PRELIMINARY REPORT

MINERAL RESOURCES OF NORTHERN ALASKA

MIRL Report #13

Submitted to the "North Commission"

by

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SUMMARY

PURPOSE

This report is a preliminary report by the Mineral Industry Research Laboratory to the NORTH committee on the subject of mineral resources in the region to be traversed by a proposed railroad.

STATUS

Literature surveys and interviews are in progress as well as evaluation of favorable areas. A brief overall picture of mineral occurrences in Alaska is included.

EFFECTS OF PRESENT RAILROAD

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. Extensive, though unexplored areas of low to medium grade phosphate rock occur.

Northwest 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. It contains an estimated 100 million tons of ore at 1.2% copper. 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 Hogatsa 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 known, 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.) WO₃ plus indicated ore at 0.60%

193,000 units of inferred ore at 0.5% WO₃ containing up to 1% tin.

130,000 units of inferred ore at 0.2% WO₃ and up to 0.4% tin.

**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, 37,500 tons of concentrate per year
- At 5,000 tons per day of 2.5% copper, 115,000 tons per year of concentrate
- At 10,000 tons per day of 1.5% copper, 160,000 tons per year of concentrate
- At 20,000 tons per day of 1% copper, 190,000 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.

**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

**AIRBORNE GEOPHYSICS**

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, and the additional cost of a combined survey is well justified.

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 the proposed route with an airborne magnetometer and plotted the results on
RECOMMENDATIONS

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 ($19,500,000) or roughly 2 million dollars per year. A suggested division of this investment is 14% for the Division of Mines and Minerals, 5% for airborne geophysics, and 1% for research. It is also suggested that the airborne geophysics be contracted to a private company, and the Division of Mines and Minerals administer this 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 major 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.

A further recommendation of this report is that the 50 million dollar five year program of the Federal Mineral Survey and Research for Alaska proposed by the U. S. Department of the Interior be instituted. Ground support of the airborne surveys would be done under this program.

CONSULTANTS REPORTS

Two reports, by E. N. Wolff (in consultation with others) and by Charles F. Herbert are included. It is hoped that more of these reports will be ob-
tained, since they represent private opinions, to some degree independent of published reports.
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INTRODUCTION

Purpose of present report

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 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 obtain cost estimates for airborne geophysics.

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

1. Review of the literature and interview of informed people to compile a listing of presently known ore bodies and prospects.

2. Have prominent geologists and engineers assess the geology and known mineralization for the purpose of outlining areas that they would choose for exploration.

3. Evaluation of the area based upon regional structures that are believed favorable to ore formation for the purpose of delineating areas favorable for exploration effort.

4. Evaluate the area utilizing statistical and computer techniques.

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

The original proposal stipulated that a preliminary report containing the opinions of prominent consultants would be prepared. This preliminary report is submitted to meet this requirement. Few of the consultants' reports have been received. This is due to a number of factors, but principally the short time available after the field season, made even shorter by the loss of time due to the Interior floods.
Status of the project

Literature surveys and interviews of informed people are currently in progress. No attempt is made to incorporate preliminary information concerning this phase of the project in this report, other than to give an overall picture of the resources of northern Alaska. A brief tabulation of the mineral claims along the route is given in Table 1; Figure 1 shows the location of these claims with respect to the proposed railway route. (Data supplied by the State of Alaska, Division of Mines and Minerals).

