RESOURCE EVALUATION OF THE WESTERN BROOKS RANGE 17(d)(2) LANDS

By: Uldis Jansons, Alaska Field Operation Center
Anchorage, Alaska

Thomas C. Mowatt, Alaska Field Operation Center
Anchorage, Alaska

* Situation Report

UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES
John D. Morgan, Acting Director

ABSTRACT

The exploration history is reviewed for lands in the western Brooks Range which have been withdrawn from mineral entry since 1971 under section 17 (d)(2) of the Alaska Native Claims Settlement Act (ANCSA). Eight different base and precious mineral deposit types, or geological associations, are present or can be anticipated in the withdrawn lands. Exploration interest in this area from the late 1890's through the 1950's was oriented primarily toward placer gold. Extensive base metal exploration by two major mining groups ~~did~~ was started in this area ~~not start until~~ the 1950's and 1960's. This work led to the development of major copper and zinc-copper deposits in the area which ~~have been~~ is extensively explored and ~~are~~ still being actively [illegible]. A detail sampling of an area of lead-zinc-b[illegible] mineraliz[illegible] (the Red Dog prospect) by the Bureau of Mines in (d)(2) lands indicates that the zone is at least 9000 feet by 3500 feet wide. The geology from the known deposits extends into or across other areas of the withdrawn lands wh[illegible] evidence suggests that similar deposits may be present

An inventory of publicly and privately available information shows that at least 61 zones of reported mineralization are present in this area. Twenty-eight regions of mineralization containing 45 separate prospects were investigated on contract

for the Bureau of Mines. Of the 28 general areas investigated, 18 contain sedimentary rock hosted base metals, three are placer gold areas, three are areas of ultramafic rock with known chromite and one has associated platinum, four are mineralized granites and associated host rocks, and one is an area of reported lead-zinc float mineralization. One of the above areas contains both placer gold and lead-zinc mineralization.

The potential for non-metallic minerals was not investigated. Zones of minor uranium, asbestos, jade, oil shale, and barite are ~~reported~~ known to be present

Within the withdrawn lands are deposits with at least 13 commodities of national economic interest, ~~and~~ only two of these commodities are produced in sufficient quantity in the United States not to require imports.

Economic mining feasibility studies of four deposit types that may be anticipated in these (d)(2) lands show that with available ground transport several base metal deposits could be exploited now. Others are near economic, but require slight increase in ore grades and/or metal prices to be economically minable.

A review of the exploration costs for metal deposits in North America shows that expenditures of more than $15,000,000

over ten or more years may be required to find a mine. Only one company has spent this type of money in this area, and successfully found two zones of major mineral concentrations and several smaller zones, but none of these are mines.

TABLE OF CONTENTS

List of Figures

List of Tables

INTRODUCTION

This report summarizes briefly the results of various studies of the mineral resources and potential in selected lands in northwestern Alaska. The data in the final report are to be used in conjunction with other resource data to determine the best use of these public lands. The specific areas dealt with in this report cover the following four proposed classes of lands as defined under the Alaska Native Claims Settlement Act (ANCSA), Public Law 92-203:

1. Noatak National Arctic Range
2. Gates of the Arctic National Park
3. Selawik National Wildlife Refuge
4. Kobuk Valley National Monument

A three-phase program was undertaken to (1) compile a list of known mineral deposits and prospects within these lands and select the best for field follow-up; (2) sample, map, and evaluate as many of the best prospects as possible within the funds and time available; and (3) summarize the results of the field work and identify areas, on the basis of geologic inference, which would be the most promising for future exploration for selected mineral commodities.

Phases 1-3 of the program were contracted to a firm with experience in this area. This program was initiated in 1975 and consisted of library research in the early summer, followed by field work in 1975 and 1976 (a total of 76 field-days worked), plus data compilation and integration of new data with the previously compiled information.

Meanwhile, the Bureau of Mines undertook related projects including (1) search for and compilation of additional data on mineralized areas in these lands and (2) economic mining feasibility studies of deposits that are present or could be expected in the lands under consideration. The latter studies give some indication of the feasibility of economically mining certain types of deposits in this area. They also serve to indicate which parameters would be critical in making these deposits economically viable.

Mineral resource exploration in the western Brooks Range (d)(2) lands has been very limited, especially in the more remote areas. Hence, a realistic inventory of resources of the entire region is not possible with the data presently available. The rather meager information now on hand points out the need for more data on the geologic relationships and mineral resource potential of this vast and complex region. The information on hand

strongly suggest that this region contains a variety of mineral resources, perhaps in amounts and of types which would be quite significant to the nation's economy and way of life. Further exploration and evaluation may well demonstrate that deposits of such magnitude do not, indeed, exist within this region. However, with our present degree of knowledge, it would be decidedly premature to pursue a course which would not entail such further investigations. Of equal importance is the need for this further exploration work to be carried out extensively and intensively, employing the most sophisticated methods, concepts, and instruments, so that a truly valid, realistic assessment of the mineral resource potential may be obtained. A very minor portion of the entire region has received this degree of effort to date. The geologic data base currently available is quite inadequate to permit intelligent decisions regarding land use.

Exploration until the 1950's was largely limited to individual prospectors and small companies interested principally in placer gold. Modern exploration has since been carried out by a major mining company and an exploration syndicate.

