
Barrett (16.75, 0.9)	B. 1139, p. 306	Au, Ag, Pb, Co, Cu, Ni (?)		

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bear Creek (12.75-14.6) (6.6-7.55)	B. 1139, p. 306	Au Placer		Some placer gold produced in 1935. Concentrates contain magnetite, cassiterite and ilmenite. It is postulated that conditions of mineralization here may be similar to those of the Tofty area.
Big Denver Creek (16, 1)?	B. 1139, p. 306	Au (?)		Second mineralized zone north of the Barrett cobalt deposit. Zone said to extend 3000 feet. Type of mineralization present is unknown.
Bonanza Creek (12.05-12.3) (5.85-6.3)	B. 1139, p. 307	Sn, Au Placer	Vogt	
Boothby Creek (20.8, 3.95)	B. 1139, p. 307	Au Placer	Strandberg Mines	Currently active.
Boulder Creek (Big Boulder Creek) (14.0-14.7) (2.6-2.75)	B. 1139, p. 307	Au, Cr, Mz Lode & Placer	Louis Anderson; Dan Cobin; C. Dart; Farrell; L. Heiner; Higgens; Howell & Cleveland; Fred Lund; Mathoone; Nurstees; E. Wolff; Marco	Hydraulic plant used in 1931. Benches known to be mineralized. One property to be mined in the summer of 1968; two others being intensively prospected. Rockers were used on the benches in the 1920's, 30's and 40's.
Cache Creek (15.9-16.15) (1.8-2.2)	B. 1139, p. 307	Au, Ag, Sn, Cr Lode & Placer	Benson; Lincoln Quartz Nos. 1 and 2; McGee; McLaughlin; Strandberg Mines	Discovered in 1901. About 40 feet of overburden and ten feet of gravel. Gold in birdshot sized pebbles to very fine flakes. Currently being mined.
California Creek (18.95-19.65) (3.85-4.5)	B. 1139, p. 307	Au Placer		Small producing camps on this creek in 1932.
Chapman Creek (20.9-21.05, 6.15)	B. 1139, p. 307	Au Lode (?) & Placer		Anomaly discovered here in 1966 by DMM.
Chicago Creek (19.35, 3.35)	B. 1139, p. 307	Au Placer	Erickson	Discovered in 1904. Indications of gold at the mouth of the creek.
Colorado Creek (13, 1)	B. 1139, p. 307	Au Placer (?)		In 1937 there were several one-man camps on the creek.
Columbe Creek (1, 6)	B. 1139, p. 307	Au Placer		Creek said to have yielded wages by shovel methods of mining prior to 1907. Lower down on the creek a hole is said to have been sunk 119 feet without reaching bedrock.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Cooney Creek (17.0-17.05) (2.2-2.7)	B. 1139, p. 307	Au Placer	Stanley Dale; J. Neubauer	Discovered in 1912. Very low grade but with widespread irregular gold occurrences. Currently being mined.
Dalton Creek or Gulch (16.1, 2.05)	B. 1139, p. 307	Au, Sn Placer		Discovery, 1910. By 1957, 460 oz. of gold and 3000 lbs. of SnO_2 concentrate had been recovered. Most paystreaks are small and discontinuous. Total overburden about 60 feet with gravel of two to four feet thick. Most paystreaks averaged \$.50 per square foot of bedrock at \$20.67 per oz.
Deep Creek (14.7-15.25) (1.2-1.35) approx.	B. 1139, p. 308	Au, Sn, Ag, Cr, Ni Placer	Albrecht & Hanson; Bock; Bock & Hanson; Deep Creek Mining Co.; Fred Hansen; Larsen; Strandberg Mines, Inc.	By 1957, 6864 oz. of gold, 653 oz. of silver and 56,200 lbs. of cassiterite concentrate had been recovered. Gravel 30-40 feet deep. Chromite is abundant, comprising 10% of the placer concentrate. Samples were taken about 1961 by the USGS.
Donnelly (NE 1/4 16, 0)	B. 1139, p. 308	Au (?), Co (?)		A prospect just south of the Barrett Cobalt prospect. Very little exploratory work done.
Doric Creek (20.65, 3.85)	B. 1139, p. 308	Au Placer	Frank & Co.; Strandberg Mines, Inc.	Gravel about 15 feet thick. Gold averages a little over \$16 per oz. Two nuggets worth \$75 and \$45 were found. Currently active.
Dry Creek (S 1/2 13, 3)	B. 1139, p. 308	Au Placer	Scotty Anderson; Farrell; Heiner & Wolff; Higgins	A tributary of Trail Creek. Was worked in 1917. Upper portion of the creek has gravels 3-6 feet deep. Property produced approximately \$1000 per year for one man. Groundsluicing prior to WW 2. In 1967 a 13 foot hole was sunk which did not reach bedrock at the mouth of the creek. Currently active.
Eighteen Pup (21.0-22.0) (6.6-8.4)	Kardex 48-18	Au Placer		Tributary of Hoosier Creek. Claims staked in 1956. Currently active.
Eureka Creek (20.4-20.8) (3.8-4.25)	B. 1139, p. 308	Au, Sn, Ag Placer	Boston Boys; Brock & Johnson; Farmer & Jones; Frank & Co.; Gill; Strandberg Mines, Inc.	Discovered in 1878. "Considerable" gold found in the bedrock below the gravels. Ten to 20 feet of overburden. In 1931 "poorest" assay showed 0.780 for gold and 0.213 for silver. A few pebbles of SnO_2 have been found in the gravel. Currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Farmer & Jones (20.4-20.8) (3.6-4.25) approx.	B. 1139, p. 308	Au Placer		Reported good production by this group on Eureka Creek benches.
Ferguson Gulch or Draw (16.15, 2.1)	B. 1139, p. 308	Au, Sn Lode (?) & Placer		Discovered in 1909. A few nuggets weighing up to 4 oz. were found. Yields 0.3 to 0.4 oz. per square foot for gold and 0.1 to 0.4 lb. per square foot for SnO_2.
Florida Creek (20.95-21.2) (7.75-7.9)	B. 1139, p. 308	Au Placer		Gravel up to 15-20 feet thick. Not much other information available.
Glen Creek or Gulch (20.15-20.2) (2.75-3.85)	B. 1139, p. 309	Au, Sn Placer	Beardsley, Belseat & Dillon; Eagle Mining Co.; Johnson & Hensley; Johnson & Johnson; Johnson & Toftaker; Strandberg Mines, Inc.	Discovered in 1901. More than $1,000,000 in gold recovered. A few pebbles of SnO_2 occur. Believed to be all worked out. Seven to ten feet of overburden.
Gold Basin Creek (16, 2)	B. 1139, p. 309	Sn, Au Placer		Discovered in 1912. Not much information available.
Gold Hill (1.45, 3.55)	B. 1139, p. 309	Au, Ag Lode		Mined from 1890 to 1908. The first lode mine in interior Alaska. Vein traced for 110 feet. Outcrop is 2-3 feet wide. Sheared and broken veins were abandoned.
Gold Run (20.05-20.1) (3.8-3.9)	B. 1139, p. 309	Au Placer	Pringle	Discovered in 1900. $200,000 in gold recovered. Deposit overlain by about 20 feet of overburden. Gold shotty, somewhat worn but with some crystalline outline evident. Currently active.
Granite Creek (18.9-19.5) (4.8-5.2)	USBM No. 3 DMM Report No. 12	Mn Lode		Claims located between heads of Granite and Rock Creeks.
Grant Creek (0.4-0.5) (3.4-4.4)	B. 1139, p. 309	Au, Sn Placer	Fisher & Fisher; Edgington	Prospecting but no mining reported by 1911. Reports of up to $1 per square foot of bedrock. Gravels 10-12 feet deep. "Live waters" here.
Harter Gulch (15.85, 2.0) approx.	B. 1139, p. 309	Au, Sn Placer		Discovered in "early years of mining". $90,000 worth of gold recovered in one summer. Low concentration of SnO_2.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Hokeley Gulch (14.95, 1.5) approx.	B. 1139, p. 309	Au, Sn Placer	Bock; Hansen & Lindeberge	A large area of rich placer ground located by Bock on the Wild Goose claims in 1913. During 1914, over fifty men were employed. Deposit 130 feet deep with lower 6-8 feet being gravel. Considerable areas yielded $4 to $6 per square foot. Hokeley Gulch may be the same as "Oakley Creek".
Homestake Creek (11.95, 5.75) approx.	B. 1139, p. 309	Au Placer		Some gold extracted by 1911.
Hoosier Creek (21.05-21.95) (8.15-8.4)	B. 1139, p. 310	Au, Hg, W, Cu Placer		Discovered about 1900. By 1934 two of the best claims on the creek had produced $50,000 in gold. Gravel averages six feet thick and is overlain by 1-10 feet of silt and muck. One $250 nugget recovered. In 1934 the gold was valued at $19.49 per oz. Native copper and cinnabar have been identified. Currently active.
Hot Springs Dome (16.7-17.0) (1.2-1.4)	Kardex 48-48	Co, Cu, Au, Pb, Ag Lode		Discovered in 1931. Some tunnelling done.
Hunter Creek (21.2-21.85, 8.95)	Kardex 48-43	Au, Ba, Hg, Pb, Cu Placer	Hunter; Swenson	Discovered in 1896. Gravel 5-6 feet thick with 1-40 feet of muck overburden. Gold is in lower three feet of gravel and in the upper fractures of the bedrock. Worth $19 per oz. with nuggets up to 10 oz. Currently being worked. See Hunter Creek in Livengood Quadrangle.
Hutlinana Creek (20.9-22.1) (3.1-4.2) approx.	B. 1139, p. 310	Au Placer	Hutlina Creek	Some gold found on the most northwesterly tributaries of this creek but as of 1931, no good pay streaks had been located. Concensus of opinion locally it that the headwater portion may have a paystreak but that the ground is deep and although unfrozen, is uneconomical for small scale mining.
Idaho Bar (21.8-21.9) (8.65-8.75)	B. 1139, p. 310	Au Placer	Consolidated Natural Minerals, Inc.; Farrell & Assoc.	Deposit of high gravel that forms the top of the ridge between the bend of Little Minook Creek and the junction of Dawson and Hunter Creeks. One of the old shafts said to be sunk 100 feet to bedrock. 1500 feet of bedrock cleaned by tunnelling in 1930-31. Said to go as high as $1 per bedrock foot in places. Water in very short supply.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Idaho Gulch or Creek (15.4, 1.75)	B. 1139, p. 310	Au, Sn, Ag Placer	McGee; Strandberg Mines, Inc.	Circa 1890. $250,000 gold removed in 1911, 61 oz. in 1957. Gold is in rich paystreaks. Tailings have been re-worked. Drift mining in 1919-20. In 1920, 0.77 lbs. of cassiterite per square foot of bedrock were produced, which had been buried by 24-32 feet of sand, silt and muck. Some placers buried up to 85 feet. Gravel is 2-5 feet thick. Currently active.
Innesvale Gulch or Creek (15.0, 1.3) approx.	B. 1139, p. 310	Au, Sn, Ag Placer	Hansen & Albright	Largest camp in the Woodchopper-Tofty area in 1931. Drifting conducted during that summer by an 11-man crew. 5-6 feet of gravel overlain by 60 feet of muck. Ground is frozen. Gold is 840-856 fine and averages in size about a grain per piece but some $20 nuggets found. "Large amounts" cassiterite found in the gravels.
Johnson & Hensley (20.15, 3.8)?	B. 1139, p. 310	Au Placer		Reported placer production by this partnership. Creek name unknown.
Jordan Bar (21.0, 4.15) approx.	B. 1139, p. 310	Au Placer		Somewhat lower tenor than Last Bench. Forty feet of overburden.
Joseph Creek	DDM Geochem. Report No. 12	Sb, Cu, Zn, Mo Lode & Placer		Prospecting only, mostly for stibnite. A geochemical sampling was run by the DMM in 1966. All but zinc occurred in anomalous amounts.
Killarney Creek (16.75, 2.7) approx.	B. 1139, p. 310	Sn, Au (?) Placer		Discovered in 1912. Not much information available.
Lancaster Creek (1.65, 3.65) approx.	B. 1139, p. 310	Au Placer		An open cut was made in 1917.
Last Bench (21.0-21.15) (4.1-4.2) approx.	B. 1139, p. 311	Au Placer	Gill	Gold said to be worth $16.50 per oz. Largest piece found valued at $20.
Little Boulder Creek (NE 1/2 of NE 1/4 13, 2)	B. 1139, p. 311	Au Placer	Farrell & Higgins	Low grade prospects found in 1916. One man diverted the creek in 1917 in order to prospect the gravels. Alluvium found to be 6-12 feet deep. Currently active.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Little Minook Creek (21.25-21.8)	B. 1139, p. 311	Au, W, Cu, Pb, Cr Hg (?), Bi Lode & Placer	Cunningham & Assoc.; Langford; Minook Ltd.	Also called Little Mynook. In 1893 some nuggets of native copper, galena and cinnabar (?) were found. By 1934 one claim had produced $1,000,000 in gold. Largest producer of gold (placer) in the Rampart District. Gravel is 5-6 feet deep with little or no overburden. A 1929 assay showed gold 0.917, silver 0.079, with gold at $18.99 per oz. and silver at $.57 per oz. A 1931 assay showed gold 0.920, silver 0.075, with gold at $19.05 per oz. and silver at $.29 per od. One $360 nugget has been found. Currently active.
Little Minook Jr. Creek (21.1-21.45) (8.45-8.5)	B. 1139, p. 311	Au, Pb, Ba Placer	Antonsen; Hawk; McLean; Wells; Martin Ott; Weisner	Discovered about 1900. Gravel average 4-5 feet thick. Most of the gold is found in the upper 1 1/2 feet of bedrock. 18-25 feet of muck overburden. One $200 gold nugget found. Gold averaged $18 per oz. Some barite and galena evident.
Lynx Creek (0.5-0.95) (3.9-4.1)	B. 1139, p. 311	Au Lode (?)		Currently active.
McCaskey Bar (20.55, 3.58)	B. 1139, p. 311	Au, Hg Placer	Farmer & Jones	Ground first worked in 1924. 15-20 feet of overburden with gold occurring 1-2 feet above bedrock. 1929 assay showed gold 0.802, silver 0.191, with gold worth $14.49 per oz. Largest nugget reported valued at $8. Cinnabar is present.
McDonald Bar (21.1, 7.75) approx.	B. 1139, p. 311	Au		
McKinley Creek (19.8-20.0) (2.2-3.4) approx.	B. 1139, p. 311	Au Placer (?)	McIntyre; Youngstrom	Good prospects reported from this creek in 1902. Claims were staked in 1966 and the property is currently active.
Miller Gulch or Creek (15.3, 1.6)	B. 1139, p. 312	Au, Sn, Ag, Rare Earths Placer	Dean; Millianich; U.S. Assoc.	Discovered in 1912. Deep Miller Creek may be the same as either Miller Creek or Deep Creek, or both. By 1957, 17,576 oz. of gold, 2668 oz. of silver and 101,875 lbs. SnO_2 concentrate had been recovered. At that time USGS indicates 78.7 tons of concentrate in the tailings and $.21 per square yard as a gold value. Reported recoveries about 1957 of 0.2 to 0.5 lb. per square foot of bedrock on SnO_2. Grav-

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Miller Gulch or Creek, cont.				el is from 35-120 feet deep. The proportion of SnO_2 is as high here as anywhere in the tin belt, as confirmed by the USGS survey of tailings in 1957. Claims were staked on the property in 1953 and 1958 and it is currently active.
Minook Creek (20.1-21.05) (7.0-8.95)	B. 1139, p. 312	Au, Ag Placer	Havrilack; Minook Ltd.; Rampart Gold Mining Co.	Discovered in 1893. Low grade but widespread gold concentration. In 1904 two small areas between Ruby and Slate Creeks produced \$3 to \$4 per square foot in gold and \$90 nuggets. Currently active.
Moose Creek (12.8-12.9) (2.6-3.4)	Kardex 48-115	Au Placer (?)	Cobin; Monroe; Louie Anderson	A tributary of Big Boulder Creek. Cuts Boulder Creek benches. Known to have some gold. Water from creek is presently being used to mine Big Boulder bench.
Moraine Creek (0-3, 3-6)?	B. 1139, p. 312	Au		Some prospecting done in 1929 and some (?) gold recovered. May be in Melozitna Quadrangle.
Morelock Creek (12.05-12.2) (5.75-5.9)	B. 1139, p. 312	Au, Sn Placer	Vogeler & Hirst; Vogt	
Ness (19-20, 3-4)	B. 1139, p. 312	Au		Operated a hydraulic placer mine on unknown creek. Reported as a good producer.
New York Gulch or Creek (13, 1)	B. 1139, p. 312	Au Placer		As of 1931 mainly prospecting only had been done here.
Oakley Creek (S 1/2 SE 1/4 quad.)	B. 1139, p. 312	Au Placer		Large placer camp(s) reported on this creek in 1915. May be the same as Hokeley Gulch.
Omega Creek (19.35-19.55) (3.3-3.5) approx.	B. 1139, p. 313	Au, W, Hg Placer	Trumpey	Discovered in 1899. Gravel about two feet thick. A few nuggets valued at \$38 and \$48 have been found, with gold worth \$20.67 per oz. Active and is currently being mined. May be the same as "Orange Creek".
Orange Creek (19.35-19.55) (3.3-3.5) approx.	B. 1139, p. 313	Au Placer		Two placer mining outfits were in production here in 1934.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Patterson Creek (14-16, 1-2)	B. 1139, p. 313	Au, Sn, Ag Placer		By 1957, 2599 oz. of gold, 385 oz. of silver and 20,287 lbs. of cassiterite concentrate had been recovered.
Pioneer Creek (20.55-21.15) (3.8-4.2) approx.	B. 1139, p. 313	Au, W, Hg Placer	Brock & Assoc.; Grace Loe; Frank & Co.; Frank & Graham; Strandberg Mines, Inc.	Claims staked in 1957 and 1964. North Fork is currently active.
Poker Creek (19.8, 3.35) approx.	B. 1139, p. 313	Au Placer		Creek was being prospected for placer gold in 1931. No further information is available.
Quartz Creek (trib. Sullivan River) (15.7-15.8, 2.55) approx.	B. 1139, p. 313	Au Placer	Homestake Bar	Discovered in 1907. Prospecting only.
Quartz Creek (trib. Yukon River) (11.9, 4.9)	B. 1139, p. 313	Ag, Pb, Au Lode	Otto Anderson; Parker; Vogeler	Discovered in 1890. Small quartz veins ten feet occur in limestone.
Rhode Island Creek (19.95-20.1) (3.6-3.9) approx.	B. 1139, p. 314	Au Placer	Pringle & Assoc.; Strandberg Mines, Inc.	Discovered in 1900. Not much is known about it, but it is currently active.
Ruby Creek (20.4-20.85) (7.45-7.7)	B. 1139, p. 314	Au, Ag, Ba, Bi Placer		Gravel is 5-7 feet thick with 1-4 feet of muck overburden. Gold is found in bedrock. The nuggets are very smooth and weigh up to 2 oz. Garnets up to one inch in diameter are common. Barite has also been identified. Silver is fairly common, with one 20 oz. nugget recovered. Bismuth (?) also identified. Claims staked in 1956 and is currently active.
Seattle Bar (21.0-21.15) (4.1-4.2) approx.	B. 1139, p. 314	Au Placer		Gravel is nine feet thick. Gold is chunky to flat in shape.
Seattle Creek (19.9, 3.9) approx.	B. 1139, p. 314	Au Placer	Pringle; Strandberg Mines, Inc.	Discovered in 1900. Not much information is available. Currently active.
Seattle Jr. Creek (21.0, 4.1) approx.	B. 1139, p. 314	Au Placer	Frank & Co.	

TANANA QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Shevlin Creek (10.3-11.5) (4.15-5.9)	B. 1139, p. 314	Au Placer		Prospecting in 1907. Gravels found to contain gold. Correct spelling is "Schieffelin".
Shirley Bar or Bench (20.1, 3.8) approx.	B. 1139, p. 314	Au, Hg, Pb Placer	Johnson & Toftaker	Discovered in 1900. Gravel 2-10 feet thick. Assay in 1929 showed gold 0.791 3/4, silver 0.203 with silver worth $.56 per oz. 1930 assay showed gold 0.792, silver 0.204, with silver worth $.38 per oz. Evidence of mercury and lead but has not been worked for these. Claims staked in 1953 and 1957. Currently active.
Skookum Creek or Gulch (21.15, 4.2) approx.	B. 1139, p. 314	Au Placer	Frank & Co.; Gill; Strandberg Mines, Inc.	Not much information available, but is currently active.
Slate Creek (20.5-20.75) (6.8-6.95)	B. 1139, p. 314	Au, Ag, Cu (?) Placer		Discovered in 1902. Gravel is as much as 36 feet thick. The lower three feet of gravel and upper foot and a half of bedrock contain the gold. Silver is commonly associated with the gold and copper is said to occur. An $8 gold nugget was the largest found by 1908. Is currently active.
Sullivan Creek (15.3-15.6) (1.3-2.0) approx.	B. 1139, p. 315	Au, Sn, Ag, Rare Earths, Cu Placer	Abe Lincoln; Cleary Hill Mines, Inc.; Dakota Bar; Hartner; McGee; Howell & Cleveland; Lieber & File; Junction; McVicar, Synder & Marshall; Midnight Sun; Synder & Kempter; Tilleson & L'Heureux; Strandberg Mines, Inc.	By 1957-58, 136 oz. of gold, 5463 oz. of silver and 215,445 lbs. of SnO_2 concentrate had been recovered. Ground averaged $3.50 per square foot with the gold worth $20.67, and some areas were worth up to $20 per square foot. Hydraulic operations started in the early 1920's. Gravel averages six feet thick and is overlain with 40-50 feet of muck in which are found the remains of Quaternary mammoth, bison and horses. Presently being mined.
Thanksgiving Creek (SE 1/4 18, 3)	B. 1139, p. 315	Au, Ag Placer	Lanning	By 1909, the Baker Creek group had produced a total of $406,100 in gold, of which $83,700 was produced in the winter of 1903-04, and $61,300 in the summer of 1904. Currently active.
Tofty Gulch (15.45-15.55) (1.8-1.9) approx.	B. 1139, p. 315	Au, Sn, Ag Placer	Cleary Hill Mines, Inc.; McGee; Snyder, Harter & Kempter	Discovered in 1906. Is believed to be the same as Tufty Gulch. By 1957, 8855 oz. of gold, 1376 oz. of silver and 19,600 lbs. of SnO_2 concentrate had been removed from the property. Gravel averages three feet thick.

TANANA QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Tozimoran Creek (1.4-1.9) (6.55-6.7)	B. 1139, p. 315	Sn, Au, Pb Lode & Placer (?)	Purkeypile & Webories	In 1946 galena and some cassiterite were reported in the gravel. Currently active.
What Cheer Bar (20.6, 3.85) approx.	B. 1139, p. 316	Au, Hg, W Placer	Strandberg Mines, Inc.	Worked out years ago according to a 1931 report. Most of the gold was in the lower part of the gravel and the upper two feet of bedrock.
Woodchopper Creek (14, 1)	B. 1139, p. 316	Au, Sn, Ag Placer	Albrecht & Hanson; Bock & Co.; C. Dart; Hansen & Linberg; Mohawk Assn.; Rolke; Strandberg Mines, Inc.	Work had been done on the creek by 1913. By 1957, 28,501 oz. of gold, 3402 oz. of silver and 40,300 lbs. of SnO_2 concentrate had been recovered. In 1961, an estimated 85 tons of cassiterite were in the tailings. Estimated values that year were $.54 per square yard for cassiterite and $.62 per square yard for gold. Boulders in the gravel, which is 30-40 feet deep, are rounded sandstone. Currently active.
--- (20.0, 2.1)	Kardex 48-126	Au		Claims staked in 1967 on the south slope of the hill between Tofty Road and Baker Creek, near the head of Baker Creek.
--- (21, 4)?	B. 1139, p. 316	Ag, Pb Lode		Deposit said to have been found at the head of either Eureka or Pioneer Creek. Two assays of sulfides said to have shown 100 oz. of silver per ton, and 70% lead.
--- (SE 1/2 20, 5)	B. 1139, p. 316	Sb Lode & Placer		Deposit found by the USGS in 1931 along the top of the ridge between Granite and Upper Minook Creeks. Occurs as scattered oxidized pieces. The vein has not been exposed for examination.

TELLER QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Agiapuk River (SE 1/4 quad.)	B. 1139, p. 317	Au Placer		Dredging thought possible in 1931. Trace amounts produced in 1928.
Alaska Chief (12.8, 7.8)	B. 1139, p. 317	Pb Lode		Development work included a shaft and adit. Low grade galena ore occurs in faulted, brecciated limestone. Some production.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Alder Creek (20.65-21.0) (1.55-175)	B. 1139, p. 317	Au Placer	Bartholomae Oil Corp.; Johnson	Stream and bench placers in 1908. Cla[illegible] were staked in 1965.
Alliene Creek (21.55-21.65) (5.95-6.6)		Au		Claims were staked in 1962.
American River (Windy Creek, Budd Creek) (22-25, 10-14)	B. 1139, p. 317	Au Placer	Budd Creek Gold Dredge Co.; Sullivan & Dobson; Muncey	Three camps were mining in 1927. A small camp was operated in 1933.
American Tinfields, Inc. (First Chance Creek & Good Wine Gulch) (7.7-8.1) (10.05-10.4)	B. 1139, p. 318	Sn Lode		This is an area of abundant tin mining. There was an increase in production in 1935.
Anikovik River (9.65-1.01) (8.7-9.3)	B. 1139, p. 318	Au, Sn Placer	American Gold Dredging Co.	Tin in placer deposits. No production since 1916 but some assessment work has been done since then. Two dredges were installed in 1914.
Baituk Creek (8.8-9.4) (9.2-10.1)	B. 1139, p. 318	Sn Placer		Small amounts of tin ore were reported in 1903.
Banner Creek (10.1-11.0) (9.05-9.4)	B. 1139, p. 318	Sn Placer		Small amounts of tin ore were reported in 1903.
Bear Creek (12.3, 8.0)	Kardex 43-93	Be Lode		Claims were staked in 1962 about five miles above the junction with Lost River.
Bering Creek (2.19-20) ?	B. 1139, p. 318	Au Placer		There are some good values but water is a problem. Gold in on stream and bench gravels.
Bessie & Maple (13.15, 8.05)	B. 1139, p. 318	Ag, Pb, Sb, Sn, W, Cu Lode	Bessie; I; J; Maple; Poorman; Southern Cross; Tigar; U.S. Tin Corp.	A tunnel was driven exposing a few galena veins and small amounts of limonite. Little work has been done.
Black Mountain (16.3, 8.3)	Kardex 43-115	Au Placer		Claims were staked northwest of the head of the West Fork of Constance Creek in 1967.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Bluestone River (20.5-21.8) (2.0-3.7)	B. 1139, p. 318	Au Placer		Worked continuously from 1900-1908. A dredge was installed in 1930. Claims were staked in 1967.
Bluestone River (Right Fork) (19.0-20.5) (1.8-2.3)	B. 1139, p. 319	Au Placer		A small amount of gold was found in 1908 but not in a quantity that made it profitable to mine.
Boulder Creek (7.4, 10.75-10.9)	B. 1139, p. 319	Sn, Rare Earths Placer	Bering Straits Tin Mining Co.; Lagoon Creek; Loman & Gabrielson; Loman Commercial Co.; Monz, Edwards & Worm; Zenda Gold Mine Co.; Palmer	Some tin was found in the gravels but is not profitable at present due to the heavy overburden. Drilling was done. Two tin claims were staked in 1953. Radioactive minerals reported.
Brook Mountain (13.4-13.6) (9.05-9.35)	B. 1139, p. 319	Sb, Bi, Cu, Fluorite, Pb, Ag, Sn, W, Zn Lode	Cameron; Foggy Day; Hellerich & Association; Iron Cap; Read; Luther; Square Zero; Sunny Day; Midniteson; Pageite; USSR&M; Tourmaline	Stibnite occurs and a tunnel has been driven for it on the west side of the mountain. A small galena prospect reported. Iron oxide gossan containing lead and bismuth occurs at the limestone granite contact.
Brooks Mountain (13.4-13.6) (9.1-9.4)	B. 1139, p. 319	Radioactives Lode		Located approximately 25 miles northwest of Teller. Claims were staked in 1958. DMM color coded as interesting property.
Brown Creek (12.3, 8.5)	Kardex 43-94	Be Lode		Claims were staked near the head of Rapid River in 1962 and 1963.
Brown Creek (12.3, 8.5) approx.	Kardex 43-104	Be Placer		Claims were staked near the head of Rapid River, at the confluence of the East and North Forks, in 1962.
Buck Creek (10.55-11.25) (11.05-11.65)	B. 1139, p. 319	Sn, Au Lode & Placer	American Gold Dredge Co.; Lee Bros. Dredging Co. (?); Kendall; American Tin Dredge Co.; York Dredge Co.	Dredges operated in 1911 and in the 1930's. Cassiterite has three modes of occurrence: (1) impregnation in quartz porphery dikes, (2) quartz stringers and (3) with arsenopyrite. There were many claims staked in 1965. In 1966 three claims were deeded to U.S. Steel.
Budd Creek (25.2, 11.4)	B. 1139, p. 319	Au, Hg, Cu, Sn (?) Placer	Budd Creek Gold Dredge Co.; Dodson; Johnstone; Pasadena Gold Dredge Co.; Welch & Doran	Copper minerals were found in placer concentrates. Some drilling and exploration was done in 1940.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Burke Creek (24.2-24.8) (12.65-12.7)	B. 1139, p. 320	Au (?) Placer		A little placer gold was mined in 1930. Prospecting was done in 1933.
Buttner Creek (10.1, 9.25) approx.	B. 1139, p. 319	Sn, Au Placer		Stream tin was found in 1900. Gold gravels were reported in 1908.
Camp Creek (13.1-13.5) (7.9-8.6)	Kardex 43-95	Be Lode	Grothe	Beryllium deposit was drilled by USBM in 1963 and 1964. Crysoberyl and fluorite occur, along with minor amounts of tungsten and tin. Ore has not been successfully beneficiated as of this date.
Canyon Creek (21.55-22.3) (0.52-2.3)	B. 1139, p. 320	Au Placer		Prospecting reported in 1927.
Cape Creek (7.7-7.8) (10.05-10.3)	B. 1139, p. 320	Sn Placer	Loman & Gabrielson; Loman Commercial Co.; Palmer; Peterson & Association; Stines & Kirklin; Tin City Creek; Zenda Gold Mine Co.; Lee Bros.	Some tin mining was done in 1931 but in no appreciable amounts. In 1944 some churn drilling was done and some placer pits sunk. Claims were staked in 1953. The property is currently active.
Cape Mountain (7.35-7.7) (10.25-10.55)	B. 1139, p. 320	Sn, Fluorite, W, Zn Lode & Placer	Adams; Bartells Tin Mining Co.; Bartells & Associate; Carlson & Goodwin; Empire Tin Mining Co.; Goodwin & Carlson; Hinton; Jefferson; Seward Tin Mining Co.; Treemont; U.S. Alaska Tin Mining Co.; Walker, Lovell Co.; Winfield	Produced considerable amounts of tin in tunnels, shafts and winzes in 1915. Approximately 457 acres were patented.
Cassiterite Creek (13.6, 8.7)	Kardex 43-23	Sn Placer		This is active property.
Christophosen Creek (25.15, 1.15)	B. 1139, p. 320	Graphite Lode	Graphite Bay; Uncle Sam Alaska Mining Co.; Uncle Sam Graphite Mining Co. Ore Syndicate	Commercial deposits containing graphite lenses; graphite in quartz schist and some calcite.
Clara Creek (12.8-13.3) (10.3-10.8)	B. 1139, p. 320	Sn (?) Placer		There are small amounts of placer tin, according to reports of 1903.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Cobble Stone River (26.2, 0.85) approx.	B. 1139, p. 320	Au Lode		Some free milling quartz was mined but values not reported. Claims were staked in 1962.
Collin Creek (23-25, 13-15)	B. 1139, p. 320	Au Placer		Gold was reported in 1903 but no further information is available.
Columbia Creek (27.75-28.55) (12.7-13.3)	B. 1139, p. 320	Au Placer		There were 20 claims staked in 1903. This creek had coarse gold with some quartz attached.
Coyote Creek (19.8-20.0) (3.8-4.9)	B. 1139, p. 321	Au Placer	Tweet & Sons	Placer was mined with a bulldozer in 1940.
Cox (12.2-12.3) (8.0-8.5)	Kardex 43-113	Sn, Be Lode		Claims were staked along and on the Rapid River Dike in 1967.
Crosby Creek (20.3, 16.05)	B. 1139, p. 321	Sn Placer		Cassiterite in gravels was reported in 1959.
Deer Creek (19.95, 16.05)	B. 1139, p. 321	Sn Placer		Cassiterite in gravels.
De(a)se Creek (20.3-21.1) (3.4-4.55)	B. 1139, p. 321	Au Placer	Tweet & Sons	A dredge was operated on the creek in the 1940's.
Dewey Creek (20.85-21.2) (5.55-5.95)	B. 1139, p. 321	Au Placer		Gold occurs in silts and gravels. Some prospecting was done in 1903.
Diomede Creek (10.05-10.3) (11.65-11.85)	B. 1139, p. 321	Sn Placer		Placer samples were taken in 1949. Drilling showed a trace amount of tin. Most of the ground is frozen.
Ear Mountain (19.7-20.1) (16.65-17.0)	B. 1139, p. 321	Sn, Cu, Pb, Au, Ag, Fluorite, Zn, W, Sb, Hg Lode	Alaska Tin Corporation; Eunson Shaft; Vatney; Vatney Gulch	Small lenses of chalcopyrite were found while prospecting for tin. Some development work was done in 1917. Shistosic limestone gangue. Cassiterite is present, as are deposits of antimony, garnet and tourmaline. In 1925, 44.618 acres were patented.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Eldorado Creek (20.3-20.8) (16.7-16.75)	B. 1139, p. 321	Sn, W, Fluorite Lode	Alaska Tin Corp.	Nuggets of cassiterite can be picked off bedrock riffles. Black tourmaline is present. Claims were staked in 1953.
First Chance Creek (7.7-7.75) (10.1-10.15)	B. 1139, p. 322	Sn Placer	Loman & Gabrielson; Loman Commercial Co.; Zenda Gold Mine Co.; Lee Bros.	Low grade tin deposits in some drilled holes and prospect pits were reported in 1955. Tin is angular and coarse. This creek is under further investigation for lode deposits. Properties currently active.
Gold Run Creek (19.5-20.85) (0.95-2.0)	B. 1139, p. 322	Au, W Placer	Bartholomae Oil Corp.; Martenson & Associate; Metalsmith Mines Corp.; Bon Davis; Dickman; Fidgeland Brothers	Beach deposits were mined by simple hydraulic methods. A dredge was operated in 1940. Placer scheelite occurs in fairly large amounts in the schist bedrock. Claims were staked in 1957 and 1965 for gold. Mined in the 1950's and early 60's. The creek has produced and is currently active.
Goodwin Creek (8.0-8.1) (10.35-10.65)	B. 1139, p. 322	Sn Placer	Bering Straits Tin Mining Co.; Christensen; Douglas & Assoc.; Loman & Gabrielson; Loman Commercial Co.; Zenda Gold Mine Co. Lee Bros. Dredging Co.; Al Doyle; Bill Smith	Tin bearing gravels were prospected and some significant amounts of placer tin were found. Some drilling was done. Lack of funds in 1959 stopped the work. In 1965 six claims were staked.
Goodwin Gulch (8.0-8.1, 10.4)	B. 1139, p. 322	Sn Placer	Douglas & Assoc.; Loman & Gabrielson; Loman Commercial Co.; Zenda Gold Mine Co.; Lee Bros. Dredging Co.; Al Doyle; Bill Smith	Large part of tin production was in 1931 but there was no gold in the gravels. Trace amounts of radioactive elements were found while prospecting in the 1940's. Six claims were staked in 1965.
Granite Creek (7.65-7.7) (10.55-10.8)	B. 1139, p. 322	Sn (?) Placer	Bering Straits Tin Mining Co.	Claims are currently held. Only a trace amount of tin was found in 15 drill holes in 1948.
Graphite Creek (25.5, 1.35)	B. 1139, p. 322	Graphite Lode	Alaska Graphite Mining Co.; Glacier Creek; Tweet & Sons	Lenses of graphite in quartz schist. Some mining was done.
Grouse Creek (11.25-11.45) (11.05-11.15)	B. 1139, p. 323	Sn, Au Placer	American Tin Mining Co.; Skooum Creek; Sterling Creek; York Tin Dredge Co.; York Dredge Co.; York Tin Mine Co.	In 1920 tin placers appeared to have been worked out. Dredge was operated in 1917.
Igloo (29, 3)	B. 1139, p. 323	Bi (?) (?)		A 3/4 lb. bismuth nugget was reported found in 1945.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Igloo Creek (Moonlight Creek) (20.45-21.0) (5.7-6.4)	B. 1139, p. 323	Au Placer	Moonlight Creek; Tweet Brothers; Cremidas; Reed; Johnson	A trace amount of gold was found in the early 1900's.
Ilene Creek (21.55-21.65) (5.95-6.6)?	B. 1139, p. 323	Au Placer		A trace amount of placer gold was recovered in 1930.
Imuruk Basin (23-26, 2-3)	B. 1139, p. 323	Garnet Placer		Trial shipment of garnet was sent in 1920.
Imuruk Basin (25.15-25.5) (1.15-1.35)	B. 1139, p. 323	Graphite Lode		There are graphite lenses in schist.
Iron Creek (10.5, 11.35-11.45)	B. 1139, p. 323	Sn Placer		In 1917 a few tons of cassiterite were mined. Gravels were 4-5 feet deep. Water supply is a problem.
Joe Creek (25.35-26.5) (11.2-11.5)	B. 1139, p. 323	Au (?) Placer		Drilling and exploration work accomplished in 1939.
Kanauguk River (10.3-11.8) (8.1-8.8)	B. 1139, p. 323	Sn (?) Placer		Reported to carry placer tin in 1962.
Kigezruk Creek (9.2-9.7) (9.0-9.2)	B. 1139, p. 324	Sn (?) Placer		Small amounts of placer tin were found in 1903.
Kreuger Creek (20.6-20.8) (16.55-17.0)	B. 1139, p. 324	Sn (?) Placer	Alaska Tin Corp.	Placer tin considered mineable in 1958 by the Alaska Tin Corp. In 1953 churn drilling was done. Claims were also staked that same year.
Lagoon Creek (7.7-7.8) (9.8-10.1)	Kardex 43-37	Sn Placer		
Lawson Creek (23-25, 12-14)?	B. 1139, p. 324	Au Placer		Small amount of gold produced in 1903; a high grade deposit.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Lee (7.6-7.7) (9.7-9.8)	Kardex 43-102	Sn Placer		In 1966 claims were staked on the tidelands of the Bering Sea extending east and west of the mouth of Cape Creek.
Lost River (13.55-13.6) (8.7-8.9)	B. 1139, p. 324	Sn, W, Fluorite, Pb, Zn, Sb, Cu, Bi, Be Lode & Placer	Grothe; Carry Gow; Cassiterite Creek; Crim, Randt & Obrian; Dolcoath; Holpin & Assoc.; Ida Belle; JAMME Syndicate; Johnson & Assoc.; Lost River Tin Mine Co.; National Tin Mine Co.; Obrian; U.S. Tin Corp.; Peterson; U.S. Steel	Tin and tungsten are widely distributed. Cassiterite and wolframite are the chief ore minerals and fluorite is also abundant. Currently being mined for residual placer tin. In 1965 U.S. Steel drilled here.
Lost River (SW 1/8 13, 8)	B. 1139, p. 324	Ag, Pb, W, Sn, Fluorite Lode		At Tin Creek small amounts of stibnite associated with fluorite were found but not in profitable quantities. Wolframite-topaz occur in lode deposits and stannite and galena were also found.
Lucky Shot (13.0-13.2) (8.1-8.2)	Kardex 43-96	Be Lode		Claims were staked on a mountain between Tin and Curve Creeks in 1962.
McKinley Creek (21.5-21.75) (5.0-5.5)	B. 1139, p. 324	Au Placer		Gold gravels prospected but no work was done in 1903.
Mint Creek or River (12.0-12.8) (10.0-12.0)	B. 1139, p. 325	Sn (?) (?)		Some reports of tin but they have never been confirmed.
Offield Creek (21.85-22.05) (4.95-5.3)	B. 1139, p. 325	Au Placer		Open cut and hydraulicing done in 1939. Gold gravels had small output.
Peluk Creek (10.65, 11.65-11.7)	B. 1139, p. 325	Sn Placer		In 1908 a shaft was sunk on quartz in slates. Abundant pyrite and some cassiterite occur. Seven feet of overburden and three feet of pay gravel in the placer.
Percy Gulch (8.05, 10.3-10.7) approx.	B. 1139, p. 325	Sn Placer		Tin gravels were prospected in 1920.
Pinguk River (16-18, 10-11)	B. 1139, p. 325	W Lode (?)		Large amounts of wolframite reported.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Pinnacle Creek (20.0-20.2) (16.2-16.6)	B. 1139, p. 325	Sn Lode & Placer		Contained biotite, epidote and large amounts of cassiterite in the concentrates. There are some radioactive minerals present in the area.
Potatoe Creek (9.7-9.95) (11.5-11.8)	B. 1139, p. 325	Sn Placer		Placer tin in gravels. One dredge operated in 1918.
Potatoe Mountain (10.4-10.5) (11.65-11.85)	B. 1139, p. 325	Sn Placer	Alan Dale	Considerable amounts of placer tin were produced and open cuts made in 1917. Prospecting failed to show ore body extent. Several claims were staked in 1967.
Quartz Creek (19.55-19.8)	B. 1139, p. 325	Rare Earths Lode & Placer		Xenotime was reported; also tremolite, brookite, danburite and scapolite.
Quartz Creek (trib. Gold Run Creek) (20.0-20.1) (0.8-1.0)	Kardex 43-9	Au Placer		Claims were staked in 1960.
Rapid River (12.9-13.5) (7.8-9.4)	Kardex 43-105	Be, Fe, Pb Lode	Al Doyle; Fred Pankratz	Claims were staked a mile north of Esch Creek Saddle between the headwaters of Anderson Creek and the East Fork of Lost River and up Tin Creek in 1963 and 1964.
Ruby Creek (25.35, 1.25)	B. 1139, p. 326	Graphite Lode	Alaska Graphite Mining Co.; Tweet & Sons	Considerable work was done in 1920. Occurrance reported as lenses in schist and gneiss.
Step Gulch (19.8-19.95) (16.5-16.65)	B. 1139, p. 326	Sn Placer		Cassiterite reported in 1945. No mining reports.
Sterling Creek (11, 10) ?	Kardex 43-49	Au, Sn Placer		A tributary of Grouse Creek.
Sunset Creek (20.0-20.45) (6.15-6.4)	B. 1139, p. 326	Au, W Placer	Andrews; Anglo American Gold Dredge Corp.; Rice; Arctic Mining Co.	Good returns using bulldozer and sluicing methods for gold in 1940. Dredged for gold in 1915. Bench gravels were found. 746 acres were patented in 1911.
Sutter Creek (10.7-10.85) (11.25-11.3)	B. 1139, p. 326	Sn, Au Placer		Small amount of placer tin was recovered by sluicing in 1915. Not worth further development at that time.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Swanson Creek (20.0-21.65) (6.55-6.7)	B. 1139, p. 326	Au Placer	American Gold Dredge Co.; Peck; Rice; Vogen	Some dredge mining was done.
Tin Creek (13.75, 8.25) approx.	B. 1139, p. 327	Sb, Fluorite Placer		Small amounts of stibnite associated with fluorite are to be found at the head of the creek.
Tuttle Creek (18.0-19.7) (16.0-17.1)	B. 1139, p. 327	Sn, Au, W, Rare Earths Placer	Alaska Tin Corp.	Cassiterite with auxinite, uranium, scheelite, olivine and danburite have been reported.
Village Creek (6.7-6.95) (10.8-10.9)	B. 1139, p. 327	Sn Lode	Bering Straits Tin Mining Co.	Cassiterite bearing veins. Claims were worked and drilling was done in 1943. Claims were staked in 1953.
Ward (Copper Co.) (27.15, 13.75)	B. 1139, p. 327	Cu Lode	Arkansas; Butte; Excelsor; Gem; Side; Victor	Open cuts and shafts. Ore assays 30-40% copper. In 1946 found signs of older work but no further development. 152 acres were patented in 1925.
Willow Branch (16.2, 9.3)	Kardex 43-116	Au Placer		Claim staked parallel to and south of Willow Branch in 1967.
Windy Creek (trib. American River) (25.2,11.4)	B. 1139, p. 327	Au, Sn (?) Placer	American Gold Dredge Co.; Estabrook	Dredge operated in 1916.
Windy Creek (trib. Bluestone River) (19.4-19.75) (1.55-2.2)	B. 1139, p. 327	Au Placer	Trilby Co.	Fairly good amounts of gold were recovered in 1931.
Worchester (27.8, 12.0)	B. 1139, p. 327	Cu, Pb Lode		Several lode claims were staked. Mineralization includes malachite, azurite and galena.
Yankee Creek or River (12.3-13.55) (10.5-12.5)	B. 1139, p. 327	Sn (?) Placer		The stream carries placer tin.
Yankee Girl (13.6, 8.3) approx.	B. 1139, p. 328	Pb, Fluorite, Sn, Cu, Ag, Au (?) Placer	Blomquist & Goodwin	Lead, tin and copper are present with arsenopyrite.

TELLER QUADRANGLE, Cont.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
York Creek (13.5-14.5) (9.7-12.0)	B. 1139, p. 328	Sn Placer		Probably not completely prospected.
Zenda Gold Mining Co. (20.1, 17.45)	B. 1139, p. 328	Sn Placer		Some churn-drill sampling was done in 1958.
--- (25.4-25.5) (1.3-1.4)	Kardex 43-31	Graphite		Located four miles east of Graphite Bay. Claims were staked in 1962.
--- (13.2, 9.5)	Kardex 43-114	Sn Placer		Placer tin claim was staked on the west slope of Brooks Mountain and the unnamed mountain to the west, in 1967.
--- (13.2, 7.8)	Kardex 43-108	Sn Lode		Three claims were deeded to U.S. Steel in 1966. Property located southwest of the confluence of Tin Creek and Lost River.
--- (19.9-20.2) (16.8-17.2)	Kardex 43-112	Sn Lode		Nineteen claims were deeded to U.S. Steel in 1966.
--- (12.3, 7.9) approx.	Kardex 43-106	Be Lode		Claims staked between two unnamed tributaries of Rapid River about six miles above the confluence of Lost River, in 1963.
--- (13.6, 8.2)	Kardex 43-101	Be Lode		In 1962 claims were staked on the southeast slope of a mountain between the head of Tin and Camp Creeks.
--- (13.3, 8.1)	Kardex 43-100	Be Lode		Claims were staked in 1962 on the westerly slope of a mountain near the junction of Tin Creek and Lost River.
--- (13.2-13.4) (7.9-8.0)	Kardex 43-99	Be Lode		Claims staked in 1962 south of the confluence of Tin Creek and Lost River.
--- (13.2, 8.1) approx.	Kardex 43-98	Be Lode		Located between Camp and Tin Creeks, near the mouth of Tin Creek.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
--- (13.6-13.7) (8.1-8.2)	Kardex 43-97	Be (?) Lode		Located on the north and west slopes of an unnamed mountain near the junction of the North and South Forks of Tin Creek.