TABLE 1
CLAIM LOCATIONS ALONG PROPOSED RAILROAD ROUTE

| Location | Claims | Reference (USGS) | Type
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Work on categories 2, 3, and 4, page 1 is in progress. It may not be possible to complete category 4, Statistical Analysis of the region, due to the lack of geological knowledge of the area concerned. This possibility was noted in a supplementary statement accompanying the original proposal. A mineral economist has been added to the project.
FIGURE 1 - Mining claims along the proposed railroad route

MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

- ▲ Cold placer
- ■ Cold lode
- □ Gold, silver, platinum, copper lode
- ● Copper lode
- — Proposed Railroad Route
Some effects of the present railroad

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 becoming 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 had begun 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 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 the Yentna, Willow Creek, Kanai, Valdez Creek, Chistochina, Bonniefield, Hot Springs, Hughes, Innoko, Kantishna, Koyukuk, Marshal, Melozitna, Rampart, Ruby, and Tolovana. After the advent of roads and airplanes, the camps of Chandalar, Circle, Fortymile, Eagle, and Chisana were served. Fairbanks, and to a lesser extent, Nanana, became distribution centers for the
Some unrelated events increased the need for and the value of the railroad. Ten years after the completion of the road, the price of gold was advanced. At about the same time the newly developed bulldozers began to be used in placer mining, greatly increasing the number of creeks that could be mined with machinery. 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. 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

A standard system of names and definitions of mining regions in Alaska was 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 regions would be influenced by mineral developments along the proposed railroad route. These four mining regions are: Northern Alaska, Northwestern Alaska, Seward Peninsula, and the Yukon River.

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

Northern Alaska region: (U. S. Senate Comm. Print, 1964; Ransome, Kerns, 1954)

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 line on the east to and including the Kivalina and Wulik Rivers on the west.

Mineral resources for exploration and development in this mining 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 Prud Bay.

A medium-sized oil field at Umiat was discovered with an estimated reserve of 70 million barrels and a small oil field at Simpson with perhaps 12 million barrels reserve.

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.
FIGURE 2 - Mineral Fuels in the regions

MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

- Uranium and thorium
- Gas Field
- Oil Field
- Bituminous Coal
- Subbituminous Coal or Lignite
- Small area or isolated occurrence of unknown extent
- Proposed Railroad Route
FIGURE 3 - Iron and ferro-alloy metals in the regions

MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

- Iron
- Chromite
- Nickel
- Tungsten
- Tin
- Antimony
- Antimony with recorded production
- Proposed Railroad Route
FIGURE 4 - Gold, silver, and platinum in the regions

MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

- ▲ Gold-Silver lode
- ■ Platinum placer
- □ Gold placer
- - Proposed Railroad route
MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

FIGURE 5 - Base-metals in the regions
MINING Regions:
I. Northern Alaska
II. Northwestern Alaska
III. Seward Peninsula
IV. Yukon River

- Asbestos (jade)
- Phosphate Rock
- Mica
- Graphite
- Fluorite
- Proposed Railroad Route

FIGURE 6 - Key Industrial and Chemical Minerals in the regions
Extensive resources of predominantly low to medium grade (8 percent to 25 percent or more) phosphate rock occur in the central portion of the Arctic slope of Alaska in the Tligulpuk 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 metallic minerals have been reported from the Northern Alaska region. No production, and nothing more than cursory exploration has taken place. The Pirth River area, in the 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. 

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, Kugarok, Selawik, and Kauk Rivers.

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 copper deposits in the Ruby Creek area at the west end of the proposed route. This is the largest known Alaskan copper reserve containing more than 100 million tons of ore of greater than 1.2 percent copper (Min. Eng., 1961, p. 1353). After more than ten years of exploration and testing of this deposit, the Kennecott Copper Corporation has purchased the property and has established a division to plan for production. Access roads and camp facilities are built. Underground exploration is underway (Kennecott Ann. Rpt., 1966).

The Kobuk region that contains the deposit at Bornite is the scene of much prospecting and exploration for copper. Work has been underway over an east-west distance of more than 200 miles, including reconnaissance and actual drilling.

The Kobuk area is also known to contain other minerals besides copper.
These include iron ore, coal, asbestos, and jade. At the present time no evaluation of these can be made other than in very general qualitative terms.

**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.

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 about 600,000 ounces of gold having a value of about $17,000,000. The western end of the Hot Springs district contains considerable placer tin. Extensive drilling by the U. S. Bureau of Mines has outlined the extent of the placer tin, but estimates of reserves have not been made other than in tailing piles. These contain approximately 733,000 pounds of tin in 1,259,000 cu. yards of gravel with an average tenor of 0.58 lbs. per cu. yard. This figure gives some idea of the tenor of unmined portions.

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.

Much energy has been expended in trying to locate a lode source for the placer tin, so far with no success. Should lode tin of commercial grade be discovered, the district would take on new importance.
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.

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.

Between the Yukon and Koyukuk rivers, an area generally known as the Kokrine Hills and the Ray Mountains, is an area roughly 50 miles wide and 200 miles long in which very little prospecting has been done and no settlements exist. Reconnaissance geologic mapping to date indicates that the area is a favorable one to prospect. All production has come from the edges of the area, close to the Yukon and Koyukuk rivers.

An area on the central Koyukuk River, known as the lower Koyukuk or Hughes district, is centered near the town of Hughes. Two or three creeks produced several hundred thousand dollars in gold; there is no mining at present.

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 about $10,000,000. Because mining with machinery has not been as extensive there as elsewhere, reserves may be somewhat higher on a proportional basis, than in other districts. There has been a small production of antimony, all from small stringers.

The Chandalar district, west of the Koyukuk, was, until the advent of the airplane, the most isolated mining camp in Alaska. Production of placer gold has been perhaps 15,000 - 20,000 ounces or $500,000. Much larger reserves, almost entirely unprospected, probably exist. The Chandalar district also contains...
lode gold, some of which is comparatively high grade. At present there are proved reserves of $2,000,000 averaging $85 per ton, and an unknown amount of possible ore.

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 and Egavik Creek and their tributaries to the southeast.

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 chief placers, those at Nome, are mostly marine deposits, and although placer mining is almost shut down, there is much interest in offshore beach placers. It is probable that fair reserves of placer gold remain on the Seward Peninsula, although of lower grade than those that have been worked in the past.

The tin deposits on the Seward Peninsula represent probably the best known tin occurrences of North America, but known reserves are limited in size. Past production has been about 2000 tons of metal from placers and 350 tons from lode sources. It is reported that, from known occurrences this region might produce approximately 500 tons of tin per year for ten years or more at prices above $1.35 per lb. (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 2 million tons of 50% fluorite, most, if not all, of which could be economically recovered as a byproduct of tin mining. Indicated and inferred reserves of beryllium are estimated at about 2,000,000 short tons at 0.18 to 0.29% beryllium with additional
"large indicated and inferred resources containing 0.01 to 0.07% Be and up to 0.3% tin."

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 WO₃ plus indicated ore containing 0.60%. Lower grade reserves are 193,000 units of inferred ore at 0.5% WO₃ (containing up to 1% tin) and 130,000 units of inferred ore at 0.2% WO₃ 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 Bunker Hill Mining Co. of Kellogg, Idaho is drilling a group of claims in the northeast part of the Peninsula.

Silver could be expected as a byproduct, should a lead mine be developed. Deposits noted for their silver content alone are notably lacking.


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 future prospects. 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, base metals, mica, graphite, uranium, and coal.
POSSIBLE IMMEDIATE TONNAGES

Placer gold

It is apparent that placer gold mining has accounted in the past 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 require 1200 lbs. of fuel. Other requirements could boost the consumption to 1500 - 2000 lbs. per day. A placer mine, after the initial move to an area, could therefore require 80 - 100 tons of freight per season.