WISEMAN QUADRANGLE

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Archibald Gulch or Creek (18.65-18.9) (8.9-8.95)	B. 1139, p. 339	Au, Sb Placer	Dow & Chappell	Left limit tributary of Nolan Creek. $6000 worth of gold recovered by 1909.
Birch Creek (10.1-10.75) (7.1-9.0)?	B. 1139, p. 340	Au Placer		Discovered in 1905 or 1906. Probably the stream called "Flat Creek" on recent maps. $10,000 in gold recovered by 1909. Creek flows across a 30-90 mile gold bearing schist.
Buckeye Gulch (19.5, 9.4)	B. 1139, p. 340	Au Placer		$1200 recovered by 1909. Gold concentration is mainly at the mouth of the creek. Mined intermittently.
Chapman Creek (17.0-17.25) (1.75-1.8)	B. 1139, p. 340	Au Placer		Worked 1908-1909. 13 or 14 holes 9-14 feet deep were sunk along this creek from a quarter of a mile to a mile above its mouth. Blue schist gravel on bedrock pans 2-3¢. Bench deposits 20-30 feet above the creek about two miles above its mouth were found to contain 5-10¢ per pan. Lack of adequate water presents a mining problem.
Clara Gulch or Creek (19.1-19.9) (5.3-5.5)	B. 1139, p. 340	Au Placer	Harvey	$3000 in gold produced by 1909. Creek about three miles long. Gravels mined in 1900 and 1901. Mining in progress in 1934.
Confederate Gulch (19.5-19.75) (8.3-8.6)	B. 1139, p. 340	Au Placer		Prospects only by 1909. Coarse gold. No known mining. Number of yards may be limited.
Crevice Creek (6.5-8.5) (6.2-7.0)	B. 1139, p. 340	Au Placer		Total production by 1909 was $2500.
Eagle Bluff or Cliff (20.1, 1.35) approx.	B. 1139, p. 340	Au Placer		Bench deposit. Gold believed to be derived from the surrounding mountains.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Emma Creek (18.8-19.1) (6.1-6.15)	B. 1139, p. 340	Au Placer		$160,000 worth of gold recovered by 1909. A rich deposit formed by a steep gradient stream flowing through a narrow boulder laden gulch. Boulders made mining difficult.
Fay Gulch or Creek (18.7-18.9) (9.0-9.05)	B. 1139, p. 340	Au, Sb Placer	Gamblin & Ferguson	Left tributary of Nolan Creek. Produced $30,000 in gold by 1909. Gold is rough and angular and has quartz attached. One of the important creeks in the district.
Ferguson (19.1, 8.5)	B. 1139, p. 340	Sb		
Fool Creek (5.2-6.4) (6.35-6.6)	B. 1139, p. 340	Au Placer		Prospects have been found on this creek and one of its tributaries.
Gold Bench (17.55, 0.35)	B. 1139, p. 340	Au, Sn, Hg, W, Cu, Pb, Bi (?) Placer	Votilla; Elmer Kertulla	$125,000 production of gold by 1909. Best known placer locality of the South Fork of the Koyukuk River. Deposit of high stream gravels on northeast side of the South Fork about ten miles south of the Tramway Bar. Rich enough to produce $85 to $90 per man day with rockers. Mined in the 1940's with heavy equipment.
Goldbottom Gulch (19.7, 9.0)	B. 1139, p. 340	Au Placer		Produced a total of $10,000 by 1909. Gulch draining the north face of a mineralized mountain mass. Profitable ground was near the mouth. A $400 nugget was found in 1904. About 600 to 700 feet of the length of the gulch have been mined.
Grubstake Bar (19.5, 1.5) approx.	B. 1139, p. 340	Au Placer		Total production about $4000, from a low bench which was worked by hand.
Hammond River or Creek (19.5-19.95) (8.55-9.8)	B. 1139, p. 341	Au Placer	Anglich; Brady; Collins; Watts, Harvey & Neck; Detroit Mining Co.; Kelley, Foley & Burke; Spinks & Irish	$20,000 production by 1909. Very coarse gold found on three levels. River is 35 miles long but production has been from short gulches tributary to it within five miles of its mouth. Most work in the river was unprofitable due to boulders and high water. A nugget worth $849 was found on Claim No. 6, one worth $842 on Discovery, one worth $1000 and one

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Hammond River or Creek, cont.				worth $1100 were found in the valley. Bench gravels are about 66 feet deep. Mined until 1950. Large production from drift mining at 40 foot levels and a deep (1001 feet) channel.
Ironside Bench or Bar (17.7, 0.5) approx.	B. 1139, p. 341	Au Placer		Total production of $2000 by 1909. A gold bearing bench deposit where prospects of gold have been found but little mining has been done.
Jay Creek (11.05-11.4) (7.4-7.8)	B. 1139, p. 341	Au Placer		Discoveries reported on this creek but no other information available.
John River (4.8-8.5) (5.0-7.0) approx.	B. 1139, p. 341	Au, Cu, Sb ---		Float found in the river containing coppery pyrite and some bornite. Supposed to be a vein of considerable size containing iron and apparently copper pyrites, in a steep limestone cliff of the Skajit formation overlooking the river.
Jones & Boyle (18.65, 8.8)	B. 1139, p. 341	Sb Lode		
Kelly Gulch (18.7-19.05) (5.6-5.7)	B. 1139, p. 341	Au (?)		Total production by 1909 was $500. A small mountain stream on the west side of Middle Fork about two miles in a direct line above Coldfoot.
Lake Creek (9.4-9.85) (8.45-8.6)	B. 1139, p. 341	Au, W, Sb, Bi, Cu Placer	Mangles; Rooney	East tributary of Wild Lake. Discovered in 1903 or 1904. Production $2000 in gold by 1909. Coarse nuggets, some of which range in value from $90 to $150 each.
McKinley Creek (4.2-6.2) (7.2-8.8)?	B. 1139, p. 341	Au Placer		
Mailbox Creek (17.0-17.2) (2.15-2.7)	B. 1139, p. 342	Au Placer		Active production in 1934.
Mascot Creek (16.3-16.55) (8.4-9.2)	B. 1139, p. 342	Au Placer		Produced $145,000 by 1909. Only stream in the North Fork basin that has been mined. Gravels are shallow, a few inches to three feet deep. The gold

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Mascot Creek, cont.				is coarse, with some nuggets worth $100 or more. About three miles of the creek have been mined. Benches contain gold.
Michigan Creek (10.8-12.5) (5.1-8.2) approx.	B. 1139, p. 342	Pb, Au, Ag Lode		Galena reported to have been found in a ledge. Said to be of considerable size and to carry gold and silver. Also called "Silver King". Ledge five feet wide. Little information available.
Midas Creek (4.8-5.2) (5.0-6.2)	B. 1139, p. 342	Au Placer		Prospects have been found.
Minnie Creek (19.6-20.25) (7.7-7.8)	B. 1139, p. 342	Au Placer		Production may have been partly in the Chandalar Quadrangle. $1000 recovered by 1909. Creek is about nine miles long with ample water. Bedrock is wet which hampered sinking of prospect shafts. One hole yielded $500 in heavy shot gold from a short cross-cut at the bottom.
Moose Gulch (18.8-19.2) (6.65-6.8)	B. 1139, p. 342	Au Placer		Reported to contain gold prospects which have not been worked due to the presence of boulders.
Nolan Creek (18.45-18.75) (8.6-9.1)	B. 1139, p. 342	Au Placer	Haslen & Assoc.; Le Boyteau; Standish; Ulen; Wooll	$765,000 in gold recovered by 1909. Gold is coarse. Bench and creek deposits. Placers in this basin are bench gravels, shallow gulch gravels and deeply buried frozen gravels. Most of the pay comes from the deeply buried frozen gravels, which are approximately 135 feet deep. Drift mining supported about 100 men.
Old Man Creek (SE 1/8 quad.)?	B. 1139, p. 342	Au Placer		Occurrence of placer gold on this creek reported in 1910.
Pasco Creek (17, 8)?	B. 1139, p. 342	Au Placer		
Porcupine Creek (17.7-18.5) (4.6-5.2)	B. 1139, p. 342	Au Placer	Neck; Standish Bros.	$2000 in gold recovered by 1909, with total production $100,000 (?). Coarse gold. Gravels are 20 feet deep and said to contain boulders.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Rose Creek (18.7-18.9) (3.9-3.95)	B. 1139, p. 343	Au Placer		Shown as Rosie Creek on recent maps. 130 feet to bedrock. Gold bearing strata is a slaty, flat, shingle shaped gravel with about 20 feet of blue clay over a thin layer of gravel which rests on bedrock and is said to contain many colors of gold.
Rye Creek (10.6-11.3) (7.0-7.55)	B. 1139, p. 343	Au, W, Pb, Cu Placer		Prospects reported in 1915. Heavy equipment used in the late 1940's. Little production.
Sawyer Gulch (18.55-19.2) (6.4-6.7)	B. 1139, p. 343	Au Placer		Reported to contain prospects of gold, but has many boulders.
Sixtymile River (3.0-5.2) (6.2-8.0)	B. 1139, p. 343	Au Placer		Some coarse gold mined in 1922.
Smith Creek or Gulch (18.6-18.75) (8.75-8.8)	B. 1139, p. 343	Au Placer	Boyle; Jones, White & O'Leary	$208,000 produced by 1909. A rich left limit stream of Nolan Creek. Worked by hand until the 1960's. Small, steady production.
Spring Creek (9.6-10.1) (9.1-9.15)	B. 1139, p. 343	Au Placer		About $7000 produced by 1909. Water not abundant at all times.
Summit Creek (9.6-10.05) (9.2-9.4)?	B. 1139, p. 343	Au ---		Single piece of gold speckled quartz float found. Not of economic interest.
Surprise Creek (9.85-10.25) (9.15-9.45)	B. 1139, p. 343	Au Placer		Some mining in progress in 1930.
Swift Gulch or Creek (19.4-19.55) (9.0-9.15)	B. 1139, p. 343	Au Placer		Production of $7200 by 1909. Work on this creek intermittently has yielded the equivalent of wages. Some of the gold is coated with a white mineral matter.
Tramway Bar (16.9, 1.7)	B. 1139, p. 343	Au Placer		Yielded about $8000 by 1909. One of the earliest known localities for placer gold in the Koyukuk Valley. Consists of a deposit of stream gravels on a bench cut in conglomerate and sandstone from 80 to 100 feet above the river.

Coordinates	References	Commodity Lode or Placer	Names of Claims or Workers	Discovery Date, Values Recovered, Remarks
Twelvemile Creek (17.0-17.85) (3.6-4.0)	B. 1139, p. 343	Au Placer		Produced $5000 by 1909. A west side tributary of the Middle Fork, twelve miles above Tramway Bar. Gravels said to contain a little gold but has been worked only occasionally with little reward.
Union Gulch or Creek (19.3-19.65) (8.15-8.45)	B. 1139, p. 343	Au Placer	Watts	$30,000 recovered by 1909. Gold is coarse and shallow. Deposit confined to about one claim length. Some mining in 1934.
Vermont Creek (19.15-19.4, 9.8)	B. 1139, p. 343	Au Placer		$172,000 production by 1909. 90 feet deep. Gold is coarse. $2400 panned in two days. Frozen ground. Very productive by drift mining. Yielded several nuggets worth more than $200 (each?).
Wannemaker & Wortman	B. 1139, p. 344	Sb Lode		
Washington Creek (17.3-18.1) (9.3-10.0)	B. 1139, p. 344	Au Placer		Produced $5000 worth of gold by 1909. Did not yield enough, however, to encourage serious mining operations.
Wild River or Creek (9.4-10.75) (7.1-9.4)	B. 1139, p. 34	Au Placer		Mining in this area in the 1930's.
Wilson Creek (17.6-17.8) (0.4-0.9)	B. 1139, p. 344	Au Placer		Gold prospects reported here but not worked.
Wiseman Creek (17.8-19.5) (7.5-9.2)	B. 1139, p. 344	Au Placer		Discovered in 1908. Prospects only by 1909. 300 feet deep, 30 feet of gravel, few colors. Glaciated.

GEOLOGY OF WESTERN NORTH AMERICA AND ALASKA

E. N. Wolff and L. E. Heiner

Introduction

Prospectors are guided in their search for minerals by many criteria, some consciously followed, some unconsciously. Generally, all of the criteria reduce to this: is the geology here similar to that where minerals have been found? Depending on the scope of the search, the geologic features examined are larger or smaller. In this section an attempt will be made to provide some guides to economic minerals on a regional scale, and hence the features considered must be of regional size. In order to trace similar geology from one area to another with maximum chance of success it is necessary to know the directions of regional geologic trends, called the grain or fabric. For this reason, a summary of the geology and tectonic framework of Northwestern North America, and Alaska's place in it will be given first. As Gates and Gryc (1963) said "to go from Denver, Colorado to Umiat, In Northern Alaska, you must travel about 2,500 miles geographically, but geologically you would travel scarcely at all, for on arrival at Umiat, you would still be at the boundary between the Rocky Mountain system and the Interior Plains."

Tectonics and Geology of Northwest North America

THE NORTH AMERICAN CORDILLERA

The Pacific basin is rimmed on three sides by a belt characterized by volcanoes and earthquakes, both being manifestations of crustal unrest and deep rifting of the crust; such a belt is known by the appropriate name m o b i l e b e l t . Along the coast of South America this belt is narrow, but in North America it widens to as much as 1,000 miles. Through Canada it narrows, then widens again to something like 700 miles as it makes a great bend through Alaska toward the western part of the Pacific. In the western Americas, the mobile belt is called the Cordillera.

To the east of the mobile belt the crust is stable; this stable region is characteristic of most of the central part of the continent. Although much mineral wealth has come from the stable interior, it is the mobile belt that has produced the great bonanzas of hydrothermally deposited metallic minerals.

In the central states, at the widest part of the Cordillera, the flat lying sedimentary rocks of the stable interior abruptly bend up and thin out against the Precambrian rocks of the central and southern Rocky Mountains. If one traveled west from here, there would be found many regional features, such as the Colorado Plateau (actually part of the Rockies), and several intermontane basins, but the next large geologic province is the Basin and Range area of western Utah and Nevada. Here the crust, unlike that in the mountains, has undergone tension, with great normal faults separating downdropped basins and intervening ridges.

Near the Nevada-California boundary, another belt of mountains occur, the Sierra-Nevadas, followed by another down-faulted and folded zone, the Great Valley, and finally the Coast Ranges of California. This same general pattern exists in Oregon, Washington, British Columbia and Yukon Territory, Alaska. Figure 11 shows the patterns of geographic features in the Cordillera.

DEFINITIONS AND CONCEPTS

When studying geologic history, the existence of sedimentary rocks in a certain area means that the area was receiving sediments at one time, hence was a basin, below sea level if the sediments are of marine origin, above sea level if they are nonmarine. Sedimentation then, implies that an area was depressed, sometimes, depending on the type of sediments deposited, also implying that it was quiescent. On the other hand a lack of sedimentary rocks means that the area was uplifted above sea level, often implying disturbance, tilting, folding, faulting, and most important to us, intrusion of igneous rocks, possibly with accompanying mineral deposits.

Currently, mobile belts are viewed as consisting of several strips parallel to a coast. Bordering a stable continental platform, part of which may be above sea level and part below, is a g e o s y n c l i n e . This is a long submarine trough that is subsiding as sediments are depositied in it. On the continental side, merging with the stable platform, is a fairly shallow and slowly subsiding trough called a m i o g e o s y n c l i n e . Outside this is a shallower threshhold or s h e l f , followed by a deeper more rapidly subsiding trough called a e u g e o s y n c l i n e . Bordering the eugeosyncline on the outside is a chain of volcanic islands, with other islands protruding periodically through the eugeosyncline.

All of these components of the mobile belt and adjacent areas have different environments and hence produce different records. The emergent part of the stable shelf is undergoing erosion and furnishes sediments to the submarine parts; it therefore has a break in its record. The submerged parts of the stable shelf are quietly receiving sediments from the emergent parts; these sediments consist predominantly of limestones, quartzose sandstones and shales. The miogeosyncline is receiving much the same type of sediments as the stable shelf.

The eugeosyncline, however, is more active. It is rapidly subsiding, receiving sediments largely volcanic in origin from the chain of volcanic islands. These sediments are dark graywackes and shales with occasional conglomerates from an uplifted portion temporarily emergent in response to the continuous mobility. Much chert occurs in such rocks, perhaps the product of siliceous organisms. Very important constituents of such e u g e o s y n c l i n a l a s s e m b l a g e are two igneous rocks: basalts and ultramafic intrusives. It is postulated that the volcanoes bordering the eugeosyncline tap the lower crust or mantle (below the crust) and that submarine basalts interlayer with the accumulating sediments. From the same source, gabbros, peridotites and serpentines are intruded into the accumulating geosynclinal pile. In many parts of the world, such eugeosynclinal basalts contain anomalous, although still small, amounts of copper. On the other hand, tremendous outpourings of plateau basalts such as in the Columbia River and Dekkan areas do not contain any appreciable amount of copper.

With these definitions and concepts, we are ready to describe the history of the various parts of the Cordillera, remembering that much of this history is still imperfectly understood.

BRIEF HISTORY OF CORDILLERA

(Note: Much of the general information contained in this section is from King (1959, 1966) and Eardley (1962).

Through much of the Precambrian and Paleozoic time the area between the Colorado Rockies and the West Coast was intermittently submergent, receiving sediments in an environment that was stable continental on the east, miogeosynclinal in the central part and eugeosynclinal in the west. The site of the present Colorado Rockies and Plateau in fact, was a stable shelf, and acquired only a thin cover of sedimentary rocks. At the west edge of the Colorado Plateau, miogeosynclinal rocks first appear; it may be argued that this is the true eastern edge of the mobile belt. Miogeosynclinal rocks give way to eugeosynclinal rocks in western Nevada and continue into the Sierra Nevadas and Klamath Mountains.

Beginning in Devonian time, and continuing into Pennsylvanian, an uplift created several positive areas that shed sediments into the eugeosynclinal, miogeosynclinal, and stable shelf areas. These positive areas were subsequently worn down, and sedimentation from place to place continued into Jurassic time.

The orogeny that forms mountains from geosynclines characteristicly begins with uplift of the eugeosynclines, the areas that have been depressed to the greatest depths. In Middle to late Jurassic, such uplift began in the eugeosynclinal belt, and progressively moved eastward, leaving a trough to the west in California which continued to receive sediments. By late Cretaceous time the uplift had reached the present site of the Colorado Rockies. The earlier orogeny in the west is now called Nevadan, while the later one in the east is called Laramide.

Tertiary and Quaternary events have given the present relief to the Cordillera, but only in the coastal areas have they created new structures. At least two epeirogenic uplifts have raised the Rockies to their present positions. In the miogeosynclinal area in the United States, tensional deformation of the crust between the Colorado Plateau and the Sierra Nevadas has created block faults, expressed topographically in Basin and Range features. The Sierra Nevadas owe their present height to block faulting and tilting, probably associated with this extension of the crust.

The Cascades and the Coast Ranges of California, Oregon and Washington are younger than the mountains in the east. The Coast Ranges have been formed from sediments that continued to be deposited after the Nevadan orogeny had started to the east. The Cascades are the result of Tertiary and Quaternary volcanism, and cut across the Nevadan structures of northern California, Oregon, and Washington.

In Canada the principal ranges as listed continue, but the Cordillera narrows. The region between the Canadian Rockies and the Canadian Coast Range (which is an extension of the Sierra Nevadas) is occupied by plateaus, but not of a width comparable to the Basin and Range province. The Coast Ranges of the United States have their extension in the westernmost islands of Southeastern Alaska or swing out to sea to reappear in the St. Elias Range of Alaska-Yukon. The relationships of the geographic and tectonic features along the whole Cordillera may be seen in Figures 11 and 12.

CORDILLERA IN ALASKA

In Alaska the entire Cordillera plus a narrow strip of Stable Interior is represented. Although this requires some contraction, it is not so much as is sometimes thought. The ratio of widths of the Cordillera at Umiat and at Denver is about two to three, but when the Alaskan section is compared with that in Canada, the widths are about the same.

As is true farther south, in Alaska there are differences between the physiographic provinces and the geologic ones. For example, although in the area north of the Brooks Range, the foothills and coastal plain merge into each other physiographically, geographically there is a significant boundary between the Colville Geosyncline and the Arctic Coastal Plain (Plate 3). This boundary separates a stable platform area to the north from a geosynclinal area to the south.

The following tabulation compares features in Alaska with those already described. In Alaska the order is north to south; in the U. S. and Canada, from east to west.

ALASKA	UNITED STATES and CANADA
Alaska Coastal Plain	Stable Interior
Colville Geosyncline	Basins east of Front Range, e.g. Denver Basin
Brooks Range	Rocky Mountains
Interior Lowlands and Plateaus	Basin and Range, Columbia Plateaus, Canadian Intermontane Plateaus
Alaska Range	Canadian Coast Range, Sierra Nevada
Series of basins: Cook Inlet, Susitna basin Copper River basin	Troughs in Southeastern Alaska, Puget Sound, Willamette Valley, Great Valley
Pacific Border Ranges	Mountains in outer Alexander Archipelago, Coast Ranges of the United States

These relationships are partially shown in Figure 11.

BRIEF GEOLOGIC HISTORY OF ALASKA

(Note: Much of the general information in this section is from Gates and Gryc (1963) and Herreid (1961).

Pre-Mesozoic

The geologic and tectonic history of Alaska and the configuration of tectonic features correspond surprisingly well with those farther south.

During early Paleozoic time a volcanic archipelago extended around what is now the

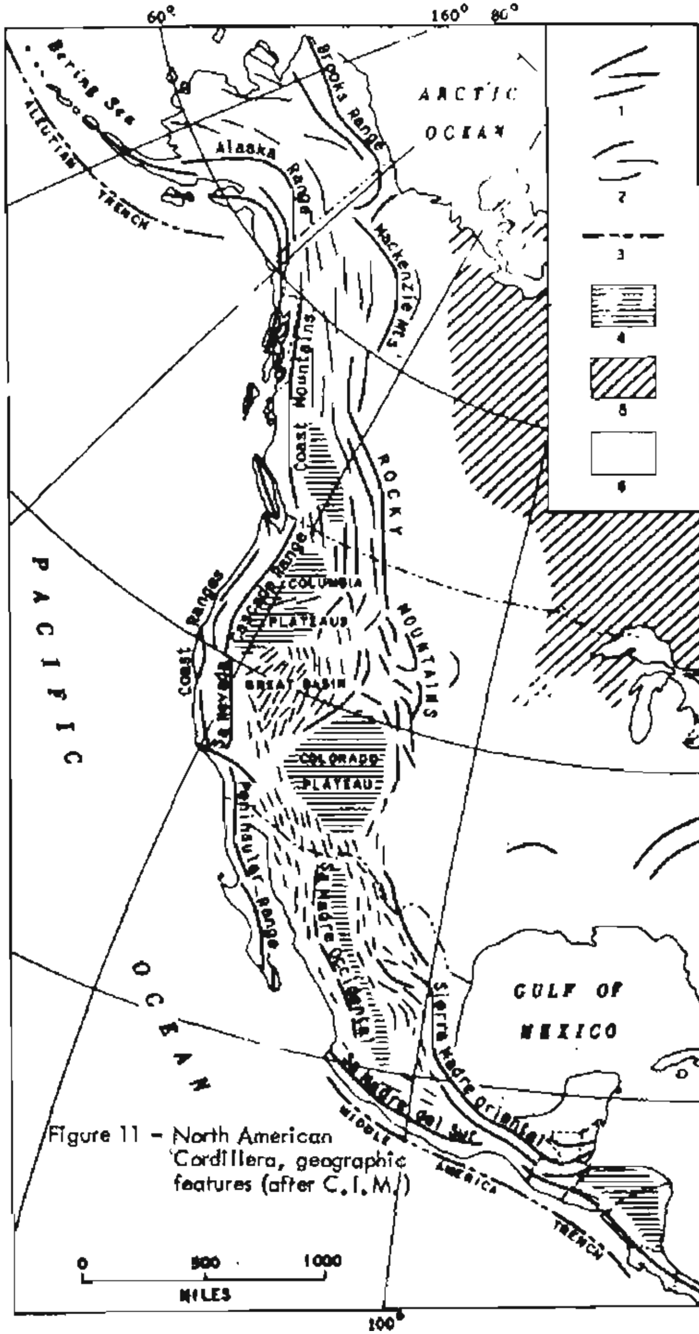


Figure 11 – North American Cordillera, geographic features (after C.I.M.)

Map of North American Cordillera and adjacent areas, to show present topographic configuration.

Explanation of symbols:

1-Major Mountain ranges.
2-Minor Mountain ranges.
3-Oceanic trenches.
4-Plateaus.
5-Canadian Shield
6-Lowland areas.

← Figure 11

Figure 12 →

Map of North American Cordillera and adjacent areas, to show the gross tectonic pattern by means of various selected features.

Explanation of symbols:

Features of Cordilleran belt:

1-Eastern margin of geosynclinal area.
2-Tertiary volcanic rocks.
3-Granitic plutonic rocks.
4-Metamorphic complexes.
5-Transverse zones between segments.
6-Letters and numbers designating the transverse zones and segments that are discussed in text.

Features east of Cordilleran belt:

7-Canadian Shield.
8-Edge of Appalachian and Ouachita fold-belts.
9-Folds in cratonic area in front of geosynclinal part of Cordillera.

Subsea features:

10-Oceanic trenches.
11-Fracture zones.

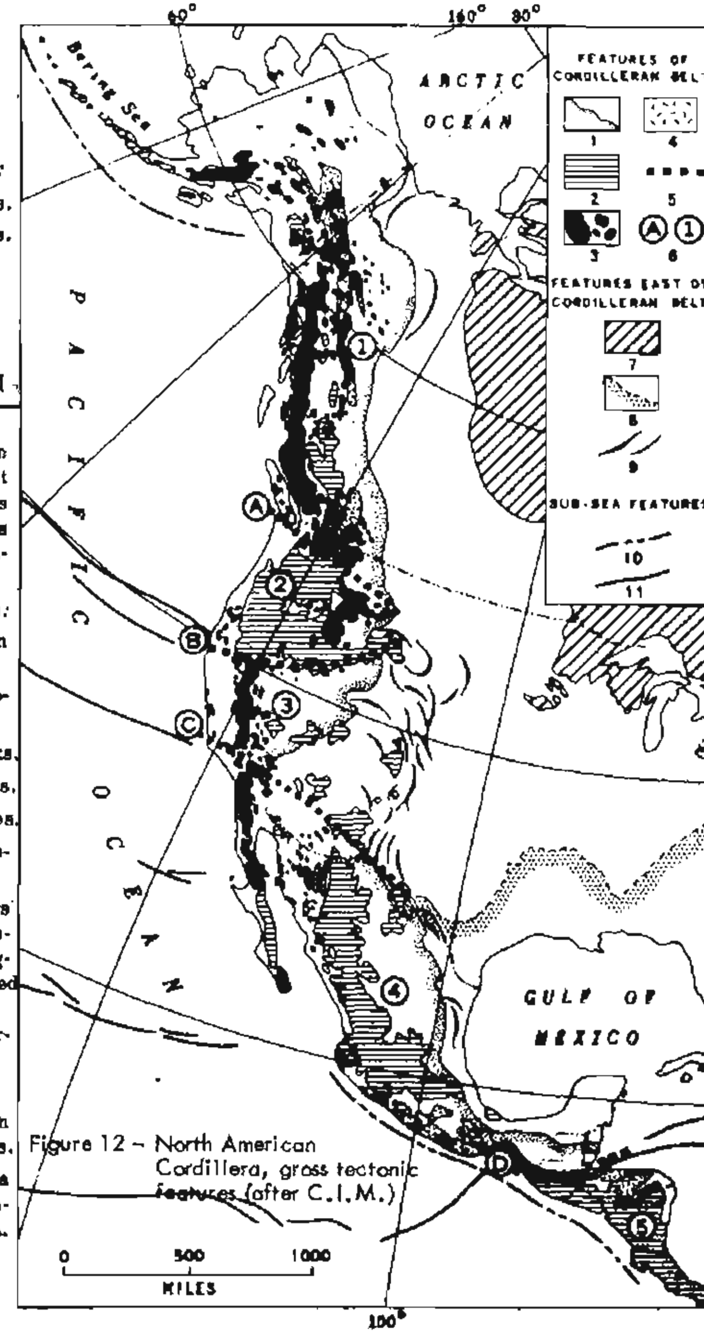


Figure 12 – North American Cordillera, gross tectonic features (after C.I.M.)

southern and southeastern border of Alaska, with a eugeosyncline extending north and east approximately to the northern side of the Alaska Range. The lower Paleozoic rocks of this area are conglomerates, graywackes, andesitic and basaltic flows, pyroclastics and limestone. North of the Alaska Range, the lower Paleozoic rocks consist of shale and carbonate, indicating that the central part of Alaska was occupied by a miogeosyncline (see Figure 13). This graded into a shelf area with a shoreline presumably in the area of the Brooks Range. During early Paleozoic time there were intermittent uplifts and subsidences; more intense in the eugeosyncline than in the miogeosyncline.

In pre-Middle Devonian time, there was uplift and disturbance in both the eugeosyncline and miogeosyncline; unconformities were formed over much of the area, and when sedimentation resumed eugeosynclinal conditions had shifted north over the southern parts of the former miogeosyncline. Upper Paleozoic rocks in central Alaska are therefore siltstones, graywackes, volcanics and limestones. In the northern part of the geosyncline and on the stable shelf, this deformation was less intense, with a northward shift of the miogeosyncline, and an advance of the sea northward to encroach on the land to the north.

No marked events of deformation occurred at the end of Paleozoic time, and late Paleozoic conditions persisted through to the end of Triassic time. There was, however, unrest during the whole interval, and there are extensive unconformities in Pennsylvanian and Triassic time. Apparently little igneous activity of the type that produces granitic intrusive rocks accompanied Devonian, Pennsylvanian, or Triassic movements. In Southern Alaska, Upper Triassic rocks were again miogeosynclinal.

Mesozoic

In Jurassic time there began a sequence of events that have given Alaska its present tectonic and physiographic aspect; these events correspond very closely with those farther south, and are part of the Nevadan, and later, Laramide disturbances. In a general way, they represent an acceleration of the mobility that began in Devonian time all along the Cordilleran geosyncline. The Nevadan and Laramide distrubances shaped the Cordillera, and since most of Alaska lies in the Cordillera, they may be said to be the greatest events of Alaskan geologic history.

These Mesozoic events consisted of the breaking up of the geosyncline and stable shelf into alternating troughs and ridges whose axes curved across Alaska. Figure 14, after Gates and Gryc (1963) shows the distribution of troughs and ridges, and Plate 3 (in pocket) shows them in relation to ore deposits and igneous rocks. Ages of filling of the troughs are shown in Figure 15 (Gates and Gryc, 1963). The troughs, actually geosynclines, were formed from Middle Jurassic to late Cretaceous time. There are seven principal ones, from south to north: (1) Chugach Mountains, (2) Matanuska, (3) Alaska Range, (4) Kuskokwim, (5) Koyukuk, (6) Kobuk, (7) Colville. Most of them contain several tens of thousands of feet of eugeosynclinal sediments. Note from Figure 15 that subsidence started first (Middle Jurassic) in the Matanuska geosyncline, and, with some irregularity,

Figure 13 – General Relations within Geosyncline in Alaska, early and late Paleozoic time

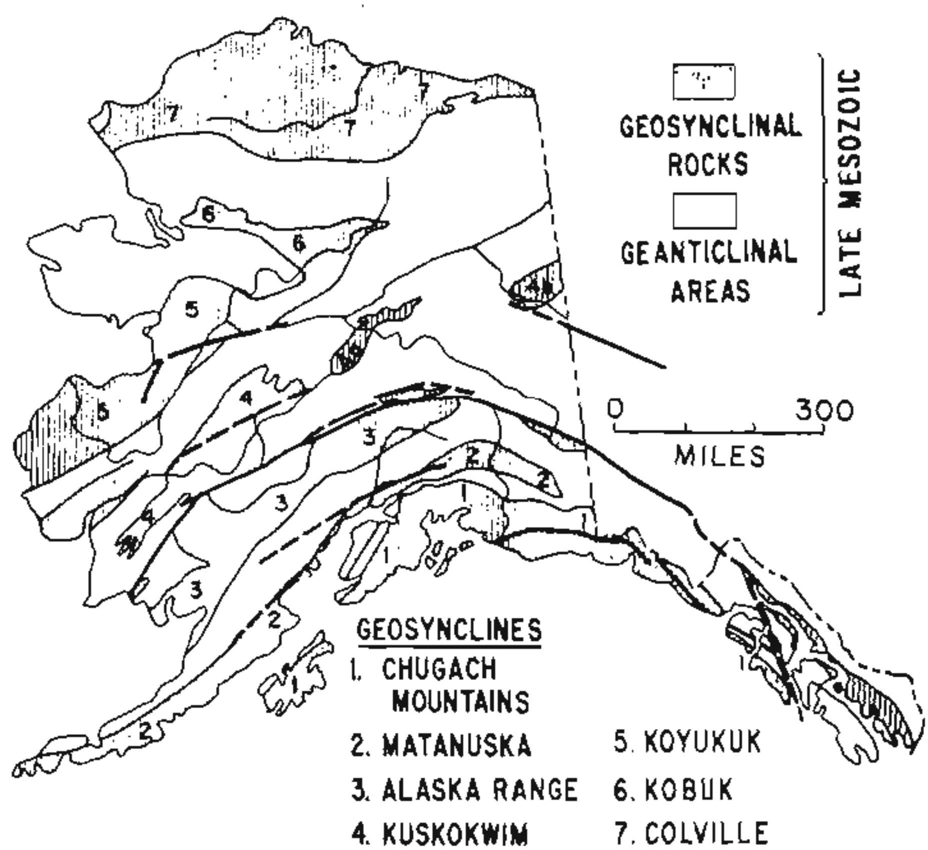


Figure 14 – Late Mesozoic Geosynclinal rocks of Alaska; 4-a is Tofty segment, and 4-b is Kandik segment of the Kuskokwim Geosyncline (after A.A.P.G.).

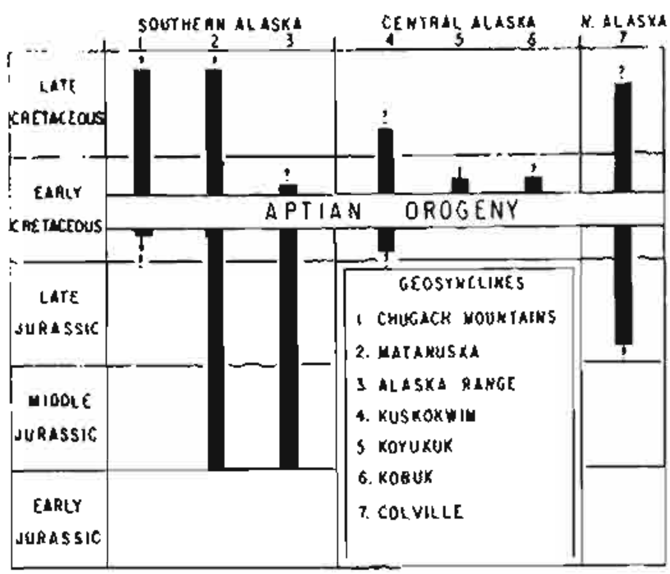


Figure 15 – Range in Age of sediments of late Mesozoic Geosynclines of Alaska (after A.A.P.G.).

proceeded north, then jumped back in the Cretaceous to the southern Coast in the Chugach Mountain geosyncline. There is, indeed, a Tertiary geosyncline along the coast south of the Chugach Mountains. These younger troughs on the seaward side of the Nevadan deformations are suggestive of those in California.

The formation of these geosynclines, and their deep filling, implies that geanticlinal ridges were rising between them to supply the masses of sediments. The geosynclinal piles then are clastic wedges shed in both directions from the rising uplifts. Herreid (1964) believes these uplifts were formed from deep wrinkles - eugeosynclines - that developed in late Paleozoic time (see section following). This too, corresponds to the formation of numerous separate basins during the same time farther south.

Although uplift of the geanticlines and simultaneous filling of the geosyncline by clastic wedges continued from Middle Jurassic into late Cretaceous time, orogeny seems to have reached a climax in mid-Early Cretaceous (Aptian) time, see Figure 15. Apparently all of Alaska was emergent at this time; geanticlines and geosynclines both were uplifted and subjected to erosion. In the Kuskokwim and Alaska Range geosynclines, folding accompanied the uplift. In the Alaska Range there was no more marine sedimentation, and the structure therefore, first dates from this event, although the Range was not nearly so lofty as it is today.

Sedimentation in the other geosynclines continued as shown in Figure 15, but toward the end of the Mesozoic Era, Laramide orogeny folded both geosynclines and geanticlines to varying degrees. This orogeny blocked out the shapes of the present mountains. The Brooks Range was uplifted and folded from a geanticlinal area, and the Alaska Range from a geosynclinal area. However, all areas were uplifted and the clastic wedges of the geosynclines underwent folding of varying intensity in early Tertiary time.

Tertiary-Quaternary

During the Tertiary uplift, clastic wedges of Tertiary rocks were, of course, laid down. All of the Tertiary basins are not shown on Plate 3, but Figure 16 shows the general arrangement of those that are preserved. The Tertiary rocks of the Interior are all non-marine, unless marine rocks are hidden beneath Quaternary deposits.

During Tertiary and Quaternary times, deformation in Alaska was chiefly by block uplift, rather than by folding, except for the Tertiary sediments. The Tertiary was mostly a time of erosion, and at least two extensive periods of erosion are recorded, with uplift between them. Toward the end of Tertiary time, and continuing into the Quaternary, further uplift and downwarping has given the present configuration to the Alaskan landscape. Quaternary basins, the great "flats" of Alaska, are not shown on Plate 3, but their distribution may be seen by inspection of any topographic map of the State. Many of these are undoubtedly bounded at least partially by faults, and some are underlain by Tertiary sediments.

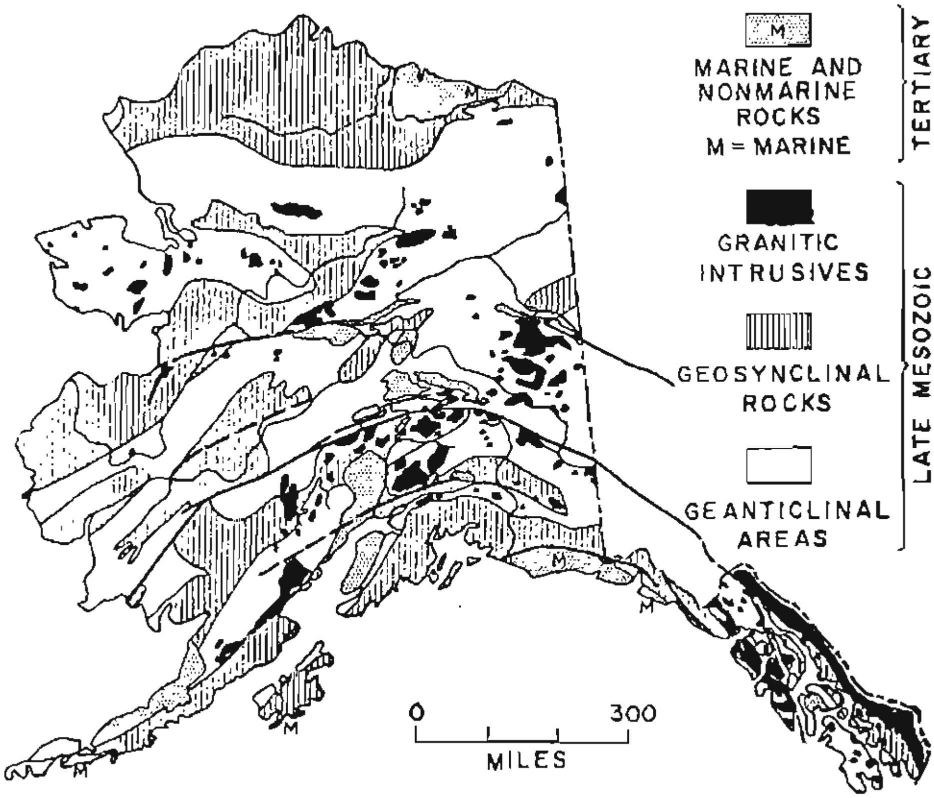


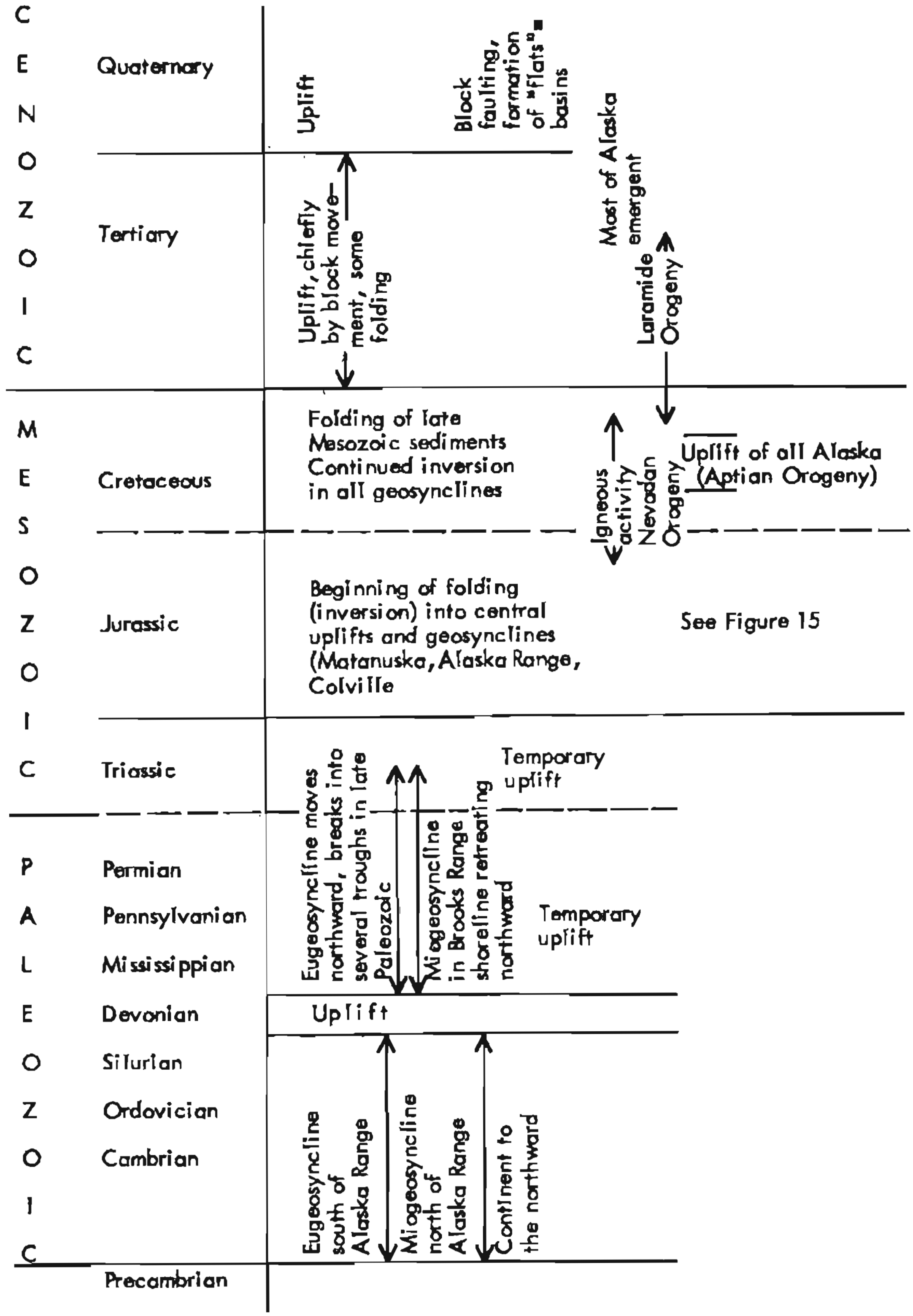
Figure 16 - Late Mesozoic and Tertiary tectonic elements of Alaska (after A.A.P.G.).

Igneous Activity

Of great interest to economic geology are igneous rocks that accompanied the orogenies of Mesozoic and Cenozoic times. As the time of deformation differed, so the time of intrusion did also. The oldest known intrusions (Gates and Gryc, 1963) of Middle Jurassic age, border the oldest geosyncline, the Matanuska geosyncline. It is probable that as age data accumulate, a rough correlation will be found between the age of Mesozoic geosynclines and the age of intrusions that occur along their borders. During the Tertiary deformations, intrusive and extrusive rocks invaded both the Mesozoic geosynclines and the geanticlinal areas. Igneous activity in pre-Mesozoic time was chiefly confined to the formation of volcanic and basic intrusive rocks, both typical of earlier phases of geosynclinal development.

An attempt has been made to show the chief events in the history of Alaska graphically in Figure 17.

Figure 17 - Principal geologic events in history of Alaska



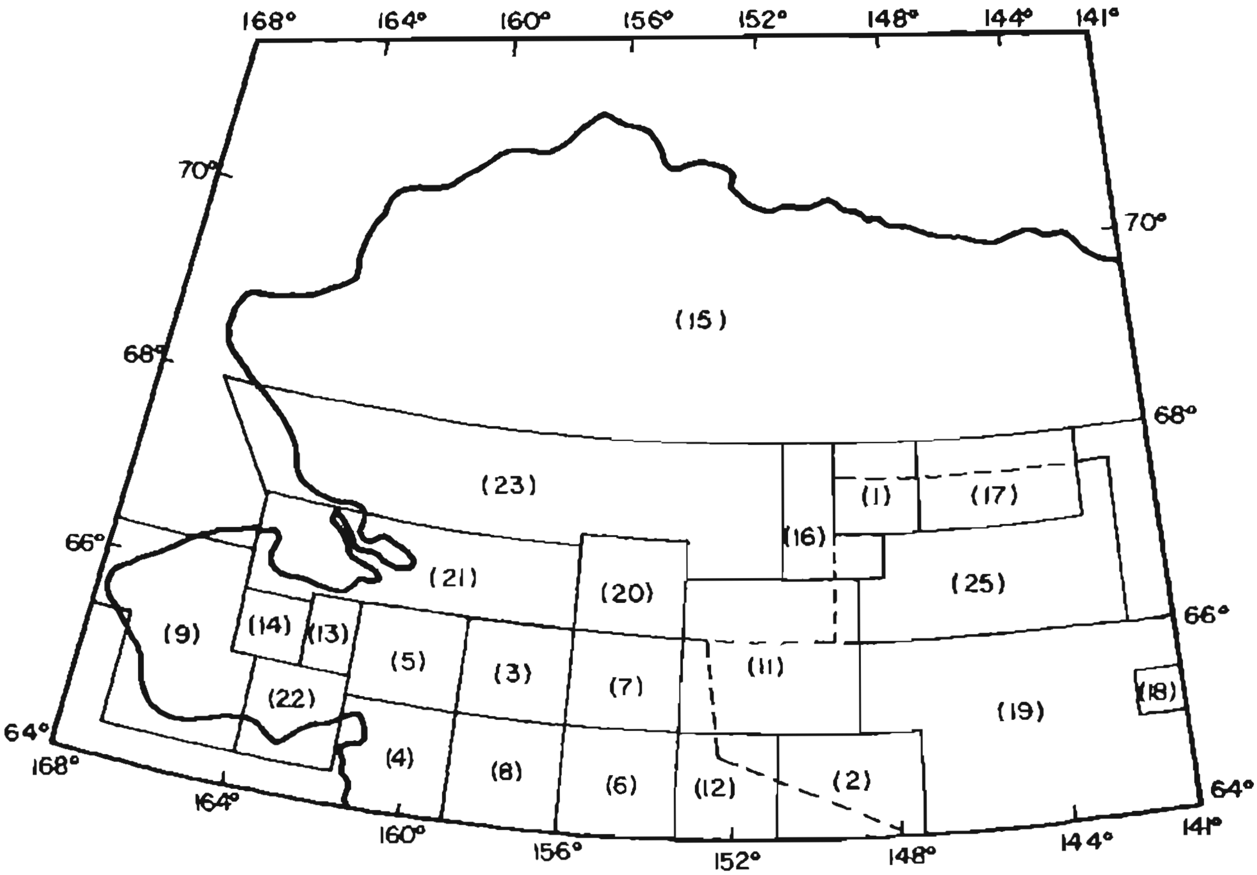
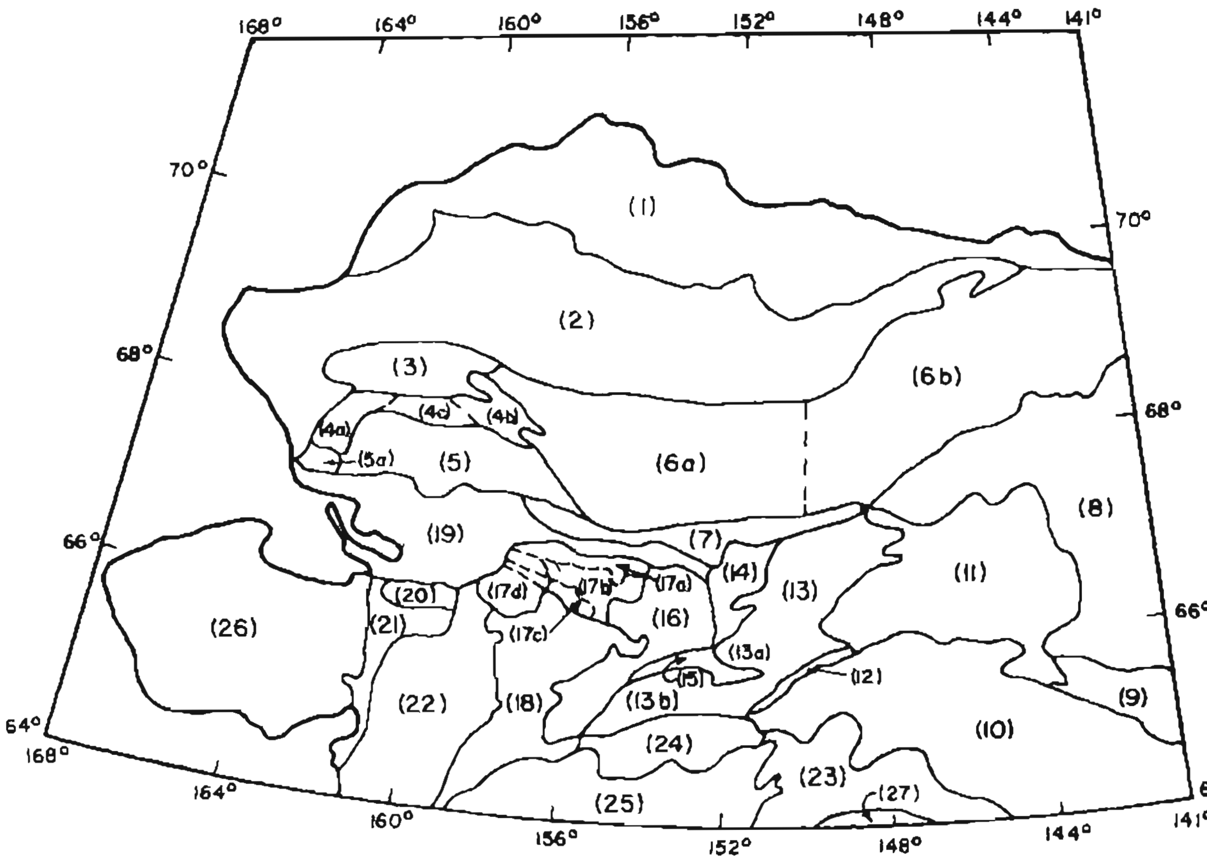


Figure 18 - **Sources of Map Information**

(Numbers Refer to References)

(1) Brosgé and Reiser, 1964
(2) Capps, 1940
(3) Cass, 1957
(4) Cass, 1959
(5) Cass, 1959a
(6) Cass, 1959b
(7) Cass, 1959c
(8) Cass, 1959d
(9) Collier, Hess, Smith, and Brooks, 1908
(10) Dutro and Payne, 1957
(11) Eakin, 1916
(12) Eakin, 1918
(13) Harrington, 1917
(14) Hopkins, 1963
(15) Lathram, 1965
(16) Maddren, 1913
(17) Mertie, 1927
(18) Mertie, 1930
(19) Mertie, 1937
(20) Patton and Miller, 1966
(21) Smith, 1913
(22) Smith and Eakin, 1911
(23) Smith and Mertie, 1930
(25) Williams, 1962



1. Arctic Coastal Plain
2. Arctic Foothills
3. DeLong Mountains
4. Noatak Lowlands
   a.) Mission Lowlands
   b.) Aniuk Lowlands
   c.) Cutler River Upland
5. Baird Mountains
   a.) Igichuk Hills
6. Central and Eastern Brooks Range
   a.) Central Brooks Range
   b.) Eastern Brooks Range
7. Ambler – Chandalar Ridge and Lowland Section
8. Porcupine Plateau
9. Ogilvie Mountains – Tintina Valley Section
10. Yukon-Tanana Upland
11. Yukon Flats
12. Rampart Trough
13. Kokrine-Hodzana Highlands
   a.) Ray Mountains
   b.) Kokrine Hills
14. Kanuti Flats
15. Tozitna-Melozitna Lowland
16. Indian River Upland
17. Pah River Section
   a.) Lockwood Hills
   b.) Pah River Flats
   c.) Zane Hills
   d.) Purcell Mountains
18. Koyukuk Flats
19. Kobuk-Selawik Lowland
20. Selawik Hills
21. Buckland River Lowland
22. Nulato Hills
23. Tanana-Kuskokwim Lowland
24. Nowitna Lowland
25. Kuskokwim Mountains
26. Seward Peninsula
27. Northern Foothills of the Alaska Range

Figure 19 – **Physiographic Divisions of Northern Alaska**
(after Wahrhaftig, 1965)

Geology of Northern Alaska by R. M. Slatt

PURPOSE

In order to evaluate the mineral potential of an area as large as northern Alaska, the detailed geology of that area must be known. In the last sixty years, geologic mapping has been done in several different areas, however few attempts have been made to combine or correlate the work. Dutro and Payne (1957) have compiled a regional geologic map of Alaska, however this is of little value in assessing the mineral potential of a given area. More recently, Lathram (1965) has compiled a preliminary geologic map of Alaska north of 68° North latitude which, although sufficiently detailed, does not encompass the entire area affected by the proposed railroad route.

This report is a compilation of the geology of Alaska north of 64° North latitude, the entire area affected. The detailed geology presented herein will aid in evaluating the mineral potential of this region.

PREPARATION OF REPORT

Geologic Map of Northern Alaska

Figure 18 shows the sources of information concerning the geology of northern Alaska; delineated areas represent geologic map coverage used from each source. Data from these maps were compiled and used to prepare a detailed geologic map of northern Alaska at a scale of 1:1,000,000 (Plate 1). Because of the considerable time span between older and more recent reports (1908-1966), the degree of detail of geologic mapping and description is quite variable, therefore no attempt was made to correlate rock units from different reports. Rock unit symbols were taken from the specific reports thus accounting for the large number of symbols on the Geologic Map. Geologic structure was not included on the map.

Description of the Geology of Northern Alaska

Because the geology of Alaska is complex, a description of the area as a whole is of little value, and a better description may be made by subdividing the area. Since physiography and geology are related, a slightly modified version of Wahrhaftig's (1965) physiographic classification of Alaska was used as the basis of subdivision. Based on differences in regional and local physiography, Wahrhaftig has broken Alaska into specific Divisions, Provinces, Sections, and Subsections, however for the purpose of this report, all the physiographic units are given equal merit and are merely considered as "divisions". The classification is shown in Figure 19 and outlined on the Geologic Map.

Using this classification, the various rock types comprising each division in northern Alaska are briefly described. Also included for each division are brief physiographic descriptions taken from Wahrhaftig (1965) and the references cited. In several instances, the unit is described separately under each division, for although this results in repetition, the necessity of cross-referencing is eliminated.

Relation between Rock Units

Although no correlation of rock units has been attempted in this report, relationships are generally established on the basis of age and rock type. The age distribution of the rocks is shown in Plate 2. In this diagram, rocks have been grouped according to their igneous, sedimentary, metamorphic, or undifferentiated nature.

GEOLOGY OF NORTHERN ALASKA

1. Arctic Coastal Plain

The Arctic Coastal Plain is a marshy plain gently sloping northward toward the Arctic Ocean. Several rivers, such as the Colville, Sagavanirktok, Canning and Meade flow north across the plain to the ocean. Because the plain is poorly drained, it contains numerous lakes, the largest of which is Teshekpuk Lake.

Most of the area is covered by Pleistocene (?) silt (Qs) of the Cubik Formation. Alluvium and glacial material (Qag) is associated with river valleys. Exposed bedrock is largely Tertiary conglomerate and sandstone (Tc) of the Sagavanirktok Formation with some Tertiary siltstone and sandstone (Ts) including the Nuwak Formation. Some Cretaceous sandstone, conglomerate, and shale (Ksc) including the Nanushuk Group and lower part of the Ignek Formation is exposed along river valleys. Much of the geology in the northeastern corner of the plain is unknown (U). (Lathram, 1965).

2. Arctic Foothills

The Arctic Foothills section consists of rolling plateaus and low mountains which rise toward the south. Rivers such as the Colville flow across the foothills to the Arctic Ocean.

Almost the entire section is underlain by east-west trending belts of Cretaceous rocks: 1) sandstone, conglomerate, and shale (Ksc) which includes the Nanushuk Group and lower part of the Ignek Formation, 2) shale of the Torok Formation (Ks), 3) sandstone, shale, and conglomerate (Kss) which includes the Colville Group and upper part of the Ignek Formation, and 4) conglomerate and sandstone (Kc) of the Fortress Mountain Formation. Less common rocks include: 1) Tertiary conglomerate and sandstone (Tc) of the Sagavanirktok Formation, 2) Jurassic-Cretaceous shale (KJs), 3) Permian-Cretaceous shale, chert, and limestone (KPs) 4) Permian-Triassic sandstone and siltstone (T_RPs) of the Sadlerochit Formation and undifferentiated shale and chert (T_RPsh) of the Siksikpuk and Shublik Formations, 5) Triassic shale, limestone, and chert (T_Rs) of the Shublik Formation, 6) Mississippian-Permian limestone (PMl), 7) the Carboniferous Lisburne limestone (Cl), and 8) Paleozoic and Mesozoic mafic and ultramafic rocks (m) which are largely gabbros and basalts, but which include dunites, pyroxenites. Some Mississippian shale (Ms) and basic effusive and intrusive rocks (br) of uncertain age crop out along the western coast. River valleys are floored with alluvium and glacial material (Qag/Qsg) and in some locales Pleistocene (?) silt (Qs) of the Gubik Formation is found. The geology in certain parts of the section is unknown (U). (Lathram, 1965; Smith and Mertie, 1930).

3. DeLong Mountains

The DeLong Mountains section consists of rugged ridges and hills dissected by tributaries of the Noatak River and smaller streams flowing north to the Arctic Ocean.

The geology of a large part of this section is unknown (U). Known bedrock is dominantly: 1) Mississippian-Permian limestone (PMl) of the Lisburne Group, shale, limestone, chert, and mafic igneous rocks (PMs), and arkose and chert (PMa) of the Nuka Formation, 2) Permian-Cretaceous shale, chert, and limestone (KPs) including the Shublik and Siksikpuk Formations, and 3) Jurassic-Cretaceous graywacke, chert and mafic igneous rocks (KJg) including the Okpikruak and part of the Tiglukpuk Formations. Lesser occurrences include: 1) Devonian dolomite, limestone, sandstone, and shale (Ddl) of the Kuguruk Formation, 2) Permian-Triassic shale and chert (T_R Psh), 3) Triassic shale, limestone, and chert (T_Rs) of the Shublik Formation, and 4) mafic and ultramafic rocks (m) which are largely gabbros and basalts, but which also include some dunites, pyroxenites, and peridotites mainly of Jurassic age. River valleys are floored with alluvium and glacial material (Qag). (Lathram, 1965).

4. Noatak Lowlands

This section consists of two broad plains, the Mission Lowland (4a) to the west and the Aniuk Lowland (4b) to the east, separated by the Cutler River Upland (4c). All three areas are drained by the Noatak River.

The Mission Lowland is floored with sand, gravel, and mud (Qsg); only a few outcrops of basic effusive and intrusive rocks (br) of uncertain age are found. Geology of the eastern margin is unknown (U). Most of the geology of the Aniuk Lowland is also unknown (U), but sand, gravel, and mud (Qsg) is found along the southern margin. The Cutler River Upland is largely composed of: 1) Devonian siltstone and sandstone (Ds), 2) Devonian-Mississippian conglomerate (MDc), and 3) the Carboniferous Noatak Sandstone (Cn) which consists of sandstone and shale with a few coal beds. Minor outcrops of Mississippian-Permian limestone (PMl) and Jurassic-Cretaceous graywacke, chert, and mafic igneous rocks (KJg) are also found. River valleys in the Upland are floored with alluvium and glacial material (Qag/Qsg). (Lathram, 1965; Smith and Mertie, 1930).

5. Baird Mountains

The moderately rugged Baird Mountains are drained primarily by tributaries of the Noatak and Kobuk Rivers.

Geology of the central part of the mountains is unknown (U). The southern margin is largely composed of early Paleozoic or older highly metamorphosed rocks (mr), but also includes some early Paleozoic or older highly metamorphosed limestone (ls) and Tertiary sandstone, shale, and conglomerate (Ts). River valleys are floored with sand, gravel, and mud (Qsg) which locally contain muck and peat beds.

The Igichuk Hills (5a), which comprise the southwestern margin of the section, are underlain by the Silurian Skajit Limestone (Ss) which is predominantly metamorphosed limestone and dolomite. Minor outcrops of the Carboniferous Lisburne Limestone (Cl) are also found. The Noatak River valley, which crosses the hills, is floored with sand, gravel, and mud (Qsg). (Smith and Mertie, 1930).

6. Central and Eastern Brooks Range

The Central and Eastern Brooks Range consists of high, rugged east-west trending ridges and mountains drained by numerous rivers, some flowing north to the Arctic Ocean and others south to the Yukon, Koyukuk, and Kobuk Rivers. For descriptive purposes, the Central Brooks Range (6a) is here considered as that area west of 150° West longitude while the Eastern Brooks Range (6b) is that area east of this meridian.

The Central Brooks Range is largely underlain by a series of Paleozoic east-west trending belts including: 1) early Paleozoic or older highly metamorphosed rocks (mr) dominantly of sedimentary origin, 2) Silurian (?) undifferentiated limestone (Sas/Sl), 3) the Silurian Skajit limestone (Ss) which is predominantly metamorphosed limestone and dolomite, 4) Devonian sandstone, shale, and slate (Ds - south of 68° North latitude) and siltstone and sandstone(Ds - north of 68° North latitude), 5) Devonian-Mississippian conglomerate (MDc) including the Kanayut conglomerate, Noatak Sandstone, and Kekiktuk Conglomerate, 6) Mississippian shale (Ms), 7) Mississippian-Permian limestone (PMl) of the Lisburne Group, and 8) Mississippian-Permian shale, limestone, chert, and mafic igneous rocks (PMs). The only major Mesozoic unit is Jurassic-Cretaceous graywacke, chert, and mafic igneous rocks (KJg). Less common occurrences include: 1) pre-Ordovician (?) Birch Creek Schist (bc) which consists of various types of schist with some limestone, quartzite, and greenstone, 2) the Carboniferous Noatak Sandstone (Cn) which consists of sandstone and shale locally containing small coal beds, 3) Mississippian-Permian arkose and chert (PMa) of the Nuka Formation, 4) Permian shale (Ps) including the Siksikpuk Formation, 5) Permian-Triassic shale and chert (T_R Psh), 6) Permian-Cretaceous shale, chert, and limestone (KPs), 7) Cretaceous conglomerate and sandstone (Kc) of the Fortress Mountain Formation, 8) mainly Mesozoic mafic and ultramafic rocks (m), 9) greenstone and greenstone schist (gn) of uncertain age, and 10) intrusive rocks (gr) including granites, monzonites, and diorites also of uncertain age. River valleys are floored with alluvium and glacial material (Qag/Qsg). Much of southern part of the Range is unknown (U).

The Eastern Brooks Range contains many of the same rock types found in the Central Brooks Range. The most dominant of these are (Ds - both north and south of 68° North latitude), (MDc), and (PMl) while less common units include (Sl), (Ms), (Ps), (m), and (T_RPsh). Additional extensive units include: 1) Devonian limestone (Dl/Dsk), limestone and siltstone (Dls), metamorphic rocks (Dsm) of the Neruokpuk Formation, and quartz-mica schist (Dqm), and 2) Permian-Triassic sandstone and siltstone (TRPs) of the Sadlerochit Formation. Less common rocks include: 1) Devonian albite-chlorite mica (Da/Daq/Dac), quartz mica (Dqg/Dqm), and quartzite (Dsq) schists, 2) Devonian greenstone and greenschist (Dg/Dgs), calc-silicate hornfels (Dch), calc-schist and marble (Dcm), and slate and phyllite (Dsp), 3) Mississippian-Triassic chert and argillite (TRMc), 4) Upper Paleozoic or Mesozoic gneissic granite, quartz monzonite and granodiorite (MPg), 5) Triassic shale, limestone, and chert (TRs) of the Shublik Formation, 6) Jurassic-Cretaceous shale (KJs), and 7) Cretaceous sandstone, shale, and conglomerate (Kss) including the Colville Group and upper part of the Ignek Formation, sandstone, conglomerate, and shale (Ksc) including the Nanuskik Group and lower part of the Ignek Formation, and granite (g). River valleys in this area are floored with alluvium and glacial material (Qag/Qal). (Brosgé and Reiser, 1964; Lathram, 1965; Maddren, 1913; Mertie, 1927; Smith and Mertie, 1930).

7. Ambler-Chandalar Ridge and Lowland Section

This section consists of a series of east-west trending ridges and lowlands. The western part of the section is drained by the tributaries of the Kobuk River, primarily the Ambler River, whereas the central part is drained by the Koyukuk River and its tributaries, and the eastern part by the Chandalar River.

The western part is largely underlain by early Paleozoic or older highly metamorphosed rocks (mr) dominantly of sedimentary origin, but smaller occurrences of highly metamorphosed limestone (ls) of the same age, and Tertiary sandstone, shale, and conglomerate (Ts) are also found. Common Mesozoic rocks include: 1) Cretaceous graywacke and mudstone (Kgm), chert and argillite (Kc) with interbedded rhyolitic tuff, sandstone, and grit, and sandstone and shale (Ku) with numerous thick coal beds, 2) Jurassic or late Paleozoic undifferentiated altered volcanic rocks and phyllite (JDu), and 3) Jurassic altered mafic volcanic rocks (Jv) including andesite and basalt flows, diabase, intrusives and chert. Some Devonian phyllite (Dp) and limestone (Dl) are also found. Tributary valleys of the Kobuk River are floored with alluvium (Qsg/Qfp) and younger (Qyg) and older glacial drift (Qga).

The geology of much of the central part of this section is unknown (U). Exposed rocks include Cretaceous sandstone and shale (Ku) with numerous coal beds, and limestone, sandstone, shale, and conglomerate (Kl) which is locally intruded by igneous rocks. Alluvium (Qal) is also found in this area.

The eastern part is dominated by alluvium (Qal). Minor outcrops of Devonian (?) cherts, slates, and diabase (Csd), phyllite (Dp), greenstone (Dg), graywacke and phyllite (Dgw), and volcanic rocks and chert (Dv) are found. (Brosgé and Reiser, 1964; Maddren, 1913; Patton and Miller, 1966; Smith and Mertie, 1930).

8. Porcupine Plateau

The Porcupine Plateau consists of gently rolling hills and ridges separated by broad valleys. Some isolated mountains are also found. The plateau is drained by tributaries of the Yukon River, the largest of which is the Porcupine River.

The geology of almost all the central and eastern part of the section is unknown (U). Exposures of Devonian or Carboniferous chert and slate (Dc) with associated basic intrusives are found along the Sheenjek River. The river valley is floored with alluvium (Qal) as is the southern margin of the plateau except for a few areas of alluvial-fan and related terrace deposits (Qat/Qaf).

Dominant bedrock in the western and northern marginal parts of the section are, from southwest to northeast: 1) pre-Silurian schist and phyllite (Sp) with associated greenstone and meta-diorite, 2) Devonian biotite (Db), biotite-staurolite (Dbs), and quartz-mica schist (Dqm), and sandstone, siltstone, shale, and slate (Ds), 3) Devonian-Mississippian conglomerate (MDc), and 4) the Mississippian-Permian Lisburne Group (PMl). Lesser rock types along the western margin include: 1) pre-Devonian metamorphic rocks and assorted intrusives (pDmu), dominantly schist, 2) Devonian phyllite (Dp), greenstone (Dg), greenschist (Dgs), siltstone and grit (Dsg), volcanic rocks and chert (Dv), and calcareous schist and marble (Dcm), and 3) Upper Paleozoic or Mesozoic granitic rocks (MPp) including granodiorite, quartz monzonite, and granite. Lesser rock types along the northern margin include: 1) Silurian (?) and Devonian undifferentiated metamorphic rocks (Dsm), 2) Devonian limestone and siltstone (Dls), 3) Mississippian shale (Ms) including the Kayak Shale, 4) Permian shale (Ps) including the Siksikpuk Formation, 5) Permian-Triassic shale and chert (TRPsh) and sandstone and siltstone (TRPs), 6) the Triassic Shublik Formation (TRs) which includes shale, limestone, and chert, 7) chert and argillite (TRMc) of uncertain age, and 8) mafic and ultramafic rocks (m) also of uncertain age which are largely gabbros and basalts but which include some dunites, pyroxenites, and peridotites. Valleys along both marginal areas are floored with alluvium and glacial material (Qag/Qal/Qd/Qat).

The Carboniferous Rampart Group and associated intrusives (Crv) and Cretaceous quartzitic sandstone, slate, and shale (Ks) make up a small exposure near the Ogilvie Mountains. (Brosgé and Reiser, 1964; Lathram, 1965; Mertie, 1927, 1937).

9. Ogilvie Mountains-Tintina Valley Section

The rugged Ogilvie Mountains are drained by tributaries of the Yukon River which include the Kandik and Nation rivers. The Tintina Valley, which lies south of the mountains, is a narrow belt of low ridges and valleys also drained by small tributaries of the Yukon River.

Three northwest trending belts of rocks may be defined in this area. The southernmost belt is dominated by Devonian undifferentiated rocks (Dnc). Minor outcrops of Precambrian (?) Birch Creek Schist (pC) and associated meta-igneous rocks, Devonian ultrabasic and basic intrusives of greenstone habit (Dbi), and Mesozoic granite and quartz diorite (grd) are also found.

The middle belt is dominated by Tertiary shales, sandstone, and conglomerate (Tsc). Less extensive units include: 1) Precambrian (?) Birch Creek Schist (pC), 2) the Carboniferous Livengood chert and associated intrusive rocks (Clg), Calico Bluff Formation (Ccb), Nation River Formation (Cnr), and noncalcareous sedimentary rocks (Cm) and 3) Triassic shale and limestone (Tr).

The northernmost belt is dominated by Cretaceous quartzitic sandstone, slate, and shale (Ks). Less extensive units include: 1) the Precambrian and lower Cambrian (?) Tindir Group (Tn/Tnl) and associated intrusive rocks, 2) the Devonian Woodchopper Volcanics (Dwv), and 3) the Carboniferous Nation River Formation (Cnr), Calico Bluff Formation (Ccb), and Tahkandit Limestone (Ct).

The geology of some parts of this section are unknown (U). Tributary valleys cross-cutting these belts are floored with alluvium (Qal). (Mertie, 1930, 1937).

10. Yukon-Tanana Upland

The Yukon-Tanana Upland, an area of low ridges and divides interspersed with rugged mountains, is drained by several tributaries of both the Yukon and Tanana rivers.

Except for the northwestern part, the Upland is dominated by Precambrian Birch Creek Schist (pC) and associated meta-igneous rocks, undifferentiated pre-middle Ordovician rocks (pO), and Mesozoic granite and quartz diorite (grd). Lesser rock types include: 1) Devonian undifferentiated rocks (Dnc) and ultrabasic and basic intrusives of greenstone habit (Dbi) and 2) Tertiary rhyolite and dacite (Tev) and shale, sandstone, and conglomerate (Tsc).

To the northwest, Devonian undifferentiated rocks (Dnc) are more common, as are: 1) the Carboniferous Rampart Group and associated intrusives (Crv), Livengood Chert and associated intrusive rocks (Clg), noncalcareous sedimentary rocks (Cm) and limestone (Cml), and 2) Cretaceous quartzitic sandstone, slate, and shale (Ks). Less common rocks described include: (pO), (Dbi), (grd), and (Tsc). Minor outcrops include: 1) the Ordovician Fossil Creek volcanics (Ov), 2) the Silurian Tolovana Limestone (St), 3) Devonian Woodchopper volcanics (Dwv) and limestone (Dl), and 4) Tertiary quartz monzonite (Tqm).

River valleys in the entire section are floored with alluvium (Qal) and some glacial deposits (Qm). (Mertie, 1937)

11. Yukon Flats

The Yukon Flats section, which comprises the broad, marshy drainage basin of the Yukon River, is largely covered with Quaternary sediments derived from the Yukon, Chandalar, Christian, and Sheenjek rivers; the major sediments are alluvial-fan and related terrace deposits (Qat), but some flood-plain and low-terrace alluvial deposits (Qal) are also found. The southern part of the section is largely covered with loess (Ql). Alluvial-fan silt deposits (Qaf) are associated with terrace and loess deposits. Large occurrences of eolian sand (Qs) are found to the west in the vicinity of the Yukon River as is some high-level alluvium (Qtg). Outcrops of Devonian-Carboniferous sedimentary and volcanic rocks and associated intrusive igneous rocks (CD) are scattered throughout the section while also to the pre-Devonian metamorphic rocks and associated intrusive igneous rocks (pDmu) are found as limited outcrops. In the northwest corner of the area, scattered outcrops of Devonian volcanic rocks and chert (Dv) are found. The geology of a small area to the northwest is unknown (U). (Mertie, 1937; Williams, 1962)

12. Rampart Trough

The Rampart Trough forms a narrow valley through which the Yukon River flows. The trough is floored with alluvium (Qal). (Mertie, 1937)

13. Kokrine-Hodzana Highlands

The Kokrine-Hodzana Highlands consist of rugged mountains such as the Ray Mountains (13a) in the central part of the section and low rolling hills such as the Kokrine Hills (13b) to the southwest.

The Kokrine Hills area, which is drained by tributaries of the Melozitna River, is largely underlain by pre-Cretaceous intrusive rocks (ir) including granite, syenite, monzonite and quartz diorite which is locally altered to augen gneiss and mica schist (ira) and a Precambrian or Paleozoic metamorphic complex (mc) consisting of several varieties of schist and some phyllite, slate, chert, and quartzite. The western margin, near the Melozitna River valley, is composed of a belt of Cretaceous rocks including the Shaktolik Group (Ks), which consists of graywacke, shale, grit, and conglomerate, and the Ungalik Conglomerate (ku) which consists of conglomerate, grit and graywacke. Tributary valleys are covered with alluvium (Qal). The geology of the northeastern part of the Kokrine Hills in unknown (U).

The east-west trending Ray Mountains, like the Kokrine Hills, are underlain by a metamorphic complex (mc) and intrusive rocks (gr/gra) which include granites, monzonites, and diorites. In addition, some Devonian or Carboniferous greenstones, diabases, lavas, and tuffs (gns) and greenstones and greenstone schists (gn) of uncertain age are found. The eastern margin, near the Yukon River, is underlain by Carboniferous Rampart Group and associated intrusives (Crv). Tributary valleys are floored with alluvium (Qal) and alluvial-glacial deposits (Qgl). The geology of a part of the Ray Mountains area is unknown (U).

The geology in most of the northern half of the Kokrine-Hodzana Highlands is unknown (U). Known bedrock is largely the metamorphic complex (mc) and intrusive rocks (gr) described above. Precambrian (?) Birch Creek Schist (bc) and Devonian (?) cherts, slates, and diabase (Csd) are common and some greenstones, diabases, lavas, and tuffs (gns) of Devonian or Carboniferous age are found. Minor outcrops of: 1) pre-Devonian metamorphic rocks and associated intrusive igneous rocks (pDmu) including quartzite, schist, and phyllite and associated intrusives, and 2) Tertiary sandstone, shale, and conglomerate (Ts), clays, shales, sandstones, and conglomerates (Tcs), and lavas (lv) including basalts, andesites, and andesite breccias are also found.

The northern margin of the section is largely underlain by upper Paleozoic or Mesozoic granitic rocks (MPp) including granite, quartz monzonite, and granodiorite which are in places gneissic (MPg). Smaller units include Devonian migmitite (Dm), quartzite and schist (Dq), biotite-staurolite schist (Dbs), and volcanic rocks and chert (Dv). Valleys such as the Hodzana River valley are floored with alluvium (Qal/Qaf) and alluvial-glacial deposits (Qgl). (Brosgé and Reiser, 1964; Cass, 1959 b, 1959, c; Eakin, 1916; Maddren, 1913; Mertie, 1937)

14. Kanuti Flats

The Kanuti Flats is a low plain drained by the Koyukuk and Kanuti Rivers and their tributaries. The entire area is covered with flood-plain alluvium (Qal) and silts, sands, gravels, and morainic deposits (Qgl/Qsg). Most of the geology in the southern extension of the Flats is unknown (U). (Eakin, 1916; Patton and Miller, 1966; Smith and Mertie, 1930)

15. Tozitna-Melozitna Lowland

The Lowland is a narrow plain, drained by the Tozitna and Melozitna Rivers. It is floored with alluvium (Qal) and silts, sands, gravels, and morainic deposits (Qgl). The geology in much of the eastern part is unknown (U). (Cass, 1959 c; Eakin, 1916)

16. Indian River Upland

The Indian River Upland is a series of low rolling ridges and hills separated by lowlands and river valleys. The Upland is drained by the Koyukuk River and its tributaries.

Ridges and hills south of 66° North latitude trend northeasterly and are largely underlain by the Cretaceous Shaktolik Group (Ks) which includes graywacke, shale, grit, and conglomerate. Cretaceous (?) and post-Cretaceous (?) mafic intrusive rocks (Qtki) are fairly common and some volcanic rocks (Vr) which are chiefly basalt and andesite of uncertain age, and Cretaceous (?) or Tertiary (?) intrusive rocks (Tki) which are chiefly granitic are found. Tributary valleys are covered with alluvium (Qal).

Ridges and hills north of 66° North latitude have irregular trends and are underlain by a variety of Cretaceous rocks. Most of the central and northern part of the area is composed of graywacke and mudstone (Kgm) while the southern part is underlain by igneous rocks such granodiorite and quartz monzonite (Kgq), the Koyukuk Group (Kk) which consists of basalts, basalt porphyries, tuffs, and agglomerates, and Jurassic-Cretaceous andesitic volcanic rocks (KJv) which include tuffs, tuff breccias, andesites, trachyandesites, and basalts. Large parts of the area are also underlain by volcanic graywacke and mudstone (Ktg). The eastern margin is largely underlain by conglomerates, grits, sandstone, slate, and shale (Kcg), but small outcrops of hypabyssal intrusive rocks (Khi), albite granite (Kag), and quartzitic conglomerate and quartzite (Kqc) are widely distributed. River valleys are covered with alluvial deposits (Qfp/Qal/Qsg), alluvial and eolian deposits (Qae), and older glacial drift and alluvium (Qga/Qgl). (Cass, 1957, 1959b, 1959 c, 1959 d; Eakin, 1916; Patton and Miller, 1966)

17. Pah River Section

The Pah River Section consists of an assemblage of hills and low mountains separated by broad lowlands. Physiographically, it may be divided into: the Lockwood Hills (17a), the Pah River Flats (17b), the Zane Hills (17c), and the Purcell Mountains (17d).

The east-west trending Lockwood Hills form the northern part of the Section. From west to east, bedrock includes: 1) the Cretaceous Bergman Group (Kb) consisting of sandstones, conglomerates, shales, and coal, 2) Cretaceous sandstone and shale (Ku), 3) Cretaceous graywacke and mudstone (Kgm), and 4) Jurassic-Cretaceous volcanic rocks (KJv) which include tuffs, tuff breccias, agglomerates, andesites, trachyandesites, and basalts. Valleys are floored with older glacial drift and alluvium (Qga). Geology of the southwest portion of this area is unknown (U).

The Pah River Flats, drained by the Pah River, encompasses the central part of the section and consists almost entirely of older glacial drift and alluvium (Qga), with some flood-plain deposits (Qfp) of the Hogatza River, and small outcrops of Cretaceous tuff, volcanic graywacke, and mudstone (Ktg). Geology of the western part of this area is unknown (U).

The northwest trending Zane Hills are largely underlain by volcanic rocks (KJv) equivalent to those comprising the Lockwood Hills as well as : 1) Jurassic or Cretaceous limestones, sandstones, and shales with associated pyroclastic and extrusive rocks (Kk), 2) intrusive rocks ranging from Cretaceous granodiorite and quartz monzonite (Kgq) to granites monzonites, and diorites (gr) of uncertain age, and 3) Tertiary or Quaternary basaltic lava flows and volcanic ash (bl). Small outcrops of the Bergman Group (Kb) are also found.

The geology of the Purcell Mountains is unknown (U). (Patton and Miller, 1966; Smith, 1913; Smith and Mertie, 1930).

18. Koyukuk Flats

The Koyukuk Flats comprise the floodplain of the Koyukuk and, in part, Yukon rivers. Most of the section consists of flood-plain alluvium (Qal), however the central part is underlain by a northwest trending belt of volcanic rocks (Vr), chiefly basalt and andesite of uncertain age, and undifferentiated bedrock (Ub), also of uncertain age, along with some Cretaceous (?) or post-Cretaceous (?) mafic intrusive rocks (Qtki). A large area of eolian sand (Qs) is found along part of the western margin of the section. Geology of the northernmost part is unknown (U). (Cass, 1957, 1959b, 1959c, 1959d; Patton and Miller, 1966; Smith, 1913)

19. Kobuk-Selawik Lowland

This section, which includes the Baldwin Peninsula, comprises the floodplain of the Kobuk and Selawik rivers.

Geology of almost all of the western half of the lowland is unknown (U), but the westernmost part of this half is floored with sand, gravel, and mud (Qsg) of glacial origin. The Waring Mountains consist of Cretaceous sandstone and shale (Ku) and early Paleozoic or older highly metamorphosed rocks (mr), dominantly of sedimentary origin.

The eastern half of the Lowland is the broad valley of the Kobuk River. The valley is floored with younger (Qyg) and older glacial drift (Qga) and flood-plain deposits (Qfp), but some outcrops of Cretaceous graywacke and mudstone (Kgm) are found. (Smith, 1913; Smith and Mertie, 1930)

20. Selawik Hills

The geology of the Selawik Hills has not been mapped, but according to Wahrhaftig (1965), bedrock consists of Paleozoic and Mesozoic metamorphosed volcanic and granitic intrusive rocks and some Quaternary volcanics. (Smith, 1913; Wahrhaftig, 1965)

21. Buckland River Lowland

The Buckland River Lowland, a low rolling area, is almost entirely underlain by volcanic rocks (Vr) which are chiefly basalts and andesites of undertain age. The western margin is covered with sand, gravel, and mud (Qsg) which in some locales contains muck and peat. Alluvium (Qal) is associated primarily with the main fork of the Buckland River. Small outcrops of the Shaktolik Group (Ks) which includes graywacke, shale, grit and conglomerate are also found. Geology of the northern part of the lowland is unknown (U). (Cass, 1959a; Smith, 1913)

22. Nulato Hills

This section consists of low hills and ridges dissected by numerous streams. Dominant bedrock is the Cretaceous Shaktolik Group (Ks) as described above, however in a few locales the Cretaceous Ungalik Conglomerate (Ku) consisting of conglomerate, grit and some graywacke crops out. To the north, a fairly large section of volcanic rocks (Vr) of uncertain age consisting chiefly of basalt and andesite with rare occurrences of rhyolite, tuff, chert, agglomerate, and breccia is found; equivalent rocks (Vr) crop out locally near the western and eastern margins of the section. Tertiary intrusive rocks (Ti) which are chiefly dioritic, Cretaceous (?) or post-Cretaceous (?) mafic intrusive rocks (Qtki), and pre-Cretaceous intrusive rocks (ir) including granite, syenite, monzonite, and quartz diorite are found in a few locales. River valleys are floored with alluvium (Qal). A few scattered locales contain undifferentiated bedrock (Ub) of uncertain age, and in some areas no photographic coverage (Np) has been provided. Geology of the area north of 66° North latitude is unknown (U). (Cass, 1957, 1959, 1959a, 1959d; Smith, 1913)

23. Tanana-Kuskokwim Lowland

This section, which mainly comprises the low, broad floodplain of the Tanana River, is largely covered with alluvial and glacial deposits (Qal/Qag). Geology of the southeastern part of the lowland is unknown (U). (Capps, 1940; Eakin, 1918; Mertie, 1937)

24. Nowitna Lowland

The Nowitna Lowland is the broad floodplain of the Yukon River; the river parallels the northern boundary of the section and is joined by the Tanana River toward the northeastern margin. Most of the area is covered with alluvial and glacial deposits (Qal/Qgl). The central part of the lowland is underlain by a Precambrian or Paleozoic metamorphic complex (mc) which is predominantly schist; less extensive outcrops of Carboniferous (?) or post-Carboniferous metamorphosed igneous rocks (mi) are also found. Some Quaternary clay, silt, sandstone, conglomerate, and lignite (Qtcs) is found along parts of the Yukon River. (Cass, 1959b, 1959c; Eakin, 1918)

. Kuskokwim Mountains

This section, which comprises the northern parts of the Kuskokwim and Kaiyuh mountains, consists of relatively low ridges and hills dissected mainly by tributaries of the Yukon River. Bedrock is dominantly a Precambrian or Paleozoic metamorphic complex (mc) consisting of several varieties of schist with some phyllite, slate, chert, and quartzite, and Carboniferous (?) or post-Carboniferous metamorphosed igneous rocks (mi), which are largely greenstones; scattered occurrences of Precambrian or Paleozoic recrystallized limestone (mcl) are also found. Tertiary intrusive rocks (Tki) which are dominantly dioritic, and Cretaceous (?) or Tertiary (?) extrusive rocks (Tke) consisting of basaltic, andesitic, and rhyolitic flows, tuffs, and breccias are found throughout the section, but are more common toward the west. Early Mesozoic (?) chert and slate (Mc), grits and sandstone (Ms), and quartzite and phyllite (Mq), and Devonian (?) diabase and basalt (Db), and limestone and siltstone (Dl) comprise most of the eastern part of the section. Cretaceous chert and argillite with interbedded rhyolitic tuff, sandstone, and grits (Kc) crop out to the south, while to the southwest, outcrops of the Ungalik Conglomerate (Ku) consisting of conglomerate, grits and graywacke, and the Shaktolik Group (Ks) which consists of graywacke, shale, grit, and conglomerate are found. Alluvium (Qal) is associated with the many streams that dissect the area. (Capps, 1940: Cass, 1959b, 1959 d; Eakin , 1918)

26. Seward Peninsula

The Seward Peninsula is a mixture of broad uplands and lowlands and deep river valleys with isolated groups of rugged mountains such as the Kigluaik, Bendeleben, York, and Darby mountains. Many small streams drain the peninsula.

The western half of the Peninsula is largely underlain by the Silurian-Ordovician (?) Port Clarence Limestone (Sop) and undifferentiated limestones, slates, and schists (Sos/Sosl); fewer outcrops of the pre-Silurian (?) Kigluaik Group (Kg) which includes crystalline limestones, schists, and gneisses are also found. All these units are interspersed with intrusive rocks (gr) including granites, monzonites, and diorites of uncertain age, and post-Carboniferous greenstones and greenstone schists (gs). Phyllites and slates (pS) of Paleozoic age crop out to the northwest. Some Tertiary or Quaternary basalts (b) which locally include andesite lavas and tuffs crop out to the west, as does the Carboniferous Lisburne Limestone (Cl). Lowlands in this area are covered with silts, sands, and gravels (Qgr).

The eastern half of the Peninsula is described in somewhat greater detail. The northern margin of this half is dominated by Paleozoic phyllites and slates (pS). Fairly extensive sections of Tertiary or Quaternary basaltic lava flows (bl) and Mesozoic basic effusives and intrusives (eb) largely consisting of diorites, gabbros, andesites, and pyroclastics are found, as are a few outcrops of granitic intrusive rocks (gr) of uncertain age which include granites, monzonites, and diorites, and Paleozoic undifferentiated limestones, dolomites, and associated rocks (pl). Just south of the marginal area, extrusive rocks have been differentiated into 1) the Quaternary basaltic Lost Jim lava flow (Qlj), Imuruk (Qi), and Gosling volcanics (Qg) which are basalts and basaltic andesites, and the basaltic Camille lava flow (Qc), and 2) the Quaternary and/or Tertiary Kugruk volcanics (Qtkv) which are basalts and basaltic andesites. Other rocks in this immediate area include Paleozoic schist (Pzs) and gneiss (Pzg), and Jurassic (?) or Cretaceous (?) quartz monzonite (Kjqm). The dominant rock types to the east of this area are volcanic rocks (Vr) probably similar to those to the west, but which are only described as "chiefly basalt and andesite of unknown age"; less extensive units in this area include: 1) pre-Silurian undifferentiated metamorphic rocks (udm) and older metamorphosed sedimentary rocks (Omu) which are dominantly schists, 2) Silurian, Devonian, and Carboniferous (?) Paleozoic rocks (Pr/Chg) which are largely limestones, dolomites, and slates, 3) Devonian-Carboniferous (?) younger metamorphosed sedimentary rocks (Ymu) similar to (Cmu), 4) pre-Cretaceous intrusive rocks (ir/gr) including granites, syenites, and monzonites, and 5) Tertiary-Quaternary basalt (b). The southerly part of the eastern half of the Peninsula is composed largely of the same rock types, but here (Vr), (gr), (gs), and (b) are subordinate to older (Omu) and younger (Ymu) metamorphosed sedimentary rocks, undifferentiated metamorphic rocks (udm), and Paleozoic sedimentary rocks (Ckg). Less extensive units include: 1) pre-Cretaceous undifferentiated non-metamorphic intrusives and effusives (udi), 2) Cretaceous sandstone, and shale (Ku), and 3) Carboniferous (?) or post-Carboniferous metamorphosed igneous rocks (mi) which are dominantly greenstones. Quaternary sediments in the eastern half of the Peninsula include sand, gravel, and mud (Qsg) locally containing muck and peat beds, glacial drift (Qno), lake sediments (Qlu/Qli), and floodplain alluvium (Qal). (Cass, 1959, 1959a; Collier, Hess, Smith, and Brooks, 1908; Harrington, 1917; Hopkins, 1963, Smith and Eakin, 1911).

27. Northern Foothills of the Alaska Range

Only the small part of this section which lies above 64° North latitude is considered here. Bedrock is dominantly the Tertiary Nenana Gravel (Tn); the Totatlanika Schist (pt), which consists of altered rhyolite and metamorphosed sedimentary rocks is also common. Small outcrops of undifferentiated Tertiary sediments (Tu) including conglomerates, sandstones, and shale with interbedded coal are also found. Stream valleys such as that of the Nenana River are floored with alluvial and glacial deposits (Qmg). (Capps, 1940)

FAVORABLE AREAS BASED ON GEOLOGY

Metallic Deposits

E. N. Wolff and L. E. Heiner

In the next section of this report, a paper by Herreid (1964) is republished. This paper should be studied in conjunction with Plate 3. Herreid reviews some of the Russian literature and applies it to Alaska. He concludes that the geanticlines shown in Figure 14 and Plate 3 are "inversions", or late Paleozoic eugeosynclines that were folded upward in Mesozoic time, shedding clastic wedges into the geosynclines forming simultaneously on either side. The geanticlines are called central uplifts. The degree of uplift and the sharp differentiation between central uplifts and geosynclines makes it appear that the uplifts rose partly as blocks, and that the boundaries between them are partially made up of large shear zones of regional dimensions. Plate 3 indicates some tendency toward alignment of intrusive rocks along some of these boundaries, lending plausibility to the existence of great shears.

On the north side of the Brooks Range, along such a tectonic boundary, several faults are mapped (Plate 3). Elsewhere, however, the great wrench faults of Alaska cut the boundaries at small angles. Observations in other mountain systems, including the Appalachians, indicate that characteristically there are great thrusts away from the central uplifts. Such thrusts, as well as the general uncertainty as to exactly where to put the boundaries, might obscure any deep faults or shear zones along these boundaries, so it is not surprising that more faults are not mapped along the boundaries. As an example of the uncertainty in locating the marginal zones, the Bornite Copper deposit on the Kobuk is shown on Plate 3 as being on the north edge of the Hogatza Arch (after U. S. Geological Survey Bull. 1094). Earlier Survey maps (I-84 and Geologic Map of Alaska, 1957) indicate that it could as well be associated with the south edge of the Brooks Range Geanticline.

Assuming that the boundaries are the sites, at least in places, of deep fractures, such boundaries should be investigated as favorable for mineral deposition, especially where reactive sedimentary or metamorphic rocks and igneous intrusions occur. On Plate 3 about 100 mineralized districts and ore deposits have been plotted. No attempt has been made to show all deposits, only those that have produced minerals,or prospects that are generally known are given. There appears to be some tendency toward a concentration of deposits along the boundaries. Table 6, following, gives some idea of this tendency. It will be noticed that a great shear zone, apparently an extension of the Rocky Mountain trench, passes through Dawson and Eagle. This tectonic lineament has been extended tentatively around the south side of the Yukon to join a fault system that reaches the Coast near Norton Sound. This is done on the basis of hot springs along the line, and the authors' belief that the flats of Alaska are partially bounded by faults. A large number of deposits also lies along this line, as well as along other prominent fault zones.

Herreid's paper also suggests other features favorable to ore deposition, and papers

TABLE 6

Ore Deposits and Tectonic Features

Anticline or Syncline	Feature	Number of Deposits	Av. Width of Feature(miles)	Av. Distance (miles)	Standard Deviation
A	Romanzof	1	50.8	14.4	0
A	Brooks Range	4	92.2	14.4	4.1
S	Kobuk	2	33.9	9.6	0
A	Hogatza	2	53.8	16.0	9.1
S	Koyukuk	5	100.5	34.6	18.9
S	Ruby	5	60.48	14.7	12.3
A	Kuskokwim	8	48.6	14.0	13.2
A	Goodnews	2	65.6	11.2	5.1
A	Tanana	15	73.2	27.2	19.8
S	Healy	1	21.8	12.8	0
S	Alaska Range	4	77.8	12.0	3.2
S	Talkeetna	5	60.2	12.0	6.0
S	Matanuska	4	34.9	17.6	10.0
A	Seldovia	2	17.0	6.4	0
S	Chugach	6	52.5	15.5	10.0
S	Yakataga	7	44.5	10.0	6.2
A	Coast Range	12	61.4	8.3	6.8
S	Seymour	4	38.1	8.8	6.6
A	Prince of Wales	6	56.0	10.7	8.2
	All of Alaska	100		23	18.0

by Herbert (1963) and Sandvik (1959), reprinted in the following section, suggest more possibilities.

All of the people consulted while this report was being written stress the importance of placers as possible guides to lode deposits, and all believe that the poorer or minor placer districts should hold the most promise. Placers, in this view, provide wider targets, analogous to geochemical halos, but the major ones represent lode deposits which have been completely eroded away. The authors agree with this view. At the time when most of the prospecting was being done, with thousands of men pushing to remote areas, nothing was known of geochemical prospecting. An eroding mineral deposit would, however, make known its presence by specks of metal in the alluvium of the streams draining it. Any of the areas known to contain placer gold (see Figures 4, and 10, and Table 3), should have a higher than average probability of containing additional mineral deposits.

The association of more than one of these features: boundaries, faults, intrusive rocks, placers, and reactive rocks should enhance the chances for ore deposits.

It has also been suggested (Sandvik, April 1968, personal communication) that the boundaries may be important in another way. They represent the intersection of the earth's surface with unconformities at the base of the Mesozoic clastic wedges. Unconformities are recognized as important ore controls (Mills and Eyrich, 1966, p. 1232). In this connection, the unconformities at the base of lower Devonian and below the Upper Triassic should be investigated.

Ney(1966, p. 302) says there are two fundamental requirements for an ore deposit, "availability of a source of metal, and a mechanism of concentration". Structure he considers less important. By this he means that the crust must contain disseminated metal, and there must be a mechanism, generally conversion of a portion of the crust to magma with subsequent differentiation into rocks and hydrothermal deposits. The brief geologic history of Alaska already presented, and Herreid's paper, indicate the correlation between types of rocks with stage of development of a geosyncline and subsequent inversions. Certain types of rocks(graywackes, basalt, ultramafics) are formed in early eugeosynclinal stages, others (granitic rocks mobilized from the crust) in later stages. There is much evidence that in many places copper is present in the basalts of early eugeosynclinal sedimentary rocks. Where igneous intrusions move into an area of such rocks, or form from their melting, there exists an "availability", and a "mechanism". If, further, reactive rocks are available, such as impure limestone, there is a site for concentration. Ney did not, of course, mean to deprecate the role of structure; structures are the channelways, barriers, traps, permeable zones, etc., which in general act to bring the "availability" and the "mechanism" together.

Metals may be made available by other processes. Before the breaking up of the Paleozoic geosyncline in Mesozoic time, the edge of the emergent continent lay along the site of the Brooks Range. Long continued erosion of the land and deposition along the coast could accumulate large quantities of metals distributed through the sediments in trace amounts. Both of these sources, eugeosynclinal basalts and muddy sediments, have been suggested as a source for the Bornite, Alaska copper (Chadwick, 1960, p. 8). At present it is not known which, if either, of these sources is the right one.

Although the example given above deals with copper it is believed that the controls already mentioned, boundaries of geosynclines, long fault zones, unconformities, igneous intrusions, placer deposits and reactive rocks, indicate favorable conditions for other metallic deposits. It is not the purpose of this report, nor within its scope, to go into a discussion of the occurrence of ore deposits. The relationships that exist between different metals and rocks are well known to all geologists, and the presence of certain igneous rocks should be some indication of what metals might be expected.

Granted that the controls and sources of mineralization that have been discussed in this section are broad, it is believed that presently they provide the best guides available. Plate 3 covers the entire State of Alaska, and may be perused in its entirety. Here, however, we are dealing specifically with the northern part of Alaska and will discuss controls of mineralization only in Northern Alaska. Referring to Plate 3, first, it is known that copper mineralization crops out from the vicinity of Bornite east as far as the Chandalar drainage. In some places weak copper mineralization is found along streams, suggesting that the streams follow shears along which the minerals concentrate (Thomas G. Hamilton, personal communication). The zone roughly follows the Paleozoic shoreline and the approximate boundary of the Brooks Range-Kobuk Trough boundary. Certainly the north and south sides of the Kobuk Trough should bear exploration as well as the boundary zone at the east end of Seward Peninsula. A northeasterly trending line across the northwest part of the Peninsula (not shown on Plate 3) may also be favorable. Herreid (see next section) shows that this is a zone between metamorphosed and unmetamorphosed Paleozoics(?) and may be a zone on the edge of a central uplift. The entire length of the long shear from Dawson to Norton Sound may be favorable. Perhaps the most intriguing possibility is the boundary on the north side of the Brooks Range. In this whole length only the Firth River gold has been considered well enough documented to be put on Plate 3. A radiometric anomaly in the Romanzof Mountains, is the only other prospect. This boundary is undoubtedly obscured by extensive thrust faulting northward from the Brooks Range over the Colville Geosyncline, and indefinitely located. However, it represents 500 miles of virgin territory, and reconnaissance mapping indicates intrusions north of the Noatak as well as faulting along part of its length. To a determined prospecting program, it should not offer logistics problems too much more difficult than those on the south side of the Range.

As mapping outlines areas of intrusive rocks, faults, smaller folds, and reactive rocks along the boundaries, such areas will become favorable targets for mineral exploration. The linear zones (Plate 3) are, again:

North side Brooks Range
Borders of Romanzof Mountains
South side of Brooks Range east to Chandalar
Margins of Hogatza Uplift
Line from Teller to Candle (West Seward Peninsula)
Line from Cape Darby to Candle (East Seward Peninsula)
North side Ruby Geanticline (Ruby to Chandalar)
Length of major fault (Unalakleet to Eagle)
Axis of Kuskokwim Geosyncline (unconformity at base of
Mesozoic rocks occurred along this line before erosion)
Margins of Kandik segment and Nation Arch.

Mineral Fuels and Nonmetallics

PHOSPHATE

This section so far has been concerned with metallic minerals. Figure 3 showing the distribution of Industrial and Chemical minerals, indicates that they are distributed somewhat in accordance with the favorable tectonic pattern already discussed. Mica and fluorite are derived from hydrothermal solutions and should be guided by the same controls as metallic minerals. Phosphates occur in unmetamorphosed sedimentary rocks (limestones and cherts) and show a surprising alignment along the south edge of the Colville Geosyncline and the north edge of the Romanzof Uplift. The chief formations are the Alapah limestone of Mississippian age and the Shublik formation of Triassic age (Patten and Matzko, 1959). Phosphate is found in marine sedimentary rocks, and probably requires secondary concentration from other sedimentary rocks. At the present time, the only specific guides to phosphate occurrence are the phosphatic zones of the two formations named. On a regional basis, any of the unmetamorphosed limey sedimentary rocks of the northern Brooks Range should bear investigation.

OIL AND GAS

Oil and gas occur in sedimentary rocks, and the targets are traps in the sediments. Each of the Mesozoic or Tertiary geosynclines and troughs is potentially an area of oil production, as are the unmetamorphosed areas of Paleozoic and early Mesozoic rocks, which crop out on the margins of the geosynclines, if they are not too severely deformed or metamorphosed. Where the rocks of any age are too complexly or tightly folded, the chances are reduced, even if they are not metamorphosed.

Possibly then, favorable conditions generally exist from the crest of the Brooks Range to the Arctic Ocean, excepting (1) complexly folded or faulted areas, (2) metamorphosed areas in the Romanzof Mountains, and (3) areas of nonmarine rocks, chiefly in the northwest. Even in areas of nonmarine rocks, there may be marine, petroliferous rocks beneath.

Only one well has been drilled in the Yukon-Koyukuk Geosyncline near Nulato, and little is known of the geology. Conditions are considered best in the Upper Cretaceous rocks, well away from the Hogatza Uplift.

Because of the complex deformation in the Kobuk Trough, chances for oil are not considered favorable.

Although oil shale is not of commercial interest at present nor in the foreseeable future, its presence indicates possibilities for petroleum. "Oil shale is common in an almost continuous belt of Triassic rocks exposed along the north front of the Brooks Range "(Miller, Payne, and Gryc, 1959). These Triassic rocks (Plate 1) crop out generally in the Arctic Foothills Province (Plate 4).

Possible petroleum provinces in Alaska are shown in Plate 4, in pocket (after Miller, Payne, and Gryc, 1959, Plate 1).

COAL

Although detailed prospecting has not been done, the coal fields of Alaska have been fairly well outlined (Barnes, 1967). Figure 2 indicates the distribution of coal-bearing rocks. Barnes (1967) shows large areas underlain by subbituminous and bituminous coal in Northwestern Alaska. Any of the Cretaceous sedimentary rocks in that region, as shown in Figure 2, are potentially coal-bearing.

Comparative Lode Metal Potential in Alaska
(Map from Battelle Memorial Institute)

The Battelle Memorial Institute has prepared a map for the Alaska International Rail and Highway Commission as a broad general guide to planning future transportation. This map (see Figure 20) compares regions in terms of lode metal potential. The Alaskan portion is shown on the accompanying map, which was based on published Alaskan geological maps and critically reviewed by government and industrial geologists. It is emphasized, however, that it serves only as a broad indication of the relative promise of finding metals in the various areas. As with any guide of this type, individual geologists might disagree on large areas.

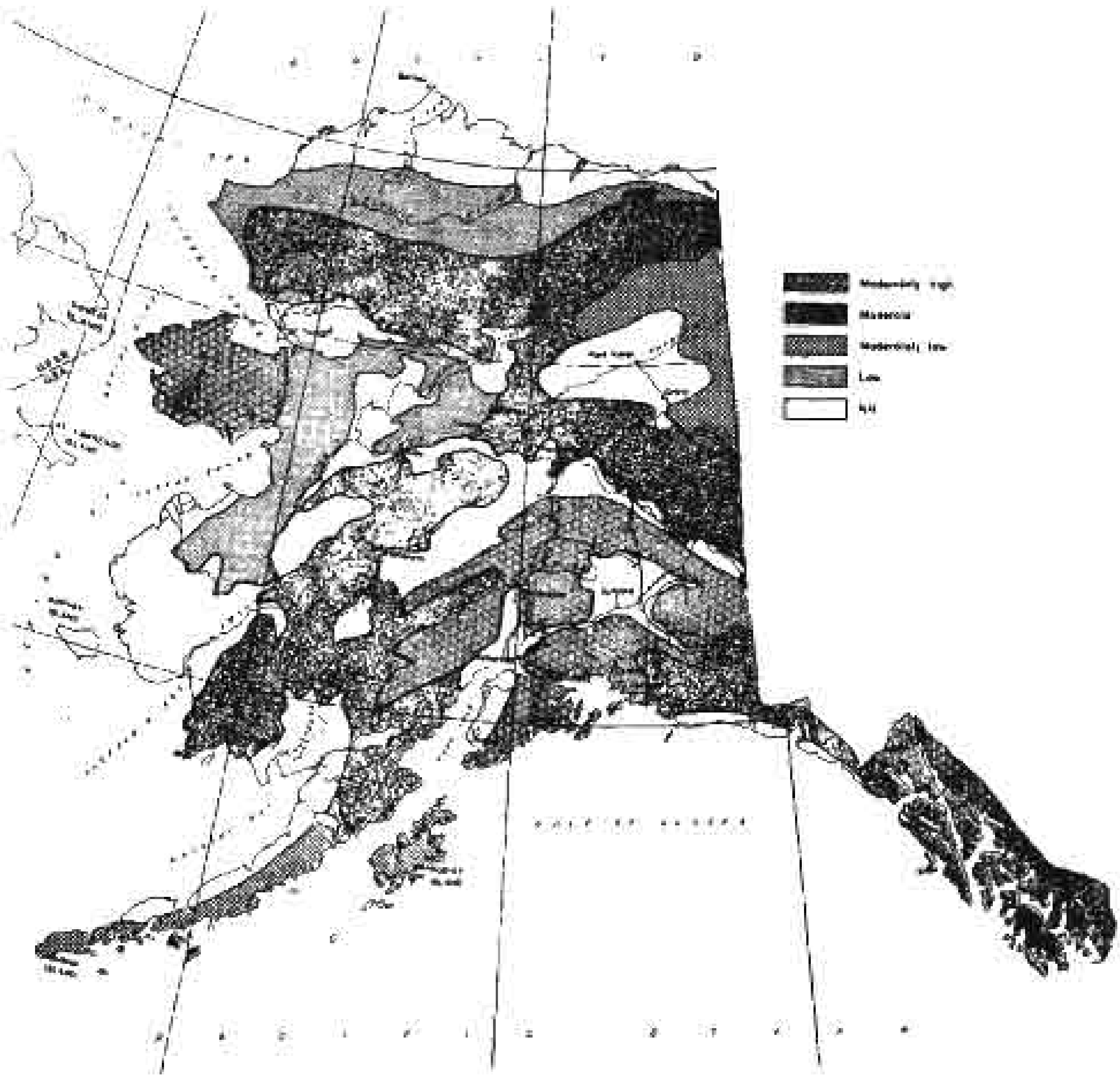


Figure 20 – Comparative Lode-Metal Potential in Alaska

Tectonics and Ore Deposits in Alaska

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INTRODUCTION

The purpose of this paper is to analyze the regional geologic patterns of Alaska and attempt to relate ore districts to some of the major features of the geology. In order to do this it is convenient to consider the geology from a tectonic point of view, tectonics being the study of the large scale uplift and subsidence of the earth's crust and the movements along major crustal fractures.

The geologic map of Alaska shows a rather orderly arrangement of arcuate metamorphic-igneous belts flanked by late Mesozoic sediments and Cenozoic basins, all expressions of the tectonic frame work. These arcuate belts are followed or cut at small angles by major arcuate fractures or lineaments which in some areas appear to control the location of igneous intrusive and extrusive rocks and ore deposits. I will discuss first the development of these regional geologic features, and then a possible relationship of ore districts with them.

The whole of Alaska lies within a mobile belt that extends along the Pacific fringe of the North and South American continents. For most of its length this belt is the transition zone between the Pacific Ocean basin and the continental platforms and along it the crust has been more mobile than in either the ocean areas or on the continent. In recent years it has been shown, particularly by a number of Russian authors, that there is a rather definite succession of events in the history of the mobile belts in different regions. The following resumé of the development of an idealized mobile belt through one cycle of deformation consisting of three phases is taken largely from the Russian literature (Beloussov, 1962; Krasnyy, 1963; Matveyenko and Shatalov, 1963).

THE TECTONIC CYCLE

Early Geosynclinal Phase

A cycle of deformation begins with an increase of crustal mobility over a large region. During this early geosynclinal phase there takes place subsidence and uplift of elongated geosynclines and geanticlines which are somewhat like waves on the sea. The areas of subsidence predominate and may be up to several tens of miles wide. Deep fracturing of the crust, often in the more mobile areas, results in lava flows and sheet intrusions of basic magma. Topographic relief is moderate with siltstone the principal sediment deposited, often interbedded with basic volcanic rocks. Little folding takes place. Toward the end of this phase the relief becomes even less and limestone may be widespread. In Central Alaska this early geosynclinal phase probably began in the Middle Devonian and continued to the end of the Triassic.