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

Bornite copper

Kannecott originally planned a 500 ton per day operation, producing ore containing 10% copper. This would have resulted in approximately 37,500 tons per year of concentrate. Now it appears as if the mine (if Kennecott decides to put the property into production) would probably produce at a capacity of 5000 tons per day at the start. Assuming that the grade would be 2.5% copper, 360 tons of concentrate per day would be produced. Yearly tonnage (320 days/year) would be 115,000 tons of concentrate. If after mining commenced, production was stepped up to 10,000 tons per day at 1.5% ore, it would yield about 160,000 tons of concentrate annually. If a mine could be operated at a rate of 20,000 tons per day of 1% ore, it would produce about 600 tons per day of concentrate. It should be understood that these are speculations based on published statements and known geologic conditions in the area. 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.
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:

<table>
<thead>
<tr>
<th></th>
<th>Low volatile coking coal</th>
<th>Medium volatile coking coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>2-4%</td>
<td>2-4%</td>
</tr>
<tr>
<td>Ash</td>
<td>5-6%</td>
<td>5-6%</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>16-19%</td>
<td>20-24%</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.8% max.</td>
<td>0.8% max.</td>
</tr>
<tr>
<td>Free swelling index</td>
<td>7-9%</td>
<td>7-9%</td>
</tr>
</tbody>
</table>

Little is known about the analyses of coals along or at the terminus of the railroad route. A recent analysis by Dr. Rao of the Mineral Industry Research Laboratory, however, indicates the presence of certain coals in the Kukpoweruk 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:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>1.60%</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Ash</td>
<td>2.54%</td>
<td>BTU</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>38.85%</td>
<td>Free swelling index</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>57.01%</td>
<td></td>
</tr>
</tbody>
</table>

The need for sub-bituminous, steaming coal will drop steadily. Until new uses for this coal is found it probably will not be brought south.

Gas and oil

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 bbls.

2. A small oil field at Simpson with perhaps 12,000,000 bbls. reserve
3. A prospective oil field at Fish Creek

4. A medium size gas field at Cubik with probably as much as 300 billion cu. ft. of reserve

5. A small gas field at Barrow, with 5 - 7 billion cu. ft. of reserve

6. Prospective gas fields at Mead and Square Lake.
COMPARATIVE LODE-METAL POTENTIAL IN ALASKA

(Map from Battelle Memorial Institute)

The Battelle Memorial Institute (1961) has prepared a map as a broad general guide to future transportation planning showing comparative lode-metal regions of the entire area covered in the study for the Alaska International Rail and Highway Commission. The Alaskan portion is shown on the accompanying map. This map was critically reviewed by a number of government and industry Geologists, but it is emphasized that it serves only as a broad indication of the relative promise of finding metals in the various areas.
Figure 7 - Comparative Lode-Metal Potential in Alaska
Need for Scientific Prospecting

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, geochemical and geophysical exploration techniques will be used increasingly to discover resources under the remaining ninety percent.

Professor Louis B. Schlichter 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 winning."

Roger E. 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 was 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 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 geophysics can do a great deal in delineating potentially important areas, and would an-
hance the mineral potential of Alaska.

**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 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.

Airborne geophysical methods may be classified as 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 Methods**

Magnetic instruments measure variations in the local geomagnetic field which are produced by differences in the intensity of magnetization in various rock formations. The magnetic method is a valuable tool therefore for regional geological mapping. Airborne readings are now generally reduced (corrected) by automatic data processing techniques. Corrected data are plotted on maps, and the maps are evaluated, often resulting in good "guesses" as to the regional geology of the area being flown. Ground geologic mapping programs are
greatly assisted when airborne magnetic maps are available.

Canada has published an enormous 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 Methods

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 conductive material. A variety of airborne electromagnetic systems are available, differing in the aircraft employed, frequencies, coil separations, flight height and so on.

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. This coupling is inductive; the induced voltage must therefore be in phase with the electromagnetic field and the current in the transmitting coil.

If conductive material is brought into the vicinity of the coil system it will introduce additional coupling between the coils. The additional voltage induced in the receiver coil produces components both in phase and quadrature (90° out of phase). Both of these components are used as the “detector” in many electromagnetic systems.