Late Geosynclinal Phase

The late geosynclinal phase is marked by a general predominance of uplift over subsidence with orogeny taking place in those geosynclines with the thickest early phase deposits. This orogeny is termed inversion by Beloussov (1962) and is characteristically accompanied by folding, metamorphism, granite intrusion, and uplift over large areas in the geosyncline. He has called these uplifted early geosynclines in the mobile belt central uplifts. They are compensated by subsidence in marginal troughs which may begin as marine troughs and end as intermontane troughs as the uplift of the entire region progresses. If the inversion of the geosynclines is well developed, these marginal troughs may finally overlie the margins of the original geosyncline giving a complete reversal of the topographic features. Inversion may not be carried to completion, however, particularly along the continental margin, in which case granite intrusion, metamorphism, and uplift are not so well developed. During inversion, large wedges of clastic material eroded from the rising land area are deposited in the marginal troughs. Much of Alaska is underlain by Mesozoic clastic wedges of this type flanking areas of older rock. In Alaska the late geosynclinal phase persisted from the Jurassic until early Tertiary time.

Young Platform Phase

The young platform phase begins when block faulting takes the place of folding as the principal means of deformation. This consolidation of the folded belts may take place at different times in different places when block uplifts and basins are superimposed on the earlier folded structures. Deep fractures formed at this time are responsible for narrow belts of igneous intrusions and extrusions. This is a continental period which, in Alaska, has lasted from the early Tertiary to the present.

The geosynclinal evolution that has been described applies to the area on the oceanward side of the mobile belt. This is the true or eugeosyncline. Near the continental platform, geosynclinal subsidence is slower and is unaccompanied by volcanism so that limestone, sandstone, and shale are the normal sediments, and the inversion is not usually accompanied by granite intrusion or metamorphism. This is the miogeosyncline, which represents a gradation between the platform and the eugeosyncline.

In general, during both early and late phases of geosynclinal development, rapid warping of the crust leads to the formation of deep fractures which give rise to igneous activity. After consolidation, in the young platform stage, igneous activity accompanies deep fracturing without warping, often with block movements.

TECTONICS OF ALASKA

Development of Geosynclines and Central Uplifts

In Alaska fossiliferous early Paleozoic rocks crop out sporadically in and around the central uplifts as far south as the Alaska Range. These rocks are largely limey and shaley sediments without volcanics and, with some exceptions, are typical of miogeosynclinal sediments deposited along the relatively stable continental margin. Beginning in Devonian time this shelf became more mobile, and in the Goodnews Arch, post-Devonian rocks changed from limestone to mainly impure clastic rocks and volcanics. On the northern flank of the Yukon-Tanana plateau Upper Devonian limestone is interbedded with volcanics, and along the south side of the Brooks Range Middle Devonian carbonates are succeeded by increasingly clastic Upper Devonian sediments. Thus, by late Devonian time, the shelf area as far north as the Brooks Range had disintegrated into a mobile volcanic province typical of the early phase of geosynclinal development. This rather sudden change probably represented an encroachment of crustal mobility and deep fracturing from an area south of the Alaska Range onto the Shelf. The areas along and north of the Brooks Range remained relatively stable until Mesozoic time.

The most complete section of early geosynclinal phase sediments is found in the Goodnews Arch. Here from Mississippian to Triassic time an estimated 10,000 feet of marine sediments were deposited, largely siltstone but associated with chert and limestone and, particularly in the late Paleozoic and Triassic, much greenstone. On the southern slopes of the Alaska Range, in the Wrangell Mountains, and along Cook Inlet, Upper Paleozoic greenstone and Upper Triassic limestone indicate the extension of the early geosynclines into the area. The lack of clastic rocks indicates the low relief during this period.

Further north, metamorphic rocks are common in the cores of the central uplifts and are a great source of confusion in the interpretation of the geologic history. These metamorphics were usually dated as older than the oldest nonmetamorphosed sediments by the early mappers. The latest Geologic Map of Alaska (compiled in 1954) shows these rocks to be predominantly pre-Devonian Paleozoics, except for the Birch Creek schist which is shown as lower Precambrian.

The Birch Creek schist and associated gneiss which underlies a great area in the Yukon-Tanana plateau has long been dated as Precambrian. This was done on the basis of metamorphism and differences in lithology of the quartz mica schist relative to the Cambrian and Ordovician rocks which crop out locally near the margins of the metamorphic area. In earlier days it was reasonable to assume that the great mass of schist was older than the surrounding rocks which were unmetamorphosed. However, this simple conclusion does not satisfactorily relate the known facts when the region is considered from a tectonic viewpoint. I would like to suggest a reinterpretation of the facts.

Along the northern part of the Yukon-Tanana plateau the upper Paleozoic rocks are a eugeosynclinal assemblage containing much chert and greenstone. To the northeast across the

Canadian border there is a change in facies – the rocks of the same age are miogeosynclinal without any volcanics. Thus, during the latter half of the Paleozoic, the present northern boundary of the Yukon–Tanana plateau appears to have been the northern limit of a eugeosynclinal basin. The rocks along the northern edge of this basin have been unaffected by metamorphism due to lack of deep burial. Further south the basin underwent inversion during the Mesozoic with consequent regional metamorphism, folding, granite intrusion, and uplift. These metamorphosed eugeosynclinal rocks constitute the Birch Creek Schist.

This interpretation of the origin of the Yukon–Tanana central uplift offers a simple explanation of the facts and is consistent with the history of better-studied regions outside of Alaska. From this point of view the belt of Devonian basic and ultra basic intrusives that cuts the Birch Creek Schist is seen as part of the basic igneous activity typical of the early phase of geosynclinal development. The regional metamorphism and granite intrusion are part of inversion, gneisses being early granites emplaced before the end of folding while nonfoliated granites were intruded after folding. As a result of uplift during inversion a clastic wedge was shed northward into the Kandik area during the Cretaceous.

In the Ruby geanticline and the Brooks Range the early mappers dated the metamorphic rocks as older than the oldest fossil–dated sediment, usually with some evidence of unconformities. The implication is that the metamorphic rock was the basement on which later sediments were laid down, the metamorphism having taken place at some early, perhaps Precambrian, date.

Recent detailed studies made in the metamorphic belt along the southern Brooks Range by Brosgé and Reiser (1962) indicate that the metamorphic rocks are of Upper Devonian age, younger than the oldest sediments, which are Middle Devonian limestone. The metamorphics clearly cannot be the basement.

This metamorphic belt along the southern Brooks Range was the site of a narrow east-trending upper Paleozoic eugeosyncline trough. Other mapping by the USGS indicates that this trough was flanked immediately to the north by a parallel miogeosyncline with an eroding highland located still further north. Inversion of this eugeosyncline during Jurassic time resulted in a reversal of relief, with clastic wedges being shed onto the adjacent areas, north and south. The parallel with the Yukon–Tanana plateau is striking.

The Ray Mountains, south of the Brooks Range, also appear to be an upper Paleozoic eugeosyncline which was inverted during the Mesozoic.

The Seward Peninsula is another of these metamorphosed central uplifts. Unmetamorphosed shelf limestone and shale of early to middle Paleozoic age in the northwest part are flanked on the southeast by metamorphic rocks whose lithology was originally rather similar except for a larger porportion of clastic rocks and basic igneous rocks. No fossils have been found in the metamorphic rocks and their age is conjectural. In the metamorphic area both early foliated and late nonfoliated granitic rocks are present. This area was the site of a Paleozoic geosynclinal trough which underwent Mesozoic inversion, metamorphism, granite intrusion, and uplift. The history of the Seward Peninsula is closely analogous to that of the

Brooks Range.

The interpretation of the early tectonic history of these areas has been partly on the basis of their later inversions and clastic wedges shed as a result of inversion. This approach can be applied to the Aleutian Range–Talkeetna Mountains–Wrangell Mountains belt, hereafter referred to as the Talkeetna geanticline, which is another metamorphic-igneous belt flanked on both sides by Mesozoic clastic wedges which extend, with interruptions, from Kodiak Island to Yakutat and beyond on the south side and from the Nutzotin Mountains to the Mulchatna River (north of Lake Clark) on the north side. The clastic wedges, at least, suggest that this is a single belt interrupted by the Copper River and Susitna River Basins, an upper Paleozoic geosyncline inverted during the Mesozoic.

Rocks of the early phase geosynclinal trough ranging in age from Mississippian to Triassic crop out along the belt in a number of places. They are particularly well exposed in the Wrangell Mountains, also in the northern section of the Copper River Basin, and sporadically in the northern Talkeetna Mountains.

The rocks in the northern Copper River basin were warped up along with the Talkeetna geanticline uplift. Subsequently during Cretaceous time the southern Copper River basin subsided, possibly as a compensation for the uplift of the Talkeetna Mountains, and was filled with Middle to Upper Cretaceous and Cenozoic sediments.

This analysis of the central uplifts indicates that they, and possibly the ranges along the Talkeetna geanticline, represent thick sedimentary and volcanic troughs. These troughs were superimposed on lower Paleozoic limey shelf type sediments. These thick geosynclinal piles were folded, regionally metamorphosed, invaded by granite, and uplifted during middle Mesozoic time. As a result of this uplift, clastic wedges were deposited in adjacent areas during middle to late Mesozoic time.

This history indicates that the early Paleozoic sediments which crop out around the margins of the central uplifts are the basement rock, if such can be said to exist, and that the metamorphic rocks are younger products of Mesozoic orogenies rather than the oldest rocks,as they are still often mapped. Some of the margins of the central uplifts have, since upper Paleozoic time, been sharply differentiated from the surrounding areas which are now the sites of basins and clastic wedges, so that these margins are likely to be important tectonic junctions. There is a tendency for the central uplifts to behave as blocks with recurrent movements and igneous activity along these junctions.

Young Platform Stage

The Mesozoic clastic wedges were strongly folded during early Tertiary time, uplifted, and eroded to surfaces of low relief. After the folding had nearly ceased, these sediments, which generally do not contain interbedded volcanic rocks, were invaded by acidic and basic igneous rocks emplaced as shallow intrusives and extrusvies. This igneous activity is the result of deep fracturing and indicates consolidation of the region into a brittle young platform. The age of the igneous rocks is only poorly known but the belts of granitoid stocks cropped out on the Late Tertiary erosion surface and were probably intruded during the Miocene.

At the end of the Tertiary the Mesozoic central uplifts were gentle hills surrounded by flats. The patterns of the major rivers were controlled by the locations of the hills. Thus the Yukon flowed along the northern edge of the Yukon-Tanana central uplift at Eagle, and after crossing the Yukon flats continued southwest along the edge of the Ruby geanticline and finally crossed the geanticline along the course of a major fault. The Kuskokwim cuts around the south end of the Ruby geanticline. Since late Tertiary time the lowlands underlain by clastic wedge deposits have been uplifted slowly enough to enable the rivers to maintain their courses across the mountains that were formed. Examples are the Kuskokwim River's course across the Kuskokwim Mountains, the Chisana across the Nutzotin Mountains and the Susitna's course through the northern Talkeetna Mountains. The late Tertiary erosion surface on which these rivers flowed has been preserved over large areas as accordant summit levels which stand up above a younger rolling surface which in turn stands above the basins, thus indicating two stages of uplift of the mountain blocks since late Tertiary time. These block uplifts are responsible for much of the present topography.

TECTONIC CONTROL OF ORE DISTRICTS IN ALASKA

The three major ore deposits that have been found to date in Alaska are all near arcuate tectonic lineaments. Each is near the edge of one of the Mesozoic metamorphic-igneous belts of inversion. The Alaska Juneau Mine lies near the western edge of the Coast Range igneous-metamorphic belt that extends along the west side of the Coast Range batholith for several hundred miles. Kennecott lies along the southern margin of the Talkeetna geanticline, the site of much faulting and igneous activity. Ruby Creek lies near the southern edge of the southern Brooks Range metamorphic belt.

The control of granitic stocks by deep fractures and the preferential location of ore deposits near stocks along fractures seems to be indicated by the pattern of ore deposits in the Kuskokwim region. Certainly a more than average concentration of ore deposits occurs along these faults. The Iditarod fault in the Kuskokwim region is a major arcuate fracture of Tertiary age which has localized Tertiary volcanics and a number of granitic stocks with associated ore. The Flat, Nyac, and Candle placer camps, several quicksilver deposits, possibly the Goodnews Bay platinum placer, and some other smaller mining camps are located along this break. The Farewell fault, an apparently similar tectonic fracture approximately 70 miles southeast of the Iditarod fault has a number of intrusives and known mercury, lead, zinc, and gold deposits along it. The two best known deposits along the Farewell fault are in McKinley Park, in or near intrusive rocks.

One of the principal conslusions of early mappers for the U. S. Geological Survey was that the widely scattered placer camps in the Interior were related to granitic stocks. In many of the camps the ore minerals are gold, scheelite, cassiterite, stibnite, and cinnabar. These indicate temperatures of deposition ranging from high to low in a small area typical of telescoped deposits around shallow intrusives. The richest placer deposits have been due to stream concentration of many small veins, and to date no large lode deposits have been found in these camps. Placer camps on recurrently active major structures seem to offer the best possibilities for large lode deposits. An example of this is Kennecott. Here, along a major structural junction, a great copper deposit and a typical placer deposit with placer gold associated with a little galena and cinnabar are located near a granite stock. The intrusive is not generally considered to be the source of the copper at the Kennecott mine, but it is likely the two are related, at least by a common source on a common structure.

The concentration of the mineral deposits around the Wrangell Mountains along the faulted northeast and southwest sides provides a good example of the localization of ore along boundaries of tectonic blocks. The lack of visible control by major faults in these areas illustrates that the relation of tectonic fractures to ore deposits is not direct and simple. Willow Creek, on the southern edge of the Talkeetna central uplift, offers a somewhat more direct connection. In this district, gold deposits in quartz diorite are controllled by minor faults which parallel the major Castle Mountain fault along the southern edge of the uplift.

Postmagnetic ore deposits are thought to form when cooling intrusives are cut by faults at the proper time. Such juxtapositions of faulting and igneous activity should occur with greatest frequency along tectonic lineaments, particularly those at the margins of the central uplifts. The lineaments of particular interest for mineral deposits are those marked by belts of intrusives and extrusives. This igneous activity indicates that deep layers of the crust have been tapped by fracturing. Faulting at the surface along these zones may or may not be evident. Typically the igneous activity occurs in isolated centers just as ore districts are usually isolated centers. I believe that these isolated igenous centers along tectonic lineaments have significantly greater than average probability for ore deposits.

In assessing the ore possibilities of Interior Alaska, even using the possibly erudite methods of tectonic analyses, it is well not to overlook any clues. The mineral industry of Alaska has largely resulted from conditions during the Cenozoic which were particularly well suited for making concentrations of placer gold. Areas with only scattered small gold veins or a little gold associated with base metal deposits may contain placer deposits. Both Ruby Creek and Kennecott have gold placers nearby. The areas around even small gold placer districts have a better than average probability for containing base metal deposits.

General criteria for ore favorability that have been mentioned here are: (1) areas along tectonic lineaments, (2) areas along linear igneous belts (intrusive and/or extrusive), (3) areas along margins of central uplifts, and more specifically, (4) areas around (small) granitoid intrusives along any of these belts, and (5) areas near placer gold deposits.

CONCLUSION

I have attempted to outline a coherent succession of tectonic events that have shaped the geology of Alaska since mid-Paleozoic time, stressing the development of the central uplifts as the major tectonic units in Interior Alaska. I have also emphasized the importance of deep crustal fractures as guides to ore, particularly those fractures localized along the margins of central uplifts. I believe that tectonic thinking along the lines used here can give a useful sense of direction to exploration and regional geologic investigations in Alaska.

EXAMPLES OF FAVORABLE AREAS, BASED ON TECTONIC CHARACTERISTICS

The north-trending igneous belt that separates the Seward Peninsula from the Koyukuk geosyncline contains a number of placer creeks. The pre-Cretaceous and Cenozoic volcanics and Mesozoic granitic intrusives indicate recurrent deep fracturing along the margin of the Seward Peninsula block; and placer deposits on a number of creeks indicates mineralization in the area. Platinum and base metals occur in some of the placers. Further west a parallel igneous belt trends north from Cape Darby. Here Mesozoic granitoids are intrusive into limestone-schist bedrock. Lead-silver mineralization including the Omilak deposit lies near this zone. The geology is somewhat similar to that of the southern Brooks Range metamorphic belt which contains the Ruby Creek copper deposit.

Southwest of Nyac where some placer gold has been found, the Iditarod fault zone contains several different kinds of intrusive and extrusive rocks, all of Tertiary age. Deep fracturing has evidently been recurrent in the area, and the possibility of finding economic deposits appears to be good.

The Farewell fault between Farewell and Swift River separates the early Paleozoic limestone from Cretaceous clastic wedge deposits. Within the last few years cinnabar has been found in the limestone and some placer gold is known in the area. Any granite bodies along this fault (there is at least one known) near the cinnabar would indicate favorable areas.

Further southwest along the Farewell fault in the Tikchik Lake region, scattered granite intrusives are centered around a large domal area. The fault cuts along one side of the dome and should provide local structures favorable for ore deposits.

Along the north side of the Talkeetna geanticline four small granitoid intrusives with associated molybdenum and/or copper are known. These are the Orange Hill copper-molybdenum deposit, north of the Wrangell Mountains; the molybdenum deposit on Long Lake in the Slana district; the molybdenum deposit at Portage Creek, north of the Talkeetna Mountains; and the Hayes Glacier molybdenum deposit, west of the Susitna lowland. The geology of the entire area is not too well known but the location is analogous to that of the porphyry copper and molybdenum deposits in British Columbia, and it seems possible that this may be a porphyry belt.

North of Lake Minchumina a belt of Cenozoic intrusives and extrusives extends in a northerly direction for approximately 60 miles. This igneous belt lies at the eastern edge of the metamorphic rocks of the Ruby geanticline and probably marks the location of a tectonic fracture along the margin of this old central uplift. Only a little placer gold has been found, perhaps due to the deep overburden in the creeks, and not much prospecting appears to have been done. This area is analogous to the igneous belt along the eastern margin of the Seward Peninsula and has a similar potential.

Regional Structural Control of Mineralization in Alaska

by

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Then at School of Mines, University of Alaska

for

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INTRODUCTION

The area considered in this paper is that portion of Alaska lying west of 141° W longitude - that is all of Alaska exclusive of Southeastern Alaska.

This paper is of a preliminary nature. The geologic structure of a major part of Alaska is only sketchily known, that portion which is mapped in detail being of limited extent, for the most part confined to areas of economic interest. However, the broader structural and tectonic features are rather well understood. These features have been mapped by the U. S. Geological Survey in the map of Mesozoic and Cenozoic Tectonic Elements of Alaska (Map I-84). The structural features which have been important in ore genesis in the State are reflected generally in topographic expression making possible the use of topography in a study of regional structural control of mineralization.

Mineralization in the portion of Alaska under consideration is related to orogenic and intrusive activity principally of Jurassic, Cretaceous and Tertiary age. Ore districts occur in areas of repeated strong to intense deformation accompanied by intrusive activity.

LOCAL STRUCTURAL CONTROL

Hydrothermal ore deposits throughout the world are found, almost exclusively, in areas where enclosing rocks have been prepared in advance by structural deformation of some kind.

Areas of orogenic activity bring about the association of structural deformation and igneous activity. They are, therefore, favorable for formation of ore deposits. Within mountain belts certain areas are more favorable than others for both intrusive activity and ore deposition as a result of intersection of deformational trends. At such intersections fracturing, shearing, and breaking are pronounced. They become zones of weakness where regional pressures may be released with attendant igneous activity and ore deposition. It is important that ore solutions be available shortly after, or concurrently with structural deformation in order that solution channels not be filled with other materials such as barren gangue or alteration products. Much evidence indicates that in the majority of ore deposits the introduction of mineral occurs synchronously with the stages of deformation which produce the structural features in which the ore occurs. In Alaska the igneous bodies to which mineralization is genetically related appear to be, to a large degree of the same age as the mountain building.

The importance of local structural controls in ore deposition is well known. These are the structures which determine the locations of lodes within a district, and of ore shoots within a lode. Structural features on this scale may be divided into primary and secondary structures. Primary structures are features developed during the original deposition such as bedding surfaces, igneous contacts and intergranular spaces, etc. The effect of these primary structures in ore deposition is mainly indirect in that they influence the type of failure and the distribution of fractures resulting from later stresses.

The secondary structures - faults, folds, joints, shearing, and brecciation - are of greater importance in control of ore deposition than are primary structures. These features act as channelways for ore-bearing solutions and as major loci of deposition. They develop during mountain building.

Local structural control is important. However, it becomes more apparent as information accumulates that the occurrence of ore districts is the result of large-scale regional or continental forces rather than local, small-scale activity. The smaller structural controls are located where they are, and are loci of ore deposition, by virtue of their relation to intersecting or superimposed structures or zones resulting from the forces responsible for major orogenic movements. Detailed mapping is of great importance in deciphering the larger regional patterns. It is felt that detailed study and mapping of the areas between districts will disclose new, hidden districts within provinces in a manner analagous to the disclosure of hidden ore bodies in a district by detailed study. In Alaska a completely open field for this type of study exists. The first step involves detailed structural studies in known mining districts, these to be followed by extension into adjacent areas within metallogenetic provinces.

METALLOGENETIC PROVINCES OF ALASKA

The mining districts of Alaska may be grouped surprisingly simply into a few mineral provinces or metallogenetic provinces. These provinces, it will be seen, are related to topographic units resulting from specific periods of mountain building. With very few exceptions every mining district and nearly every reported metallic mineral occurrence fits into this broader pattern. The provinces as outlined on Figure 1, Map of Metallic Mineral Occurrences and Proposed Metallogenetic Provinces, may be designated as follows:

1. Chugach Mountains - Talkeetna Mountains Province
2. Alaska Range Province
3. Kuskokwim Mountains Province
4. Yukon-Tanana Upland Province
5. Seward Peninsula Province
6. Western Brooks Range Province
7. Eastern Brooks Range Province.

The separation of the last two units, it might be argued, is somewhat arbitrary. It is difficult to draw a line between eastern and western Brooks Range; however, there is a suggestion of a division into two arcs, both concave toward the south; intersecting in the vicinity of Anaktuvuk Pass. The eastern portion includes the area of the Romanzof Uplift which has been considered as separate from the Brooks Range.

The Chugach-Talkeetna Province might also, perhaps, be questioned. In this instance the question is one of combination rather than separation. It might be argued that the Talkeetna Mountains should be designated as a separate province rather than as a part of a larger province. However, the designation is preliminary, and subject to change.

Let us examine the provinces as designated on the map to see how well the known districts fit into the pattern. Or rather, since it is already shown on the map that the districts do fit in let us enumerate them.

The Chugach Mountains-Talkeetna Mountains Province consists of the following districts: (1) Kenai chromite, (2) Kenai Peninsula gold, (3) Willow Creek gold, (4) Little Nabesna River gold, (5) Valdez Arm gold, (6) Bremner River gold, (7) Nizina gold, (8) Copper River copper, and (9) Prince William Sound copper, and others.

The Alaska Range Province includes (1) Peters Creek gold, (2) Kantishna gold, (3) Bonnifield gold, (4) Valdez Creek gold, (5) Chistochina gold, (6) Nabesna gold, (7) Chisana gold, (8) MacLaren River copper, and (9) White River copper.

The Kuskokwim Mountains Province is made up of : (1) Goodnews Bay platinum, (2) Kilbuck Mountains gold, (3) Nyac gold, (4) Flat gold, (5) Ophir gold, (6) Poorman gold, (7) Medfra gold, (8) Ruby gold, and (9) Kuskokwim Mountains cinnabar deposits and numerous other small prospects.

The Yukon-Tanana Uplands Province includes: (1) Fairbanks gold, (2) Tofty gold, (3) Rampart gold, (4) Livengood gold, (5) Circle gold, (6) Woodchopper gold, (7) Fortymile gold, and (8) Seventymile gold.

The following districts make-up the Seward Peninsula Province: (1) Nome gold, (2) Council gold, (3) Solomon gold, (4) Kougarok gold, (5) Fairhaven gold, (6) Haycock gold, and (7) York tin.

The Western Brooks Range Province consists of : (1) Squirrel River gold, (2) Shungnak gold, (3) Sungnak copper and many other occurrences of varied metallic minerals.

The Eastern Brooks Range Province includes: (1) Upper Koyukuk gold, (2) Chandalar gold, and (3) Firth River gold, and (4) Coleen River gold.

It may be seen that the foregoing listing includes virtually all of the large metal producing areas in the portion of Alaska considered, as well as many small producers or mere prospects. Only three significant areas are excluded. These are: Indian River, Hog River and Marshall, none of which have been notably large in total production. Examination of the Geologic map of Alaska shows that although these deposits do not fit into the regional pattern they are all associated with Tertiary intrusives, which is also true of many districts within the designated provinces.

Examination of the U. S. Geological Survey map of Mesozoic and Cenozoic Tectonic Elements of Alaska (Map I-84) reveals that the provinces as they have been outlined have a direct relationship with regional tectonic elements. Figure 2, based on this map, shows the elements which have been important in the development of these provinces. They are: the

the Chugach Mountains geosyncline, the Matanuska geosyncline, the Talkeetna geanticline, the Kuskokwim geosyncline, the Tanana geanticline, the Chuckotskiy-Seward uplift, the Brooks Range geanticline and the Romanzof uplift.

The Chugach Mountains - Talkeetna Mountains Province is related to deformation of rocks of the Chugach Mountains geosyncline, the Matanuska geosyncline and the Talkeetna geanticline, and intrusion into these rocks of igneous masses during Jurassic, Cretaceous and early Tertiary orogenies.

Mineralization in the Alaska Range Province occurred along with strong to intense deformation of rocks of the Alaska Range geosyncline during the Cretaceous, and Tertiary.

Direct genetic relationship between mineralization and Tertiary intrusive bodies is most clearly seen in the Kuskokwim Mountains Province. The Geologic map of Alaska shows a linear arrangement of these bodies extending in a northeasterly direction from Goodnews Bay to the northern end of the Kuskokwim Mountains. There is a possible continuation of this line in the Tertiary intrusives of the Tofty district which would indicate a genetic tie with the Kuskokwim Mountains Province rather than the Yukon-Tanana Uplands Province. The northeasterly trend follows closely the axis of the Kuskokwim Mountains and their southwestern extension, the Kilbuck Mountains. Mineralization occurred during Tertiary orogenic activity which resulted in strong to intense deformation.

In the Yukon-Tanana Upland Province mineralization is related to Jurassic and Creta - ceous intrusives into the pre-Cambrian Birch Creek schist. Intense deformation accompanied by large-scale batholithic intrusions occurred in the Tanana geanticline during these periods. The region has been a positive area contributing sediments to adjacent negative areas during most of the time since these mineralizing periods. This fact would very likely have a bearing on the strong placer development in the region at the expense of source lodes, which appear to be very nearly removed throughout most of the province.

Mineralization in the Seward Peninsula Province is associated with Cretaceous granitic intrusives which accompanied intense deformation during the formation of the Chuckotskiy-Seward uplift. This region has been predominantly emergent since the time of mineralization.

The Brooks Range provinces are related to deformation of rocks in the Brooks Range geanticline and the Romanzof uplift. Geologic mapping is for the most part only preliminary or, in large areas, non-existant. It will be noted that compared to other provinces, little mining activity is indicated here. This is, in a large measure, the result of limited prospecting rather than a dearth of mineral. Only in recent years, with the development of the helicopter, has it become possible to carry on extensive prospecting in the areas away from major rivers, into which category most of the Brooks Range falls. To date only a small portion of the region has been subjected to detailed prospecting. The region is essentially unexplored.

The eastern end of the Brooks Range, the extreme northeastern part of Alaska, consists of a large number of large intersecting and overlapping structural units. These are the Brooks Range structures - the Phillip Smith Mountains, the Romanzof Mountains, and the Davidson Mountains - and the British Mountains and other structures of northwest Canada. These intersecting structures, from purely geologic considerations and ignoring the difficulties of the economics of transportation, make the eastern end of the Brooks Range a most favorable region for future exploration. This is one of the largest Alaskan areas in which large ore deposits might still be found by surface prospecting methods.

CONCLUSION

The foregoing information, I believe, indicates that mineralization in Alaska is related to regional structures. It is undoubtedly apparent that detailed studies within provinces are necessary to establish relationships which will be of value in exploration.

A Possible Guide to Metal Deposits in Alaska

by Charles F. Herbert, Deputy Commissioner
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Presented at the 1964 Alaska A.I.M.E. Conference
College, Alaska
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In 1962 the value of metals produced by Alaskan mines was $8,916,000, equivalent to an average production of $15 per square mile of total area in the State. In that same year, the value of metals (exclusive of iron ore and minor metals) produced in the eleven western states of the old 48 was over one billion dollars, equal to an average production of $915 per square mile. In other words, metal production in the older western states is sixty times as great as in Alaska, after adjustment for the relative areas involved.

Since the geology and geography of the eleven western states and Alaska are similar, and since gold deposits in both areas demonstrate widespread mineralization, it seems certain that Alaska's mineral industry has scarcely scratched at the possibilities for greatly increased production of gold, silver, copper, lead, zinc, molybdenum, nickel, uranium, mercury, tin, and platinum. Deposits of these metals are known in Alaska, and simple arithmetic shows that the odds of developing mines are good.

The odds for finding base metal mines can be improved by taking advantage of work done by the gold prospectors who flooded the country some sixty years ago. Their indefatigable digging served to outline the mineralized areas, and it is interesting that the two most important copper deposits and the one important platinum deposit in Alaska, and the important silver district of Yukon Territory, are near to relatively unimportant gold placer deposits.

The attached sketch shows the large number of mines, mostly gold, in Alaska and parts of Yukon Territory and British Columbia. Patterns of mineralization are evident and it is probable that the better prospecting chances will be found near, parallel to, or along the extensions of the known mineralized belts.

We know from past experience in the old West that the largest base metal mines are rarely associated with the most productive gold placers. In fact that is true even of some of the larger gold lode mines. Consequently, the less important gold placers and smaller lode gold mines should not be dismissed as possible guides to lodes of gold or base metals. However, the number of small gold mines and prospects is so large that the task of investigating the possible areas near all of them is tremendous.

Fortunately, the task may be somewhat lessened by confining the search, originally at least, to areas where placer concentrates show the existence of other metals. It may be significant that the Kennecott copper deposits and the Ruby Creek copper deposit are near gold placers that contained both copper and silver nuggets. Other districts in which copper and silver nuggets have both been found, but in which no base metal mine has yet been discovered are:

Rampart District, especially Slate and Ruby creeks
Slana District near Grubstake and Ahtell creeks
Denali District on White Creek
Chisana District on Bonanza, Bryan, and Chathenda creeks
Kenai District on Bear Creek.

Very probably this list is incomplete, and some of the old-timers could make additions to it.

Copper nuggets are rather common in the streams between the Nabesna River and the Canadian border, in the Chitina area, the Chistochina District, the upper part of the Delta River, on Sullivan Creek in the Tofty District, White River near Yakataga, and other places.

Lead minerals may be more common than has been suspected, since oxidized lead minerals are difficult to recognize and may be taken for barite, with which they often occur. A few of the places at which lead minerals have been recognized are:

Kantishna District on nearly all creeks
Tanana District in the lower portion of Morelock Creek
Rampart District on Hunter, Little Minook, and Troublesome creeks
Denali District on White Creek
Circle District on Deadwood Creek.

In the Goodnews Bay District platinum was found in gold placers some twenty years before the discovery of the rich platinum placers, which contained very little gold. Other places at which platinum has been found are:

Koyuk District on Dime, Bear, and Sweepstakes creeks
Chistochina District on Slate Creek and the Chisna River
Nabesna District on Platinum Creek
Innoko District on Boob Creek
Matanuska Valley on Albert and Alfred creeks and on Metal Creek
Beach placers at Yakataga and Lituya bays
Upper Delta River
Livengood District on Lillian Creek.

Of course, platinum in a placer may signal the presence of a nickel lode somewhere in the area.

Some metals are not likely to appear in placer concentrates, as their minerals are especially subject to solution and disintegration. Copper is rarely found unless the original copper mineral has been oxidized to native copper; galena does not travel far fom its source; sphalerite is rather easily decomposed and difficult to recognize; molybdenite is readily dispersed. However, the clay that is found near and in bedrock in nearly all placers absorbs and retains metal ions. Consequently, the tailings piles and dumps around old prospect shafts are excellent locations in which to find samples of clay which, with geochemical testing, will give information on the possible occurrence of base metals.

Gold mining to some degree has often been precedent to the discovery of large base metal mines. Within the current month (April, 1964) this relationship was dramatically illustrated when the Toronto Mining Exchange skyrocketed after the announcement that a huge, rich copper-zinc-silver deposit had been found only twelve miles from Timmins, Ontario, the heart of the old, great Porcupine gold mining district. In this presumably well-prospected area the newly-discovered orebody was found beneath a mere twenty feet of overburden.

This is a powerful argument for taking a new, hard look in and near Alaska's gold mining camps.

FAVORABLE AREAS BASED ON STATISTICAL EVIDENCE

World and Areal Considerations

Although large numbers of mineral occurrences are scattered throughout Alaska, there are not many deposits yet known to be economically significant. World averages show that Alaska is not a barren or mineral poor state, but an underdeveloped area of the earth. Bailly (1964) published a table illustrating the mineral production of various nations in dollars per square kilometer as a function of area. He points out that the average production per square kilometer is $400 and that countries with large areas, greater than five million square kilometers, average about the same as countries which have between 100,000 and 1,000,000 square kilometers. "It appears that given a varied and complex geology, any large country or large state which averages much less than $400 per square kilometer is definitely under-explored, and if subjected to modern exploration can satisfy new effective demand which may arise."

Alaska, which has "varied and complex geology", had a mineral production of only $14 per square kilometer in 1958. Since Alaska's land mass is large, it may be assumed that it is "under-explored", not under-endowed.

The figure of $14 per square kilometer was valid for the year 1958, one year after oil was discovered in the Cook Inlet area. By 1967, the figure was about $87 per square kilometer. This illustrates the effect of a sustained exploration program by the oil industry. It should be noted that this figure is still about one fifth the world average of nine years before.

Herbert (1964) compared Alaska's mineral production to that of the eleven western states. He found that up until 1963 Alaska had produced about $1.5 billion in minerals, or $2,600 per square mile, while the eleven western states had produced a value equivalent to $83,000 per square mile. Alaska has an area half that of these states, and assuming a potential equal to theirs, should have produced approximately $48 billion. Herbert's complete table is reproduced here as Table 7. It will be seen that even disregarding oil, the ratio of values of metallic minerals per square mile is greater than 15 to 1.

These assumptions and comparisons raise objections regarding the terms "favorable geology", and "potential equal to", but the fact remains that Alaska has an area large enough for statistics to average out to some value of mineral production much larger than it is now. This may be illustrated by the example of Australia. At the time of Bailly's figures (1959), Australia had a mineral production value of $45 per square kilometer, $355 per square kilometer below the world average given by Blondel. Today due mainly to the use of progressive exploration techniques, and Federal participation, Australia has a booming mineral industry.

TABLE 7

Value of Total Production Expressed as Average Value per Square Mile

(after Herbert, 1964)

State or Province	Gold	Silver	Copper	Lead	Zinc	Crude Oil	Total
California	$23,358	961	2,240	399	209	230,859	258,206
Arizona	3,978	4,178	97,574	1,317	1,773	-	108,820
Utah	6,910	12,337	60,835	14,554	4,108	8,438	105,033
Wyoming	29	1	100	-	-	65,321	65,451
New Mexico	645	767	11,945	664	2,680	41,415	57,704
Montana	4,206	7,285	31,716	1,506	4,050	8,438	57,202
Colorado	13,652	9,461	1,771	6,438	4,243	19,078	54,644
Idaho	3,480	10,000	1,286	20,382	6,155	-	41,303
Nevada	8,567	10,638	15,270	1,368	962	16	36,821
British Columbia	2,033	1,528	359	4,560	3,564	126	12,170
Washington	1,642	319	1,073	781	1,487	-	5,304
Alaska	1,772	45	702	11	-	86	2,614
Oregon	2,331	79	86	2	-	-	2,499
11 Western States excluding Alaska and British Columbia	7,153	4,983	21,065	3,678	2,225	44,035	83,139

Total production is taken from earliest record through 1962.

Production is valued in $US as:

Gold	$35.00 per ounce
Silver	1.28 per ounce
Copper	0.30 per pound
Lead	0.12 per pound
Zinc	0.11 per pound
Crude Oil	2.90 per barrel

A Statistical Model

Originally the authors had proposed to evaluate the mineral potential of Northern Alaska using statistical methods and data derived from mineral production figures and geology. After studying the area it was found that information needed for this approach, simulation theory (see Heiner and Wolff, 1967), is not available. DeVerle P. Harris, Dept. of Mineral Economics, Pennsylvania State University, has, however, studied parts of the entire State and compared them geologically with parts of the Western United States. As his analyses and conclusions have considerable bearing on estimates of mineral potential, his paper has been included in this report. His study of a part of Alaska points out that a gross mineral value of $400 million or more should exist in each of five cells 20 miles square, and values between $100 million and $400 million in each of 16 cells. The distribution of these cells, as well as those with smaller expected gross values, is shown in Figure 28 (Figure 10, Harris). It was found statistically that the total expected mineral wealth for the 21 cells (>$100 million each) is about $5.7 billion.

Harris' paper contains ample warnings as to the pitfalls of interpreting such a study. These cannot be stressed too much. Differences in geology, economics, degree of exploration and mapping between the control area (Southwestern United States) and Alaska introduce much uncertainty. An example of what can happen is the choosing of three high value cells near Fairbanks, two of which are under the Tanana Floodplain. These were chosen on the basis of geology extrapolated from nearby areas, and statistically may be valid. Economics, however, says that any ore deposits located in the bedrock of these cells would almost certainly never be located, explored, or mined.

This study does, however, confirm statistically that Alaska should have considerable unexploited mineral wealth. The paper, in total content, follows. It was presented at the Seventh Annual Symposium on Operations Research and Computer Application in the Mineral Industries, April 8 through 12, 1968, at Colorado School of Mines in Golden, Colorado, and will be published in the Fall, 1968 Quarterly of the Colorado School of Mines.

Alaska's Base and Precious Metals Resources: A Probabilistic Regional Appraisal

by DeVerle P. Harris, Department of Mineral Economics
College of Earth and Mineral Sciences, The Pennsylvania State University

Presented at the Seventh Annual Symposium on Operations Research
and Computer Application in the Mineral Industries
April 8-12, 1968

INTRODUCTION

The objective of this study is the evaluation at a relatively low level of information of the base and precious metals resource potential of parts of Alaska (see Figure 21). The perspective of this evaluation is that of 1) an explorationist planning regional exploration, 2) the mineral economist evaluating the potential of the minerals sector in the economic development of a region, or 3) the policy-maker appraising mineral endowment relative to present and predicted future requirements.

This study is based upon the proposition that for a mineral or mineral group, cumulative gross value plus estimated reserves is a meaningful measure of resource potential. In view of criteria often employed by regional explorationists, such as numbers of and physical dimensions of mineral targets (oil fields, mining districts, etc.) this seems a reasonable assumption. However, it is acknowledged that such a measure camouflages across time the cost-price and production relationships and technology differentials and ignores current cost differences between Control and Study Areas (Study Area is the area to be evaluated; the Control Area is the well explored area or areas used as a base for comparison or statistical inference).

Whether or not it makes sense to analyze an area for just one mineral or mineral group might be challenged. Historical practices seem to validate the single mineral approach; however, multiple minerals evaluation may be more in keeping with optimum exploration strategies (Griffiths, 1967; Harris, 1967). Recently, there are indications that exploration firms are beginning to adopt such a strategy (Wall Street Journal, March 13, 1968, p. 34).

A more complete evaluation calls for a multiple mineral group analysis which modifies gross value for each mineral group by cost considerations appropriate to the location of the cells, including such factors as road construction, transportation costs, and market demand and supply. A possible methodology for treating this more general evaluation problem is the subject of another paper presented at this symposium (Harris and Euresty, 1968). Regardless of whether the level of analysis is restricted to gross value or some crude estimate of net value, the gross value measure is a prerequisite to evaluation.

MINERAL DENSITY

Having established gross value as the expression of mineral resource potential in this study, the focal problem is the generation of meaningful values. A very simple resource appraisal arises from the examination and comparison of measures of mineral density for Alaska relative to other areas. Blondel and Callot (1961) found in their study of world mineral production in 1958 that some industrial countries with an area greater than 100,000 square kilo-

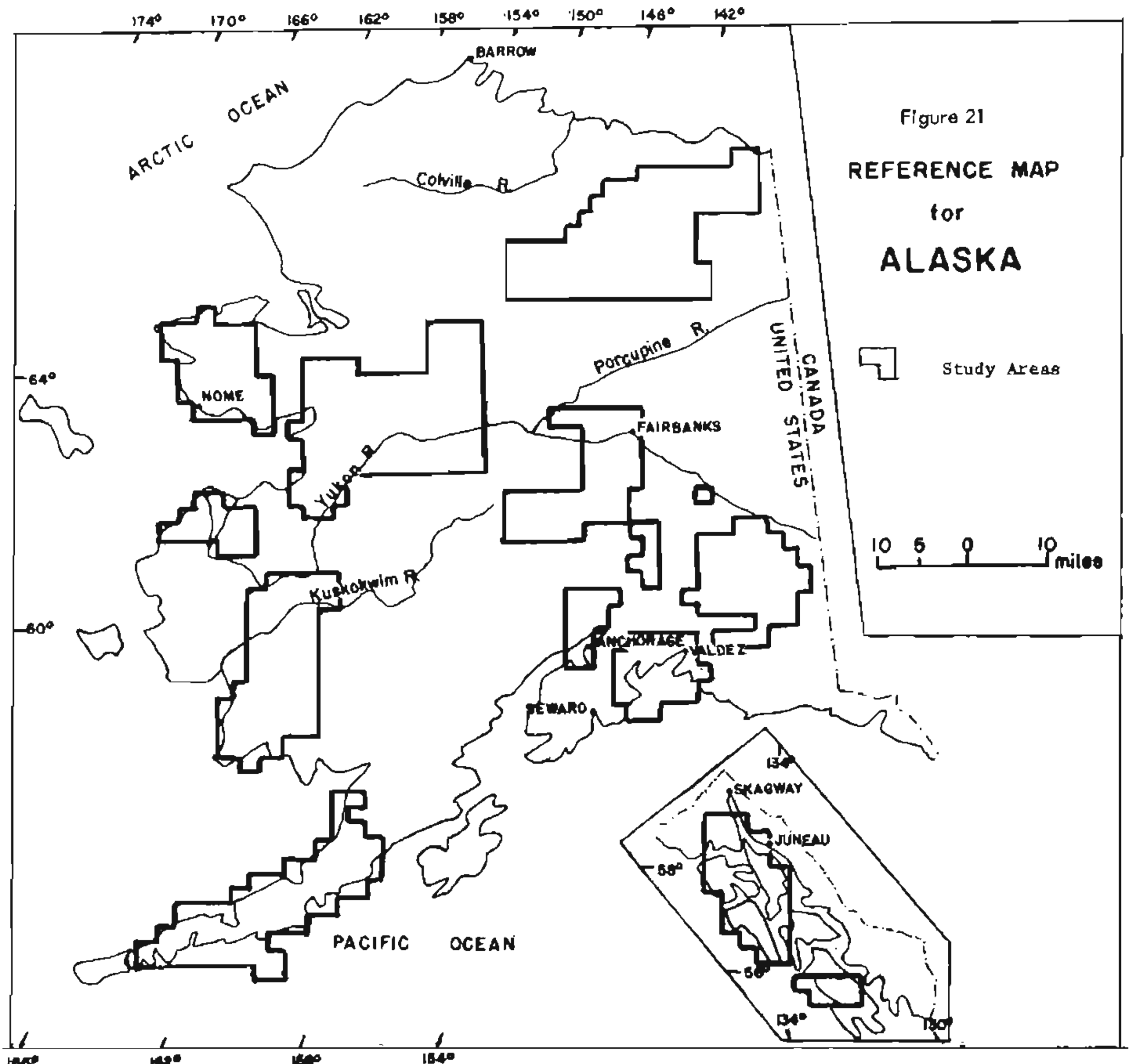


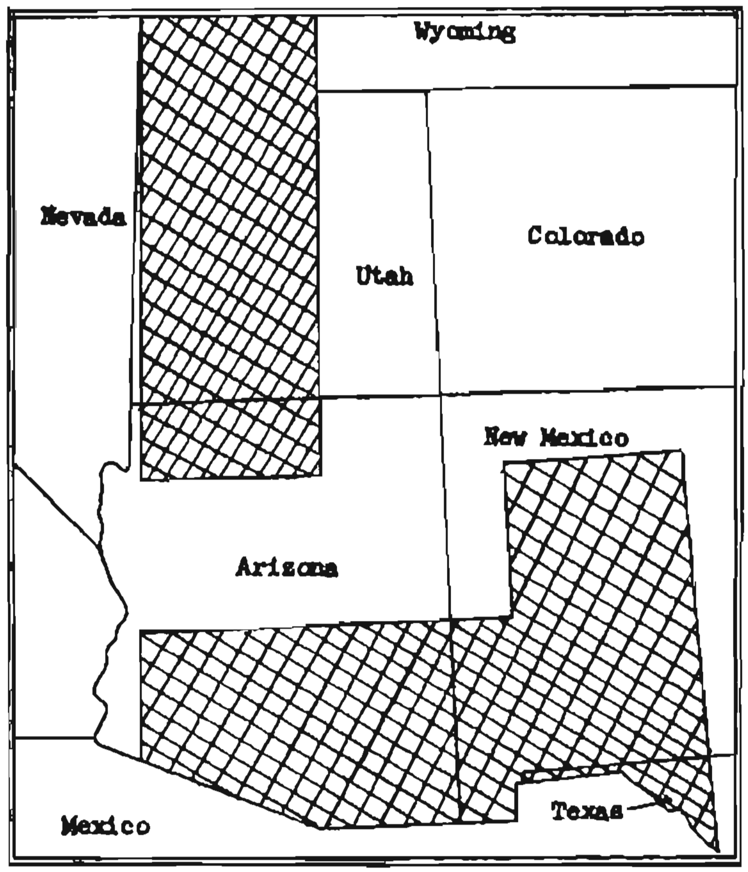
Figure 21
REFERENCE MAP
for
ALASKA
Study Areas
10 5 0 10 miles
ARCTIC OCEAN
PACIFIC OCEAN
BARROW
Colville R.
Porcupine R.
NOME
Yukon R.
Kuskokwim R.
FAIRBANKS
ANCHORAGE
VALDEZ
SEWARD
SKAGWAY
JUNEAU
CANADA
UNITED STATES

meter had a density ranging up to $11,000 per square kilometer, while the mean world density was only $400 per square kilometer. Naturally, developed countries that have had a sustained and prolonged demand upon the mineral resources over a long period of time, such as countries of Western Europe, as a general rule, have high densities. This is especially true where economic policies have supported high internal prices for domestic raw materials. Exceptions to this general rule are countries such as Kuwait with a mineral density of $25,000 per square kilometer, which is largely due to petroleum. Griffiths (1967) calculated (including metals, nonmetals, fuels, and aggregates) the <u>cumulative</u> mineral density for the U.S. to be about $127,000 per square mile.

The implication of mineral density studies is that densities for highly developed areas (countries or regions that have exploited their mineral resources) can be considered as expectations for less developed or unexploited areas. Acknowledging that this measure can be criticized upon various economic as well as geologic grounds, under certain conditions it can serve as a comparative measure of gross resource potential (Harris, 1967).

The Control Area (well explored area) in this study consists of approximately 154,800 square miles in Arizona, New Mexico, and Utah (see Figure 22). Mineral density of the base and precious metals group only in the Control Area is about $220,000 per square mile. Density for the Utah part alone is about $299,000 per square mile and for New Mexico and Arizona collectively $172,000 per square mile. These density measurements were calculated by dividing total cumulative value of production plus estimated reserves by total surface area. Value of cumulative production was determined by summing annual production figures (weight) for each district and aggregating by the 1964 price vector: Au, $35.00/oz; Ag, $1.30/oz; Pb, $.14/lb; Zn, $.13/lb; Cu, $.30/lb. To this value figure was added the value of estimated reserves. The same procedure was followed on that part of Alaska that was studied (see Figure 21 giving a density of about $17,000 per square mile, about one thirteenth of that for the Control Area.

An alternative and perhaps more enlightening comparison of mineral density derives from dividing the Control and Study Areas into cells (20 miles square subdivisions). Production values were alloted to these cells on the basis of their contained mining districts. While this procedure worked fairly well in the Control Area, in Alaska production data were often referenced to very large areas (Mining Regions, see Figure 1, containing many cells, making allocations of value to the appropriate cell difficult. In some instances judgements were highly subjective and arbitrary. Figure 23 shows the distribution of values for the Study Area. While the inaccuracy in alloting value to cells may have little significance in mineral density analysis, for the geostatistical analysis that follows, it has quite serious implications. Table 8 shows a frequency count of cells of eight different value classes for each of the areas, and Figure 24 illustrates graphically the forms of these distributions. In Table 9 a relative frequency distribution has been constructed from the data on the 387 cells of the Control Area. This table indicates that the relative frequency of occurrence of cells with a gross value in excess of one billion dollars is .025.