Graphite, pyrrhotite, pyrite, chalcopyrite, galena, and magnetite are good conductors of electricity, while hematite, zinc blende, brannite and chromite are almost insulators (Parasnis, 1966). Ores not directly suited to electromagnetic detection can be found with this method if suitable quantities of an accessory mineral having good electrical conductivity are contained in the deposit.

False anomalies may result due to graphite beds, faults, fractures in the bedrock, zones of crushed rock, fissures bearing conductive water, etc. These anomalies may, in some cases, have an indirect connection with ore deposits.
Depth penetration of 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 200-300 feet is more realistic.

The ultimate result of an airborne electromagnetic survey is, of course, the map, which provides “targets” for mineral exploration.

Radioactive Methods

Scintillation counters have been developed which differentiate counts due to radiation from different 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 well justified.

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 2. 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 airborne electromagnetic apparatus. However, they also supply auxiliary
<table>
<thead>
<tr>
<th>COMPANY</th>
<th>EM</th>
<th>SCINT.</th>
<th>PHOTOGRAPH</th>
<th>SPECTRAL PHOTOGRAPH</th>
<th>TYPE AIRCRAFT</th>
<th>INFORMATION NEEDED FOR COST EST.</th>
<th>COST PER LINE MILE</th>
<th>COST OF EQUIPMENT</th>
<th>TRAIN PERSONNEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartwright Areal Surveys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cessna Skynight Supercharged</td>
<td>Yes</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McPhar Geophysics Ltd.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Cessna 180</td>
<td>Yes</td>
<td>Yes</td>
<td>$25-$50</td>
<td>$30k to 180X</td>
</tr>
<tr>
<td>Geo-X Surveys Ltd.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Fixed wing Helicopter</td>
<td>Yes</td>
<td>$25-$50</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Aero Service (Litton Ind)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Varied</td>
<td>Yes</td>
<td>$8-$25</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Klyceptor Surveys Ltd.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Helicopter</td>
<td>$40 plus Aircraft Reduced 10% per 500 miles until $25</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Hunting Geology and Geophysics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Unable at Present time</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Lockwood Kessler and Bartlett, Inc.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Helicopter</td>
<td>Yes</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geo-Recon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterton Aeronautics &amp; Explorations Ltd.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$8-raw(73540) 405 mi. 10 mi. wide</td>
<td>$10-$20</td>
<td>Mag (25,000)</td>
<td></td>
</tr>
<tr>
<td>Seigel Associates Ltd.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Otter and Helicopter</td>
<td>Yes</td>
<td>$12(excess of 30k miles)</td>
<td>Mag (15000)</td>
<td></td>
</tr>
<tr>
<td>Heinrichs Geoseadexploration</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Cessna 411, C-45, Aero Commander, Cessna 206</td>
<td>$10-$20</td>
<td>Mag (25,000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 a single profile along the route, stating that two parallel lines are probably the minimum that should be considered. Heinrichs interjects the suggestion 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 this company's letter describes their suggestions and costs.

"On the first stage of the 405 miles referred to we would suggest a strip 10 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**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 10 miles wide and 405 miles long, 21 runs 1/2 mile apart, readings are each 528 feet. 8,505 lineal miles @ $8 per mile.</td>
<td>$68,000.00</td>
</tr>
<tr>
<td>Base and positioning expenses.</td>
<td>5,500.00</td>
</tr>
<tr>
<td>Total</td>
<td>$73,500.00</td>
</tr>
</tbody>
</table>

(In Canadian Funds)

"Readings supplied to your geologist on paper strips 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 8 miles to one inch can be used for this type of reconnaissance and our
"accuracy would be within \( \frac{1}{4} \) 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 readings 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 survey 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, mobilisation, 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 usually will 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 B.C., the Yukon and the Northwestern U.S. We have the only fully integrated computer data collecting, processing and interpretation airborne system available by contract to the mineral industry. Our technical advisory staff consists of 3 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-low altitudes (500') flight line ground control 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 crystal (6") 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 are interested in contracting airborne work, should any be initiated. These excerpts from Cartwright 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 the area's potential.
   b. Surveys to enhance existing geophysical knowledge of the area.
4. Type of terrain in the 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 combination of the above.
10. Flight height above terrain. The flight height being determined by the type of survey to be conducted (refer to 3.a, or b.).