Control Area

Figure 22 - Control Area, Southwestern United States

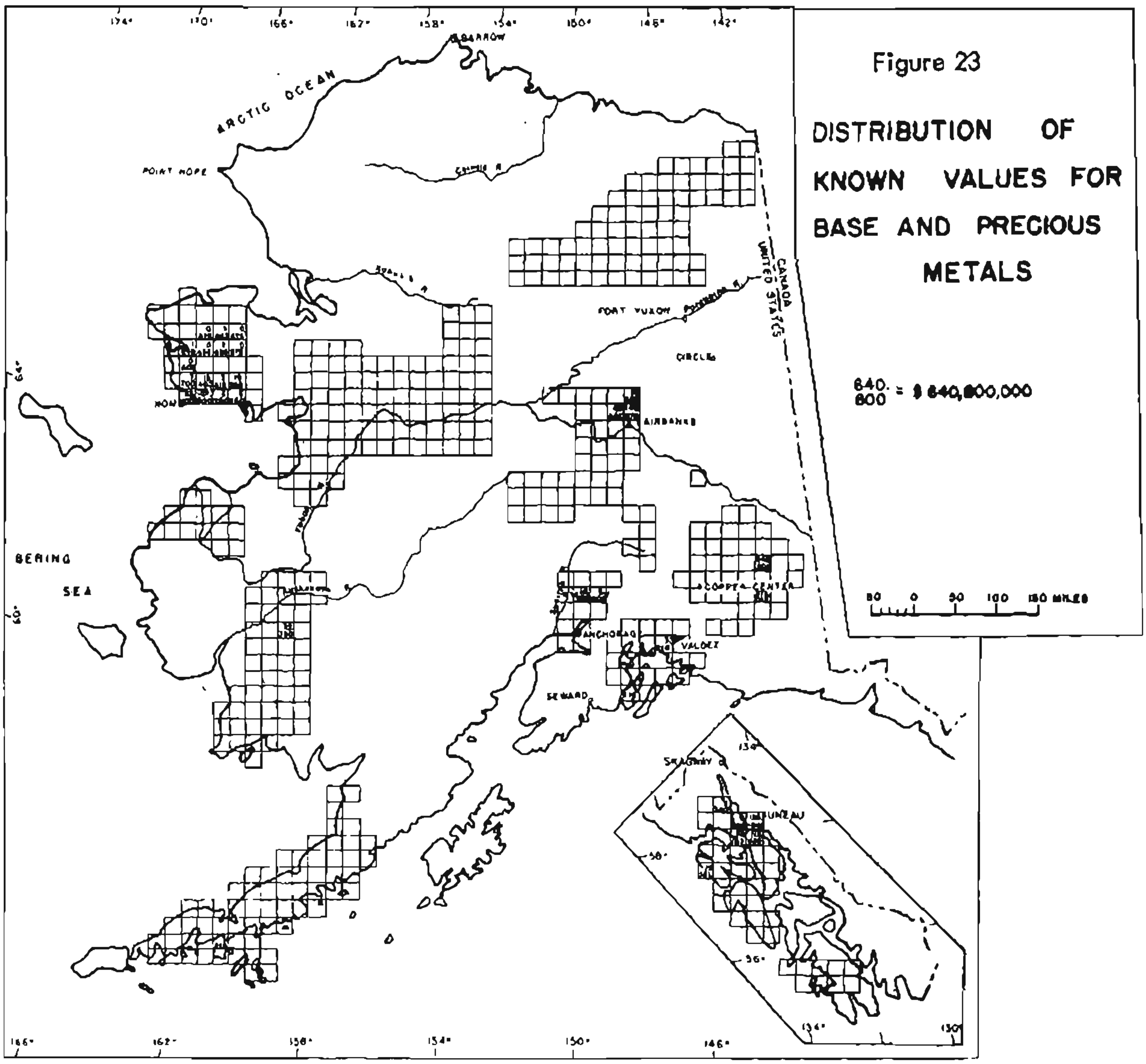


Figure 23

DISTRIBUTION OF KNOWN VALUES FOR BASE AND PRECIOUS METALS

TABLE 8

FREQUENCY ANALYSIS OF CELL VALUES

VALUE CLASS	VALUE	FREQUENCY UTAH	ARIZONA AND NEW MEXICO	UTAH, ARIZONA, AND NEW MEXICO	ALASKA
1	0 - $\$10^4$	114	151	265	460
2	$\$10^4$ - $\$10^5$	8	16	24	0
3	$\$10^5$ - $\$10^6$	4	26	30	7
4	$\$10^6$ - $\$10^7$	8	22	30	12
5	$\$10^7$ - $\$10^8$	5	17	22	8
6	$\$10^8$ - $\$10^9$	2	4	6	6
7	$\$10^9$ - $\$10^{10}$	2	7	9	0
8	$\$10^{10}$+	1	0	1	0
TOTAL		144	243	387	493

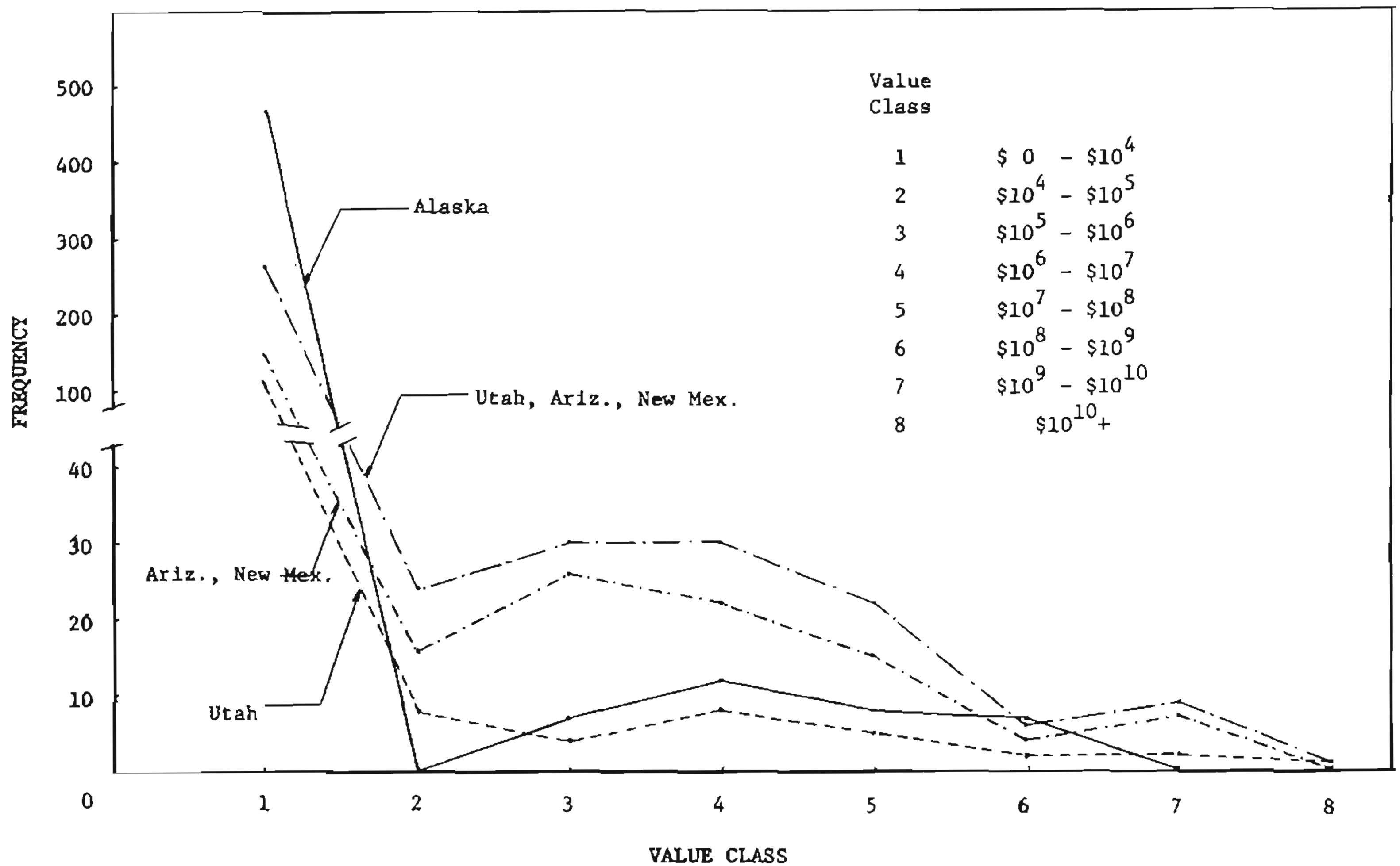


Figure 24 - Frequency Distribution of Cell Value

TABLE 9

ALASKA: EXPECTATIONS VS. KNOWN OCCURRENCES

VALUE CLASS	RELATIVE FREQUENCY*	EXPECTED OCCURRENCE IN ALASKA (493 CELLS)	KNOWN OCCURRENCE	DIFFERENCE
1	.685	338	460	122
2	.062	31	0	-31
3	.078	38	7	-31
4	.078	38	12	-26
5	.057	28	8	-20
6	.015	7	6	-1
7	.022	11	0	-11
8	.003	2	0	-2

* Relative frequency distribution is based upon the cells of Arizona, New México, and Utah

Employing the relative frequency distribution as a probability distribution which is valid only when the number of observations is large and utilizing the fact that there are 493 cells in the Study Area, column 3 of Table9 was constructed to show the expected occurrence in the Study Area of cells of the various value classes. The most conspicuous feature of Table 9 is that there is such a surplus of cells of value class one and a marked deficiency of cells of high value. The big value cells of classes 7 and 8 are completely lacking.

The impulse is strong to infer great rewards for mineral exploration for base and precious metals in Alaska. Indeed, mineralized zones which, if located in Arizona would result in the indicated gross values may exist. However, some moderation in interpretation is advised because of the noticeably greater exploration and production costs for Alaska. As demands for metals grow and technology evolves, history may very well record the discovery and production of the mineral wealth indicated, but all of these inferred targets should not be considered as economic expectations under present conditions.

Another conspicuous feature of Table 9 is the zero frequency for Alaska for value class 2. This is believed to be due in part to inadequate production data. Yet, it is reasonable even with adequate data to expect a lower frequency of occurrence for cells of low gross value in Alaska than in Western U. S., for costs may prohibit development and production of these marginal, low value cells. Obviously, inferences based purely upon spatial analysis of mineral density must be done with care because of economic as well as geologic considerations.

An additional point to consider is that even for the base and precious metals group there is an identification problem; that is, gross mineral values are a resultant of the interaction of mineral search as well as mineral occurrence. Actually, these data represent mineralization found through exploration and evaluated at the market. Indeed many valuable deposits may yet exist in the Control Area. This may tend to compensate to some degree for the over optimistic inference to Alaska due to cost and price inequities, albeit that undoubtedly there are variance differentials in the geologic-mineral resource model.

WHAT EFFECT GEOLOGY?

The contribution of geology to the discovery and exploitation of mineral resources rests upon the premise that mineral deposition, hence occurrence, is a resultant of earth processes that are reflected in rock types and structural features than can either be directly observed or inferred from indirect responses or evidences. Acceptance of this premise led to the application of earth science to mineral exploration, for it implies that geographic areas differ in their mineral potential as they differ in their geology, and in most cases geology is much easier to observe directly and evaluate than are mineral deposits. This in a nutshell is the rationale for the traditional approach to mineral exploration. Certainly, for some small area such as a 20 mile square cell, an oil or gas field is much more likely to occur in a cell located on the flanks of a sedimentary basin than in one situated in the middle of an igneous stock surrounded by high rank metamorphic rocks. Thus, geologic information serves to restrict the area for further exploration.

The argument that cells are not equally favorable loses strength as one (a) increases the size of the cells,(b) regards multiple targets or mineral groups, and(c) assumes that resources complementary to minerals are uniformly distributed (for further development and elaboration, see Harris, 1966). Although the philosophy of mineral resources and mineral exploration is a subject of considerable interest and merit, suffice it here to not elaborate further but to state simply that relative to the three conditions just set forth, this evaluation must assume an unequal distribution of resources, for the areas of reference are small (20 miles square cell); evaluation is based upon one mineral group(base and precious metals); and gross value is the adopted measure of resource potential.

This purely comparative statistical analysis of Alaska's potential relative to Arizona, New Mexico, and Utah suggested the presence of 13 cells of gross value of $100,000,000 or more and 111 of value between $10,000 and $100,000,000. This analysis ignored the implication of Alaska's known geology to its contained mineral resources. If there exists, as the science of geology testifies, a relationship between geology and mineral resources, a more accurate evaluation of mineral potential should result from appraisal of the geology. Furthermore, the regional explorationist is primarily interested in where within the Study Area these deposits might be located, so that he might optimally allocate exploration. These arguments call for geologic analysis. Figure 20 is a map prepared by Battelle Institute in 1962 for the Alaska International Rail and Highway Commission of the base and precious metals resource favorability of Alaska. This map most assuredly provides meaningful and valuable information to the regional explorationist. However, from the point of view of the regional analyst seeking quantitative measures of resource potential, the subjective judgements are not of great value. Furthermore, the areas of varying favorability are too large to be of much value in the planning of regional exploration.

Criticism of an existing practice begs the exposition of an alternative one. That alternative practice examined in this paper is multivariate geostatistical evaluation of the relationship between quantified geology and mineral wealth.

MULTIVARIATE GEOSTATISTICAL ANALYSIS

General

This technique was first demonstrated by the author in 1965. Measurements of reconnaissance geology were made for 243 cells in Arizona and New Mexico. The relationship of the measurements (variables) to mineral wealth and probability were defined by multiple discriminant analysis and Bayesian classification analysis (for a complete discussion of the methodology, see Harris, 1965). These statistical bases were used to evaluate 144 cells in Utah by processing through them the values of the geologic variables recorded for Utah. The predicted values and probabilities compared quite well to known mineral wealth in Utah (Harris, 1965b).

Basically, this same technique was applied in this study to the appraisal of Alaska, except that the Control Area consisted of parts of Arizona, New Mexico, and Utah and the explored cells of Alaska. Inasmuch as Alaska is considerably removed from the Control Area and somewhat different in geologic setting, its evaluation by geostatistical inference based upon the Control Area was viewed from the beginning as a severe test especially considering the data available. This study took as given the measurements already made in the previous study on the Control Area, thus the level of analysis was somewhat predetermined. The task was made more difficult because of the great variability in the detail and accuracy of geologic data on Alaska. In some cases the maps were of comparable detail to those available on the Control Area, while in others they were far inferior, with critical measurements such as the occurrence of igneous intrusives and details on faulting not reported (a more complete description of data problems and geologic similarities and dissimilarities is available from the author- unpublished data on the NSF Alaska Study). Naturally, the analysis can be no better than the data upon which it is predicted. The mere fact of extensive glaciation, greater alluvial cover, ice cover, and placer production values in the Study Area as compared to the Control Area present problems to geostatistical inference. It was expected prior to the analysis that some of those cells with production derived chiefly from placer production would not be identified by the model, for this type of relationship was not defined in the Control Area. However, it seemed reasonable to expect that if the cells with the placer value were not identified that an adjacent cell or cells from which the mineral values might have been derived would be identified. It is not the objective here to discuss the details of the geologic problems, but rather to illustrate the method and to show results; consequently, no further elaboration will be made, and the reader is referred to Table 10 which shows the variables used in this analysis. These measurements should be viewed as reconnaissance geologic information, as they were made from 1: 250,000 regional geologic maps. To better satisfy statistical assumptions of normally distributed variables, these measurements were transformed as shown in Table 11 (for further discussion and details, see Harris, 1965a).

Problem of Identification

Conceptually, there are two submodels in the exploration model: the occurrence model of mineral wealth and the search model. Statistics of mineral wealth even on areas considered as well explored do not really provide data on either the search model or the occurrence model, but are some mixtures of both. Well explored areas such as those of Arizona undoubtedly contain undiscovered economic deposits, perhaps some as valuable as those that are known. Some areas that appear rather mineral poor perhaps do so because of lack of endowment. Yet, there are most assuredly areas, relative to a mineral group, that even with an equal amount of exploration will never show a high density.

Even ignoring the economic factors discussed earlier, we do not have a measure of the occurrence model. To relate the measures of mineral wealth to known geology and then apply these relationships to the geology of the Study Area generates answers that are valid only under the assumption that a similar amount of exploration will be expended on the Study Area as was expended on the Control Area. To accurately define mineral occurrence and to analyze other areas requires that a measure of exploration for each cell be known and that this be treated explicitly as an additional variable; then, the resources of a Study Area could be analyzed at various levels of exploration expenditure. To make matters worse, cells have a varying degree of alluvial cover, which, ceterus paribus, tends to decrease mineral values. Some techniques of mineral exploration serve, to some degree, to decrease the effect of the alluvium. In view of these problems of identification, selecting a meaningful methodology is at best a compromise between the conceptual model and data. Inasmuch as exploration data were not available, the approach employed in this study was to define what can be considered as two bounds of bias; a positively biased relationship between geology and mineral wealth and a negative biased one.

GEOSTATISTICAL BASES

Positive Biased Analysis (PBA)

This analysis is based upon the relationship of the geology of well explored cells to mineral wealth. Well explored cells of the Control Area were defined as all cells with mines and/or prospects. To these cells were added those cells in Alaska with recorded mineral production. The Alaska cells were added to the Control Area cells to decrease the geology bias in the statistical base due to the different geologic setting of the Control and Study Areas. In this way information on the relationship of value to geology on the Study Area is incorporated in the analysis and serves to diminish the effect of differences in the geologic control between the two areas.

This analysis is considered positively biased because it is based upon explored cells only, cells that have geology which is similar and characteristic of mineral occurrence. These cells have all received some degree of exploration, as witnessed by their mines and prospects. All things being equal, cells that have been extensively explored will possess greater known mineral wealth. The exclusion of cells with no prospects from the base tends to distort the importance of the geologic variables in a positive manner. This bias may not necessarily be positive in absolute terms, for indeed there may exist in the explored cells, as well as the unexplored cells, additional valuable deposits that are yet to be discovered. But, with regards to the relative importance of the geologic variables and presently known mineral values, this analysis has a positive bias. The makeup of the statistical base for the PBA is shown in Table 12.

The cells of this statistical base were classified into one of three value groups:

TABLE 10

MEASUREMENT VARIABLES

X_1 = Percentage of cell area consisting of sedimentary rock.

X_2 = Percentage of cell area consisting of Precambrian - Paleozoic igneous intrusives.

X_3 = Percentage of cell area consisting of Mesozoic-Cenozoic igneous intrusives.

X_4 = Percentage of cell area consisting of igneous extrusive rocks.

X_5 = Percentage of cell area consisting of metamorphic rocks.

X_6 = Number of high-angle faults 8 miles or less in length.

X_7 = Number of high-angle faults greater than 8 miles in length.

X_8 = Number of low-angle faults 8 miles or less in length.

X_9 = Number of low angle faults greater than 8 miles in length.

X_{10} = Number of anticlines 8 miles or less in length.

X_{11} = Number of anticlines greater than 8 miles in length.

X_{12} = Number of high-angle fault intersections.

X_{13} = Number of low-angle fault intersections.

X_{14} = Length of contact of undifferentiated igneous intrusives with sedimentary rocks.

X_{15} = Number of exposures of the above contact.

X_{16} = Length of contact of igneous intrusives with igneous intrusives.

X_{17} = Number of exposures of the above contact.

X_{18} = Length of contact of Mesozoic-Cenozoic igneous intrusives with Precambrian-Paleozoic igneous intrusives.

X_{19} = Number of exposures of the above contact.

X_{20} = Length of contact of Mesozoic-Cenozoic igneous intrusives with metamorphic rocks.

X_{21} = Number of exposures of the above contact.

X_{22} = Length of contact of Precambrian-Paleozoic igneous intrusives with metamorphic rocks.

X_{23} = Number of exposures of the above contact.

X_{24} = Number of igneous dikes.

X_{25} = Percentage of cell area covered by quaternary alluvium, water, or ice.

TABLE 11

VARIABLE TRANSFORMATIONS

VARIABLE IDENTIFICATION	TRANSFORMATION
$X_1 - X_5$	$Y_i = 1000/\ \{(X+30)\log(X+30)\ /.3013\}$
X_6	$Y_6\quad 10/\ (X+2)^{1/3}$
$X_7,\ X_8,\ X_{10},\ X_{11},\ X_{13}$ $X_{14},\ X_{16}-X_{23}$	$Y_i = 10/\log(X+2.0)$
$X_9,\ X_{12},\ X_{15}$	$Y_i = -[(X+2)^2/200 + (X+2)^{3/4}/.30]$
$X_{24},\ X_{25}$	$Y_i = X_i$

TABLE 12

COMPOSITION OF GEOSTATISTICAL BASES

	NUMBER OF CELLS	
AREA	BASE #1 (PBA)*	BASE #2 (NBA)**
Utah	30	144
Arizona and New Mexico	92	243
Alaska	34	34
TOTAL	156	421

* PBA means positive bias analysis

** NBA means negative bias analysis

0-\$10,000

\$10,000-\$100,000,000

\$100,000,000 +

A three group multiple discriminant analysis upon this base showed the following two discriminant equations to be significant at the .05 level, as tested sequentially by the Chi Square test proposed by Rao (1952):

$$
\begin{aligned}
\text{Disc}_1 = {} & .006931y_1 - .239188y_2 - .005198y_3 - .006813y_6 + .011381y_7 \\
& + .010476y_8 + .950206y_9 + .016962y_{10} + .012856y_{11} - .113355y_{12} \\
& + .015255y_{13} + .025645y_{14} - .034683y_{16} + .072390y_{17} + .019062y_{18} \\
& + .024210y_{21} - .039576y_{22} + .065650y_{23} + .109726y_{24} + .006230y_{25}
\end{aligned}
$$

$$
\begin{aligned}
\text{Disc}_2 = {} & .002113y_1 + .249435y_2 - .037736y_3 + .051002y_6 + .010944y_7 \\
& + .024495y_8 + .959988y_9 - .012543y_{10} + .014896y_{11} + .035273y_{12} \\
& + .012800y_{13} - .009937y_{14} + .064593y_{16} - .039467y_{17} + .030239y_{18} \\
& + .013293y_{21} - .045450y_{22} + .025981y_{23} + .002107y_{24} + .003884y_{25}
\end{aligned}
$$

The first discriminant equation explains about 56.6% of the variance between groups and the second one about 43.3%.

The F statistic for testing the discriminating power of the battery of equations is significant at the .01 level for degrees of freedom $n_1 = 40$ and $n_2 = 40$:

Computed F = 1.82

Test F = 1.64

Therefore, Computed F > Test F implies that the hypothesis of no difference between the groups as measured on their geology is rejected. Thus, these equations can be considered as adequately discriminating between cells of the three value categories on the basis of their geology alone. Having determined that there are 2 significant dimensions of variance, transformation was made to the discriminant space by computing a discriminant score for each cell with each equation. To facilitate the computation of probabilities by using discriminant scores rather than geologic measurements the centroids and dispersion matrices of the discriminant scores for each group were calculated (for details on the mathematics and computational procedure, the reader is referred to Harris, 1965 a). Probabilities for each cell of the Study Area belonging to the three value groups were computed by employing these statistical bases and the following relationship:

$$PR_{ig}(V_g|\overline{DSC}_i) = \frac{\dfrac{P_g}{|D_g|^{1/2}} e^{\frac{-X_{ig}^2}{2}}}{\sum_{j}^{G} \dfrac{P_j}{|D_j|^{1/2}} e^{\frac{-X_{ij}^2}{2}}}$$

$j = 1,2,..g..,G$
$i = 1,2,...,n$

where

V_g = the gth hypothesis (in this case, group)
$\overline{DSC}_i$ = the vector of r discriminant scores for the ith cell
PR_{ig} = the probability of membership of the ith cell in the gth group
P_g = relative frequency of membership in the gth group in the mixed population
X_{ig}^2 = $M_{ig} D_g^{-1} M_{ig}$, g - 1,2,.....,G, i - 1,2,....,n
M_{ig} = $(DSC_{i1} - \overline{DSC}_{1g}, DSC_{i2} - \overline{DSC}_{2g}, .., DSC_{ir} - \overline{DSC}_{rg})$,
DSC_{ik} = the discriminant score of the kth discriminant function for the ith cell, and
$\overline{DSC}_{kg}$ = the mean of the discriminant scores of the kth discriminant function for the cells of the g^{th} group
D_g = the dispersion matrix in the reduced (discriminant) space.

The Negative Biased Analysis (NBA)

This analysis is based upon all cells of the Control Area, including those cells of no value and no prospects. To this base was added, as with PBA, the cells of known values in Alaska (see Table 12). Again, this was done to diminish the bias of the Control Area due to different geologic settings. This analysis is considered negatively biased because the relationship between geology and mineral wealth is defined on a base containing some cells that have received little exploration and therefore may contain undiscovered wealth. Since this wealth is not at present known the geology that characterizes the cells with undiscovered mineral wealth is equated to non productivity, which creates a downward bias in estimates of mineral wealth resulting from the bases that include these cells.

As with the PBA a three-group multiple discriminant analysis was performed, and it showed the following two discriminant equations to be significant:

$$\begin{aligned}Disc_1 = {} & .105462y_1 - .063392y_2 - .224022y_3 - .062172y_6 - .016333y_7 \\ & + .029461y_8 - .933465y_9 - .019278y_{10} - .015682y_{11} + .003712y_{12} \\ & + .009994y_{13} - .047867y_{14} + .021661y_{16} - .066564y_{17} - .061525y_{18} \\ & + .064230y_{21} + .115387y_{22} - .155895y_{23} - .069737y_{24} + .001695y_{25}\end{aligned}$$

$$\begin{aligned}Disc_2 = {} & .031759y_1 - .788672y_2 + .356996y_3 - .059369y_6 - .029449y_7 \\ & + .067861y_8 + .292830y_9 + .014467y_{10} - .013470y_{11} + .009845y_{12} \\ & + .042215y_{13} + .023889y_{14} - .270109y_{16} + .147155y_{17} - .121206y_{18} \\ & + .061016y_{21} + .176387y_{22} - .086685y_{23} + .013722y_{24} - .010642y_{25}\end{aligned}$$

The first equation explains approximately 74.3% of the total variance between groups and the second equation explains about 25.7%. Both equations are significant at the .05 level when tested sequentially by the Chi Square Test of Rao (1952):

> Residual variance after accounting for equation 1 is 41.4. This is larger than the test Chi value (30.14) for 19 degrees of freedom; therefore, this null hypothesis of no systematic variance in the residual after equation 1 is accounted for is rejected at .05 level of probability and a second equation is required.

The F statistic for testing the significance of both equations collectively in discriminating between cells of these value classes for $n_1 = 40$ and $n_2 = 796$ is highly significant at the .01 level:

$$\begin{aligned}\text{Computed } F &= 3.99 \\ \text{Test } F &= 1.62\end{aligned}$$

Since the computed F is larger than the test F, the null hypothesis of no difference between these groups is rejected at the .01 probability level. Thus, for the NBA these equations are accepted as adequately discriminating between cells of these value groups on the basis of their geology. The associated centroids and dispersion matrices are shown in Table 13.

THE ANALYSIS

The previous section described two statistical bases for the appraisal of the cells of the Study Area. Each of these bases could be employed to generate a set of probabilities for each cell. However, prior to evaluation of the Study Area, the data on the cells were modified to represent their geology under condition of complete exposure, that is under conditions of no alluvium, ice, water, or unmapped areas. The justification for this step is the identification problem and the fact that cover constitutes a greater portion of the geology of the Study Area than of the Control Area.

If the known geology of the cells of the Study Area were statistically related to known value, and if then 100% known geology were estimated for each cell of the Study Area and processed through the statistical bases, estimates of mineral wealth that occurs in the cells would be generated. These estimates would not be of what might be discovered with the same level of exploration as was expended on the Control Area. Since some of the discoveries in Alaska were made at a considerably higher level of information than that employed in this study, a more comparable estimate results from the model by employing the removal of alluvium as a substitute for the affect of the exploration that has transpired. The result of such an exercise should be interpreted as an expression of what might occur, not what will be found. Value discovered is dependent upon search effort as well as occurrence.

This idea may be appealing conceptually; however, such a treatment ideally calls for interpretation by a geologist of the geology of the covered areas. Since neither time nor resources would permit such, a substitute estimate was made of the covered geology by statistical inference and averaging. This method of estimation is based upon the reasonable proposition that the best estimate of what the covered portion of the cell is like is the geology of the exposed part. Then, employing the fact that a cell can have four cells adjoining it and that geology in part is continuous, at least over short geographic areas, this initial estimate of the covered portion was modified by consideration of the geology of the adjacent cells, in the manner indicated in the following equation:

$$g'_{ijk} = \left[\frac{4g_{ijk}}{(1-C_{ij})} + \frac{g_{i-1,j,k}}{(1-C_{i-1,j,k})} + \frac{g_{i-1,j,k}}{(1-C_{i-1,j,k})} + \frac{g_{i,j-1,k}}{(1-C_{ij-1,k})} + \frac{g_{i,j-1,k}}{(1-C_{i,j-1,k})}\right]\left[\frac{C_{ij}}{N}\right]$$

$$G_{wk} = g_{ijk} + g'_{ijk'}$$

where

g_{ijk} = The observed value for the kth geologic variable for the ijth cell

g'_{ijk} = The estimated value for the kth geologic variable on the covered part of the ijth cell

G_{ijk} = The final estimate of the value of the kth geologic variable for the ijth cell

N = The sum of the weights used in averaging, which varies from cell to cell depending upon the number of cells in contact with the ijth cell. The maximum value for N is 8

C_{ij} = The decimal fraction of the total area of the ijth cell that is covered by alluvium

As a general rule, cover consisted mainly of alluvium; however, it was extended in meaning to include ice and water so that those cells scattered throughout the area and possessing ice and water could be analyzed. Due to unavailability of complete map coverage, a few of the cells with significant production were in part unmapped. Because of the few cells in Alaska of large value and the desire to examine the performance of the model (albeit the conditions are not the best), these cells were added to the study and the unmapped areas were treated as cover. Those cells that were handled in this manner are shown in Table 14. Results of the evaluation for these cells should be interpreted with care.

Prior to evaluation, these revised estimates for the geologic variables were transformed just as were the original measurements upon which the statistical bases were defined.

TABLE 13

CENTROIDS AND DISPERSION MATRICES

	PBA			NBA		
	GROUP 1	GROUP 2	GROUP 3	GROUP 1	GROUP 2	GROUP 3
Disc 1	5.006251	4.552631	4.360445	11.63518	10.69042	10.18876
Disc 2	2.851315	2.996226	2.504428	-5.98863	-6.38089	-4.74179
	$\begin{bmatrix} .219303 & -.046484 \\ -.046484 & .147714 \end{bmatrix}$	$\begin{bmatrix} .305485 & .010945 \\ .010945 & .103266 \end{bmatrix}$	$\begin{bmatrix} .249373 & .093837 \\ .093837 & .341435 \end{bmatrix}$	$\begin{bmatrix} .515901 & -.082384 \\ -.082384 & .914026 \end{bmatrix}$	$\begin{bmatrix} 1.30488 & -.128763 \\ -.128763 & 1.26990 \end{bmatrix}$	$\begin{bmatrix} 1.90693 & 1.84064 \\ 1.84064 & 4.51516 \end{bmatrix}$

TABLE 14

CELLS WITH INCOMPLETE INFORMATION

CELL IDENTIFICATION	AREA	SOURCE AND AMOUNT OF UNKNOWN GEOLOGY	
		UNMAPPED	ICE-WATER COVER
326	Orange Hill		32 %
327	Orange Hill		94.9%
340	Orange Hill	15.6%	
342	Orange Hill	26.2%	
343	Orange Hill	15.6%	19.5%
344	Orange Hill	5.0%	
357	Orange Hill		3.1%
531	Orange Hill	37.8%	
443	Southeast Alaska		29 %
381	Prince William Sound		52 %
406	Prince William Sound		70 %
421	Southeast Alaska	16.4%	
529	Southeast Alaska		52.6%
428	Southeast Alasks		53 %
530	Southeast Alaska		37.2%
429	Southeast Alaska		47 %
436	Southeast Alaska	15 %	25 %
414	Southeast Alaska		45.8%

The measurement of cover for each cell was set at zero and the revised geologic measurements (representing 100% geology exposure) for each cell were processed through both PBA and NBA. Thus, two sets of three probabilities (one probability for each value class) were generated for each cell, one set representing the conservative evaluation and one set the optimistic evaluation. The probabilities generated by the two analyses for group 3 ($100,000,000+) for some of the cells (such as those in southeastern Alaska) were quite similar, but for others, such as cells in the Brooks Range they were very different. Probabilities for groups 1 and 2 were much more different for the two analyses than those for group 3.

Which of these estimates one uses must be decided by a judgment on the relative merits or seriousness of the bias built into them. This choice is particularly difficult without some evaluation of the effects of exploration upon the distribution of known mineral resources. Had there been exploration data available, they would have been incorporated explicitly in the analysis, and two analyses would not have been performed. In the absence of such data these two boundary analyses were made. The decision made in this study was to use an average of the probabilities of the two analyses. The geometric average was selected over the arithmetic average because each probability estimate is considered of equal importance and an average is desired which gives a middle position between the 2 values. The geometric mean possess such a property, while the arithmetic mean is biased in favor of high values. However, the use of the geometric mean to average the two distributions carries the penalty that the resulting distribution may sum to a value less than 1.0, where the probabilities computed by the two analyses are quite different. Thus, the resulting distribution violates a requirement that for a probability distribution the sum of the probabilities must equal one. In spite of this fact the geometric mean was employed, chiefly in the interest of obtaining a <u>conservative</u> probability estimate for each cell for group 3, for those cells with a high probability for this group are the cells of greatest interest.

ANALYSIS OF PROBABILITIES

The probabilities for group 3 are plotted in Figure25. A natural action at this point is to attempt an assessment of the reliability of the analysis by means other than measures of statistical significance of the relationships by which the analysis was made (which were previously discussed). One such measure, though not necessarily a completely valid one (for reasons to be explained later) is to examine the probabilities computed by the model for cells of known high value. Such an examination indicates only a fair accuracy of the model in identifying these cells. Employing as the decision criteria the retention of all cells with a probability of .70 or greater for group 3, 27 cells would be retained for examination in the second phase of exploration (see Table 8). At this probability level, 3 of the 6 cells with known value of group 3 are retained while 3 are not. Thus, 50% of the known cells of group 3 are correctly identified in a subset of cells constituting only 5.5% of the total cells. Of the remaining 24 cells, one has a value between 10 million and 100 million dollars and the other between 10,000 and 10 million dollars. The remaining 22 cells have no known

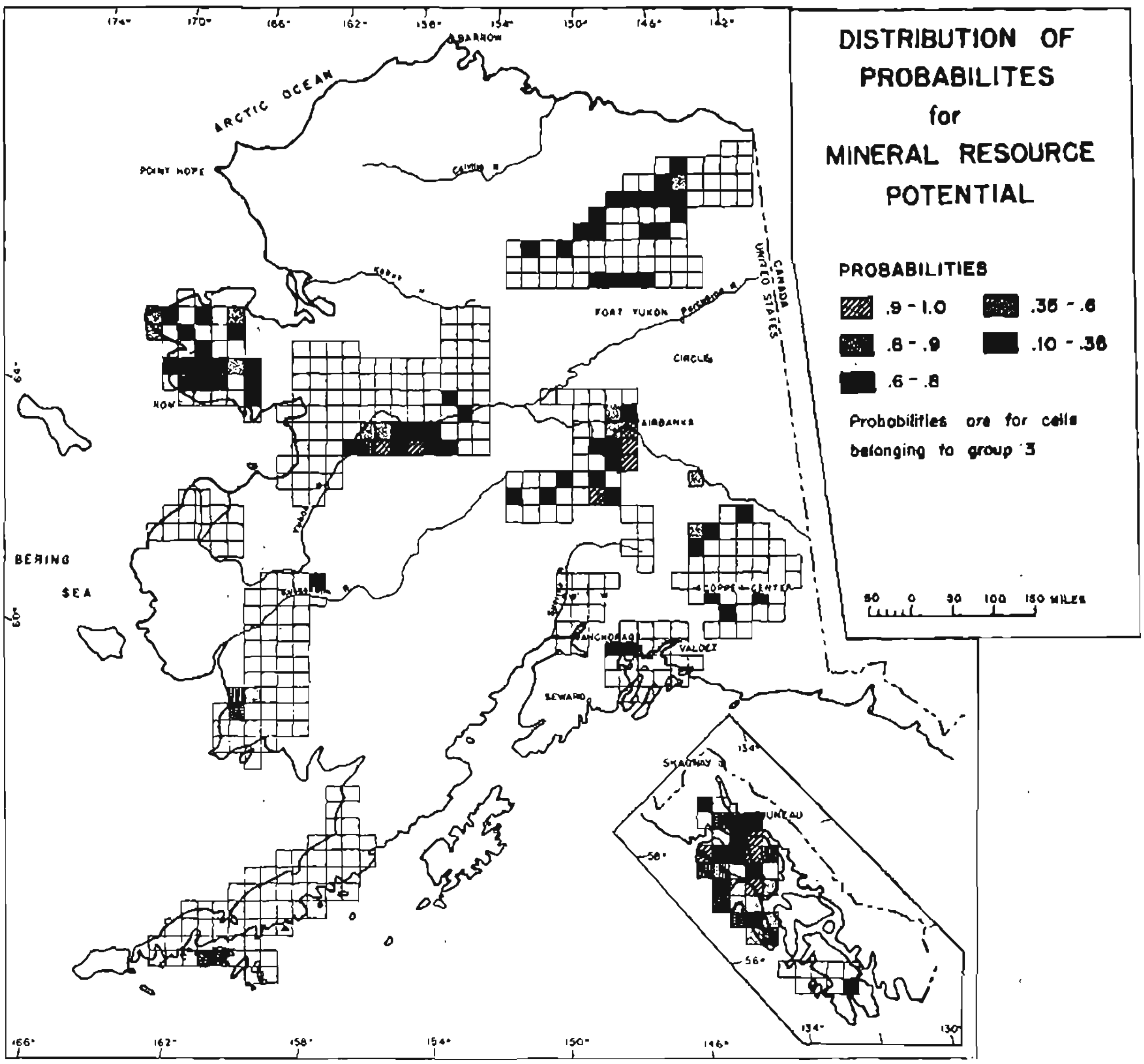

DISTRIBUTION OF
PROBABILITES
for
MINERAL RESOURCE
POTENTIAL
PROBABILITIES
.9 - 1.0
.8 - .9
.6 - .8
.35 - .6
.10 - .35
Probabilities are for cells belonging to group 3
50 0 50 100 150 MILES
ARCTIC OCEAN
BARROW
POINT HOPE
FORT YUKON
CIRCLE
FAIRBANKS
BERING SEA
ANCHORAGE
VALDEZ
SEWARD
SKAGWAY
JUNEAU
CANADA
UNITED STATES
174°
170°
166°
162°
158°
154°
150°
146°
142°
64°
60°
58°
56°
134°
130°

Figure 25

TABLE 15

SELECTION OF KNOWN VALUE CELLS USING PROBABILITIES FOR GROUP 3

PROBABILITY LEVEL	GROUP 3 $\$10^8+$ NO. CELLS	PERCENTAGE*	GROUP 2 $\$10^7-\$10^8$ NO. CELLS	PERCENTAGE	$\$10^4-\$10^7$ NO. CELLS	PERCENTAGE	TOTAL CELLS RETAINED NO. CELLS	PERCENTAGE
.90 - 1.00	1	16.7					10	2.0
.80 - .89			1	12.5	1	5.3	5	3.0
.70 - .79	2	50.0					12	5.5
.60 - .69							9	7.3
.50 - .59							8	8.9
.40 - .49							4	9.7
.30 - .39			2	37.5			13	12.4
.20 - .29					3	21.0	20	16.4
.10 - .19	1	66.7			3	36.8	27	22.3
.0 - .09	2	100.0	5	100.0	12	100.0	385	100.0
TOTAL	6		8		19		493	

* Percentage of the total cells known to be of that value class that were selected by retaining all cells with a probability equal to or greater than that specified.

mineral wealth; however, this analysis indicates their geology to be more similar to group 3 cells than to cells of groups 1 and 2. Nevertheless, the fact that only 50% of the cells of known high-value were correctly identified by the model suggests that a critical evaluation of these results requires an adjustment for this inaccuracy. With this as a premise, then the task at hand is to estimate how many of the remaining 24 cells selected at the .70 probability level really contain mineral wealth equal to or greater than 100 million dollars. Continuing with the conservative theme, one approximation to the solution of this problem derives from accepting the estimate made by spatial analysis (described at the beginning of this paper) as a measure of the number of group 3 cells that occur in the Study Area and from discounting these 20 cells by the estimated 50% accuracy of identification. The resulting inference is that 10 of the 27 cells contain mineral wealth of group 3. Since 3 of these 10 cells are known, then the set of 24 cells contains 7 cells of group 3 which at present have little or no known production or reserves. By employing the geometric mean value of 690 million dollars that was computed on the cells of group 3 of the Control Area and the accuracy-adjusted estimate of 7 cells, the critical evaluation of the results of this analysis is that the original set of 493 cells of the Study Area has been reduced in number to a set of 27 cells which contain at least 7 cells with a total estimated value of 4.8 billion dollars of unknown mineral wealth and 3 cells each with known mineral wealth of at least 100 million dollars. The two cells with known value of group 2 that are included in the set of 27 cells may or may not constitute part of the 7 cells.

A more fair evaluation of the reliability of the results allows for other considerations, such as the fact that the cell of known high value in the Seward Peninsula (Nome Area) which was not identified as a high-value cell by the model derived most of its value from placer deposits, not from lode mining. This leaves open the possibility that the geology of adjacent cells (cells indicated by the model to have moderate to high probabilities for group 3) may have generated some of the initial mineralization of gold which later was concentrated to form the placers of Nome. Then, it is unrealistic to expect the geostatistical model employed here to generate a high probability for this cell.

The general observation can be made that those cells of high known value that were assigned a low probability for group 3 are cells with a large amount of cover or unmapped areas. Even though inference and averaging were employed to provide an estimate of the covered portions, these cells may be undervalued by the model. For, if the geology of the cell of value is little known, the geology of the adjacent cells is given a greater weight in estimating its covered geology. Take as the extreme case an orebody discovered by geophysics in a cell completely covered by alluvium; the estimate of geology for the cell with the deposit is predicted completely upon the adjacent cells, which may not have the same favorable geologic setting, for if they did have favorable geology, they also would be of high value. On the other hand, a similar argument can be employed to show that heavily covered cells adjacent to high value cells may be overvalued.

Examination of the probabilities for group 2 indicates that some of the cells with low probability for group 3 have a high probability for group 2. It would not be surprising with nonuniformity of data compounding the method of geostatistical inference that a cell of group 3 would have a high probability for group 2. A 90 million dollar cell even under good data conditions is not a great deal different from one of 110 million dollars when judged by its general reconnaissance geology. Nonuniformity of data (which is currently a definite problem in Alaska) could overshadow such a small real difference, especially since quantitative measurements of the geology were employed, for lack of data results in a lower measurement for the variables and cause underestimation of value for that cell. This is especially relevant to the lack of detailed mapping (as compared to the Control Area) of the occurrence of igneous intrusives and faults, which are important variables in the discriminant equations. The fact of considerable cover and unmapped areas combined with the lack of structural detail on faults in the Copper River Area are considered as possible reasons for the low group 3 probabilities for the two high-value cells in that area. The point to be made is that the reliability of the model in identifying high-value cells is probably greater than the 50% indicated by examination of probabilities of cells of known high value and that at the .70 probability level there probably are more than 7 cells with mineral wealth of at least 100 million dollars.

An explorationist employing a more liberal strategy might wish to make decisions on the basis of the combined probabilities of groups 2 and 3, since group 2 can contain cells up to 100 million dollars in value. The sum of the probabilities for groups 2 and 3 are shown in Figure 26. The results of evaluating these probabilities relative to cells of known value are shown in Table 16 and Figure 27. If .90 is selected as the critical probability level, 100 cells are retained for further examination(see Table 16). This group of 100 cells contains 66.7% of the known cells of group 3 and 26% of those of group 2. Of the 100 cells, 89 are cells with no known value, cells that appear favorable for mineral wealth.

Expected Value and Residual Expected Value

The expected value of gross mineral wealth for each cell was computed by combining the probabilities for a cell with the mean value of the appropriate value groups, according to the following formula:

$$EV_i = \log^{-1}\left[\frac{\sum_{j=1}^{3} P_{ij}\ \bar{V}_j}{\sum_{j=1}^{3} P_j}\right] \qquad \text{where}$$

P_{ij} = probability of i^{th} cell belonging to the j^{th} value class. This distribution of probabilities for each cell was computed as an arithmetic average of the probabilities generated by the two analyses, NBA and PBA.

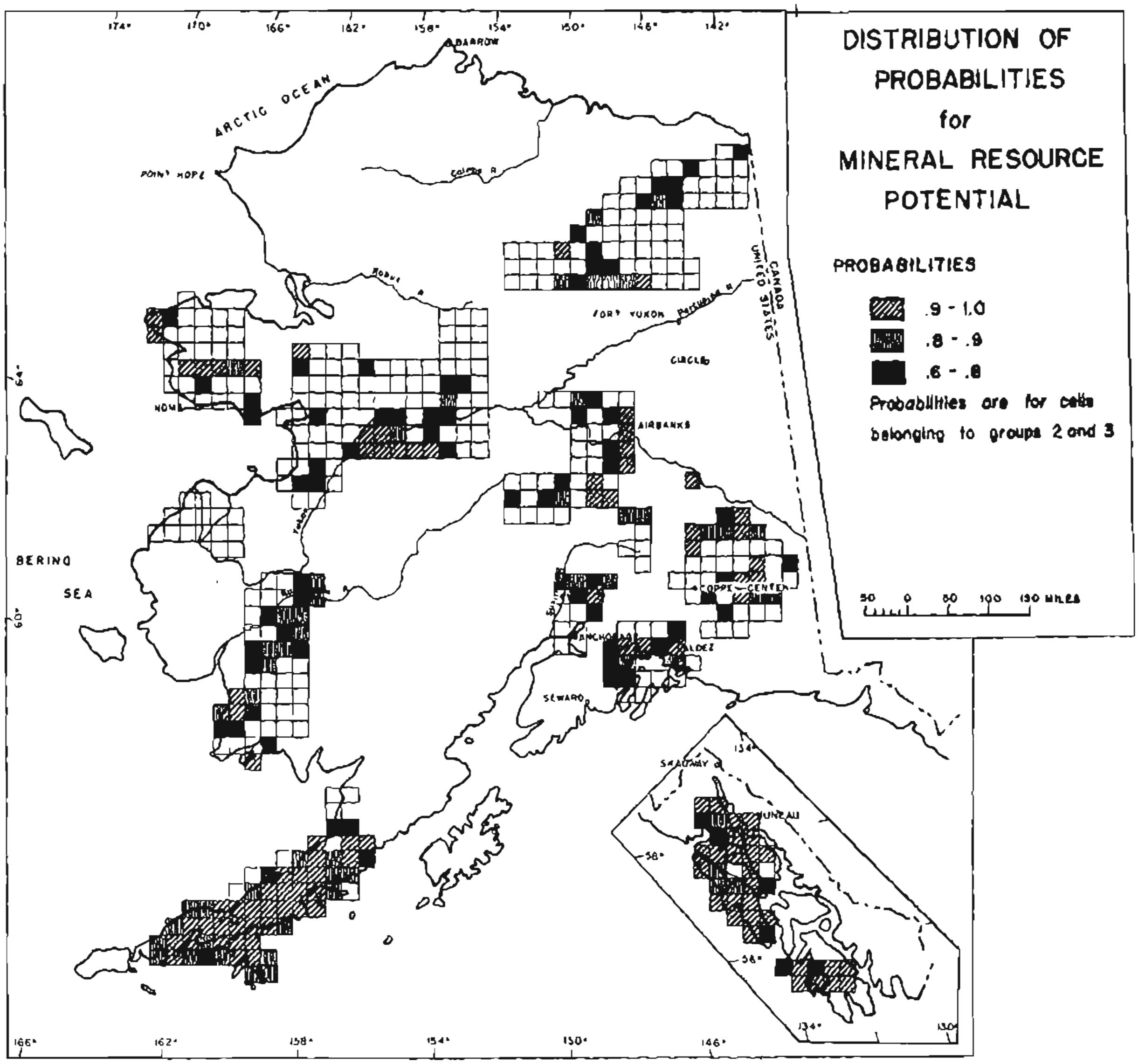

DISTRIBUTION OF
PROBABILITIES
for
MINERAL RESOURCE
POTENTIAL
PROBABILITIES
.9 - 1.0
.8 - .9
.6 - .8
Probabilities are for cells belonging to groups 2 and 3
50 0 50 100 150 MILES
ARCTIC OCEAN
BARROW
POINT HOPE
NOME
FORT YUKON
CIRCLE
FAIRBANKS
BERING
SEA
ANCHORAGE
SEWARD
SKAGWAY
JUNEAU
CANADA
UNITED STATES

Figure 26

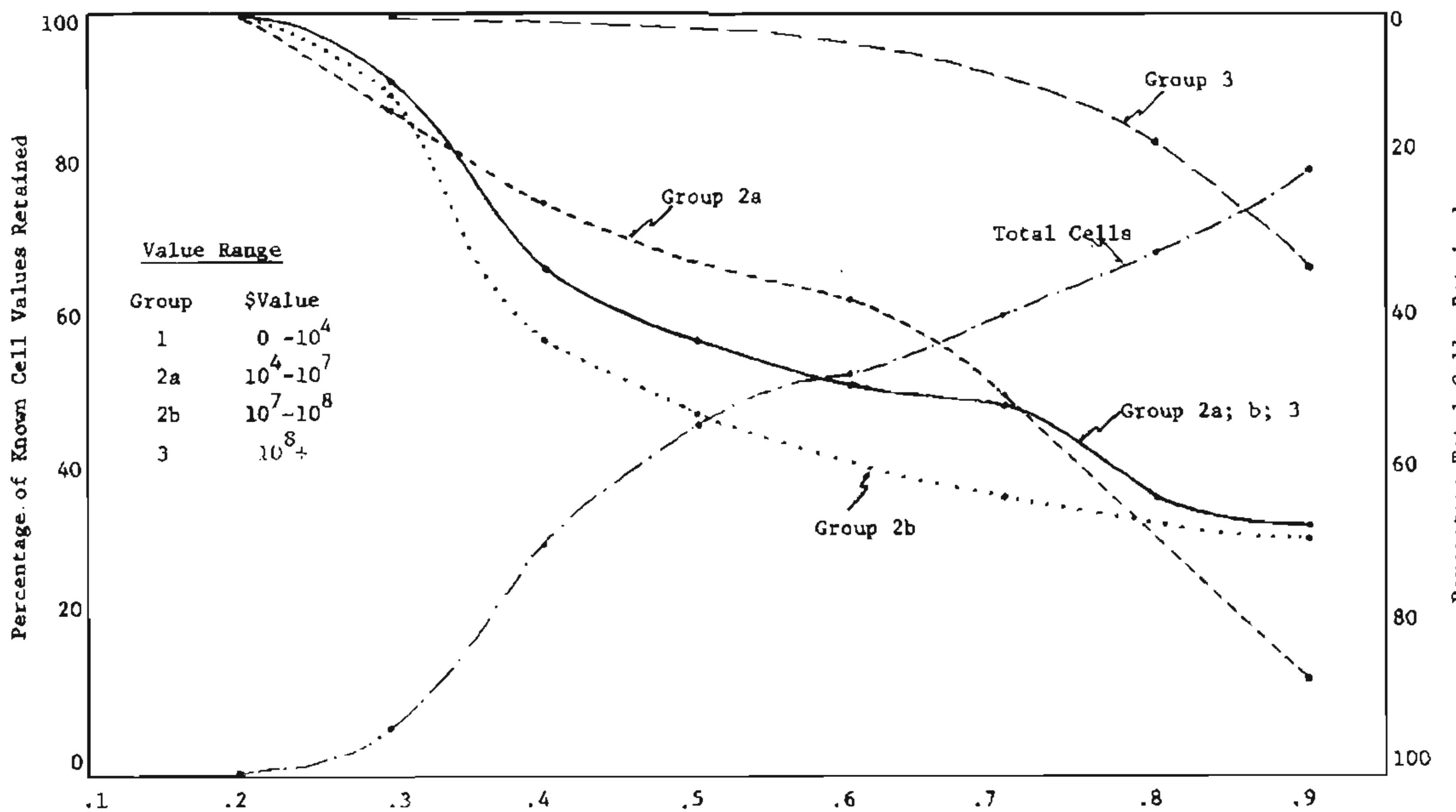


Figure 27 - Probability
Selection of Known Cells by Probability

TABLE 16

SELECTION OF KNOWN VALUE CELLS USING PROBABILITIES FOR GROUPS 2 AND 3 COMBINED**

PROBABILITY LEVEL	GROUP 3 $\$10^8+$ NO. CELLS	PERCENTAGE	GROUP 2 $\$10^7-\$10^8$ NO. CELLS	PERCENTAGE	$\$10^4-\$10^7$ NO. CELLS	PERCENTAGE	TOTAL CELLS RETAINED NO. CELLS	PERCENTAGE
.90 - 1.0	4	66.7	1	12.5	6	25.9	100	20.3
.80 - .89	1	83.3					55	31.5
.70 - .79			3	50.0	1	36.8	40	39.6
.60 - .69			1	62.5			37	47.2
.50 - .59					2	47.4	33	53.9
.40 - .49			1	75.0	2	57.9	78	69.7
.30 - .39	1	100.0	1	87.5	6	89.5	118	93.7
.20 - .29			1	100.0	2	100.0	28	99.4
.10 - .19							3	99.9
.0 - .09							1	100.0
TOTAL	6		8		19		493	

* Percentage of the total cells known to be of that value class that were selected by retaining all cells with a probability equal to or greater than that specified.

** Combining groups 2 and 3 constitutes a grouping of all cells of any value as distinguished from those cells of no value of group 2

$$\bar{V}_i = \left(\sum_{k=1}^{n_i} \log V_{ki} \right) / n_i$$

n_i = number in the i^{th} value class

$i = 1, 2, \ldots\ldots, 493.$

The distribution of these values is shown in Figure 28. Some of the cells have known mineral wealth as great or greater than their computed expected value. Those cells with high residual value (not yet known) are the cells that are the prime targets for exploration (see Figure 29). For example, each of three cells south of Fairbanks, one cell just south of Juneau and on Admiralty Island, and one cell on Chichagoff Island has an expected residual value greater than 400 million dollars. An interesting feature of the geographic distribution of these category 1 (400 million dollars +) cells is that they occur in areas that in broad terms have been major centers of mineral exploration and production, specifically, the Fairbanks and Juneau areas. The implication is that the cells near the known production centers still have the greatest potential mineral wealth. Perhaps of greater interest because they imply potentially new areas of mineral production are some of the cells of category 2 (100 million to 400 million dollars), specifically, the 4 cells in the Kaiyuk and Ruby districts (Yukon RiverRegion), the cell in the Chandalar and Sheenjek districts (Yukon River Region), and the cell in the Bethel district (Kuskokwim River Region). Especially noticeable is the fact that although there are several cells of moderate value in the Seward Peninsula, there are no cells with large residual expected value.

The statistics on expected values of mineral wealth are summarized in Table 17. The total residual expected value computed for the five cells of category 1 is approximately 2.5 billion dollars and the total for the 16 cells of category 2 is approximately 3.2 billion dollars. Aggregating the cells of these 2 categories results in a group of 21 cells with a total residual expected value of 5.7 billion dollars of mineral wealth in base and precious metals resources.

Little can be stated in absolute terms about the reliability of these results except that many of the same arguments employed in the analysis of probabilities apply to the expected values. In relative terms, these expected values are conservative estimates, because a probability-weighted geometric mean was employed rather than a weighted arithmetic mean. Actually, using a weighted arithmetic mean resulted in higher values for the cells and markedly reduced the number of cells that have produced more than their expected values; nevertheless, the more conservative weighted geometric mean of value was selected as the measure of mineral wealth.

It is emphasized again that these values are gross mineral wealth based upon the Control Area production and reserves as valued at the marked and based upon 100% geology for the cells of Alaska. In actuality some of these cells are extensively covered, thus, some of

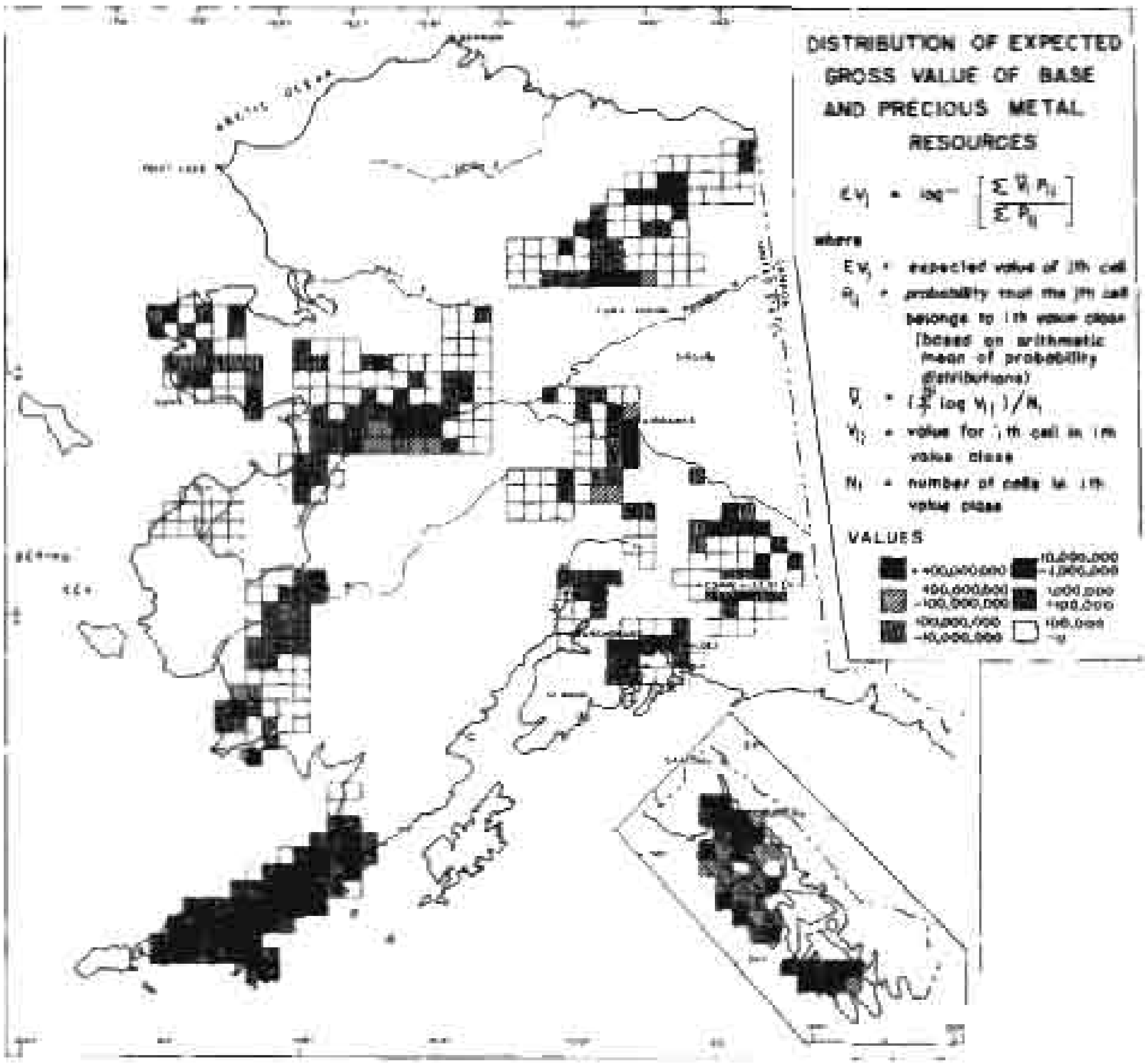

DISTRIBUTION OF EXPECTED GROSS VALUE OF BASE AND PRECIOUS METAL RESOURCES
where
expected value of jth cell
belongs to ith value class
(based on arithmetic mean of probability distributions)
value for jth cell in ith value class
number of cells in ith value class
VALUES
400,000,000 –100,000,000
100,000,000 –10,000,000
10,000,000 –1,000,000
1,000,000 –100,000
100,000 –0

Figure 28

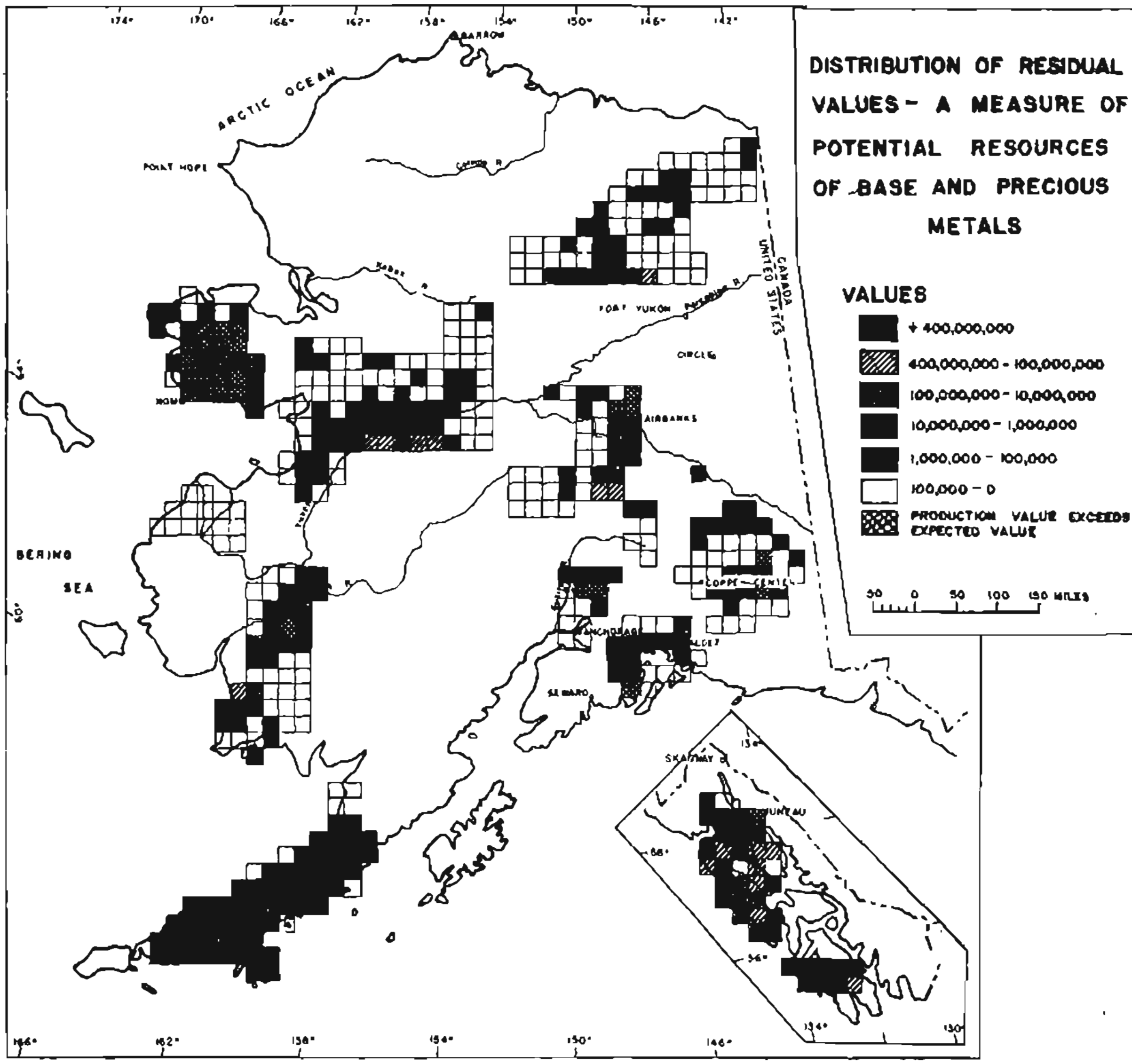

DISTRIBUTION OF RESIDUAL VALUES – A MEASURE OF POTENTIAL RESOURCES OF BASE AND PRECIOUS METALS
VALUES
+ 400,000,000
400,000,000 - 100,000,000
100,000,000 - 10,000,000
10,000,000 - 1,000,000
1,000,000 - 100,000
100,000 - 0
PRODUCTION VALUE EXCEEDS EXPECTED VALUE
50 0 50 100 150 MILES
ARCTIC OCEAN
BERING SEA
CANADA
UNITED STATES
FORT YUKON
CIRCLE
ANCHORAGE
SEWARD
SKAGWAY
JUNEAU

Figure 29

TABLE 17

FREQUENCY ANALYSIS OF EXPECTED AND RESIDUAL VALUES*

VALUE CLASS	FREQUENCY EXPECTED VALUE	RESIDUAL VALUE
$0 - \$10^5$	223	238
$\$10^5 - \$10^6$	144	138
$\$10^6 - \$10^7$	78	72
$\$10^7 - \$10^8$	25	24
$\$10^8 - \$4(10^8)$	18	16
$\$4(10^8)$ +	5	5

*Residual value is the expected value minus known value. Cells with known value greater than expected value were counted in the category $0 - \$10^5$.

the mineral wealth may never be discovered. Further, economic conditions may not permit the exploitation of all deposits similar to those that generated mineral wealth in the Control Area.

SUMMARY AND CONCLUSIONS

Based upon multivariate statistical inference from relatively well explored areas of Arizona, New Mexico, Utah, and Alaska and a set of 20 geologic variables, this study found 5 cells in the Study Area each with a residual expected gross mineral wealth of base and precious metals resources of at least $400 million dollars. Three of these cells are located in the Fairbanks Area and two in Southeastern Alaska. In addition, there are 16 cells with expected residual value between 100 and 400 million dollars and 25 between 10 and 100 million dollars. The total expected mineral wealth for the 21 cells of the 2 highest categories (100 million dollars +)is approximately 5.7 billion dollars.

These expected residual values are based upon a probability distribution for each cell that resulted from combining probabilities computed by two separate discriminant and classification analyses, 2 analyses being used as an adjustment for bias and exploration. Each analysis employed two discriminant equations, each of which was found to be statistically significant. Considering the reconnaissance level of information upon which this analysis was based and the variable, and often poor, map information on Alaska, the reliability of the model is assessed as at least fair. The effect of lack of detailed geologic information on some areas is to underestimate the mineral wealth for those areas; this is due to the nature of the geologic variables (areas, counts, lengths, etc.) and the quantitative techniques employed.

The probabilities displayed on the group-three mineral potential map are measures of similarities of the cells of the Study Area to those cells of the statistical base that have known production plus reserves of at least 100 million dollars. These probabilities can be treated as expressions of certainty; that is, a cell with an expected residual value of 100 million to 400 million dollars and a probability of .90 for group 3 is a safer bet than another cell of the same value class but with a probability of .80 . Within the basic methodology of this study (multivariate geostatistical analyses) probabilities and expected values were computed in a manner designed to produce conservative estimates.

A comparison of the results of the purely spatial analysis made at the beginning of this paper with the results of the geostatistical appraisal is made in Table 18. It is interesting to note that the spatial analysis indicates an expectation of 20 cells occurring in Alaska with a value of 100 million dollars or more, while the geostatistical analysis indicates an expectation of 23. Of course, the geostatistical appraisal also makes predictions as to which cells contain these values. At present, only 6 cells of this value class are known in Alaska. For cells of value between 10 and 100 million dollars, the spatial expectation is 28, while the geostatistical expectation is 25. The expected values for the small value classes are considerably different for the two analyses, with the geostatistical

TABLE 18

FREQUENCY COMPARISON OF TWO EXPECTATIONS:
SPATIAL DENSITY VS. GEOSTATISTICAL

VALUE CLASS	SPATIAL DENSITY	GEOSTATISTICAL	KNOWN
0 - $\$10^5$	369	223	460
$\$10^5$ - $\$10^6$	38	144	7
$\$10^6$ - $\$10^7$	38	78	12
$\$10^7$ - $\$10^3$	28	25	8
$\$10^8$ +	20	23	6

predicting less cells in the lowest value group and more in the moderately low ones. This is due to the basic postulate that mineral wealth is related to geology and to the fact that 100% ogic information was estimated for each cell.

In summary, this evaluation confirms what often has been stated, that Alaska contains considerable unexploited mineral resources. However, at the expense of being repetitious, it again is emphasized that this analysis indicates values that might exist in Alaska if the mineralization were discovered and evaluated under economic conditions that have existed in the western U. S. Transportation limitations coupled with climatic and terraine factors in Alaska serve to decrease the gross value implied by geology. Even so, the probable presence of 5 cells with expected residual value of at least 400 million dollars and 16 between 100 million and 400 million dollars should be of interest to individuals concerned with potential resources for base and precious metals.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the financial support of this research by the National Science Foundation. The following graduate students of the Department of Mineral Economics contributed significantly to this study: James Chrow, geologic analysis and measurement; Kenneth King, construction of maps and illustrations; and Azman Azis, computer programming and data processing.

MINERAL POLICY

Introduction

F. C. J. Lu, L. E. Heiner, and E. N. Wolff

Before discussing mineral policy in Alaska and the factors that can help shape the industry, something should be said concerning the unique nature of minerals. Our civilization is built upon the use of minerals, and for civilization to survive, a continuous and apparently increasing supply of minerals must be forthcoming. Three basic numbers stand out: 5 billion years of earth history, 6 thousand years of human history, and about 100 years of intensive industrial use of minerals. So far as mankind is concerned, all there is to work with is what was formed during earth history; there will be no more. Already during the hundred or so years of use, the high grade deposits and the easily found ones have been discovered and worked out or are being worked out. Lower and lower grade deposits of large size must be found and worked, necessarily with more and more efficiency.

Minerals thus are unique among natural resources. Depleted forests may be regrown, depleted soil improved, but to keep the minerals coming, they must be sought, found, and exploited where they are found. This fact generally eventually forces society to assign to mining a "higher use" function whether we like it or not. Elliott (1964) states, "It is a fundamental fact that a miner must look for mineral wherever he thinks it may occur." "Conservation" in its most realistic sense, should aim for 1) wise use of the finished product and maximum recycling of scrap; 2) efficient extraction of new minerals, without leaving sub-ore material in such a way that it is lost forever; and 3) a minimum interference with other uses of the land, compatible with 2) above.

Another characteristic of mineral deposits and the industry based upon them is that there is inherently more risk involved than in other large scale ventures. Boyd (1967) describes the White Pine copper mine in Michigan which was purchased in 1929. Thirty six years later, \$93.2 million had been spent; \$84.5 million had been returned; a deficit of \$8.7 million existed. Two good years prevented the operation from failing. Boyd expects that the mine eventually will return the investment.

At present minerals are acquired in the United States in two ways: some minerals, chiefly metallics, are appropriated and exploited in a limited form of ownership, and others, generally fossil fuels and industrial rocks and minerals, are acquired by leasing. When Alaska became a state, the constitution provided for similar modes of acquisition, with the one important difference that mining claims on State land cannot be patented.

As a corollary to the acquisition of ownership of a mining claim, a person has the right to enter upon the public domain and actively search for minerals, and his rights are protected through the acts of exploration, acquisition, development and exploitation. In leasing, except for oil, there generally is some kind of search or exploration before acquisition. For oil, a lease is obtained before a discovery is made. Leasing rather than staking is applied to certain minerals because these minerals present a larger target, and larger tracts of land are needed. In addition many of the leasing minerals are low value commodities, and may become economic only by virtue of new markets in the vicinity. Some of the element of risk has been removed when compared to the search for metallic deposits, at least for the low value industrial rocks.

Most mineral economists believe that these forms of appropriation should be retained, and that they present the best and most efficient forms of developing the mineral wealth. It would also seem that they are more in accord with the aims of a capitalistic democracy; in general, they allow a small prospector or speculator to acquire and develop a mineral property, while in no way abridging the rights of large well financed companies to do the same. Most leasing or concession schemes favor large companies, while outright government operation is abhorrent to our concepts.

Although the general methods of acquisition by staking and the present leasing procedures are favored by most mineral economists, miners, and mining lawyers, there is no agreement on what should be the role of government in the development of mineral wealth. Some believe that governmental agencies should confine their efforts to geologic mapping (Rudd, 1967), while others believe that anything, including large scale drilling programs, should be undertaken. It is the thesis of this portion of this report that in Alaska, efforts somewhat more than usual are required by government in order to interest private industry. This is because of the unusual position of Alaska due to its isolation and rigorous climate, which militates against agriculture-based industries, and results in higher costs and a disproportionately more important role of minerals in the economy of Alaska than in most other states. Enough government help should be given to neutralize the unfavorable position, but this help should be within the framework of our present laws. The balance of this section describes what is being done, and suggests further ways in which policy may be implemented. In addition to this, some comments on mineral policy will be found among the separate consultants' reports.

A Comparison of Some Factors that Affect the Mineral Industry

During the past twenty years there has been a spectacular growth of the mining industry in Canada; in this same period metal mining in Alaska has steadily declined. Assuming that geological conditions are somewhat similar, it would seem pertinent to list practices, laws, customs, and economics that are similar or that differ in Canada and Alaska.

Of all the items listed above, economics is the most important. When economics are discussed, cost is generally stressed; certainly cost is of prime importance. There is however, a less tangible aspect to economics that must be considered; and that is the fact that there seems to be less incentive for the Alaskan population to utilize the natural resources of the country than in, say, northern Canada. This is partially also a social phenomenon and includes the attitudes of the people toward government and of the government's attitude toward the exploitation of natural resources. The prospect of spending a summer "in construction" has replaced the dream of a "farm out west", or a "gold mine in the Klondike".

Similarly, although economic data on Siberia are scant, one gets the impression from general works that people go to the frontier to develop and exploit the natural resources, and that the resources must provide their livings. With an appreciation of the intangible effects of these differences in attitude, some of the factors that influence mining in Canada and in Alaska can now be described and compared. Before doing so, however, it must be stated that there is no criticism of any of our agencies expressed or implied, when comparisons are made. Programs depend on money, and if we want them we must pay for them.

COSTS

It has been stated as a rough rule of thumb for estimating costs in Alaskan towns that the cost of living index, compared with Seattle as a base (100) increases with distance north and west from Seattle (Battelle Inst., 1961, p. IV-14). Indices on which this rule is based are about as follows: Ketchikan, 122; Sitka, 125; Juneau, 124; Seward, 132; Anchorage, 138; Fairbanks, 150; and Nome, 154.

Cost of living indices are not readily available for Canada, but Table 19 indicates the mean annual wages for male workers in various parts of western Canada, and compares these with those in the United States.

Table 19 - Comparative Costs, Selected Regions United States, Canada, Alaska

	Av. annual wage Male, 1961	Percentage	Cost of Living Index
All Canada	$ 3679	100	
Vancouver area	4140	112	
Victoria area	4040	110	
S. Central B.C.	3460	79	
Kittimat	4370	119	
N. Central B.C.	3400	92	
NW. B.C.	4400	120	
NE. B.C.	3880	116	
Yukon Territory	4410	120	
MacKenzie	4420	120	
Keewatin	3740	102	
Franklin	4820	131	
		Median, 1961	
All U.S. (Med., 1961)	5000	136	
Wash. State (Med., 1959)	6225	169	100
Ketchikan			122
Sitka			125
Juneau			124
Seward			132
Anchorage			138
Fairbanks			150
Nome			154
All Alaska (1959)	7305	199	

(Camu, Weeks, Sametz, 1964; Goldfield, 1967; Battelle, 1961)

The foregoing table can be used for making qualitative comparisons only, because of the extremely large areas included in the averages and median, and because wages and living costs are not strictly synonomous. What it indicates is that in 1961 the average wage paid to male workers in all Canada was $3679, while similar wages in the Vancouver area were ten percent higher, and in northwest British Columbia and Yukon Territory twenty percent higher. The median wage for male workers in the United States was about $5,000 in 1961, or thirty-six percent higher than the average of Canada. Based on a median income of $6,225 (1959) for Washington State, wages for that area are about seventy to seventy-five percent above the average for Canada. The last half of the table shows comparative cost of living indices for Alaska compared with Seattle.

In 1967, the Mineral Industry Research Laboratory, of the University of Alaska (unpublished ms.) conducted a study of the problems involved in mining and milling of gold lodes in the Fairbanks district. Based on costs then current, the costs of operating were calculated as follows:

Minimum value of Ore, $/ton, for 50 TPD-$75.637; for 100TPD-$61.977;for 500TPD-$40.980.

The very high minimum values result from the fact that the relatively narrow veins do not lend themselves readily to large productions, with resultant high labor costs. An open pit mine would, of course, have much lower costs.

Chadwick (1960) discusses the economics of mining on the Kobuk River. He found the following approximate cost differentials between the Western States and the Kobuk area for large installations.

Construction labor	300%
Construction materials, equipment	6%
Total capital costs	70%
Operating labor	25%
Operating supplies, except fuel	10%
Fuel	>10%
Freight on blister copper	<10%
Townsite operation	Break Even
Total operating costs	30%
Overall differential	50%

All of the above figures, taken from different sources, indicate that the rule of thumb for cost of living already given will probably apply approximately to mining costs as well. The figure of 50% for the Kobuk compares with 54% for Nome over Seattle. The Canadian figures, based on wages, cannot be compared directly, but indicate that costs generally will be considerably lower in Canada than in Alaska for comparable operations and degree of inaccessibility. Some idea of this can be gained from the figures for the newly opened copper mines near Whitehorse, Y. T. A feasibility report in 1965 recommended that open pit mining begin at a rate of 2,000 tons per day with reserves of five and a half million tons of ore grading 1.20% copper (Hilker, 1967).

At present there is little that can be done to reduce the actual costs as discussed above, since they appear to be based on geography. We may therefore inquire as to what more can be done in the way of government help, in terms of tax incentives, services, transportation facilities, and easing of regulations that unduly burden the industry without creating compensating benefits for other segments of the population.

TAX INCENTIVES

The right of government to levy taxes can be its most powerful regulatory function. A wise tax program, like all other activities of government, should aim for the greatest good for the greatest number; to derive a just portion of the income from mining for the country as a whole, while at the same time encouraging the discovery and development of new deposits. It should devise a legislative formula which will bring about the optimum recovery of mineral resources in the State, under conditions which will yield maximum benefits to its people while affording a fair deal to those who risk their capital to achieve this development. The remainder of this section describes some of the tax policies practiced to attain this end.

The following tax provisions have been applied to mining in Canada in order to stimulate the industry:

1. A three-year tax exemption period on new mines coming into production, which allows a mining operator his return of capital very rapidly.

2. A depletion allowance and write-off of pre-production exploration and development expenditures. Depletion is allowed at the rate of 33 1/3 percent of profits. In the case of gold, the depletion rate is $4 per ounce or 40 percent of profits, whichever is greater.

3. No tax on capital gains, which encourages speculation in mineral exploration.

4. Depreciation of mining machinery, equipment, and mine buildings at the rate of 30 percent.

5. Mine shafts, main haulage ways and similar underground construction costs can be depreciated at the rate of 30 percent.

6. Mine roads may be depreciated at 4 percent.

7. Costs for exploration, drilling and development are allowed as expenses.

8. Exemption of mining equipment from sales tax.

9. Government support in the development of a transport network, infrastructure and mining community.

10. A subsidy to gold miners where the cost of production exceeds $26.50 per ounce. The subsidy is limited to a maximum of $12.33 which is reached when the average cost of production rises to $45 per ounce of gold produced.

Australia, a new-comer in mineral resources development, also has a positive mineral policy similar to that of Canada. State and Federal governments in Australia play an active role in mineral resources development. Aerial photographs and maps are available, and are continuously increasing in number. Subsidies, testing and research facilities, and custom mills are other supports offered by the government.

Of particular interest is the "zonal allowance", dependent upon distance from urban centers, given Australian miners on their personal income tax (Mining in Canada, April, 1968, p. 48-49). This inducement could be adopted to advantage in Alaska.

In Minnesota, prior to 1964, the iron mining industry, although exempt from the State's corporate income tax, was declining due to occupation and royalty taxes which taxed them at a rate about three times that of the corporate income tax. In 1964, the Taconite Amendment was passed guaranteeing a 25 year moratorium on any tax increase on taconite production above the general corporate level. This legislation was in a sense a tribute to the industry's initiative in developing the technical ability to work the taconite; State and industry together have revitalized the iron industry in Minnesota.

In Alaska, the mineral industry is subject to Federal, State, and local - Borough and city taxation (unimproved patented claims are assessed at $200 each at Fairbanks), as is any other industry or individual. The mine operator pays Federal income taxes and local ad valorem property taxes as well as sales tax. In addition, the State government levies a corporate income tax at the rate of 18 percent of the calculated Federal income tax, and a personal income tax at the rate of 14 percent of the Federal tax. All mining ventures must also have a State mining license. The license fee, based upon net income, is levied on mining firms according to a graduated scale. The maximum is 7 percent on net income above $100,000, but mining operations are not required to pay any license tax during the first three and one-half years of production. Both income and license taxes are subject to a depletion allowance at the rate of 10 percent for coal mines, 15 percent for metal mines, 23 percent for sulfur and uranium mines, and 27 1/2 percent for oil and gas. However, depletion claimed may not exceed 50 percent of net profit, computed without allowance for depletion. Apparently many people do not understand the purpose of the depletion allowance. It corresponds to depreciation, and represents the expense that must be borne to find new deposits with which to replace the old, and thus keep the company in business and the nation in minerals.

Alaska's Industrial Incentives Tax Credits Act allows for exemption from all State taxes for periods of up to ten years for new industries depending upon the amount of capital investment. The tax credit cannot, however, exceed 75 percent of the value of the business investment. Mining is excluded, but milling and other ore processing industries are included.

Perhaps the tax practice which has the most immediate effect on exploration in the United States is the one that allows exploration costs to be deducted as an expense. There are now two alternatives; expenses up to $100 thousand per year, or $400 thousand total may be deducted, or all exploration expenses may be deducted. Under the latter alternative, however, the amount deducted must be included as income or subtracted from the depletion allowance if the prospect becomes a mine and gets into production.

GOVERNMENT FINANCIAL AID

Government at all levels provides many sorts of financial aid, either as direct grants as loans, or as services.

Canada

The Federal Government of Canada has launched a major exploration program in the

Arctic regions called the Northern Mineral Development Program. The initial financing is $20 million, which is to cover anticipated requirements for the first three years of search. A number of companies have contributed different amounts. It is truly a joint government-industry program (E & MJ, Jan., 1968).

The undertaking represents the first major effort to determine the mineral and oil possibilities in a huge area previously considered too remote to be of interest, but now believed to be well within the reaches of modern technical skills and procedures, presenting difficulties probably no greater than those overcome in the Yukon. The search will cover a total of 44,137,000 acres across a number of Arctic Islands.

Various incentive programs for nothern mineral exploration have been introduced by the Department of Indian Affairs and Northern Development. In one, prospectors may receive up to $900 a year from a $30,000 yearly fund in each of the two Northern Territories (Yukon and Northwest). The grants are disbursed on a first-come, first-served basis; in 1967, 74 prospectors received grants. The program is designed to assist individual prospecting endeavors but two or more prospectors may pool their resources to reduce charter flying costs and other common expenses and each be eligible for the maximum grant. Two-thirds of the $900 per year may be given in advance, to enable the prospector to outfit himself; the balance is payable on completion of his pre-approved prospecting activities.

Another exploration assistance program, the Northern Mineral Exploration Program, has played an important role in stimulating mineral exploration in the Yukon and Northwest Territories. Its main features can be summarized as follows:

1. Up to 40% of the exploration costs of approved programs will be paid by the government with repayment set at not less than 10% of the principal amount of the grant per annum in the event of successful production for gain. Repayments would commence one year after production started with interest from that date. Repayment will be waived, should exploration prove unfruitful.
2. Where repayment is required, annual interest will be calculated at a percentage rate of two plus the interest rate now paid by the Federal government on its long term borrowing.
3. The program is available to Canadian citizens over the age of 21 who are the beneficial owners of mineral claims, leases, or exploration permits in the Yukon and Northwest Territories.
4. It is available to private Canadian companies, 50% of whose shares are beneficially owned by Canadians.

In 1967-1968 over $1.25 million in Northern Mineral Exploration assistance grants were allotted in Canada to 15 qualifying companies. In 1967-1968 Canada allotted $1.25 million in Northern Mineral Exploration assistance grants to 15 qualifying companies.

The Northern Roads program provides 100 percent of the cost of development roads; and two-thirds for mine access roads; latest examples are the access road to the Anvil Mine site and the development road from Ross River to Carmacks, Yukon. A ten-year program of road construction, calling for the expenditure of $100 million in Yukon Territory and the MacKenzie District, has also been approved. Eventually, a broad network of truck roads will open up the country so that no area of resource potential will be more than 200 miles from a network road. The program also includes provision for construction of tote trails, initial access roads and permanent access roads on a cost sharing basis with private developers.

In some cases the Canadian government will finance economic and feasibility studies of proposed northern primary production operations. Assistance and services, such as financial support for the Chambers of Mines, subsidized assay services, and the provision of strategically located Mining Recorders' offices, are also provided to the mineral community interests at large.

In addition to these Federal financial aids, the Provinces and Territories also grant grubstakes to bona fide prospectors.

Alaska

In Alaska both Federal and State financial aid is available for exploration. At the Federal level the Office of Mineral Exploration provides loans on a joint participation basis. These loans are for approved projects and may be for from 50% to 75% of the cost, depending upon the metal. The program is administered in the field by the U. S. Geological Survey and the U. S. Bureau of Mines. The loans are paid back at a fixed percentage of the production of the mine. If the mine fails to produce enough, the unpaid portion of the loan is cancelled. It would undoubtedly encourage prospecting, if this program was broadened to include regional exploration programs in which the element of speculation is high. Herbert's paper at the end of this report also contains some suggestions regarding the O.M.E. program.

In the spring of 1963, the Alaska State legislature enacted the Prospector Assistance Program. This program provides for financial assistance to qualified prospectors with reimbursement for up to 75 percent of the expenses incurred for certain items, including transportation, on approved prospecting ventures. Maximum yearly payment to a single prospector is $2,000 and to a party of two or more it is $4,000. Reimbursement is made only after the prospecting is finished and maps and reports are submitted to the Alaska Division of Mines and Minerals. The statistics from 1963-1967 are shown as follows:

Year	Number of Inquirers	Number approved Applicants	Reimbursed by State	Number to receive Reimbursements
1963	25	19	$ 7,299	9
1964	N.A.*	19	9,495	9
1965	165	22	12,908	11
1966	29	21	16,566	13
1967	39	20	21,562	12 (plus 6 pending)

Source: Alaska Division of Mines and Minerals
N.A.* - not available

This is a very effective program in that qualified prospectors are able to go to the field each summer and do excellent work at a minimum cost to the State. The program is probably underfunded because all of the funds are allotted early in the season, making it necessary to reject applicants, but it is a start in the right direction. A modification of the program which would allow partial wages for the prospector would result in an increase in the number of prospectors.

In 1968 the State legislature appropriated money for mine access roads. Under this program a miner may be compensated for part of his expenses incurred in building access roads. This is a very beneficial aid, and should result in new roads of a type urgently needed.

LAWS, RULES, PRACTICES AND CUSTOMS AFFECTING THE INDUSTRY

In addition to taxes, there are other practices and regulations, some of which are not aimed directly at the mineral industry, but which nevertheless affect it more than they do others.

Jones Act and Export Regulations

Among these regulations there are two which severely affect the industry. These are the Jones Act,which prohibits foreign ships from engaging in coastwise trade, and the one prohibiting the exportation of certain metallic ores. This latter rule is especially crippling to exploration in Alaska, because it removes a practically inexhaustible market and a good source of capital. It also nullifies one of the few advantages Alaska has in its competitive position: nearness to Japan.

Cost of exploration, development, and production in Alaska far exceeds that of Canada. Since the price of metals is controlled by the law of supply and demand, Alaskan mining is in competition with mineral producers in all other parts of the world, including Canada. A liberalization of the United States export laws could, however, help place Alaska in a more competitive position because it is geographically closer to the Pacific market than other western producers.

Financial Regulations

The Security and Exchange Commission has effectively put speculative participation by the public in prospecting ventures almost beyond the realm of possibility. Canada does not have such strict Securities Exchange regulations as those set by our Federal government. Public support of exploration ventures in Canada far exceeds that which may be obtained in Alaska. In Canada the general public has the chance to , and does, speculate in exploration and mining ventures. Mining is a highly speculative endeavor,and risk capital, such as that gained by public participation through mining stocks , is necessary, especially in the early stages of exploration.

It is absolutely impossible to finance exploration programs, even in well mineralized areas, through banks; it is almost impossible to finance mining operations through them.

Price of Gold

Gold mining has been the mainstay of the Alaskan mineral industry. With the setting of the price of gold at $35 per ounce, gold mining showed a spectacular increase, then began a steady decline as inflation began to increase the monetary cost of operation. Whether or not one agrees with the necessity for a fixed price for gold, the fact is that Alaskan mining has been hit hard. It is as if copper were selling at 9 1/2 cents per pound today instead of 40 cents; lead at 3.8 cents instead of 14 cents; or zinc at 4.1 cents instead of 14 cents.

Land Withdrawals

In the introduction to this section, the unique character of mineral deposits was discussed, i.e. that mineral deposits must be found and exploited where they occur, not where they can be raised or manufactured. The policy of setting aside large areas for one-use purposes, therefore, works against mining more so than other industries. In Table 3, the areas covered by patented claims in Northern Alaska are presented; in Table 4, the number of active claims is shown. Figures 7, 8, and 10 show the distribution of mining claims in the same area. These tables and figures show that mines of the type found in Alaska take up little room. Operating mines are a boon to the tourist industry, and the practice of prohibiting, by law or regulation, the search for minerals in certain areas is against the National and State interest. Figure 30 shows withdrawn areas in Alaska.

A somewhat related problem, for which there probably is no solution, is the rise in suburban living. Around the cities and towns of Alaska, as in other areas, land that has passed into private ownership has been subdivided and converted to homesites. The effect has been to withdraw potentially mineral bearing land, and more important, to put home owners in a position of having to oppose possible mineral development to protect their investments. This has been generally the result of the steady advance of population and improved transportation, but the relative ease of acquiring and patenting large areas under liberal homestead laws has contributed to the situation.

Water Pollution Regulations

The Alaska legislature specifically exempted the products of placer mining from its water pollution regulations. The Federal government says that the State law must be brought into accord with Federal policy, which considers that these products are pollutants. Again, the fact that fishing streams may be restocked, but that mines cannot be created, must force mining into a superior position. The tables and figures quoted above indicate that placer mines occupy an extremely small proportion of any drainage basin, and probably would not have any appreciable effect upon the fish population.

Comments on some of the items listed above, and on others, will be found in a report prepared by Charles F. Herbert, appearing near the end of this report.

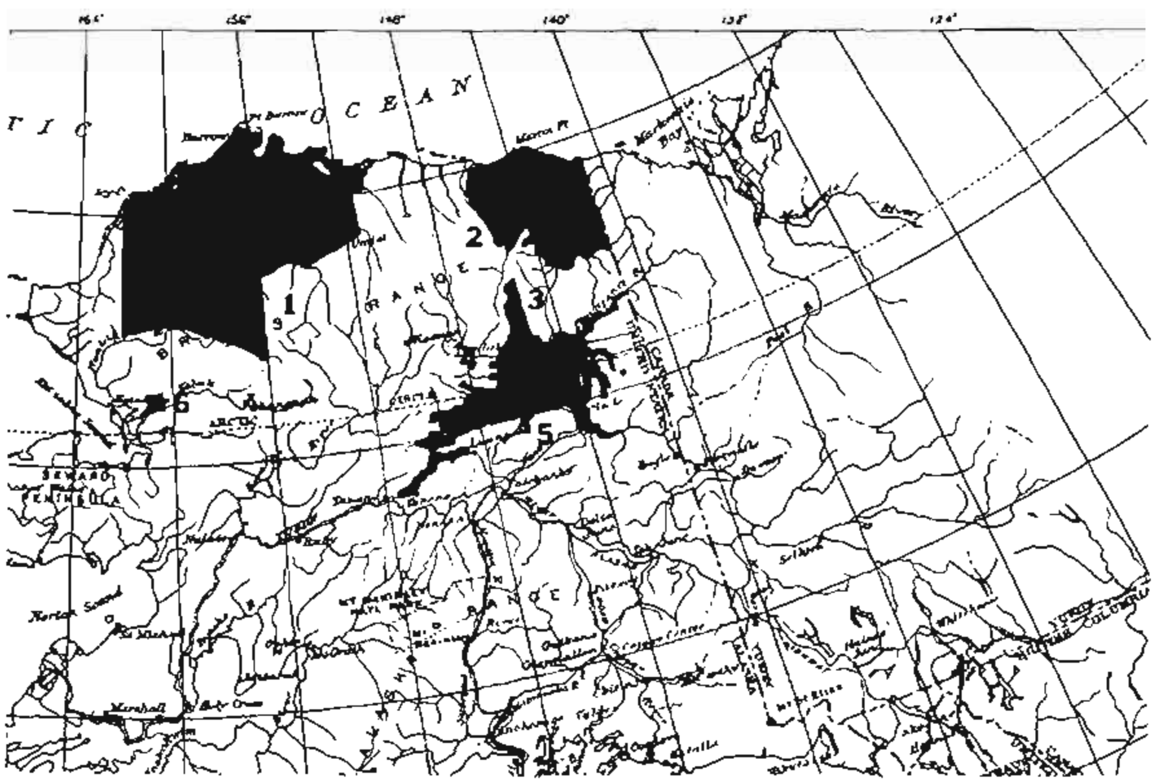


Figure 30 – Index to Federal Land Withdrawals

Name	Average	Open to Mining Locations	Open to Mineral Leasing
1. Naval Petroleum Reserve No. 4	23,000,000	Yes*	No
2. Arctic National Wildlife Range	8,900,000	No	Yes**
3. Venetie Indian Reserve	1,408,000	No	No
4. Power Site Class 455 (Rampart)	8,958,720	Yes	Yes
5. Yukon Command Training Site	256,000	No	No
6. Kobuk Native Reserve	144,000	No	No

*– With B.L.M. and Navy concurrence
**– See 43 C.F.R. 3120.3-3

TECHNICAL AID AND SERVICES

The types of technical aid and services available to the mining industry in Canada and Alaska are similar; any differences lie in the amounts. The same techniques of mapping (helicopter, air photo, magnetic, etc.) are available to both, but more is being done in Canada. British Columbia and the Yukon Territory receive more assistance at the Federal and Territorial level than Alaska does. Geologic mapping and airborne magnetic surveys cover a greater percentage of western Canada than Alaska.

The Geological Survey of Canada in 1963 had 100 men working in British Columbia preparing maps and reports of potential mineral bearing areas (Elliott, 1964). The Canadian Survey, in addition to its topographic and geologic mapping, publishes aerial magnetic survey maps, which are issued simultaneously at many offices. These are detailed maps, with flight lines at one-fourth to one-half mile intervals. It is a commentary on the relative amounts of interest in Canada and Alaska, that prospectors are waiting at the doors for these maps, and race for anomalous areas that appear on them.

In addition to issuing geologic maps and reports, the Canadian Survey also writes and publishes books on prospecting and mining, which it sells at low cost.

Both the British Columbia and Yukon governments also provide technical services, administered through the appropriate departments (Dept. of Mines and Petroleum Resources in B.C.). These services include the preparation of detailed geological maps and reports of special areas, issuance of an Annual report, assisting in financing access roads and trails, and providing grubstakes and free assay service. They also cooperate with the Canadian Federal Government on aerial magnetic surveys, and prepare and sell maps of mineral claims (Elliott, 1964).

These latter maps are of great value for exploration companies interested in prospecting in a particular area. Alaska is far behind in this service although it is understood that the Division of Mines and Minerals is making a start. Assistance is available now, however, through the cross-referenced Kardex file of mineral occurrences and claims maintained by the State Division of Mines and Minerals at the College office. Also available at that office are unpublished property examinations (Miscellaneous Reports and Professional Reports) and a comprehensive library. The Miscellaneous Reports and Professional Reports are partially a carry-over from the Territorial days when the Territorial Dept. of Mines had "roving" mining engineers visiting properties and writing reports concerning them; a service which is of value today when information is desired of a target area for mineral exploration. An inspection of Table 5 will indicate that published information on prospects is very scarce after the 1930's, when the U.S. Geological Survey discontinued writing up the prospects. This practice should be resumed, insofar as it can be done without violating confidential information.

In Alaska, the U.S. Geological Survey, the U. S. Bureau of Mines, and the State Division of Mines and Minerals provide many technical services including topographic and geologic mapping, property examination, mineral identification and fire assays, and other services.

Alaska is now covered by topographic maps at a scale of 1: 250,000, and the U.S. Geological Survey is mapping at 1: 62,500. Still, only a very limited portion of the State has been mapped geologically to show details important to economic geology at a scale of 1: 62,500 (1" = 1 mile approx.) and less than 20% of the State has been mapped at 1: 250,000 (1" = 4 miles approx.). Large portions of the State are not covered by even a reconnaissance geologic map, and there is no systematic program of aeromagnetic surveying in the State. (The Canadians on the other hand have a well, planned and continuous aeromagnetic program.

The problem of the lack of maps and data for exploration was attacked by the President's Materials Policy Commission in 1952:

> "The Commission recommends that the U.S. Geological Survey accelerate the geologic mapping of the United States and Alaska by 50% within five years and 100% as soon thereafter as possible, with priorities given to localities of most probably mineralization; that the Geological Survey and the Bureau of Mines, in cooperation with State mining agencies and the mining industry, develop a program for a coordinated national system of libraries of core samples and other geologic evidence; that an intensive program of basic scientific research and technical development be undertaken, led by a special committee under the National Science Foundation, on methods and instruments of exploration for minerals, enlisting experts in Government, private industries, and universities; and that direct exploration by Government–limited to situations in which private industry cannot be expected to undertake it–be part of the continuing activities of the Geological Survey and the Bureau of Mines." (Paley, 1952, p. 27).

The problem is still in existence in Alaska.

In 1962, the National Academy of Sciences - National Research Council, also made a statement on the areal geology of the United States:

> "To develop additional mineral resources it is necessary to obtain a more thorough knowledge about their distribution and the geological environments in which they occur. As only 65 per cent of the area of the United States has been topographically mapped, and only 20 per cent mapped geologically, it is obvious that our knowledge of the geology of the United States is not sufficient to reveal its true mineral-resource potential. To develop the knowledge we need, we should increase our effort to understand the setting within which our present and future mineral resources must be found. Facts and interpretations must be adequately presented in maps which synthesize field and laboratory data on geology, geochemistry, and geophysics. It is recommended that the Federal efforts that result in the publication of geologic maps in the standard quadrangle series by expanded at the rate of 10 per cent per annum during the next decade." (NAS-NRC, 1962, p. 30).

In Alaska, if we desire to speed up mineral exploration activities, the publication of geologic maps must be expanded far more rapidly than at the rate of 10 percent per annum as NAS-NRC has recommended for the United States in general.

The U.S. Geological Survey has, of course, other functions besides mapping. A great deal of research into geochemical methods and instrumentation has been done at the National level, and in Alaska these methods have been applied extensively. A few studies of the geochemistry of mining districts have been made, and geochemical sampling has been done in the course of regional quadrangle mapping (Brosgè and Reiser, 1964). The Survey is also conducting experimental ground geophysical studies in Alaska. Under the Heavy Metals Program, intensive geological and geochemical studies, with the aid of portable laboratories, are being conducted on selected mining districts. One of these, at Fairbanks is being done under contract with Dept. of Geology, Univ. of Alaska. It may be hoped that such studies might eventually result in the discovery of another deposit of sub-microscopic mineral such as at Carlin, Nevada.

A few years ago the U. S. Geological Survey adopted the policy of publishing immediately short resumés of geological research for the past year. These are published as Professional Papers, and allow the public to keep up with current work of the Survey.

The U. S. Bureau of Mines conducts research on problems of mining at the national and regional levels and reports on investigations of new methods and developments. A recent example is the study of offshore mining techniques, which may be of significance in Alaska. The Bureau is also experimenting with rotary drills for placer prospecting, and on improved methods of thawing permafrost.

A well established function of the Bureau is the examination, possibly with trenching and drilling, of mineral deposits or suspected mineral deposits, where discovery and development would serve the national interest. Much effort has been expended on tin deposits in this way, but other base metals, and precious metals, have received attention. Some of this work at present is being done under the Heavy Metals Program.

The State Division of Mines and Minerals provides geologic mapping, geochemical investigations, property examinations, free assaying, public information and assistance, and administrative functions for the mineral industry. The Branches of the Division are: administrative, mining, metallurgy, petroleum, and geology.

Other technical assistance offered to prospectors by the Division include the use of a complete library of Alaskan Reports, a comprehensive mineral prospect file and property examinations by geologists or mining engineers. The "roving" engineer principle of the early days of the Territorial Department of Mines is not in existence today. Given the proper funding, this principle results in recording information concerning prospects and claims that may never be preserved otherwise for later use by exploration companies. The unpublished files of the Division of Mines and Minerals are a good example of the type of information that can, and should, be recorded.

A relatively new function of the State Division of Mines and Minerals is its Ore Province Evaluation Program. The work has fallen between the regionally-oriented geologic mapping of the U. S. Geological Survey and the trenching and drilling of the U. S. Bureau of Mines. The aim of the Division is to carry through on investigations of each mineral province to the point where the preliminary reports on portions of the province can be integrated into a comprehensive report on the relationship of the known mineral deposits to the regional geology. A series of reports and maps have been published under this program (Geochemical Report Series) which are beneficial to regional mineral exploration.

RESEARCH AND DEVELOPMENT

All of the agencies already mentioned are doing research and development to varying degrees. In addition, there are others, chiefly the University of Alaska, but so many agencies and organizations are engaged in research activities that might affect the mineral industry, it would be impossible to name them all. The following are a few of the most important: The U. S. Congress, chiefly through its Senate Committees,has had many reports prepared by government agencies and private consultants. The Federal Field Committee for Development Planning in Alaska has issued several reports on the economic and industrial problems in Alaska. Various State agencies, such as the Department of Economic Development and the Alaska State Housing Authority, have also sponsored studies and research that contain some bearing on the mineral industry. The most directly concerned organizations, however, are at the University of Alaska. In the course of educating geologists and mining engineers, a great deal of research results, published in journals or written up in theses. The presence of the University library and the concentration of specialists are in themselves stimuli to research.

The Mineral Industry Research Laboratory of the University of Alaska was set up to conduct basic and applied research beneficial to the Mineral economy of the State. It is funded directly by annual State appropriation and indirectly by contracts. The Institute for Social, Economic and Government Research has issued economic reports, some of which contain mineral studies.

With the advent of computers, methods and scope of storage of geologic information have been revolutionized. The interpretation of exploration data and the design of exploration and mining programs have also been given much more flexibility than previously. For Alaska, new operation research, statistical analysis and computer techniques could help delineate mineral-favorable areas, but geological data and maps are required for these studies. Therefore, widespread use of these methods can advance no faster than the field mapping.

The establishment of a computer processible mineral prospects file would greatly enhance the value of the already important Kardex system maintained by the Division of Mines and Minerals. The Research Council of Canada has recently allotted $50,000 for research leading to the development of a computer processible file for Ontario and Canada as a whole. Once such a file is set up, mineral information can be rapidly updated and distributed, and mineral statistics can be obtained at will for any element for any portion of the State.

A nationwide computer network has been started by the U. S. Geological Survey. Programs are being developed to assist in the search for clues to gold, silver, mercury, and other heavy metal deposits. The computer network, centered in Washington D. C., is linked to smaller computers in U. S. Geological Survey facilities in Menlo Park, California; Denver, Colorado; Rolla, Missouri; and Flagstaff, Arizona. Alaska would benefit greatly by the establishment of a computer network for the development of mineral resources in the

Arctic and sub-Arctic lands. State government might consult with Federal agencies to have such a computer network extended to all of Alaska.

Statistical simulation and modeling can be rapidly applied to the search for ore once the computer programs are set up. (Such programs now exist at the Mineral Industry Research Laboratory). These statistical studies can provide new clues and guides to ore deposits (Heiner and Geller, 1967; Heiner and Wolff, 1967).

Statistical techniques and operations research can also contribute to the refinement of a mineral program. Cost benefit analyses may show the extent of responsibility of Government or of private industry. If the ratio of prospecting and/or exploration cost to profit is found to be less than one, yet in the interest of the State or National economy, it may be wholly or partially carried out by Government agencies or endowed research foundations. If the ratio is greater than one, the operation is one in which private capital can and should be employed (Ridge, 1962, p. 6).

Only extensive research and development can develop the new technologies that will enable the discovery and exploitation of the very large very low grade deposits upon which we must depend in the future. A large-scale effective mechanism for Government-Industry-University joint research is urged.

MINING LAWS

An excellent report covering a comparison between Alaskan and Northwest Canadian Mining Laws has been prepared by Herbert (1967). The reader is referred to this publication for a detailed comparison between Alaskan and Canadian laws, and recommendations for policy regarding United States Federal and State laws.

Space is not allotted here to mention the many similarities in the laws between Alaska and Canada; only the differences are noted.

There is considerable difference (Table 20) in the sizes of the various types of claims which can be located. On Federal land in Alaska, a lode claim must not exceed 600 feet by 1500 feet (20.66 acres). It must be marked by four posts, plus a monument at the point of discovery. On State land a mining claim (lode or placer) must not exceed 1320 feet by 1320 feet (40 acres) and be marked by four posts; side lines should be run in cardinal directions. In British Columbia and the Yukon Territory only two posts, marking the location line, are required to locate a claim 1500 feet by 1500 feet (51.65 acres). Both State and Federal laws in Alaska require a discovery before a mining claim is deemed valid. In British Columbia and Yukon Territory, a claim may be staked although no discovery of mineral is made. Since minerals are generally concealed beneath overburden and can only be discovered after expensive trenching, drilling, shaft sinking, or geophysical or geochemical work, land tenure is unstable during the prospecting period. The State of Alaska has provided for prediscovery rights to 160-acre prospecting sites on State land. The owner of a prospecting site has exclusive right to prospect and stake claims within the area covered by

Table 20 Comparison of Types of Claims
Alaska, B.C., Yukon. (Herbert, 1967)

TYPE OF CLAIM	ALASKA FEDERAL	ALASKA STATE	BRITISH COLUMBIA	YUKON TERRITORY
Lode				
Shape	1500' x 600'	1320' x 1320'	1500' x 1500'	1500' x 1500'
Area	20.66 acres	40 acres	51.65 acres	51.65 acres
No. of posts	4[a]	4	2	2
Placer				
Shape	1320' x 660'[b]	Not differentiated from lode claim	250' x 3000'	500' x 2000'[c]
Area	20 acres		5.7 acres	23 acres
No. of posts	4		4	2
Placer Lease	NA	NA		
Shape			2640' x 1320'	variable
Area			80 acres	entire streambed
No. of posts			2 to 3	2 or more
Prospecting Site	NA		NA	NA
Shape		2640' x 2640'		
Area		160 acres		
No. of posts		1[d]		
Tunnel Site		NA	NA[e]	NA
Shape	3000' x 3000'			
Area	206 acres			
No. of posts	5			

[a] A discovery post must also be erected at the point of discovery.

[b] An association of persons may stake 40 acres in a precious metal placer claim or up to 160 acres in a placer claim for other minerals. Twenty acres is allowed to each person in the association.

[c] Dimensions shown are for a "creek claim." A "bench claim" is 1000 feet wide.

[d] Double markings must be used at the three corners not marked by a post.

[e] When a tunnel is driven to develop or drain a mine, the owner may stake any vein discovered by him within 15 days following the discovery, unless it occurs on land that had been staked prior to discovery.