"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. provide 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 balloons 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 $140 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 klystron 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 0.1). 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 aeronomagnetic 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 lump sum basis for a specified amount of survey.

Seigel Associates Ltd.

Excerpts from correspondence best explain services and costs of this company.

"Seigel 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 which 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 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 ¼ mile or at the very most ½ mile. This would comprise a survey of some 2,000,000 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, cost 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 enumerated 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
Each type of system has advantages and disadvantages for certain geophysical applications. Some are limited to use in 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 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 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 Cessna 411, C-45 and twin engine Aero Commanders.

Seigel Associates Ltd.

Seigel 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 do not include the price of the aircraft.
Known Geophysics

Many known and possible petroleum provinces of Alaska have been flown with airborne magnetometers. Figure 8 indicates such areas for which maps are available from the United States Geological Survey. Many of these maps are in open file reports, available for reading, and in some cases reproduction, at USGS offices.

Aero Service, a division of Litton Industries has flown areas along portions of the proposed railroad route (see Figure 9). Copies of these maps are available for purchase by mining companies.

Various airborne surveys and methods have been conducted in the state by private companies. Results of these surveys are, however, confidential.
LEGEND
Denotes Type of Report
(No. refers to specific report)

- Open File Report
- Geophysical Investigations Report
- Oil and Gas Map
- Proposed Railroad Route

SCALE
50 0 50 100 150 MILES
AEROMAGNETIC MAPS from AERO SERVICE

LEGEND

Survey Performed With

- Fluxgate Magnetometer
- Optically Pumped/Optically Monitored Magnetometer
- Proposed Railroad Route

SCALE

50 0 50 100 150
MILES

Figure 9 - Aeromagnetic Maps from Aero Service
SUMMARY AND RECOMMENDATIONS

This brief analysis of the mineral potential of northern Alaska points out that there are no known large reserves of untapped resources awaiting a railroad for development, other than the copper deposit at Bornite. Large numbers of mineral occurrences are however widely scattered throughout the State indicating a mineral potential of some magnitude. By 1963, Alaska had produced about 1½ billion dollars in minerals, or $2,600 per square mile, while the eleven western states had produced a value equivalent to $83,000 per square mile (Herbert, 1963). Alaska has an area half that of these states, and assuming a potential equal to theirs, should have produced approximately 48 billion dollars.

Assumptions based upon geographic dollar distributions are dangerous to use, but Alaska has a large enough area so that this comparison seems to indicate that the state is presently producing at a dollar rate far below its potential.

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 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.

Combined airborne geophysical surveys provide a valuable first broad re-
connaissance 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 Surinam (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 born electromagnetic survey totaling 3,100 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.

Currently, Canadian mining companies are spending an average of 4.6% of the value of minerals produced on exploration. In 1966 the state of Alaska derived $19,500,000 directly from mineral resources. It would seem reasonable, in a concentrated effort to catch up, that the State might invest at a rate twice as great as industry; ten percent of the 1966 income would be about $2,000,000.

A suggested distribution for this investment would be 4% for Division of Mines and Minerals activities, 5% for airborne geophysics and 1% for mineral research. 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 company, and State and Federal organizations.

It is also recommended that the $50 million 5 year program of Federal Mineral Survey and Research proposed by the U. S. Department of the Interior in its report to the Secretary, Department of the Army entitled, "Alaska Natural Resources and the Rampart Project," June 1967, be instituted. 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 modification of current 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."