TABLE 21

COMPARISON OF REQUIREMENTS FOR ANNUAL ASSESSMENT WORK ON MINING CLAIMS

Type of Claim	Annual Expenditure Required	Payment in Lieu of Work	Annual Cost Per Acre on Maximum Size Claim	Carryover Credit for Excess Work	No. of Claims That May be Grouped(a)
U. S. Land					
Lode	$100	No	$4.85	No	No limit
Precious Metal Placer	$100/ 20 acres	No	5.00	No	No limit
Other Placer	$100	No	0.63	No	No limit
State Land					
Claim	$100	No	2.50	No	No limit
Leasehold	$100	Yes	2.50	No	No limit
Prospecting Site, first year	$5/acre	No	5.00	No	No limit
Prosp. Site subs. years	$10/acre	No	10.00	No	No limit
Offshore Pros. Permits first 2 years	$0.50/acre	Yes	0.50	1 yr.	No limit
Subs. years	$1/acre	Yes	1.00	No	No limit
Offshore Lease	$1/acre	Yes	1.00	No	No limit
British Columbia					
Claim	$100	Yes	1.94	Yes	40 (incl. leases)
Mineral Lease first 10 yrs.	$4/acre (b)	Yes	4.00	Yes	40 (incl. leases)
Subs. years	$6/acre (c)	Yes	6.00	Yes	40
Yukon Territory					
Claim	$100	Yes	1.94	4 yrs.	16
Mineral Lease first 21 yrs.	none (d)				
second 21 yrs.	none (e)				
Placer	$200	No	8.70	4 yrs.	10

(a) Claims that are contiguous (i.e. have at least one common boundary) may be grouped so that all of the required work may be done on one of the claims in the group.

(b) Plus a rental payment of 50 cents an acre.

(c) Plus a rental payment of $1 an acre.

(d) $50 is paid for a 21-year lease. Lease will not be issued unless $500 worth of work has been done (or $500 paid in lieu of work), the claim is surveyed, and a discovery has been made.

(e) $200 must be paid for a 21-year renewal.

the site during its term. This is probably the best way to handle land tenure problems.

On Federal land in Alaska a mining claim has "extra-lateral" rights if its end lines are parallel. This means that the owner of a mining claim may follow a deposit down its dip outside of his claim side lines so long as he remains within the vertical projection of the planes that include his end lines. Numerous lawsuits have resulted from this provision. The State of Alaska does not recognize extra-lateral rights. Since a discovery is required on each State mining claim, it is possible to lose control of a vein which dips outside the original claim boundaries unless a discovery can be made on an adjoining claim. This danger is somewhat alleviated by the greater width allowed on State lands (1320 feet) as compared to 600 feet allowed on Federal claims.

Requirements for assessment work for holding mining claims in Alaska and Yukon-British Columbia are summarized in Table 21 (Herbert, 1967). In all four legal subdivisions work to the value of $100 must be done on each mining claim per year. On Alaska State lands a claim may be converted to a "lease" and payments may be made to the State in lieu of assessment work. This procedure is followed in Yukon and British Columbia also.

Suggested Mineral Resource Development Policies for Alaska

"--- Generally speaking, the discovery and exploitation of exportable mineral resources usually precedes other industrial developments" (U. S. Dept. of Interior, 1967). If we accept this, even "generally speaking", it appears that putting first things first, the formulation and implementation of policies that encourage exploration should have a high priority among government actions in Alaska.

There are several difficulties encountered in trying to do this. One is uncertainty over the future. There are uncertainties of geology, costs, price behavior, and politics. Yet it is basically because of this uncertainty that policies must be adopted. Another difficulty is that perhaps no two people agree on which policies will have the desired results. A compromise must be reached between all the needs of society; not just the need for minerals.

Many suggestions have already been made in this section and others are put forth in the following paragraphs. Others are found in the consultants' statements at the end of this report. Because of the considerations just stated they are put forward as suggestions only, for the guidance of future policy-makers. Certainly, something as important to Alaska and to the Nation as the adoption of a "mineral policy" should be the work of many people. Some of the suggestions deal with subjects of great importance, which would require congressional action to implement, others are relatively minor, and represent ideas that have occurred to one or another of the authors. The suggestions have been taken from a wide range of sources and not all of them are necessarily accepted by all of the authors.

If the State of Alaska is to develop a sound mineral industry it will have to help itself, as well as push for Federal help. Currently Canadian mining companies are spending on exploration an average of 4.6% of the value of minerals produced. In 1967 Alaska derived

$35 million from taxes, royalties, and lease rentals directly from mineral resources. It would seem reasonable, in a concentrated effort to catch up, that the State might invest at a rate of ten percent of its income from the mineral industry. A suggested distribution for this investment would be nine percent for the Division of Mines and Minerals of which five percent would be earmarked for airborne geophysical surveys administered by the Division, and contracted to private industry. One percent would be for mineral industry research by the College of Earth Sciences and Mineral Industry and the Mineral Industry Research Laboratory of the University of Alaska.

It is the opinion of people who have had experience in mineral exploration in underdeveloped countries that once potential targets such as magnetic or geochemical anomalies, are found, private industry will be more than willing to expend the necessary time and money to prove or disprove them. A well funded and continuing program of airborne magnetic surveys funded through the U. S. Geological Survey but contracted to private industry is needed. This would be in addition to State efforts, or perhaps could be jointly funded. In addition, more geological mapping at a scale of at least 1: 250,000 is necessary for planning and executing exploration programs. Again, a joint mapping program such as that done in Kentucky, might get the job done faster. In the "Kentucky project", the State of Kentucky and the U. S. Geological Survey pooled resources to map the State.

Besides a serious lack of basic data and factual information concerning geology and mineral resources in Alaska, there are regional problems existing in the development of mineral resources, particularly in underdeveloped Northern Alaska. Government assistance in transport networks and other infra-structure will substantially reduce the cost of exploration and mining. The access road program recently (1968) made into law by the State legislature should be retained and expanded. Under this program, the State reimburses a miner or prospector for a part of his expenses in road building. Of particular importance is the need for relaxing of Federal highway standards in Alaska, to allow the Federal Government to participate in the building of secondary gravelled roads with a minimum of engineering overhead, and a maximum of mileage.

The U. S. Department of the Interior realized the need for action to spur exploration and research in Alaska when it presented its report to the Secretary, Department of the Army, entitled "Alaska Natural Resources and the Rampart Project", June, 1967, recommending a $50 million five year program of Federal Mineral Survey and Research. This report states:

> "This Federal effort would be shaped to inspire concurrent private, local and State actions, and would be limited to programs either beyond the capability of, or not now economically justified for undertaking by private mineral interests and State Agencies. The program would include establishment of a permanent Institute of Arctic Mineral Resources at the University of Alaska to accomplish research on the exploration for and exploitation of mineral resources in Arctic lands. The program would also include development, in cooperation with mineral industry and State representatives, of proposals for modifications of eminent

State and Federal programs, regulations, and laws to provide to the mineral industry the maximum incentives for capital investments in Alaska compatible with the special circumstances which prevail in Alaska and with State and National interests."

With the above proposal, this report is in full accord. It is broad enough so that several of the suggestions contained herein might well be incorporated.

Continued State support of education and research is essential. Research designed to help specifically one state must of necessity be performed in that state. Many states have a mining industry large enough to support local research; Alaska does not yet. Past experience has demonstrated that mining and geology students who are trained in Alaska have a greater chance of remaining in the State, thereby contributing more to our mineral economy than those who were not.

A one-year training program, initiated by the Bureau of Indian Affairs and supported by the University of Alaska, has demonstrated that Government can not only create employment opportunities for Alaskan Native Indians and Eskimos, but also help to fill the mineral industry's demand for Mineral Technicians. Since 1965, forty students have graduated from this program. Among the graduates twenty-four have permanent jobs as mineral technicians in the metal-mining and oil and gas industries.

The many programs now offered by the Division of Mines and Minerals should be continued. They have contributed significantly to the knowledge of geology, geochemistry, and ore deposits of Alaska, and are responsible for considerable exploration activity in several areas of Alaska, including the Slana area and the Pass Creek area. There is a very good possibility that at least one mine will be developed because of this.

A provision to allow a prospector a minimum salary of for instance $500 per month in the Prospectors' Aid Program would attract more local people to the field, possibly students in geology and mining. A double function would thus be performed, getting more prospectors into the field and the training of geology and mining students with a first hand knowledge of Alaskan conditions. It is realized that this type of program may be difficult to control, and a corollary suggestion would be that prospectors working under the program be paired with experienced men or visited periodically by Division personnel.

Some sort of cash reward, such as was offered for the discovery of a new uranium mine that produced a certain amount might be offered for new discoveries. Although this would not be much of an incentive for large companies, it could be of great importance to individual prospectors.

Results of research and other investigations should be published immediately. There is little to add here except that the fine record set by all three State and Federal agencies in the last few years should be continued.

It has been noted that many people express surprise on learning of the various services performed by State and Federal Agencies. Although there are already excellent media for the dissemination of such information, eg. news releases, and Division of Mines and Minerals bulletins, no opportunity to inform the taxpayer of what he is getting for his money should be lost. This task is made easier by the fact that both Alaskan newspapers and magazines have people on their staffs who are minerals conscious and need only factual information to do a good job of reporting.

It is suggested that the Federal Field committee for Development planning in Alaska increase its already impressive interest in the mineral industry of Alaska, and emphasize mineral industry studies in cooperation with Federal and State agencies, Industry and University personnel. The mineral industry must have a large part in any future developments in Alaska.

It is a frequently stated precept of research that the mere gathering of facts is meaningless. Nevertheless, mining and exploration companies new to Alaska are acutely aware of the need for facts; facts about maximum grades on roads, facts on costs, facts, no matter how scanty, on prospects. It is recommended that State and Federal geologists and engineers visit mining districts and prospects periodically, and publish resumés of such things as the geology, conditions of transportation, any costs available, and reserves and tenors of ore (when authorized by the owners).

The following would seem trivial, but for the fact that people often judge the content of a publication by its author. It is suggested that publications dealing with the mineral industry carry the names of their authors.

Every effort should be made to get abandoned patented claims back in circulation. Probably only a State property tax can accomplish this completely.

As each geologic quadrangle map is issued, a simulation model should be prepared. (Heiner and Wolff, 1967).

The establishment of a computer processible mineral prospects file would greatly improve the already important Kardex system maintained by the Division of Mines and Minerals (see RESEARCH AND DEVELOPMENT). Mineral statistics can be obtained at will for any element for any portion of the State once the proper storage and retrieval programs are developed.

Herbert (1967) after comparing British Columbia, Yukon, and United States' laws, recommended several changes in the United States and Alaska. The authors of this report favor these changes, but some questions have been raised about Point #6. Certainly the present assessment work practice is inefficient and wasteful, often resulting in the same work being done over and over, without any real progress being made. Nevertheless, the proposal should be studied carefully before adoption, to insure that the added protection to the claim owner is actually based on more productive work.

The following changes to Federal mining law as amply stated by Herbert (1967) should be made.

1. Establish a method for obtaining pre-discovery rights, possibly using the State's prospecting site location as a model.

2. Abolish extra-lateral rights but recognize as a valid discovery geologic evidence that a mineral deposit found on an adjacent claim will continue at depth beneath the surface of a claim on which no mineral deposit is visible at the surface.

3. Have all mining claims conform in shape and size to the standard quarter-quarter section (quarter of a quarter-section = 40 acres) of the public land system at rectangular surveys.

4. Remove the distinction between lode claims and placer claims. However, some study should be given to the desirability of granting special placer leases.

5. Acceptance under Federal and State law of geological, geophysical, and geochemical work without limitation as to the total amount but subject to qualification under rules similar to those established in British Columbia.[1]

6. Permit the performance in one year of Assessment work sufficient to hold a claim for as many as 5 years.

7. A certificate of ownership of each claim to mining property must be filed with the Bureau of Land Management and all claims made in the future must be similarly filed.

8. Filing of an affidavit of performance of assessment work must be filed with the Bureau of Land Management (if the claim is on Federal land) or the Division of Lands (if the claim is on State land). The responsible agency would have authority to require correction of any errors within a definite period and would note on its records and in the records of the Deputy Magistrate those claims on which approved affidavits had been filed. Failure to file an acceptable affidavit of performance of assessment work would cause forfeiture of the claim."

The foregoing specific suggestions, either contained in the suggested mineral policies or in the preceding sections, or in consultants reports, may be summarized in a few broad recommendations:

1. That the Government should create an economic environment in which mining can grow freely, and encourage exploration and the development of potential mineral reserves.
2. That Government could attract private investment by providing exploration incentives through legislation. These have to allow for the inherent risks as well as the inevitable depletion of assets which are characteristic of the mining industry.

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[1] Under the authority of order in council No. 1491, the British Columbia Minister of Mines has issued, "Conditions governing Acceptance of Geological, Geophysical and Geochemical Surveys as Assessment work.

3. That the tax laws should provide tax relief to those companies that discover ore. Depletion allowance must be continued; zonal allowances for distance from developed areas should be made.
4. That before imposing regulations on the mineral industry such as those dealing with stream pollution, careful studies should be made to determine the amount of possible damage, and degree of economic advantage to the State.
5. That any revision of mining laws should receive the best assistance and counsel the industry has to offer.
6. That both Federal and State Governments should provide all available technical assistance to the mineral industry such as more geological maps, airborne geophysical surveys and research.
7. That the State Government should seek amplified activities of Federal agencies such as the U. S. Geological Survey and the U. S. Bureau of Mines for the development of mineral resources in the Arctic and Sub-Arctic lands.
8. That the State Government should seek optimum tax incentives for mineral exploration from the Federal Government.
9. That any laws or legislation concerning mineral resources development provide sufficient stability and protection to a mining operator to earn an adequate return from his investment.
10. That a coordinated long-range mineral resources development program should be formulated to include extensive geological, geophysical and geochemical surveying, mapping of underdeveloped regions, resources appraisal, transportation network and infrastructure, market research, cost analysis, mechanisms for mine financing, and the development of a technology for mining in the Arctic.
11. The State Government should join with Federal agencies and mineral fuels industries to foster the development of petroleum, natural gas, coal and other energy resources which must accompany the development of other minerals.

AIRBORNE GEOPHYSICAL PROSPECTING

L. E. Heiner and E. N. Wolff

Introduction

The time of the single prospector patiently searching for exposed mineralization is nearly gone. Most of the obvious ore deposits have been discovered and subsequently worked. Since less than ten percent of the earth's bedrock surface is exposed, geologic mapping and geochemical and geophysical exploration techniques will be used increasingly to discover resources under the remaining ninety percent.

Professor Louis B. Schlicter of the University of California has perhaps best defined the art of prospecting. He says:

> "Prospecting is certainly the world's biggest and best gambling business. It is a game where the chips cost many thousands and where many millions, even billions, can be won. An attractive feature of this gamble is the fact that the players are free to rig the odds as favorably as possible. Only the limited bounty of nature, the restrictions of the laws of the land, competition from other players, the limited sagacity of the player himself - only these, and other factors, restrict the possibilities for large winnings."

Roger H. Pemberton (1966) lists 113 mineral deposits discovered as a result of the application of geochemistry and/or geophysics. Ninety five of the discoveries are directly attributable to the application of one or more geophysical methods, and the development of 18 deposits were aided by one or more of the geophysical methods. Of the 95 geophysical discoveries, 39 were originally detected by airborne geophysical surveys.

Airborne surveys might provide a stimulus for the attraction of private capital to the State. Private interests may find anomaly maps powerful inducements to invest in exploration of particular areas. In any event, airborne geophysical surveys can do a great deal in delineating potentially important areas, and would enhance the mineral potential of Alaska.

Geophysics, both air and ground, have contributed greatly to Canada's mineral production. Seigel (1967) has summarized the direct contribution of geophysical instrumentation to Canada's post war mineral development: in 1966, $86 million of copper production, $32 million of lead production, $107 million of nickel production, $9.3 million of silver production, $3.8 million of gold, and $153 million zinc, or a total of $378 million of production of these metals was derived from mines discovered as a direct result of geophysics.

Applications and Types

The principal objective of airborne geophysics is the separation of areas which appear to be barren from those which appear to hold promise of ore. In addition, a considerable amount of regional structural information can be obtained from airborne measurements. Airborne work permits the rapid accumulation of data over very large areas. Therefore, the costs of airborne surveys per line mile are many times smaller than the costs of corresponding ground surveys provided that the area being surveyed is large. Fixed costs of airborne surveys usually rule them out for use in small areas. Aerial work can be carried out over areas covered with alluvium, lakes, glaciers, swamps, etc. to which access may be difficult for ground parties.

Costs of airborne surveys depend upon a number of factors:

1. Size of the project
2. Logistics
3. Instrumentation
4. Type of aircraft
5. Topography.

Geophysical methods suitable for airborne surveys are, magnetic, electromagnetic, and radiometric. There are available on the market a great many variations to each of these methods. Only the basic approach for the general methods will be discussed.

MAGNETIC

Magnetic instruments measure variations in the local geomagnetic field which are produced by differences in the magnetic susceptibility of various rocks. The magnetic method is a valuable tool therefore for regional geological mapping as well as for mineral prospecting. Airborne readings are now generally reduced by automatic data processing techniques. Corrected data are plotted on maps, and the maps evaluated, often resulting in good estimates of the regional geology of the area being flown. Ground geologic mapping programs are greatly assisted when airborne magnetic maps are available.

Canada has published a large number of magnetic maps through the office of the Geological Survey of Canada. These maps outnumber those produced by all other countries of the free world.

ELECTROMAGNETIC

All electromagnetic systems detect the presence of electrically conductive material by measuring the change that takes place in the mutual coupling between two coils when they are brought near the conductive material. A variety of airborne electromagnetic systems is available differing in such things as the aircraft employed, flight height, frequencies and coil separation.

Electromagnetic systems employ a transmitting and a receiving coil; if the transmitting coil is carrying an alternating current it will create an electromagnetic field which induces a voltage in the receiving coil proportional to the mutual coupling between the coils.

If the electromagnetic field radiated by the transmitting coil (primary) encounters conducting material, it induces a secondary voltage in it which causes a current to flow which also radiates an electromagnetic field (secondary). The resultant of the primary and secondary fields is picked up by the receiving coil and decomposed into its two components, one in phase with the primary, and one 90° out of phase. The relative amplitudes of these two components depends on the conductivity of the conducting body.

Graphite, pyrrhotite, pyrite, chalcopyrite, galena, and magnetite are good conductors of electricity, while hematite, sphalerite, braunite and chromite are almost insulators (Parasnis, 1966). Ores not directly suited to electromagnetic detection can be found with this method if satisfactory quantities of an accessory mineral having good electrical conductivity are contained in the deposit.

Depth penetration of the electromagnetic methods is limited. There is considerable controversy concerning the actual depths which may be reached by the various airborne systems. Certainly the depth is less than 500 feet; probably 200 to 300 feet is more realistic.

The ultimate result of an airborne electromagnetic survey is, of course, the map, which provides "targets" for mineral exploration.

RADIOACTIVE

Scintillation counters have been developed which differentiate radiation counts from the various elements. It is , therefore, possible to obtain individual counts for potassium, uranium and thorium. These counts are mapped, and areas high in any of the three elements stand out as anomalies. Radioactive methods are also helpful for geologic mapping. All rocks, igneous as well as sedimentary, contain traces of radioactive elements. If the different rocks, strata, and facies have significantly different radioactivity, they can be distinguished and mapped.

COMBINED METHODS

Each airborne method will produce an anomaly map. By combining magnetic, electromagnetic, radiometric, topographic and geologic maps it is possible to eliminate many false anomalies.

The additional cost per line mile of a three method survey is not justified in initial reconnaissance. Selected areas, based upon aerial magnetic maps are usually flown using this method.

Contract Services Available

In order to determine the approximate costs of airborne surveys, a number of geophysical companies were contacted. Companies which expressed a desire to conduct airborne work in Alaska are listed in Table 22. Approximate costs and services offered are tabulated where given. Brief company by company descriptions follow.

McPHAR GEOPHYSICS LTD.

The primary interest of this company is in the design, sales, and leasing of electromagnetic apparatus. However, they also supply auxiliary equipment such as magnetometers, and personnel who are experienced in all phases of airborne surveying from installation and operation to data reduction and reporting. McPhar will provide a cost figure for a contract survey but will require details of the area size, topography, geologic targets, line spacing, etc.

HEINRICHS GEOEXPLORATION COMPANY

This company can provide aerial magnetometer and electromagnetic surveys. They do not recommend a survey costing less than $35,000. The cost per line mile will depend on the total size of the area to be covered and the degree of detail assigned. They do not recommend

TABLE 22

SUMMARY OF GEOPHYSICAL SERVICES AVAILABLE

COMPANY	MAG	EM	SCINT.	PHOTOGRAPH	SPECTRAL PHOTOGRAPH	TYPE AIRCRAFT	INFORMATION NEEDED FOR COST EST.?	COST PER LINE MILE	COST OF EQUIPMENT	TRAIN PERSONNEL
Cartwright Areal Surveys	x	x	x	x	x	Cessna Skynight Supercharged Cessna 180	Yes		N/A	
McPhar Geophysics Ltd.	x	x				DeHavilland Turbo Beaver Twin Otter Cessna 180 Helicopter	Yes		30k to 180k	Yes
Geo-X Surveys Ltd.	x	x	x	x	x	Fixed wing Helicopter	Yes	$25-$50	N/A	N/A
Aero Service (Litton Ind)	x	x	x	x	?	Varied	Yes	$8-$25	N/A	
Klyceptor Surveys Ltd.	x		x			Helicopter		$40 plus Aircraft Reduced 10% per 500 miles until $25	N/A	N/A
Hunting Geology and Geophysics	x	x	?	?	?	?	Yes	Unable at Present time	N/A	N/A
Lockwood Kessler and Bartlett, Inc.	x	x	x			Helicopter	Yes		N/A	N/A
Geo-Recon	x	No					Yes		N/A	N/A
Waterton Aeronautics & Explorations Ltd.	x	x	x					$8-raw(73540) 405 mi. 10 mi. wide		
Seigel Associates Ltd.	x	x	x			Otter and Helicopter	Yes	$12(excess of 30k miles)	EM$40,000 MAG 15,000 AUX 8,000	
Heinrichs Geoexploration	x	x				Piper Aztec Cessna 411, C-45 Aero Commander Cessna 206		$10-$20 (35,000)	Mag (25,000)	

a single profile along the route, stating that two parallel lines are probably the minimum that should be considered. Heinrichs suggests that it may be possible to make a joint venture on an aerial program between the State and private industry.

WATERTON AERONAUTICS AND EXPLORATIONS LTD.

Waterton Aeronautics holds Canada patent No. 758,308, a combination magnetometer, electromagnetic and scintillometer airborne survey system. The following excerpts from their letter describes their suggestions and costs.

"On the first stage of the 405 miles referred to, we would suggest a strip ten miles wide along the route to Kobuk using Fairbanks as the base and assuming we can get fuel and landing facilities for wheel-equipped aircraft at or near Dunbar, the cost would be as follows:

Combination-Magnetometer, Electromagnetic and Scintillometer -

Area ten miles wide and 405 miles long, 21 runs 1/2 mile apart, readings are each 528 feet.

8,505 lineal miles @$8 per mile	$ 68,040
Base and positioning expenses (Fairbanks)	5,500
Total (in Canadian Funds)	$ 73,540

"Readings supplied to your geologist on paper strips 1 1/2 inches wide with a scale of one inch to one mile. We will assist in picking out the areas of interest in relation to our past experience. The U. S. A. Aeronautical charts eight miles to one inch can be used for this type of reconnaissance and our accuracy would be within 1/4 of a mile in this case. Enclosed is the explanation of our method used in the 500 ' grid surveys. Our charges for this are $12 per lineal mile. By just giving you the reading only on strips of paper we can reduce the cost to $8 per lineal mile.

"This rate is calculated without considering any tax that the U. S. Government may charge us, but as it is for the government we are assuming that it will be tax free.

"At this rate of $8 per mile we would request that your own geologist be in charge of the location of the survey and his department be responsible for converting the readings from the strips into anomalies plotted on your own maps. This is the most economical way to handle such a large area."

GEO-X SURVEYS LTD.

Excerpts from this company's letter explain its' costs and capabilities.

"Without more specific information as to the extent and quality control factors required in your proposed survey, only a price range can be given.

"In general, however, combined EM and Magnetometer surveys using a STOL type fixed wing aircraft including remote control automatic camera and continuous recording radio altimeter, computer data processing, interpretation and a professional engineer's report, would run between $25 - $50 per line mile. This range may seem wide, however, the total length of survey, mobilization, availability of services and many other factors regulate the costing. Depending on the terrain, and control factors it may be necessary to suggest a helicopter unit instead. If this is the case, the cost per line mile will usually increase about 20%. EM or Magnetometer surveys separately run about 30% less than the combined surveys.

"Our company does the majority of airborne geophysical surveys throughout British Columbia, the Yukon and the Northwestern United States. We have the only fully integrated computer data collecting, processing and interpretation airborne system available by contract to the mining industry. Our technical advisory staff consists of three Ph.D. consultants with U.B.C. and B.C.I.T. We have several engineers and technicians on our staff that are highly trained and qualified in interpretation work.

"Upon completion of field data gathering for any one area - - - - the interpreted results are available in a matter of days, without loss in quality control. We take our own high altitude (5000' - 7000') base photos and compiled mosaics.

"The instrumentation we would suggest for your job would consist of our specially designed (for rugged terrain use) Ronka EM equipment and a late model Sabre magnetometer coupled in such a way that a common control is used. We also have a large (6") crystal discriminating type airborne scintillometer unit that can be used in combination with EM and Magnetometer. Our services also include ground follow-up and anomaly checking, if desired."

The company is willing to discuss the survey and make a formal proposal.

CARTWRIGHT AERIAL SURVEYS INC.

Cartwright Aerial Surveys, Inc. could not supply approximate costs at this time. They interested in contracting airborne work, should any be initiated. These excerpts from Cartwright's letter explain data needed and type of services offered.

"To figure a cost for the survey we will need some additional information about the project.

1. The size of the area to be surveyed
2. Scope of the survey to be conducted
   a. Detailed type geophysical survey
   b. Reconnaissance type geophysical survey
3. Type of survey to be conducted
   a. General investigation and inventory of area's potential
   b. Surveys to enhance existing geophysical knowledge of area
4. Type of terrain in area of proposed survey
5. Average terrain evaluation of proposed survey area
6. Aircraft basing facilities within the area
7. Proposed starting date, duration of survey and final delivery date
8. Context of geophysical data to be delivered to the NORTH Commission or the University of Alaska
   a. Raw data which is generated by the airborne unit
   b. Magnetic contour maps compiled from airborne generated data
   c. Geological interpretation of data obtained from airborne survey
   d. All, or any comgination of the above
9. Sensitivity range of instrumentation
10. Flight height above terrain. The flight height being determined by the type of survey to be conducted (refer to #3a, or 3b).

"Cartwright Aerial Surveys can offer all types of the very latest geophysical survey instruments. Instrumentation packages can be customized to fit individual survey needs. The use of different instrument combinations enables the investigator to evaluate the total mineral potential of an area under exploration.

"The Geophysical Department of Cartwright Aerial Surveys, Inc. can offer the following instrumentation:

1. Airborne proton magnetometer used for measuring and mapping magnetic anomalies

"2. EM system used for detection of anomalies lying underneath the overburden
3. Gamma ray spectrometer used to measure the radiation from thorium, potassium, and uranium, plus total field radiation
4. Black and white or color photography for geological interpretation
5. Multi-spectral photography used to photograph an area through four different portions of the spectrum. At the same time, this is a very useful tool for geological interpretation
6. Infrared scanning equipment used for geothermal mapping
7. Topographic mapping including digital readout.

"Cartwright Aerial Surveys can also offer a recently developed method of computer reduction for most types of data obtained from an airborne survey. By using this method of data reduction we can supply our clients with preliminary anomaly plots within forty-eight hours after it has been flown."

KLYCEPTOR SURVEYS LTD.

Klyceptor Surveys Ltd. provides airborne magnetometer, electromagnetic, and radioactive surveys with a helicopter. Their costs do not include the helicopter, but do include technical personnel. Excerpts from their correspondence follow:

"Our airborne equipment is easily adaptable to any small type helicopter available, and doesn't require interconnection with either the radio or power source of the helicopter system, the total weight is in the vicinity of 200 pounds.

"Ground control is normally established by radio and baloons with the ground crews.

"Our charges do not include the helicopter, but do include technical personnel, in the air and on the ground, supplying of our own camp sites, survey equipment, analysis with completely interpreted reports, and living costs.

"Surveys in excess of 500 miles are $40 per line mile.

"Reductions to this figure are made if any of the above are supplied with the exception of the technical personnel and instruments. There would also be a reduction of 10% for every additional 500 miles until a figure of $25 per mile is reached.

"With reference to the technological requirements for detecting mineralization, it has been our experience that the electron beam type sensors comprising the klystrom two sensing head provides a greater range of reaction to geological features than any other type of airborne magnetometer to date. This is largely attributed to the continuous readings and fast recording methods combined with the relatively flat frequency response of the sensory heads (20 CPS to .01). It is common to see tectonic features across the bedding such as fractures, faults, shears, etc. that may be only a few feet across, with characteristic signatures when flown at a speed of 70 miles per hour. In many cases groups of anomalous features of interest from an airborne reconnaissance survey have been further investigated with the same equipment but with closer line spacing and ground control, to establish diamond drilling locations. This of course does not apply in very steep terrain where detail flight lines cannot be held to the required tolerance."

LOCKWOOD, KESSLER AND BARTLETT, INC

Excerpts from correspondence with this company identify their equipment and requirements:

"Organization –

"Lockwood, Kessler and Bartlett, Inc., is one of three leading contractors in the field of airborne geophysics. We employ between 500 and 600 people and own outright Lockwood Survey Corp., Ltd. of Toronto, Ontario, Canada.

"We operate internationally, having completed within the past year, projects in Saudi Arabia, Guatemala, Panama, Jamaica, and Trinidad. We are currently under contract to the Government of Liberia to conduct aerial geophysical surveys of the entire country. We have operations underway in Zambia and Swaziland. Last year we conducted extensive aerial magnetic surveys in the vicinity of Kodiak Island, Alaska.

"Equipment –

"We are licensed to use the Gulf Research and Development Company total intensity, fluxgate magnetometer. We have a highly successful in-phase/out-of-phase helicopter electromagnetic system proved again in the Anvil area, Yukon Territory, Canada. Our techniques in performing aerial radioactivity surveys are unique and are proving highly successful in the present uranium search in the United States.

"Costs –

"As you no doubt recognize, the costs of aerial geophysical surveying are highly variable depending on the size of projects, and the type of surveying done.

"In any case we advise against governmental agencies undertaking the performance of aerial geophysical surveys on their own. This point of view is based not only on our desire to do contract work, but on our desire to see the most effective completion of quality geophysical work. Experience throughout the industry shows that contractors offer by far the most efficient and practical means of performing aerial geophysical surveys.

"Planning –

"Before the NORTH Commission undertakes any analysis of the costs involved in performing aerial geophysical work it should take the following steps:

1. Delineate the areas of interest exactly. Categorize them as primary and secondary.
2. Having done step one, call on qualified contractors, such as Lockwood, to review and discuss details of methods, procedures, and scheduling. Such conferences are available without charge to the State, and will be of immense benefit.
3. Then call for bids on the final planned projects from reputable firms in the contracting business.

"Consultation –

"We will be more than pleased to come to Alaska to review your plans with you when the time is appropriate. In the meantime, if we can advise you by mail or telephone we are ready to do so."

GEO-RECON, INC.

This company provides magnetometer surveys only. The following questions need to be answered prior to submission of a formal proposal:

"1. How many line miles of survey are required?
2. Do you want only the tapes or do you want the data reduced to the form of an aeromagnetic map?
3. Do you want a report including interpretation of the magnetic data?
4. Is approximate location by reference to surface features adequate, or do you require precise location by methods such as Decca Radar?

"5. During what season of the year do you plan on conducting the investigation?"

The company would be pleased to undertake the survey on a cost per line mile, time and expense, or on a lump sum basis for a specified amount of survey.

SIEGEL ASSOCIATES LTD.

Excerpts from correspondence best explain services and costs of this company:

"Siegel Associates and its American affiliate company, Mineral Surveys, Inc., are heavily involved in airborne geophysical surveying. This past season we have had nine separate aircraft out on geophysical surveys. We would be most interested in undertaking on your behalf combined EM and magnetometer surveys or alternatively, magnetometer surveys only. One type of fixed wing airborne EM and magnetometer survey installation which would be admirably suited to the survey along your railroad routes, would be one we have installed in a DeHavilland Otter aircraft. The EM system is a low frequency in-phase and out-of-phase measuring system operating at 320 cps. This is a high resolution and fitted also with a proton precession magnetometer and a radioactive spectrometer. Auxiliary equipment includes continuous recording radioaltimeter and a continuous strip aerial camera for flight path recovery. We also have a helicopter-borne electromagnetic system operating from a 30' bird which is towed at the end of a 100' cable. If the State of Alaska owns and operates helicopters then this type of installation would be of interest to you.

"With respect to costs, you can appreciate that any figures we would presently give are estimates only.

1. For combined EM and magnetometer survey we estimate that the cost per line mile would be in the order of $12 for a survey totalling 30,000 line miles or more. This cost estimate includes mobilization and demobilization expenses, all flying costs while on the job as well as compilation of the EM and magnetic data into plan map form.
2. For an EM survey only costs for similar mileage would be in the order of $9 per line mile.
3. For a magnetometer survey only costs would be in the order of $6 to $8 per line mile."

AERO SERVICE

Systems from this company are described in an excerpt from correspondence.

"We have examined the information which you sent us in your letter of September 1, and should like to supply you the following information concerning the survey. To cover the area described in your letter of August 2nd, would probably require a survey covering an area of some 120,000 square miles. In order to satisfactorily examine the area would require survey traverses at an interval of 1/4 mile or at the very most 1/2 mile. This would comprise a survey of some 240,000 line miles.

"The airborne magnetometer is considerably cheaper than the EM or the EM combined with a magnetometer. The magnetometer would outline magnetite deposits and the results would be extremely useful in mapping the geology. The EM on the other hand would make a major contribution to the location of sulfide deposits.

"I'm quite sure that we will wish to have a personal meeting concerning this program, so I will plan on visiting you on my next trip to Alaska. But, in the meantime will attempt to give you some idea of the costs for the survey.

"Assuming that reasonably good base maps exist to be used for the navigation during the survey and for the compilation of the results, costs for the magnetometer survey would be about $8 per mile. For the combined EM/

"magnetometer, costs would probably run in the order of $25 per mile. In the event inadequate maps exist, then costs would be slightly higher. This additional cost would depend upon what would need to be done to prepare the necessary flight maps."

Cost of Airborne Equipment

Cost estimates have been received from a few companies. These are listed below, along with technical descriptions.

McPHAR GEOPHYSICS LTD.

An excerpt from correspondence describes systems available from this company.

"We have developed many airborne systems for use with different aircraft and for various geological conditions and exploration objectives. Each type of system has advantages and disadvantages for certain geophysical applications. Some are limited in use to certain aircraft for reasons such as weight carrying capacity, aircraft performance, mechanical or electrical installation requirements, etc. For such reasons, most airborne EM systems have to be designed for a specific aircraft and the choice of system will be dictated by the aircraft available as well as the exploration conditions and objectives. Of course, if the aircraft has not yet been purchased the choice is much broader.

"At the present time, the turbo-powered fixed wing aircrafts appear to be the most suitable for the low level contour flying. There are two Canadian-built DeHavilland aircraft, the Turbo-Beaver, and the Twin Otter that are ideally suited for this application. The Turbo-Beaver has the advantage of permanent pick-up points on the wings that are stressed to carry 500 lbs. Consequently, the transmitter coils for the Towed Bird Quadrature System can be installed without the cost of aircraft modifications; the main disadvantage of the Turbo-Beaver is that it is a single engine aircraft. The Twin Otter is a larger aircraft with remarkable single engine performance but modifications would be required to attach the transmitter coils for the Quadrature System. A brochure summarizing the specifications of our more popular units is enclosed.

"The advent of Turbo Helicopters has required a re-evaluation of the application of helicopter systems. These new machines have efficient operating speeds and ranges as well as the excellent climb rates required in steep topography. Helicopter EM systems do not require extensive aircraft modifications and once the initial installations have been made, can be mounted or dismantled in a matter of hours.

"Also enclosed is a write up describing systems with which our engineering department has had extensive experience. For each system we have attempted to give a brief description and its application. As many specifications as possible have been given but for some systems these can only be very approximate until a specific design for a given aircraft can be considered. The following systems are described:

A. For Fixed Wing Aircraft
   1. (a) Towed Bird Quadrature Response Single Frequency
      (b) Towed Bird Quadrature Response Dual Frequency
   2. Attached Coil System
   3. Afmag
   4. Combined EM-Afmag

B. For Helicopter Aircraft
   1. Towed Bird Quadrature Response Dual Frequency
   2. Towed Beam In-Phase and Quadrature Response
   3. Attached Beam In-Phase and Quadrature Response
   4. Afmag

"As pointed out in the description of many of the above systems, the aircraft is an integral part of the design. In such systems it is impossible to give anything more than a very rough guide in considering cost. Only in the case of the Afmag and the Towed Beam Helicopter systems can a reasonably accurate cost figure be given at this time. The following will give an idea of the cost to be expected from each system:

A. 1. (a) Between \$40,000 and \$60,000 plus the cost of installation in the aircraft and final flight testing. If this can be done in Canada the estimated cost is about \$10,000. If the aircraft is not available in Canada and the installation and final testing were done in India, our charge would be on a time and expense basis.
(b) Between \$50,000 and \$70,000 plus installation and final flight testing.
2. Between \$150,000 and \$200,000. The aircraft must be made available for approximately 5 months in Toronto, Canada
3. Approximately \$75,000 fully tested. Installation in the aircraft can be done anywhere and should cost less than \$5,000.
4. Between \$130,000 and \$180,000 plus installation and final flight testing of the EM part of the system.

B. 1. Between \$50,000 and \$75,000 plus installation and final flight testing.
2. Approximately \$90,000 fully tested. Installation can be done anywhere and should cost less than \$2,000.
3. Between \$125,000 and \$150,000 plus installation and final flight testing. The helicopter must be made available for approximately 5 months in Toronto, Canada.
4. Approximately \$75,000 fully tested. Installation in the helicopter can be done anywhere and should cost less than \$2,000.

"McPhar would make available the services of an engineer, technician or geophysicist to supervise installation, train operating and service personnel and to instruct in the interpretation of results. These personnel would be supplied as required at our normal rates plus traveling and living expenses.

"If you are interested in any of the systems described and can provide us with aircraft type, geophysical application and conditions of use, etc., we will be pleased to prepare specifications and submit quotations for your approval."

HEINRICHS GEOEXPLORATION CO.

This company gives an approximate cost of \$25,000 for a complete magnetometer system. They recommend small twin engine planes such as the Piper Aztec. Also suggested are the Cessna 411, the C-45 and the twin engine Aero Commander.

SIEGEL ASSOCIATES LTD.

Siegel can supply all necessary equipment for Airborne surveys. The electromagnetic equipment would cost about \$40,000 and the magnetic equipment approximately \$15,000. Auxiliary equipment such as aerial camera, intervalometer, and radioaltimeter would cost an additional \$5 to \$8 thousand. These costs costs do not include the price of the aircraft.

Areas Already Flown

Many known and possible petroleum provinces of Alaska have been flown with airborne magnetometers. Figure 31 indicates such areas for which maps are available from the U. S. Geological Survey. Many of these maps are in open file reports, available for reading and in some cases reports, available for reading and in some cases reproduction, at U. S. Geological Survey offices. Aero Service, a division of Litton Industries has flown areas along portions of the proposed railroad route (see Figure 32). Copies of these maps are available for purchase by interested mining companies. These surveys are chiefly high altitude and along widely spaced flight lines. They do not have the detail necessary for locating mineral deposits although they are useful in interpreting regional structures.

Various airborne surveys and methods have been conducted in the State by private companies. Results of these surveys are, however, confidential.

Recommendations

A means is needed to provide reconnaissance of large areas of virtually virgin prospective mineral producing areas by modern and progressive techniques. Airborne geophysics would provide the initial incentive for attraction of increased exploration capital to northern Alaska.

The compilation of information concerning Airborne geophysical companies indicates that services are available that range from total mineral resource valuation including literature search, geologic mapping, airborne work, data reduction, diamond drilling, etc., to services which render only raw data on paper strips. The geophysical equipment may also be purchased and operated by the State as a further alternative.

Suggested reconnaissance surveys for the proposed route range in price from approximately $35,000 to 6 million dollars. These estimates are, of course, based upon widely varying services offered, and criteria and specifications would have need to be developed prior to a call for bids from the various contracting companies.

Airborne magnetic surveys provide a valuable first broad reconnaissance of large areas as a stimulus for search by private industry. It is recommended that the State of Alaska initiate a 10 year program of mineral development. This program would involve the application of airborne geophysics to potentially favorable mineralized areas of Alaska. This type of program has proved highly successful in many parts of the world. The Country of Suurinam (Essed, 1960) initiated a 10 year development program involving airborne geophysics, geologic mapping, transportation, etc. with very good results.

The United Nations Development Program, Mineral Survey for Swaziland is now undergoing its second phase, a helicopter borne electromagnetic survey totalling 3,000 line miles (Mining Journal, Aug. 18, 1967, p. 123). The purpose of this program is to "assess, through aerial surveys and ground investigations, the mineral resources of the country in order to attract new investment capital for the mining industry."

Canada has obtained extremely good results with this type of program. Both the now famous base metal mines at Pine Point and Timmins were discovered as a direct result of airborne geophysics.

In the section on mineral policy, it was recommended that the State spend 10% of its receipts from the mineral industry on aid to the industry, with 5% earmarked for airborne geophysical surveys. It is suggested that the airborne geophysics program could best be administered by the Division of Mines and Minerals.

The purchase of airborne geophysical equipment by the state of Alaska for conducting this program is not recommended. If this were done, there would be a time lag in obtaining meaningful results due to the necessity of learning the trade and setting up the associated physical facilities. After a considerable number of reconnaissance maps were obtained, the purchase and operation of a helicopter unit by the State for follow-up surveying and research might be justified.

The administrative agency for the program would contract with private enterprise for the airborne surveying and map preparation. Private companies are well qualified and have supporting personnel and equipment which allow almost immediate dissemination of airborne results.

An attempt has been made to evaluate the chances for success per dollar expended by airborne companies. This is very difficult because the areas flown have of course varying degrees of favorability. Hundreds of thousands of line miles flown in non-productive areas might fail to turn up a deposit, whereas in a region with a good history of mineralization, discovery might be made rapidly. One major discovery for a million dollar a year program over a 5 to 10 year period has been suggested by one company as reasonable. Another company has suggested one producing mine for every 100,000 miles flown in a geologically favorable area. There have been major discoveries made in less than one year with an expenditure of \$25,000; these cases are, however, extremely rare. Many companies refuse to make an estimate of chances of success. It is therefore of utmost importance that the selection of areas to be flown be based upon the best available geological information. The administering agency should seek opinions and interpretations from qualified personnel within the geophysical companies, and state and federal organizations.

Figure 31

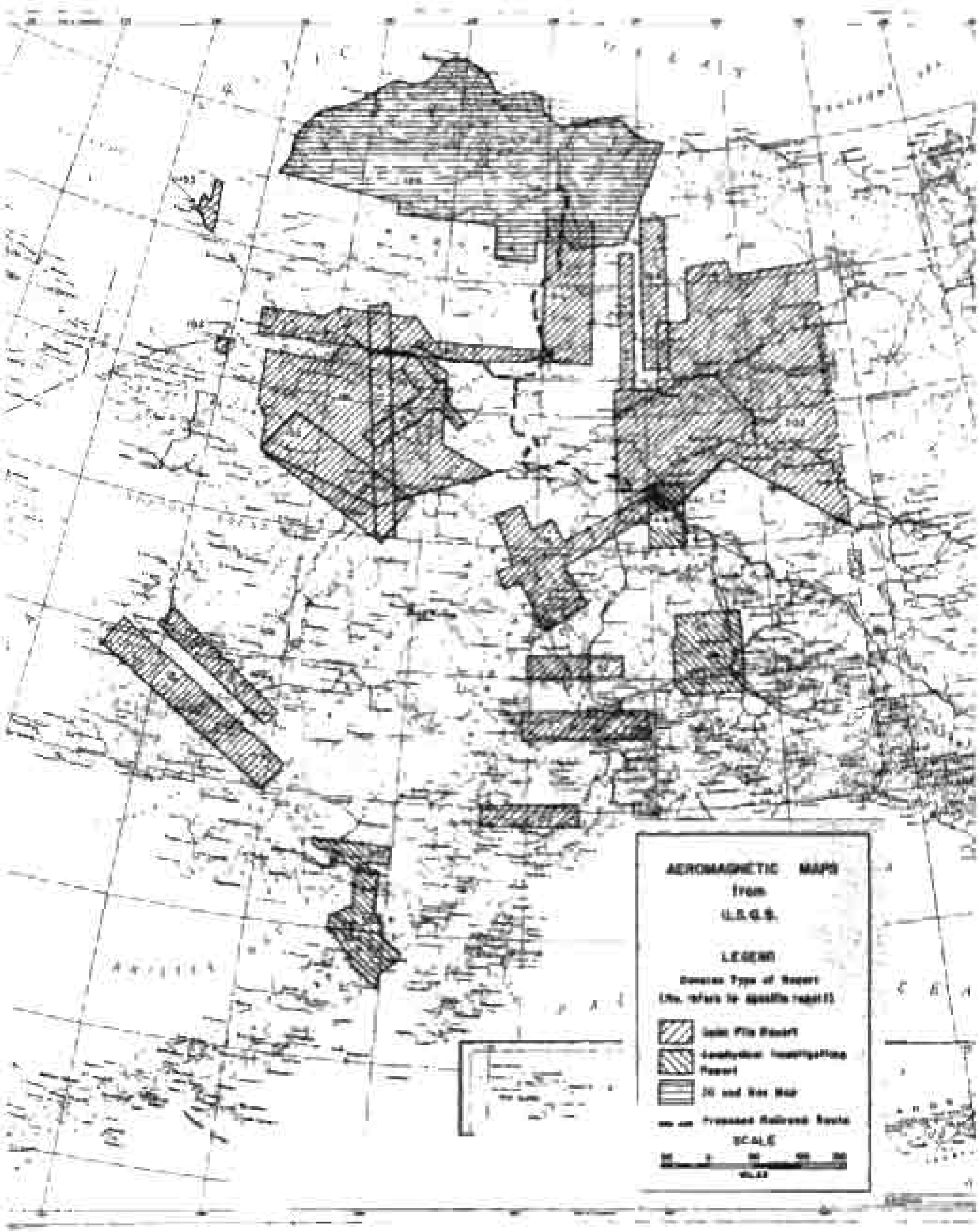
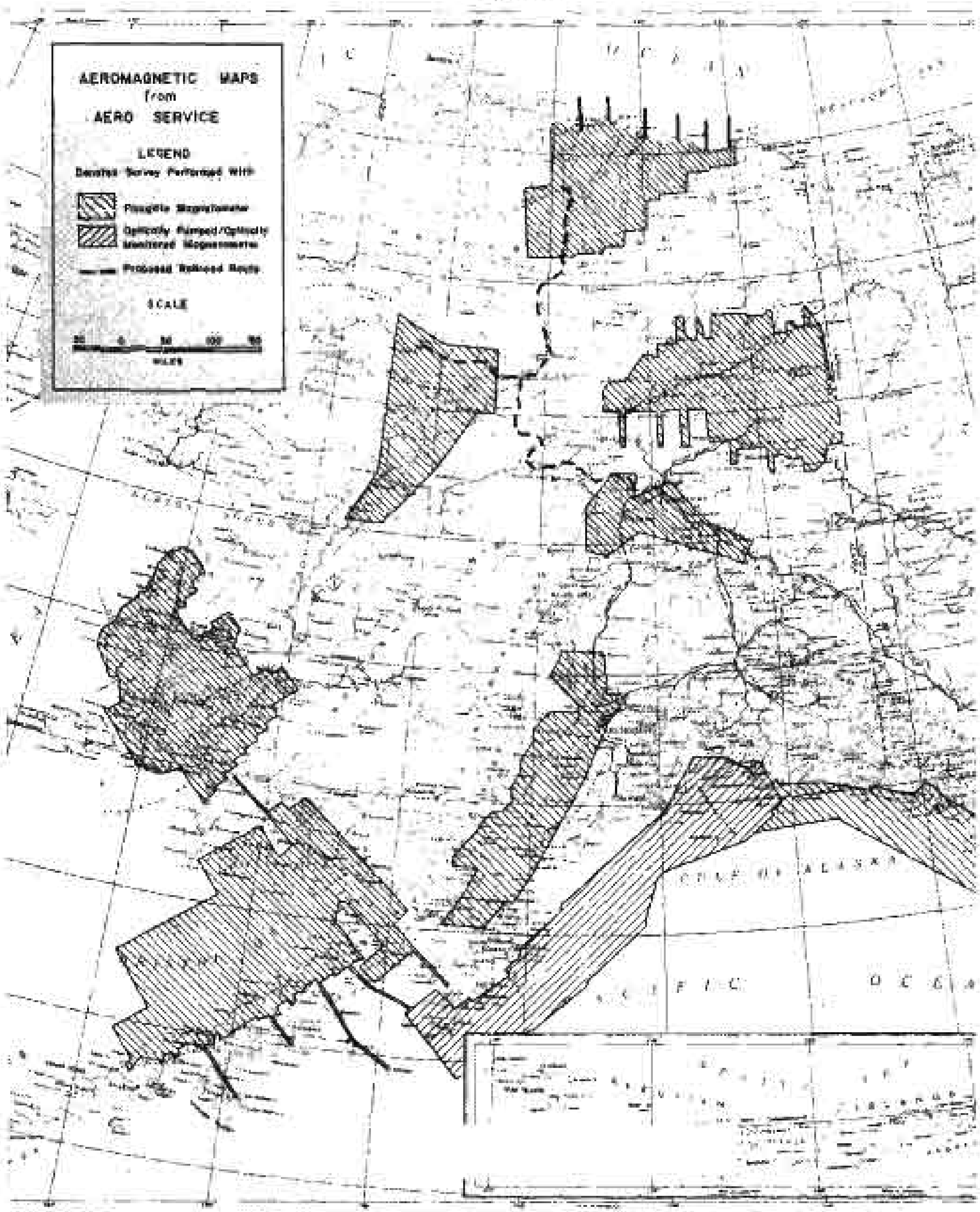


Figure 37



Inventory of Petroleum Resources – Northern Alaska

by
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There are seven areas which have potential for petroleum reserves in Alaska in the area north of 65 degrees north latitude, and these are: (1) the Kandik area, (2) the Yukon Flats Basin, (3) the Galena Basin, (4) the Kobuk Cretaceous Province, (5) the Selawik Basin, (6) the Foothills Province of the Brooks Range comprising the southern foothills and the northern foothills areas, and (7) the Arctic Coastal Plain (Miller, Payne, Gryc, 1959, p. 53-112). Continental shelf areas adjacent to any of the above are considered to be parts of the respective petroleum provinces and are discussed as such.

The areas set forth above are those which have the geologic conditions generally considered necessary for the generation, accumulation and preservation of petroleum. These conditions are:

a. abundant supply of organic material
b. preservation of the organic material upon burial
c. processes to change the organic material into hydrocarbons
d. migration routes and forces to move the hydrocarbons into accumulation reservoirs
e. an impervious seal of the reservoir to prevent escape of the hydrocarbons to the surface
f. no post-accumulation geological activity that would destroy the hydrocarbons or allow them to escape (such as igneous intrusions or severe mountain-building processes).

A large portion of Northern Alaska is classed as impossible for petroleum accumulation, as, for example, the large area of metamorphic rocks and intrusives in the Yukon-Tanana upland north and east of Fairbanks (Plate 4).

CHARACTERISTICS AND STATUS OF POTENTIAL PETROLEUM AREAS

Following is a review of each potential petroleum area in Northern Alaska. In relation to each we will discuss the geology, the oil and gas lease status, past and present activity in relation to oil and gas, and the near-term petroleum prospects.

(1) The Kandik Area: (Area approximately 3000 square miles).

GEOLOGY

The potentially productive rocks are of Mesozoic and Paleozoic ages; they are mainly marine in origin and are predominantly sandstones and shales, but there are also some fossiliferous limestones of Mississippian (approximately 1,300 feet thick), Permian (approximately 500 feet thick), and Triassic (approximately 500 feet thick) ages. Triassic oil shales occur within the area. Middle Cretaceous and younger rocks are mainly nonmarine and offer little potential as petroleum source rocks.

The structure of the rocks in the area is fairly simple, and there is no complicated large-scale overthrusting. The major structures of the area are broad open folds trending northeast. Igneous intrusions are rare or absent. No oil and gas seeps have been reported. The oil shale was tested and is reported capable of yielding 28 gallons crude per ton (Mertie, 1937, p. 263-263).

LEASE STATUS

Much of the area was leased for oil and gas in the late 1950's but these leases have been terminated or have expired. The leases in the area are available on an over-the-counter basis, but cannot be issued until the land freeze is lifted by the Secretary of the Interior.

OIL AND GAS ACTIVITY

A number of oil companies have had field parties working in the area, but generally only on a reconnaissance basis. There has been no large scale exploration or drilling program.

PROSPECTS

The best drilling prospect is the Permian-Triassic limestone sequence. A secondary objective is the marine sandstone sequence higher in the section, but there may be some permeability-porosity problems with the latter.

The limestones seem capable of yielding commercially significant production. These rocks are fairly close to the surface which would make drilling relatively inexpensive.

(2) The Yukon Flats Basin (Area approximately 11,000 square miles)

GEOLOGY

This is a basin formed during Cenozoic time in which probably no marine strata were deposited. There are early Cenozoic coal-bearing rocks which crop out on the basin margin which suggests downwarping began at about that time. The basin is filled with subsequent nonmarine sediments, and these are virtually unmodified by structural activity.

The Paleozoic strata present in the Kandik area to the southeast may extend beneath the Cenozoic cover into the Yukon Flats Basin. If the fairly simple structures of the Kandik area also exist here, and if the Paleozoic strata are present, the petroleum possibilities set forth for the Kandik area would also apply here.

There are no known oil seeps in the area.

LEASE STATUS

No oil and gas leases are issued in the area.

PAST ACTIVITY

There is no known activity by oil companies. The U. S. Geological Survey has done almost all of the work in the area and this effort has been concentrated on the surficial deposits.

PROSPECTS

The oil and gas prospects for the area are good if the fossiliferous limestones present in the Kandik area also occur here at depth. They should not be deep beneath the surface if they are present, and it is our interpretation that they are there. The structures at depth could be determined by seismic investigations.

(3) The Galena Basin: (Approximately 5,000 square miles)

GEOLOGY

The area began subsiding in early Cenozoic time as did the Yukon Flats Basin, and the present area received an unknown thickness of Tertiary rocks which are probably of non-marine origin. The youngest rocks in the basin have the greatest areal extent so that all older deposits are overlapped and everywhere concealed, and the character of the rocks cannot be determined.

There are no oil seeps in the area.

LEASE STATUS

There are no oil and gas leases issued in the area.

PAST ACTIVITY

There is no known activity by oil companies in the area.

PROSPECTS

The prime prospects for the area are the Tertiary rocks which are blanketed by the youngest material deposited in the area. It is possible that there may be an interbedding of marine and nonmarine strata that could be productive. This can only be determined by test drilling, and it is our opinion that this will not occur for some time.

(4) The Kobuk Cretaceous Province: (Area approximately 10,000 square miles)

GEOLOGY

The potential exploration objectives in this area are rocks of late Mesozoic age deposited in the Kobuk Trough, an east-west finger-like extension of the northeast trending Yukon-Koyukuk Geosyncline, a major area of downwarping and deposition during the Cretaceous Period. The Kobuk Trough as an area of deposition probably was a late-stage area of subsidence between geanticlinal areas being formed during the destruction of the Cordilleran Geosynclinal system in late Mesozoic time.

The lowermost Cretaceous rocks in the area are marine, middle Cretaceous rocks and Cretaceous rocks are near-shore marine, and the youngest rocks are nonmarine. The thickness of the entire sequence is at least several thousand feet, but it has not yet been determined. Structure of the sequence is very complex. Strata dip steeply in many places and some overturning of beds has occurred. There are small igneous intrusions into Cretaceous rocks in places.

No substantiated oil seeps have been reported.

LEASE STATUS

No oil and gas leases are issued at the present.

PAST ACTIVITY

There has been no known activity by oil companies.

PROSPECTS

The Cretaceous strata are potential sources of oil and gas, but the complex structure of the area and the igneous intrusions into the Cretaceous rocks makes the entire area a very low-priority exploration objective. The character of the rocks below the Cretaceous is not known, but these would be even more structurally disturbed than the Cretaceous strata and therefore would be even less likely to be productive.

(5) The Selawik Basin: (Land area approximately 5,000 square miles)

GEOLOGY

This is also a basin that was formed during Cenozoic time and at the present time is occupied in part by the sea (Plate 4). The chances are excellent that the sea occupied much of the basin area during the Cenozoic since the basin is so marginal to the sea. Therefore, if any of the Cenozoic basins here discussed was invaded by the sea so that marine strata could be deposited, it would have to have been this one. Not much is known of the geology of the basin area. Three oil seeps have been reported in the area, but these are unsubstantiated.

LEASE STATUS

No oil and gas leases are issued at the present time.

OIL AND GAS ACTIVITY

Some water wells drilled in the area have encountered indications of gas. The U. S. Geological Survey has investigated and concludes that the gas is probably related to decaying vegetable material and is "swamp gas".

PROSPECTS

The area is blanketed by young materials which hide the structure and character of the Cenozoic strata that are potentially petroliferous. There is not much question that there are marine strata of Tertiary age that were deposited in the basin. The structure of these strata could be determined from a seismic program. The Selawik Basin should be the first of the three Cenozoic basins herein described to be drilled for oil and gas because of the likelihood of marine deposits near the surface, but this probably will not occur in the near future.

(6) The Foothills Province of the Brooks Range:

Southern Foothills (Area approximately 16,000 square miles)

GEOLOGY

The southern foothills belt is a structurally complex area with much extreme folding and overthrusting. Rocks of early and middle Mesozoic age are exposed at the surface. Paleozoic carbonate rocks are present at moderate depths and these offer the best chances for commercial oil production at this time. Oil shales are present in rocks of Triassic age, but are also present in rocks of Jurassic and early Cretaceous age. Oil yields from these shales are on the order of 25 to 50 gallons per ton with some unusually high yields of about 150 gallons per ton from organic shales which consist of high proportions of a spore-like alga *Tasmanites* (Tourtelot and Tailleur, 1965, p.6). The Lisburne Group of late Paleozoic age and the underlying Devonian strata have a relation to the Brooks Range that is in general the same in Northern Alaska as is the relation that exists between rocks of the same age and the Rocky Mountains in Alberta. Many similarities already are known and others may well be present, but the point is that geologists might well look for similar producing situations in Northern Alaska that have already been discovered in Alberta.

LEASE STATUS

Oil and gas leases are held in portions of the southern foothills, but only a relatively few. The percentage of leases that are held by oil companies increases from south to north. Leases held in this area generally are on known geologic structures which are well exposed at the surface, whereas farther to the north there is more blanket ownership of the leases.

PAST ACTIVITY

Many oil companies have had geologists working on the rocks of this area in a general way, but very little detailed mapping or exploration has been done because the structures were thought to be too complex; no test wells have been drilled.

PROSPECTS

Oil has been found in Paleozoic carbonate rocks in Northern Alaska on the coastal plain at Prudhoe Bay (Plate 4). These same carbonate rocks are present near the surface in the southern foothills and we look for increased interest in this belt. The geology will be complex to unravel because of overthrusting, and the structures are not likely to be so large as those farther to the north, but the potential reservoir rocks, the late Paleozoic carbonates, should be capable of production in significant quantity. The southern foothills area probably should be developed at the same time as the Arctic Coastal Plain area, but the latter will lead the way.

Northern Foothills Area (Approximately 30,000 square miles)

GEOLOGY

The area is characterized by more persistent topographic features than the southern foothills, including resistant ridges which can be traced for many miles in an east-west direction. These ridges reflect the much simpler structures, almost entirely broad open folds, that exist in the area. There are few minor cross-faults or overthrusts. The belt is characterized by fairly resistant rocks of Cretaceous age exposed at the surface. The axis of the trough in which these strata were deposited trends through and roughly parallel to the northern foothills belt (Plate 4). Therefore, the late Paleozoic rocks which now seem capable of commercial oil production are buried more than 15,000 feet beneath the surface in this area. In general, the porosity and permeability of the Cretaceous rocks that are closer to the surface are low and these strata therefore are incapable of yielding enough oil to be of commercial significance at this time. The Navy program in Naval Petroleum Reserve No. 4 and early private drilling both were concentrated in this area and demonstrated that rocks of this character and age could not be considered prime exploration objectives because of the low yield capabilities.

LEASE STATUS

Some oil and gas leases in this area are held by oil companies. The ownership interest is concentrated on the axes of the broad anticlinal folds which are well exposed at the surface.

PAST ACTIVITY

A number of test wells were drilled in this area in Naval Petroleum Reserve No. 4, and the earliest drilling by oil companies also was in this area. The results always were encouraging in that there were shows of oil and/or gas in almost every test, but nothing of commercial quantity was found. The production was most often from rocks of Cretaceous age, and the results are summarized in Table

PROSPECTS

The Cretaceous System is made up of low porosity and low permeability sandstones and shales, and even though there were indications of hydrocarbons in every test well, the rocks are incapable of enough production to warrant commercial development. These strata will be brought into commercial production, however, when the development of the North Slope area moves into a secondary stage, that is, after fields capable of very large production have been discovered and pipelines to move the hydrocarbons from the large fields have been built.

At the present time, the potential yield from the Cretaceous rocks in this area is too low to warrant large-scale capital investments for pipelines and the like. The Paleozoic rocks that are capable of providing the substantial production necessary to promote the development of the area are more than 15,000 feet beneath the surface in this area which makes drilling costs astronomical. Oil companies are not willing to drill wildcat test wells to 18,000 feet or deeper to evaluate the Paleozoic carbonates in the northern foothills area when these rocks are to be found closer to the surface in other areas. Test drilling in the northern foothills will be limited for the next few years. The best prospects lie in western Alaska where the Paleozoic carbonates are closest to the surface, but oil and gas leases in this area are not to be issued until the land freeze is lifted by the Secretary of the Interior.

(7) The Arctic Coastal Plain: (Area approximately 35,000 square miles)

GEOLOGY

The strata underlying the Arctic coastal plain have undergone only mild deformation compared with the areas to the south, therefore the structures are large and simple. An ancient landmass existed north of the Arctic coast in Paleozoic time and most of the sediments deposited during the Paleozoic Era were in a shallow warm-water sea flanking the landmass. The sea was abundant with animal life. The ancient landmass subsided in early Mesozoic time, but the topographic high called the Barrow Arch remained as a remnant of the landmass during most of the Mesozoic and little in the way of sedimentation occurred there. Basement rock is only about 2,800 feet beneath the surface in the Barrow area. The Paleozoic carbonate rocks are generally within about 8,000 feet of the surface on the northern part of the coastal plain. These carbonates are progressively deeper to the south until one reaches the axis of the Mesozoic Colville Geosyncline where the carbonates are more than 15,000 feet down. These carbonates have the character to provide large-scale oil/gas production and they will be the prime exploration objective in Northern Alaska for the forseeable future. The carbonates are not everywhere present in Northern Alaska, however. The Barrow Arch was evidently above sea level during the time of deposition of the carbonates as they do not occur in the test wells drilled by the Navy in the general Barrow area.

LEASE STATUS

The area comprising the coastal plain east of Naval Petroleum Reserve No. 4 is largely under lease to oil companies. Federal noncompetitively leased lands are held close to 100 percent and about 75 percent of the State of Alaska competitive lands north of approximately 70°5' north latitude (Township 9 North, Umiat Prime Meridian) are under lease. the State is planning a competitive lease sale in Fall of 1968 in this general area.

PAST ACTIVITY

Oil companies have done extensive work on the rocks of this area. A great amount of seismic work has been done and there has been drilling in and outside of Naval Petroleum Reserve No. 4. There were no significant discoveries of hydrocarbons until early in 1968 when the test well at Prudhoe Bay brought in what appears to be a sizeable discovery. An evaluation test well has been started seven miles southeast (Sag River State No. 1) and will be completed as soon as possible.

PROSPECTS

The major prospects for the Arctic Coastal Plain are the same as those for Northern Alaska for the near-term future. Therefore, this topic is discussed in detail in the following section.

HISTORY, PRESENT ACTIVITY AND FUTURE OF NORTH SLOPE OIL

Brief History of Naval Petroleum Reserve No. 4

The Reserve, an area of approximately 37,000 square miles was set aside by President Harding in 1923. Oil seepages had been reported in 1917 and with the oil age approaching it was considered prudent on the part of the government to set aside a large potential source of supply. Some preliminary evaluations and investigations were made in the period between 1923 and 1926, but nothing much happened until,in 1943, a flying trip was made by representatives of the U. S. Geological Survey,the U. S. Bureau of Mines, the Territorial Department of Mines and Minerals, and the Navy; and in 1944 an intensive drilling and evaluation program by the Navy was started. By the time the program was halted in 1953, 78 test wells had been drilled in the petroleum reserve and three had been drilled in adjacent areas. Of these, 45 were core tests. A total of 174,360 feet were drilled. Most of the drilling was on the coastal plain and it was concentrated in the Cape Simpson area where extensive seeps occur. About twenty percent of the drilling took place in the Foothills province, including eleven test wells at Umiat. Subsequently, two more gas wells were drilled to provide natural gas to the Barrow area (1955 and 1964). The results of the drilling by the Navy are summarized on page

Private individuals and oil companies were able to begin leasing lands for oil and gas in Northern Alaska in 1958. Thirteen test wells have been drilled by private companies since then (total footage drilled is 77,892 feet). The most active companies have been BP Exploration (U.S.A), Ltd. in partnership with Sinclair Oil and Gas Co. (1963 through 1965; 8 dry holes and one abandoned gas well at Gubik), Union Oil Co. of California in partnership with BP and Sinclair (1966; 1 dry hole), and Atlantic Richfield Co. in partnership with Humble Oil and Refining Co. (1966 to present; 1 dry hole and 1 discovery well at Prudhoe Bay; presently drilling at Sag River State No. 1).

Activity by the Oil Industry

Many oil companies, singly and/or in partnership with others, hold oil and gas leases in Northern Alaska. At least 15,000 square miles are under lease. Most of the area north to the ocean and east to the Wildlife Reserve from the Umiat area is under least at the present. The area west of Naval Petroleum Reserve No. 4 was made available for leasing late in 1966 and priorities have been established for leasing these lands, but the leases will not be issued until the Secretary of the Interior lifts the land freeze.

Individual companies and/or companies in partnership which have large leaseholds are as follows:

Atlantic Richfield Company – Humble Oil and Refining Company
Atlantic Richfield Company – Pan American Petroleum Corporation – Sun Oil Corporation
Texaco, Inc.
Mobile Oil Corporation – Phillips Petroleum Corporation
BP Exploration (USA), Ltd. – Sinclair Oil and Gas
Shell Oil Company – Standard Oil Company of California
Union Oil Company of California
Gulf Oil Corporation
Colorado Oil and Gas Corporation.

Atlantic Richfield Company *et al.* made the much needed discovery in Northern Alaska early in 1968. Although it is not known how big or how good the discovery will be, the indications are extremely encouraging. An evaluation well has been spudded by Atlantic Richfield Company *et al.* some seven miles southeast of the Prudhoe Bay discovery (Plate 4) and this test well is probably on the same geologic trend; it is not yet known if Prudhoe Bay State No. 1 is producing from a geological structure or from a stratigraphic trap. Production is thought to be from upper Paleozoic carbonate rocks which are known to thin and disappear westward against the Barrow high. These carbonate rocks probably thicken and improve in oil potential eastward and southeastward from the discovery well. The location of the Sag River State No. 1 evaluation test well (Plate 4) supports this interpretation.

Future of North Slope Oil

Further evaluation drilling seeking the limits of the Prudhoe Bay Field is bound to occur even if Sag River State No. 1 is a dry hole.

The upper Paleozoic rocks which are productive in the Prudhoe Bay area will be tested in the near future by other companies having favorable leaseholds on the Coastal Plain. This additional drilling will most probably occur in the area north of 70° North Latitude and east of 150° West Longitude, and the continental shelf adjacent to this area of Alaska also will be tested. The State of Alaska has scheduled a competitive oil and gas lease sale in Northern Alaska in late 1968 and interest should run very high.

The upper Paleozoic carbonate rocks which have been shown to be productive at Prudhoe Bay, and which unquestionably are the most favorable strata for commercial production on the North Slope, plunge to depths of more than 15,000 feet beneath the surface as one moves southward toward the mountains from the coastal plain. The line or axis where these rocks are deepest beneath the surface is shown on Plate 4 and occurs in the northern foothills area. This area, then, should be the least favorable for exploration in the near future. The upper Paleozoic carbonates again approach the surface of the earth in the southern foothills area, but here the geologic structures are very complex and drilling will be done very selectively.

There will probably be little or no drilling in the area between the southern foothills and 70° North Latitude because the Paleozoic carbonates are prohibitively deep and because the overlying strata have been extensively tested in Naval Petroleum Reserve No. 4 and by oil companies and have been shown to be incapable of yielding commercial quantities of petroleum because of low permeability and low porosity.

Naval Petroleum Reserve No. 4 will eventually be opened for oil and gas development by private companies, but when this will happen is not possible for us to predict. Nor is it possible to predict when the Secretary of the Interior will lift the land freeze on Federal lands so that oil and gas leases can again be issued. A number of prime leases are tied up by this freeze at the present. The development of the area west of Naval Petroleum Reserve No. 4 is directly related to the duration of the land freeze as no Federal leases can at present be issued in the area, and the geology of the area looks extremely promising.

We do not foresee the oil shale of Northern Alaska being of any commercial significance in the near future. Pilot plant operations in other states indicate that the technology of commercially handling oil shale is still in its infancy.

The most reasonable way to move oil from Northern Alaska seems to be by pipeline and from the Prudhoe Bay area such a pipeline would pass through Anaktuvuk Pass. It has been estimated that a 12 inch pipeline would require reserves capable of producing about 100,000 barrels of oil per day to justify the construction. This is roughly three times the daily output of Swanson River Field. The present-day reserves are set forth below.

INVENTORY OF OIL AND GAS RESERVES

All of the known oil and gas reserves in Northern Alaska are on the Arctic Slope of the Brooks Range. In Naval Petroleum Reserve No. 4 there are three subcommercial oil fields and a number of gas fields, most of which are subcommercial or only suitable for local consumption of the gas. In the area outside of the Reserve one significant discovery of both oil and gas has been made (Prudhoe Bay State No. 1) and this well currently is being tested to determine its capability. Data on production capacity and reserves for Northern Alaska are summarized in Table

TABLE 23

RESERVES OF OIL AND GAS, NORTHERN ALASKA
(Collin, F. R. et al., 1967)

Field	Reserves	Number of Test Wells	Character of Reserves	Age of Rocks
Barrow Gas Field	10 billion cubic feet gas (estimate by Arctic Contractors, and U.S. Geological Survey, 1959)	8	97% to 98% Methane	Jurassic (?)
Fish Creek Oil Field	No estimate	1	Produced 9 to 12 barrels oil/day	Lower Cretaceous
Simpson Seeps Oil Field	No estimate	44	The two best producing wells could each yield about 100 barrels oil/day, 21° API gravity	Cretaceous
Umiat Oil Field	60 million barrels of oil (estimate by U. S. Geological Survey)	11	36° API gravity oil; also gas at East Umiat Unit No. 1 drilled by BP-Sinclair, capable of 3.5 MM cubic feet gas/day	Upper Cretaceous
Gubik Gas Field	200 billion cubic feet (estimate by Arctic Contractors)	3	-	Upper Cretaceous
Prudhoe Bay State No.1	Discovery well of oil and gas drilled by Atlantic Richfield Co. - Humble. No estimate of reserves possible, but appears to be significant	1	Well still being tested; initial test was 1,152 barrels oil/day through a 3/4 inch choke, 26.9° API gravity	Upper Paleozoic
Wolf Creek Gas Field	No estimate; subcommercial	3	881,000 cubic feet/day	Cretaceous
Oumalik Gas Field	No estimate; subcommercial	5	-	Cretaceous
Meade Gas Field	10 billion cubic feet gas (highly conjectural estimate)	1	-	Cretaceous
Square Lake Gas Field	No estimate; could be substantial	1	-	Cretaceous

Statement of Charles F. Herbert, Consulting Engineer

A proposed railroad route from Dunbar to the north and northwest would provide accessibility to areas with known mineralization or with geology considered to be favorable for mineralization. These have been mentioned in the literature and are covered elsewhere in this study. In addition to the known mineral deposits or recognized indicators of such deposits there are a few facts that would seem to warrant inclusion in this study.

The Tofty mining district near Manley Hot Springs is well known for its apparently sizeable reserves of gold and tin in deeply buried placer deposits. Attention has also been drawn to the potential placer deposits in deeply buried streams within the Nowitna River drainage some 75 to 100 miles southwest from Manley Hot Springs (USGS Bull. 642, p. 220; USGS Bull. 667, p. 51). Within the Nowitna River drainage small gold placers and prospects have been found in the shallower headwater streams, but the larger streams in which the processes of placer formation would have been more favorable, were too deep for prospectors without means of transporting equipment necessary for drilling or sinking deep shafts. Consequently, the more logical targets for exploration remain untested.

The Titna River in the Nowitna River basin is especially interesting since there is an authentic report of a prospector having found platinum in rather considerable amount in a tributary of that river. At the time of the discovery, several years prior to World War I, platinum was worth less than half as much as gold and the prospect was abandoned. Today, platinum is worth well over ten times its value before World War I.

Tanana - About twenty miles up the Yukon River from the village of Tanana there is one of the oldest known lode mine prospects in Interior Alaska. This is the lead-silver prospect on Quartz Creek, discovered in 1890 (USGS Bull. 631, p. 82-83). Less well known is the fact that silver-lead float (fragments) may be found for a distance of about four miles in a northeasterly direction from the prospect into the valley of Morelock Creek and its southwesterly flowing tributary, Rosa Creek. Apparently there is a lineament that carries lead and silver for a considerable distance but there is no record of any intensive prospecting effort to determine if minable orebodies exist along it.

Brooks Range - The 500 mile long belt of schists that forms the southern flank of the Brooks Range and which contains the Ruby Creek mine of Kennecott Copper Corporation at Bornite and that company's active copper prospect at Pardner Hill and near the Kogoluktuk River may contain other important mineral deposits.

Within the schist belt the more recent glacial activity was confined to the higher mountains and to the larger valleys. Consequently the rounded hills that characterize the schist bedrock are frequently at or close to the elevation of an old land surface that had persisted through one or more periods of temperate climate. Erosion is still partially checked by glacial gravels in the valleys and along the hillsides. It is not surprising then to find evidence of deep weathering and leaching of copper minerals from surface exposures, even though the present climate does not favor more than superficial weathering.

In the Wiseman district, about twenty five miles westerly from the Chandalar gold lodes, copper and silver nuggets were found on Mule Creek, in the upper valley of the Bettles River, a tributary of the Middle Fork of the Koyukuk River (USGS Bull. 442, p. 297). Nuggets of native copper are a common product from weathering of deposits of copper sulfides – they occur on the Shungnak River downstream from the copper zone in which Kennecott's orebodies at Bornite have been found.

On an unnamed creek in the upper valley of the Bettles River, presumably not far from Mule Creek, three prospectors searching for gold found no gold but returned with a "boatload" of copper nuggets. This probably happened in about 1905.

In the Wild River valley, below Michigan Creek, there is a calcareous bed that contains numerous cavities filled with iron oxides. These iron oxide casts resemble those found in leached outcrops over copper sulfide orebodies and the streams below this bed are highly anomalous in copper.

On the Allen River, within a few miles of the proposed railroad route up the John River and within twenty miles of the showing on the Wild River, a similar calcareous bed with iron oxide casts has left a "carpet" of copper carbonates as a coating on the underlying mica schist.

There is little doubt that the beds on the Wild River and on the Allen River contain copper sulfides that have been leached at the surface and transported. Possibly these, or similar beds that may be found, contain orebodies with sufficient copper to permit exploitation when reasonably reliable and inexpensive transportation is available.

On the Alatna River, within the schist belt, copper sulfides were noted by the U. S. Geological Survey (Bull. 815, p. 117) but the occurrence does not seem to have been important. In the 1940's, Ernest Johnson of Bettles found what he described as a fairly large deposit of copper ore but he did not consider that any copper deposit in that remote area had any prospective value.

It may be argued that the indications of base metal orebodies along the southern flank of the Brooks Range are indefinite and remarkably few in number for a supposedly favorable belt some 500 miles long. The argument would seem to be strengthened by the fact that the belt has had its share of prospectors – in 1898 there were about 800 prospectors in the Kobuk Valley (USGS Bull. 815, p. 321) and an estimated 1,000 men in the Koyukuk Valley (USGS Bull. 442, p. 258). Of approximately 55 placer deposits with recorded production of gold, nearly all were discovered before 1905.

However, this argument fails when consideration is given to the history of Kennecott's copper mine at Bornite. That deposit was discovered about 1900 but it was well over sixty years after the original discovery before a prospector (Reinhardt Berg) realized a reward for his stamina, skill and persistence in demonstrating the value of the discovery. Obviously, there was no incentive to develop base metals during the short lived waves of prospecting around the beginning of this century when men were searching for the rich, shallow gold placers that had made poor men wealthy in the Klondike and on the Seward Peninsula. There was no market for a base metal mine; a market for gold was no farther than the nearest trading post.

Kennecott's purchase of Berg's prospect is the first sign that a market for mines in the more remote parts of Alaska is finally being realized. That the market will grow and grow rapidly is evident from all forecasts of the future mineral requirements of the United States. For example, Secretary of the Interior Stewart L. Udall noted that the people of the United States in the last thirty years had used more minerals and fuels than all of the people of the entire world had used previously - and that our requirements for the next thirty years will likely be double those of the past thirty years (Wash. D. C., Jan. 10, 1966, Address to American Mining Congress).

To meet the national need, the less accessible parts of the United States must be made accessible, and the nearly forgotten prospector must be induced to return to the hills. These must be done before a mineral shortage begins to cripple the nation's economy. Provision of reliable transportation to potentially productive but as yet unproven areas of Alaska may be less of a gamble than the failure to do so; incentives for prospectors are a worthwhile governmental investment (as has been proven in Canada).

There are various incentives for prospecting and mine development that can be employed by Federal and State governments. Likewise, there are "non-incentives" that can and should be avoided, removed, or ameliorated.

Among the possible incentives to mineral development of the Brooks Range and other remote parts of Alaska are:

Better maps should be available. Only a small fraction of the southern flank of the Brooks Range has been mapped at a scale of one inch to a mile, and with the exception of the Chandalar Quadrangle, the geology is only partially shown on maps made from reconnaissance surveys performed many years ago.

Mneral investigations by public agencies are viewed by some as competition from government. Nevertheless, they serve to economize private prospecting effort by affording direction to known mineralization, a particularly valuable service in remote areas. Also, mineral development is more likely to be advanced than retarded by competition.

Financing of exploration and preliminary mine development should be improved. Presently, the Office of Mineral Exploration within the U. S. Geological Survey is doing a good job, and the Prospectors' Assistance Program of the State of Alaska is a valuable incentive that should be expanded. On the other hand, nearly all of the private funds for mineral exploration in Alaska are derived grudgingly from the exploration budgets of major mining companies; there are very few small, speculative mining companies or syndicates engaged in the prospecting business in Alaska even though all the large mines brought into production in British Columbia within the last fifteen years were originally financed by small companies or syndicates.

In its zeal to protect unwary investors the U. S. Securities and Exchange Commission has practically throttled mining speculation through newly formed companies, but, in spite of the poor record of mine promotions, it would seem that the SEC could relax its requirements for registration and drastically reduce the time required for approval of a registration statement if it would accept at face value an approved participation in the development of a mining prospect by the Office of Mineral Exploration. Participation in an exploration program by the OME should be proof that the speculation is justified by geologic and other evidence and that the funds will be expended in an intelligent manner.

Also the consideration should be given to expanding the authority of the Office of Mineral Exploration so as to permit financial participation by that agency in wildcat prospecting ventures, i.e. exploration of an area rather than a specified prospect. The extent of OME participation could be considerably less than the 50% or 75% now permitted for various minerals. The principal value in this type of OME loan would be assurance to the small investor that the promoter's program and proposed budget are reasonable.

Tax incentives in Canada have been credited with a major share in the remarkable growth of mineral production in that country. It is unlikely that the U. S. Federal Government will ever adopt the two most favored of the Canadian tax incentives: the three year income tax exemption on new mines, with a carry forward of depreciation charges, and the absence of capital gains tax on the sale of mines by prospectors. However, inclusion of these provisions in the Alaska Income Tax Law is worthy of study.

It is necessary to protect the depletion allowances now available in the Federal and State income tax laws. Mining company funds now spent in Alaskan exploration efforts are derived from depletion allowances. Without depletion allowances the attractiveness of any new mining venture, particularly in a remote, high cost area, would be greatly reduced. It is worth noting that the average yield of mining companies on invested capital, including depletion allowances, is no greater than the average yield in manufacturing, where no depletion exists.

Protection of fish and game, perhaps surprisingly, is an incentive to mine development in Alaska. In order to attract and hold competent men at remote camps, recreational opportunities must be available, and good hunting and fishing rank highest in recreational demands.

Among the "non-incentives" to prospecting and mining in Alaska are:

Roads and trails are deficient and there are no Federal or State provisions for sharing the costs of construction between Government and private persons.

Export controls by the Federal government effectively remove Japanese participation in metal exploration and mining in Alaska. British Columbia has benefited from the Japanese market; mines have been financed by payment in advance for metals to be shipped to Japan and about 90% of the copper produced in the province is shipped to Japan. However, Alaska cannot take advantage of the Japanese demand since the export of copper or copper ores is forbidden except on a case by case basis for limited periods of time. No copper mine in Alaska could possibly be developed and put into production for the Japanese market so long as the mine had only an indefinite exception to the export embargo.

It is difficult to see the reason for excluding Alaskan ores from the geographically logical Japanese market. The common metals have a world wide market and any addition to that market makes metal from any source more readily available to the United States. If Japan is forbidden access to Alaskan copper she will buy from Canada, Peru, or any other nation copper that otherwise might have been sold in the United States.

Withdrawals of land from prospecting and mining continually threaten investors in the speculative business of mine finding. The current (apparently successful) effort by the U.S. Department of Agriculture to force Kennecott to abandon its newly developed Glacier Peak mine in the State of Washington chills exploration men everywhere.

Taxes on mining in Alaska are not onerous but some threats of taxation are disquieting.

Under State law a borough assessor could assess developed ore reserves as real property. Since reserves sufficient for many years of mine life must be developed before major mine plant expenditures can be justified, local taxes could be a deterrent to development.

Current threats of a substantial increase in the State's oil severance tax raise fears that gross production taxes, similar to the old Gross Gold Tax, may again be imposed on the mining industry. Gross production taxes deter the development of the larger, lower grade mines, and it is such mining development that contributes most to employment and business activity.

Seward Peninsula, Alaska

Eskil Anderson - June, 1968

For about one hundred years the western part of the United States and Southern British Columbia, from the Rocky Mountains west across the Interior Plateau and including the Coastal Ranges, has been one of the great producers of metallic minerals of the world. Until 1950 the corresponding part of the northern two thirds of British Columbia and the Yukon were considered to be of doubtful importance because of the almost total lack of production of anything but placer gold.

During the last fifteen years an aggressive campaign of mineral exploration, development and production has shown that the area from the Rockies to the Coast Ranges and from British Columbia's southern regions near the U. S. border, north through the Yukon to the Alaskan border, is a continuation of the intensively mineralized western portion of the United States and that just as many great ore deposits can be expected to occur in that region as in the already developed regions to the south.

The Brooks Range (Alaskan counterpart of the Rockies), the Interior Plateau, and the region corresponding to the Coastal Ranges, bend westward and disappear under the waters of the Arctic Ocean and the Bering Sea. The great wave of exploration stopped temporarily on the west side of Yukon territory at the Alaskan border awaiting adjustments in economic and political conditions. It will be resumed with the full expectation of continuing the spectacular discoveries of British Columbia and the Yukon. The same highly mineralized area continues westward, to end on the western tip of the North American continent in a burst of mineralization on Seward Peninsula.

Opposite the west end of Seward Peninsula and very close to U. S. territory opposite Nome, the Soviet Union on its western extension of the mineral bearing zone has not only mined placer gold for many years, but has already begun intensive development of gold, tin and mercury lodes near Bilibino on Chukotka Peninsula. A 48,000 kilowatt atomic power station is nearing completion at Bilibino. It is being built by the Soviets to supply power and fuel for development of these mines and for a modern apartment house city built to house the miner's families and their service and recreational facilities.

Seward Peninsula until now has been famous for its production of over 200 million dollars in placer gold, measured by the $35 price of 1967, from the large and famous beach deposits at Nome and from many smaller districts widely scattered over its 100 by 200 mile area. Future production of placer gold, at an increased price proportionate to increases in other prices, will almost certainly exceed past production from lower grade and larger deposits and from ancient channels more easily mined with new equipment and methods. The ultimate potential of offshore production of gold and other metals is not known but is being investigated under the heavy metals program of the U. S. Geological Survey and the U. S. Bureau of Mines, and by private companies. Offshore areas of Seward Peninsula appear to be among the best possibilities known for discovering commercial undersea placer beach and old stream channel deposits. Further off shore, the Bering Sea shelf is becoming recognized as a possible source of petroleum with the investigation of those possibilities just beginning.

The land areas of Seward Peninsula are composed mostly of metamorphosed Paleozoic Schists and limestones, and some gneissic rocks, cut by a great number of intrusives and in some areas by extrusives. A more favorable environment for metallic mineralization is difficult to find. The surface has been well prospected by gold miners who perhaps found the major areas of occurrence of other types of mineralization but could do no real exploration for lode deposits. A three month summer season, permafrost, a general cover of tundra and frost riven rubble and solifluction materials, and surprisingly thorough oxidation of sulfide deposits, combine to make old time methods of hand prospecting very difficult but do little more to hinder determined modern exploration programs than to increase first costs.

Of a substantial number of large gossans which may be the result of the weathering and oxidation of sulfide deposits, none have yet been diamond drilled deep enough to learn the nature or content of their primary mineralization. A warmer climate during part of the Pleistocene period and a level of the oceans about three hundred feet lower than the present level have contributed to the thorough oxidation of some deposits, but primary mineralization should be found not more than several hundred feet deep in most of them. Judged by modern standards of exploration for lode deposits, Seward Peninsula is unexplored. Major deposits of valuable minerals almost certainly lie undeveloped and unknown within that relatively small area and wait there to be recognized by strong companies with intelligent and aggressive exploration staffs.

Beginning at the western tip of Seward Peninsula, next to Siberia, and moving arbitrarily by quadrangles east towards the base of the peninsula, the more likely possibilities for major lode discoveries vary by regions.

In the Teller quadrangle tin, beryllium, tungsten, and fluorite are most well known and occur in veins, dikes, or as disseminations in limestone and other rocks. The tin and tungsten may also occur as placer deposits with gold. Sulfides containing silver, lead, zinc, antimony and bismuth are less prominent. Graphite, pegmatites, and radioactive and rare earth minerals occur in the Kigluaik Mountains and elsewhere. Offshore tin placers may be present. Placer gold mining opportunities still exist in the eastern and southern parts of the quadrangle and investigation for disseminated gold occurrences should not be neglected.

St. Lawrence Island quadrangle contains metallic mineral occurrences of which molybdenum and copper at the present seem to require some further investigation.

Shismaref quadrangle is almost completely tundra covered gravels and sands. Placer tin deposits could occur there.

The Nome quadrangle contains one of the fabled gold placer areas of the world. Rich unmined ancient channels, wide low grade placers, beach placers, offshore stream channels and beach deposits, and the possible discovery of wide zones of disseminated gold mineralization in bedrock are the most exciting probabilities. At a higher price for gold, production from some or all of these types of deposits is certain. Bordering the rich placer areas are gossans containing lead, zinc, copper, molybdenum and other metals sulfides; and in the Kigluaik Mountains pegmatites in gneisses, schists, and metamorphosed igneous rocks contain occurrences of valuable minerals.

The Kotzebue quadrangle includes a few miles of the north edge of the eastern part of Seward Peninsula. Most of this area is tundra covered sands and gravel. Near Deering and Candle, the latter east of the map area, limestones and schists extend to the Arctic Ocean in places. Onshore and offshore placer deposits of gold in the eastern part, and tin placers in the west, are a possibility. Offshore gold deposits are of great interest as far east as the Kiwalik River area.

The Bendeleben quadrangle contains the great placer districts of the Kougarok, the Inmachuk, and Kiwalik river basins. Each of these would produce substantial amounts of placer gold from known types of deposits at higher prices. In each there is the possibility of the discovery of the wide zones of disseminated lode gold mineralization necessary for open pit mining. Some deeply buried old channels will be mined and very large quantities of low grade gravels may become profitable with modern equipment.

At some distances from the richest known gold deposits there are ore deposits containing more substantial amounts of lead, silver, zinc and other sulfides than those known immediately within the gold districts themselves. Lead, silver, zinc sulfide replacement deposits in Paleozoic limestone occur near the head of the Inmachuk River and at Independence Creek on the Kugruk River. Both of these deposits could be of substantial size. Some gossans are known to occur between these deposits.

In the Darby Mountains, silver deposits in limestone with lead and zinc are known at the Omilak Mine, and larger lead deposits with silver occur on Dry Creek and elsewhere in that vicinity. Placer tin, mica, copper, manganese, radioactive minerals, and many other valuable metals or minerals also occur within the Bendeleben quadrangle.

Solomon quadrangle in the south central part of the peninsula also contains two famous placer gold regions, the Council district and the Solomon-Casadepaga district. At substantially higher gold prices there are areas left to be mined by placer methods, some new discoveries should be made, and offshore placers may become valuable. Again the heavy metals program of government agencies might be successful in outlining large tonnages of low grade gold bearing rock. Gold, silver, lead, copper, zinc, tungsten, mercury, radioactive minerals and others are known in lodes in different parts of this area.

Candle quadrangle covers most of the base of Seward Peninsula and continues eastward to include younger Cretaceous sedimentary rocks not now important from the standpoint of metallic mineralization. In the western third of the quadrangle streams in the Kiwalik River drainage near Candle have been mined for their rich placer gold deposits since about 1900.

Schists and limestones form most of the bedrock in that area. In these placers many other valuable metallic minerals have been found in concentrates or in small veins cutting exposed bedrock. Kyanite has long been known at Gold Run Creek in the southern part of the placer area. The possibility of finding substantial tonnages of gold or other valuable ores in bedrock seems to be as great as that in the other districts. Rolling hills, permafrost and no outcrops made that search difficult for the prospector.

In the southwest part of the quadrangle the gold and platinum placer region near Dime Creek has been mined for many years. High prices for gold and platinum should make some parts of this region suitable for mining again. Exploration has been done mainly by small placer mining companies working deposits in the area. Chromite, valuable sulphides, tungsten, and radioactive minerals also occur. No large or rich deposits of these have been reported. The district has been remote and is little prospected.

SUMMARY

Seward Peninsula contains most known valuable metallic minerals, and many important non-metallic minerals, some in rich deposits. Exploration has been for placer gold. Valuable discoveries of both placer and lode deposits on the peninsula are to be expected. Offshore possibilities could be very great. Higher prices and a lowering of some costs will trigger exploration and result in discovery, development, and revival of mining as a profitable industry.

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Part II - Inventory of Petroleum Resources - Northern Alaska

by

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The first part of this statement in the NORTH Commission Report was written as the early reports were coming into Fairbanks about the oil discovery at Prudhoe Bay. There have been one and one-half years of intense petroleum industry activity in northern Alaska since then so that considerable updating is possible for this second printing. The updating consists of:

(1) a report on the changes in leasehold interests in the varous areas of petroleum potential in northern Alaska,

(2) a review of test-well drilling and the results thereof, including a discussion of technological advancements in dealing with the Arctic physical environment, and

(3) an analysis of the economic implications of what has happened.

CHANGES IN LEASEHOLD INTERESTS OF POTENTIAL PETROLEUM AREAS

A. Noncompetitive leases

There has been a freeze on the issuance of Federal oil and gas leases in all of Alaska since November 1966. The Bureau of Land Management did continue to accept lease applications on noncompetitive lands until January 17, 1969. More than 11,000 such applications for oil and gas were filed with the BLM in Fairbanks from the time of the first indications of the discovery at Prudhoe Bay until January 1969, a period of about 8 months. Almost all of these applications were for the legal maximum size of 2560 acres, so there are pending, lease applications covering almost 30 million acres in northern Alaska. Unless otherwise required by law, all these applications for leases will be given consideration for issuance beginning at 12 o'clock(noon) A.S.T. on April 2, 1971 as per PLO 4582.

All the applicants for such Federal noncompetitive leases may not be successful, however. The State of Alaska, pursuant to the Statehood Act, may select for State ownership any or all of the lands covered by these lease applications as Alaska still retains the right to select almost 100 million acres of Federal lands not under existing Federal mineral lease. The State may designate any lands so selected as open for competitive leasing whereupon the noncompetitive lease applications for such lands would be rejected. Except for lands specifically designated by the State for competitive sale, the State would, under present laws, recognize the noncompetitive lease applications that had been filed prior to

State selection and would issue valid leases.

Virtually every acre of available land in the area north of the front of the Brooks Range in northern Alaska, exclusive of the National Wildlife Refuge and Naval Petroleum Reserve No. 4 which are closed to leasing, are either under existing Federal mineral lease or applications to lease have been filed. Oil companies of all sizes and numerous private individuals have filed applications to lease, and many of these applications, although not yet matured to valid leases, have been sold, traded, or optioned as part of an international attempt to get some representation in northern Alaska, no matter how great the distance from the Prudhoe Bay discovery.

Not all the applications will mature to leases. The State of Alaska has indicated it will select for State ownership some 3 million acres of Federal lands just south of Prudhoe, and that when the selection is approved by the Federal government, the State intends to class the land as available for competitive leasing. Of the 3 million acres selected, more than 75% is under existing Federal mineral lease so there will only be a change in landlord until the present leases expire. There are, however, about 140 applications to lease filed on vacant lands (about 400,000 acres), and the applications will lose any status they might have had. Most of these applications have been purchased from the holders by oil companies, and most of the purchasing oil companies are either Canadian or French.

After the proposed selection and classification set forth above, the State will have about 5 million acres of competitive lands not already leased on the north slope.

The filing of applications for Federal noncompetitive leases has not been limited to the north slope area. In the Selawik Basin, about 100,000 acres are covered by applications which have been filed with the BLM. There are no issued oil and gas leases in either of these areas and company activity is limited to geological reconnaissance work.

B. Competitive Leases

The State of Alaska conducted its 23rd Competitive sale in September 1969 and this was the first sale in northern Alaska since the Prudhoe discovery. A number of important results from the sale follow:

(1) 164 tracts out of the 179 that were available were leased and a total of 412,548.47 acres were leased. The State at this time has about 3/4 million additional acres of competitive lands available for leasing in the general Prudhoe area.

(2) a total of just over $900 million in bonus bids was accepted by the State, and the average price per acre sold was just under $2200. The highest bid per acre was over $28,000 for tract #57.

(3) Many large companies were involved in the bidding, and the companies joined together in many different combinations. As a general trend in the bidding, the

companies that already had large acreage positions in northern Alaska did not add significantly to their holdings, but new companies, singly and in partnership bid very aggressively and are now also major acreage holders in the area. This means the subsequent production will be more broadly based than if just ARCO, BP and Humble were the major producers.

(4) The winning bids on most of the tracts were appreciably higher than the second-place bids on the respective tracts. More than $400 million dollars was the difference between the total winning bids and the total second-place bids which indicates the newcomers were very eager to obtain the acreage being offered.

(5) Two big producers of Middle East Oil paid almost $100 million in bonuses for the right to explore six tracts that can only be ranked as wildcats as there is no drilling information within 6 miles.

(6) Sen. William Proxmire has asked the U. S. Justice Department to investigate the oil company bidding activity on this as well as other competitive oil and gas lease sales. He states the joint ventures in bidding by some of the wealthiest and largest corporations in the nation violated anti-trust laws covering restraint of trade and competition.

SYNOPSIS OF TEST-WELL DRILLING AND TECHNOLOGICAL ADVANCES

There have been 52 test-wells drilled in northern Alaska since the discovery well at Prudhoe Bay and the confirmation well at Sag River State No. 1. Of this new drilling during the last 16 months, 42 test-wells were drilled on State of Alaska competitive leases (T9N and north, UPM) and the remaining 10 were drilled on Federal noncompetitive leases to the south. The following has been reported:

(1) 23 test-wells have been completed as oil wells

(2) apparently there are at least six separate oil discoveries on the north slope to date which are:

a. Prudhoe Bay structure
b. NW Eileen State
c. Ugnu
d. Delta State
e. Pt. Storkerson-Kup River
f. Kavearak Point

(3) There has been one gas discovery distinct from the above and this is in the Kavik structure

(4) In the earlier part of this report, it was stated that the major discoveries would probably be made in the Lisburne Group of Mississippian to Permian age. Since that was written, ARCO has stated that the fantastic discoveries at Prudhoe were

primarily from the Permo-Triassic with secondary accumulations in the Lisburne. Subsequent discoveries also have been made in Cretaceous, Jurassic and Mississippian-Pennsylvanian strata in addition to three additional discoveries in the Permo-Triassic.

(5) 10 test-wells on the slope have been declared dry and abandoned of which 6 were in the vicinity of Prudhoe and 4 were far distant.

(6) There are now fairly good estimates that the total primary recoverable oil from the Prudhoe Bay structure will be about 20 billion barrels. The total recoverable reserves of North America excluding any syncrude operations is about 60 billion barrels including Prudhoe oil. BP has been the only company to do any development-type drilling, and based on 8 wells, DeGolyer and McNaughton estimate BP acreage on the Prudhoe structure to contain 4.8 billion barrels of primary oil.

(7) The Prudhoe structure is a very broad northwest-southeast trending asymmetrical anticline with the more gradual limb on the south. There are secondary flexures on the limbs of the fold. The oil/water contact in the major structure is at about 9000 feet below the surface for Permo-Triassic production.

(8) There are some 23 on-shore drilling rigs on the north slope at the present and 6 to 10 more are expected in the near future. Drilling operations will continue on a year around basis in some areas, but major wildcatting will be limited to times when the tundra is frozen and mobility is not likely to injure the environment. Gravel pads have been constructed in some areas and wells are being drilled in all directions from these pads. Reservoir characteristics on the Prudhoe structure indicates a well spacing of 640 acres may be practical whereas State law requires 160 acre spacing.

(9) There is now less urgency to drill on the north slope than there was prior to the competitive sale when subsurface information was badly needed. The winter of 1970-1971 will probably be more active for drillers than the coming winter since detailed seismic work will probably be undertaken on the leaseholds just acquired in the competitive sale to determine the most desirable drilling locations. Also, it will be the middle of 1972 before the Trans Alaska Pipeline is ready to move its first oil.

(10) Summertime seismic operations were conducted for the first time in northern Alaska through the utilization of helicopters and hovercraft. There also was a limited amount of summertime rig moving by Sikorsky Skycrane helicopters. There also has been some experimentation of rig moving through the use of hovercraft.

(11) Tests for moving oil from northern Alaska via tanker to the eastern coast of the U. S. have now been completed and are shown to be operationally feasible. The major question yet to be answered is whether it will be economically feasible. The Manhattan tests have shown that much larger and more powerful tankers are necessary, that larger and more powerful ice breakers are required at strategic locations, and that there is a need for improved ice reconnaissance. Ice flows encountered averaged 4 feet to 7 feet thick with pressure ridges up to 70 feet thick. The distance from Prudhoe to the east coast of the U. S. is 4500 miles, and from Prudhoe to Tokyo is 3400 miles. London is 4500 miles from Prudhoe. The round trip time for a tanker from New York to Prudhoe now is estimated at 35 days. Humble Oil which conducted the tests now states it will cost 90¢ per barrel to ship oil by tanker from Prudhoe to New York. The Manhattan cost $39 million to construct.

(12) The pipeline from Prudhoe will terminate at Valdez and will be 48 inches in diameter. The cost of construction is estimated at $900 million and the first oil should be moving south through the pipeline by the middle of 1972. The pipeline is to be built in 7 sections with 4 of these sections north of Fairbanks. There will be 5 initial pumping stations with the number eventually totalling 17. Most of the pipe will be buried, but 42 miles of the 800 mile pipeline will be above the ground. The pipeline initially will move about 500 thousand barrels of oil a day and ultimately will move about 1.5 million barrels per day. A second pipeline from Prudhoe already is being considered. Four leading oil companies have joined with two pipeline companies to determine the technological and economic feasibility of constructing a 48-inch diameter crude oil pipeline from the north slope of Alaska through the Yukon and Northwest Territories to Edmonton where the line would connect with the existing Interprovincial line and Transmountain Pipeline system which serve the Chicago area and Pacific Northwest, respectively. This second pipeline would be more than 1600 miles long and also would be capable of moving about 1.5 million barrels per day.

(13) Analysis of a representative sample of north slope crude oil indicates no major processing problems for refiners. The oil is heavy, low in gasoline, and in the intermediate sulfur-content range containing slightly more than 1 percent sulfur.

ECONOMIC IMPLICATIONS OF NORTH SLOPE OIL

A U. S. Government task force on oil recently reported that northern Alaska crude oil could be delivered anywhere in the U. S., Japan, and northern Europe at prices that are competitive with foreign oil. On the surface, this statement is very encouraging for Alaskans as the State government can soon expect to receive a considerable amount of money every year from royalty payments and severance taxes from crude oil production. The southern U. S. is going to be consuming 6 million barrels of crude per day more than it can produce for itself by the year 1980. These six million barrels per day must come from Alaskan or foreign sources. Alaska has fantastic reserves in the Prudhoe structure alone, and if just 3 million BOPD come from Alaska it will mean a yearly income to the State government of about $300 million. The total operating budget for the State for fiscal 1969-70 is about $150 million.

Import restrictions on foreign oil are now being reviewed by the U. S. Congress and it seems a fact of economic life that in the next few years 90 percent of the oil consumed in this country will be coming from the western hemisphere with Canadian oil subjected to few if any restrictions. Alaska and Canada will be in strong competition for the U. S. marketplace.

The task force oil report states that Prudhoe Bay oil should cost about 36¢ per barrel at the wellhead, but this figure does not include leasehold acquisition or adequate royalty/severance tax payments and an official of ARCO maintains that the true cost of Prudhoe crude will be $1.26 per barrel at the wellhead. Canadian crude costs $1.27 at the wellhead and Venezuelan oil costs $1.50 per barrel f.o.b. a deep water port. One must add transportation costs to the Alaskan and Canadian crudes to determine the cost to the company at the marketplace and some examples follow:

(1) estimated tanker costs made after the Manhattan voyage are 90¢ per barrel for shipping Prudhoe crude to the east coast of the U. S. Persian crude shipped to our east coast in foreign tankers costs 50¢ per barrel to ship.

(2) estimated tanker costs for shipping Prudhoe to Japan are 65¢ per barrel. Shipping Persian oil to Japan costs 30¢ per barrel.

(3) Cost of shipping crude to the Chicago area from Prudhoe via pipeline is $1.45 per barrel.

(4) Shipping from Prudhoe to Valdez by pipeline, then tanker to Panama, pipeline across the Isthmus, and tanker to New York will cost $1.50 per barrel.

Considering the above factors, it is my interpretation that the speed with which Alaskan crude will be in demand on the U. S. and world-wide marketplace is related to several factors:

(1) The need for Alaskan crude in the southern U. S. will be governed by its cost. If there are no import restrictions on Canadian oil, then Alaskan oil will suffer

as it will cost more to get to market because:

a. Alaskan oil is farther from the market

b. The Jones Act prohibits the shipping of Alaskan crude via relatively low-cost foreign tankers

(2) The need for Alaskan crude in Japan and Europe will be governed by international political considerations. If the Middle East becomes more unstable, there will have to be a shift to Alaskan crude as the primary source of supply. Northernmost Canada is not yet ready to compete for either the Japanese or European market as the reserves have not as yet been uncovered. In international shipping, Alaska will suffer no shipping cost hardship because of the Jones Act.

REFERENCE LIST FOR GEOLOGIC MAP

Index of Rock Descriptions