Geologic mapping and field checking of geophysical anomalies, an essential part of any minerals program, would be done under the auspices of the above mentioned institute.
CONSULTANTS' REPORTS

General statement on mineral deposits along proposed railroad

Assuming that the railroad would go through the following areas: Dunbar-Rampart-Hot Springs-Tanana-Tozimoran-Kokrine Hills-Hughes district-Hog River-up Alatna River-down Kobuk to Bornite, the following might be expected. An extension to the Seward Peninsula would tap one of the large mineralized districts of Alaska.

Placer gold

Hot Springs and Rampart have produced perhaps 600,000 ounces - fair reserves.

The Tozimoran district has been a small producer but is worthy of prospecting.

The Kokrine Hills and Ray Mountains between the Yukon and the Koyukuk rivers is largely unprospected but geologic conditions are favorable.

The Hughes district is largely worked out but small reserves might be found.

The Hog River dredging probably will be finished before a railroad could help; might prolong its life.

The Zane Hills and Lockwood Hills are unprospected but favorable reports have been made.

The upper Kobuk near Bornite has several creeks that have produced.

Klary Creek (Kiana district) on the lower Kobuk has a small dredge.

Seward Peninsula is off the route but has reserves of placer gold.

Lode gold and silver

The Hot Springs and Rampart districts have small possibilities. Quartz Creek near Morelock Creek contains a lead-silver prospect with fair outlook.

No lode prospects are known along the route until the Bornite region is
reached. There are a few small scattered silver prospects between the Kobuk and Noatak rivers - chances are small for production.

Seward Peninsula contains seven mines that have produced lode gold or silver, and about 20 other prospects. Production has been low ($200,000) but may not be a good index of potential.

Copper

The Bornite occurrence is already known. There is a reported prospect in the Endicotts on the Alatna River which may prove to be extensive, but low grade.

Lead-zinc

The Quartz Creek deposit noted under silver has had considerable work done on it, but Seward Peninsula has more than 30 occurrences of lead-zinc-copper, some of which have had a small production.

The upper Koyukuk district, while not on the route, has some reported prospects.

Antimony, Bismuth, Mercury

The Seward Peninsula might develop a few small antimony producers, the upper Koyukuk perhaps one or two. There is one bismuth prospect near Nome.

Chances for mercury are small compared to the Kuskokwim.

Chromite-Cobalt-Nickel-Platinum

There are a few ultramafic areas on the route that would bear prospecting for these. However, the only reported prospects are for platinum around Haycock on Seward Peninsula.

Iron

There are two reported occurrences, one at Iron Mountain near Shungnak and one on Kotzebue Sound that little is known about and probably have little chance. There is what has been described as a gossan (rusty area) at Sinuk River on Seward Peninsula. The Japanese are reported to have looked at it; prospects unknown.
Tin
The biggest deposits are on NW Seward Peninsula, both lode and placer. Placer tin has been mined near Nome, and in the Hot Springs-Morelock Creek districts. Some work has been done to locate a lode source in the Tozimoran area but chances are unknown—probably slim.

Tungsten
A very small amount is reported on Seward Peninsula.

Industrial minerals
Limestone and quartzite are under investigation in the Rampart area which might become commercial if a dam is built.

Asbestos prospects are known in the Kobuk (Bornite) area which might become productive in a small way. Any of the serpentine areas along the route have the possibility of containing asbestos.

Jade is being produced in the Kobuk area today but by its nature, tonnage is small.

Mica is known at several places on Seward Peninsula. Little or no production to date.

Graphite occurs on Seward Peninsula. It is extensive but so far of too low a grade.

Fluorite occurs with the tin of the Seward Peninsula.
Phosphate occurs in large quantities on the Arctic Slope—more than 200 miles north of the proposed route.

Oil
So far, oil exploration along the route has turned up little. A railroad would undoubtedly stimulate oil exploration in parts of the Yukon and Koyukuk basins, but the chances of finding oil are difficult to assess. Side roads to the Arctic Slope might lower costs of exploration and production.

Coal
There are small isolated deposits of bituminous coal in the Kobuk valley that could be consumed locally. On the Arctic Slope, 200 miles north of the
Kobuk, there are 60 billion tons of lignite and sub-bituminous coal which constitute a tremendous reserve should markets arise.

It would seem that a railroad to Seward and Whittier could not do very much for Seward Peninsula areas near tidewater but that a road or railroad from Bornite to Seward Peninsula might open mineralized country to prospecting. It is also probable that along the entire route exploration of areas that do not now contain known mineral deposits would be stimulated.

Addendum to general statement on mineral deposits along proposed railroad

Phosphate rock has been sampled in northern Alaska in a very sketchy way over a wide geographic distribution, all the way across the Brooks Range from east to west. It would not be expected that this sampling would allow any estimate of reserves to be made. The best samples and thicknesses were found in the central part of the north flank of the range, at about 68.5° N. latitude and 152° W. longitude. Samples from farther west, north of the Noatak, were of low grade. Higher grade material was found in the eastern range. The material is similar to the rock from the phosphoria formation of the northwestern states.

Oil shale has also been found in many areas in the range. Yields as high as 125 gallons per ton are reported but this is unusual and comes from a material called tosmanite. Yields of 25-50 gallons per ton are more normal.

Further exploration for both of these commodities is needed, as well as for oil.
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 (1). 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 (2). 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 prospects 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.

(2) USGS Bulletin 631, pp.82-83
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 Koyokuk River (3). 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 but 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.

(3) USGS Bulletin 442, p.297
On the Alatna River, within the schist belt, copper sulfides were noted by the U. S. Geological Survey (4), 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 (5) and an estimated 1,000 men in the Koyokuk Valley (6). 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.

(4) USGS Bulletin 815, p.117
(5) ibid., p.321
(6) USGS Bulletin 442, p.258
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 peoples 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 (7).

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.

(7) Washington, D.C., January 10, 1966, address to American Mining Congress.
Mineral 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 of 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, 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 as 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.
REFERENCES

Aho, A. E., Exploration in Yukon with Special Reference to the Anvil-Vangorda District, reprinted from Western Miner, April, 1966


Hartman, R. R., Airborne Gamma Ray Spectrometry, Aero Service pamphlet, August, 1967


Heinrichs, W. E., Jr., Discovery Equals Search Plus Research, reprinted from Mining Congress Journal, September, 1966

Hurley, P. M., Airborne Magnetic Survey in Maine Speeds Search for Mineral Deposits, reprinted from Engineering and Mining Journal, August, 1949

Jensen, H., Aeromagnetic Survey helps find New Pennsylvania Iron Orebody, reprinted from Engineering and Mining Journal, August, 1951


Oil and Gas Journal, Biggest Magnetometer Survey spans 141,000 square miles, reprinted from the Oil and Gas Journal, August 19, 1963, for Aero Service Corporation


56
Rampart Project, Alaska, Market for Power and Effect of Project on Natural Resources, Prepared pursuant to March 14, 1962, agreement between the Secretary of the Interior and the Secretary of the Army, Vol.I, parts I-IV, 1965


Serverson, L., Quebec Cartier, Engineering and Mining Journal, Vol. 165, No. 9, Sept. 1964, p. 76-93

Smith, Phillip S., Past Lode-Gold Production from Alaska, USGS Bull. 917-c, 1938

Udall, S. L., Alaska Natural Resources and the Rampart Project, 1967


U. S. Senate Committee Print, Mineral and Water Resources of Alaska, Report prepared by the USGS in cooperation with State of Alaska Department of Natural Resources at the request of Senator Ernest Gruening of Alaska of the Committee on Interior and Insular Affairs, United States Senate, 1964