The company's multiyear exploration effort through selected parts of the western Brooks Range, using regional

reconnaissance, geochemical sampling, and geological mapping resulted in the discovery of several large base metal deposits. These discoveries include large zones of high grade zinc-copper mineralization in the now so-called Ambler district. They represent some of the largest, high grade, undeveloped deposits of this type in the United States. These deposits are immediately outside the (d)(2) lands. The geological environments of these high grade deposits continue into the withdrawn lands, where recent geochemical work has indicated zones of anomalous concentrations of zinc, copper, and lead similar to those found associated with the massive zinc-copper sulfide deposits.

The results of the syndicate work in the western Brooks Range have not been available for review by Bureau of Mines, but it is known that exploration follow-up has located significant areas of copper, molybdenum, and tungsten mineralization.

In addition to the work by private industry, government surveys have been active periodically on a relatively limited basis in selected areas. The surveys by the federal groups have been regional in nature while the state survey has focused more directly on areas of known mineralization and their possible extensions.

A significant lead-zinc-barite occurrence was first sampled by U.S. Geological Survey personnel at the end of the 1968 field season following a chance helicopter landing to investigate one of several iron oxide stained zones in an area that had not been explored previously by any exploration group. This discovery, which has since become known as the "Red Dog" prospect, is located on (d)(2) lands.

Sampling of the Red Dog prospect in 1975 for the Bureau of Mines indicates that the mineralization extends over an area at least 9,000 feet by 3,500 feet. No data are available to determine the depth to which this surface mineralization continues. Consequently, realistic ore reserves can not be estimated, nor will they be elucidated until exploration in depth can be conducted.

Zones of iron oxide staining similar to that found at the Red Dog prospect are reported scattered throughout the DeLong Mountains. Exploration along the westward trends of these environments, in (d)(1) lands, has resulted in the discovery and staking of claims by major mining companies. The area is described by one such company as "potentially a 'world-class' zinc-lead and possibly copper district." The geologic environments of these indicated zones of mineralization apparently extend eastward across a considerable portion of the proposed Noatak National Arctic Range

and parts of the National Petroleum Reserve-Alaska (NPRA). Another deposit, reportedly similar to the Red Dog, has been found recently at Drenchwater Creek, approximately 120 miles to the northeast, in the National Petroleum Reserve-Alaska. Since the geologic setting appears to be continuous between these deposits, an effort should be made to explore the entire trend in detail for similar deposits.

These examples demonstrate that readily discernible significant deposits can still be found by chance in this region. It would seem logical that systematic detailed work by experienced mineral explorationists could locate other deposits throughout this area of similar geology. The possibility of regionally widespread extensive zones of zinc and lead mineralization is supported by recent discoveries in the Yukon Territory, in extensions of similar geology, some 800 miles to the east. The failure to discover mineral deposits between the western Brooks Range and the Yukon Territory may in large part be attributable to the favorable areas having been excluded from mineral exploration under existing NPRA and Arctic National Wildlife Refuge regulations.

MINERAL DEPOSIT TYPES IN WESTERN BROOKS RANGE

At least eight types of mineralization, or geologic associations, are presently known to occur on the western Brooks Range (d)(2) lands on the basis of geochemical sampling, prospect investigation, and by analogy with other major mineralized areas in the world. These deposit types are briefly described below:

1. Zinc-copper massive sulfide deposits in metamorphosed volcanic rocks, such as those found on nearby (d)(1) lands, may well be present on strike extensions of the rock units on (d)(2) lands. In addition to the geologic continuity, support for the possible presence of such deposits on (d)(2) lands is given by the presence of geochemical anomalies, some of which are very similar to those found with the known zinc-copper deposits on (d)(1) lands.

2. Anomalous lead-zinc-barite mineralization associated with sedimentary rocks, particularly cherts and carbonates, was sampled in 1968 by the U.S. Geological Survey and made public in 1970. More detailed surface sampling of these materials (the Red Dog prospect) by the U.S. Bureau of

Mines indicates that the mineralization is widespread, covering an area at least 9,000 feet by 3,500 feet, and contains mineral grades up to 20% lead and 42% zinc, but averages about 3% lead and 5% zinc. Private company exploration of similar color anomaly targets on (d)(1) lands to the west of this prospect resulted from the 1975 Bureau of Mines press release of the data from the Red Dog prospect. Geological extensions of similar age and type of rock units continue to the east across northern Alaska and into Canada. In the geological extensions in northwestern Canada, numerous high grade and some very large deposits similar to the Red Dog have been found.

The number of deposits of this nature which may be present in northern Alaska cannot be evaluated or even estimated at present because areas of favorable geology have been withdrawn from mineral entry to professional exploration groups, and, hence, the data base is totally inadequate.

3. Elements of resource interest which are commonly found in association with mafic and ultramafic rock types include chromium, nickel, cobalt,

copper, and the platinum-palladium group. Some or all of these elements may well be present in economically significant concentrations in the rocks of this type which occur over extensive portions of the western Brooks Range. To date, no such economic concentrations have been discovered, but geochemical indications of anomalously high concentrations, together with several small occurrences of the appropriate type, suggest that the geologic environments are quite promising with respect to resource potential for signficant mineral deposits of this sort within the region.

Exploration for zones of concentration of economically important minerals in mafic and ultramafic rocks usually takes many years (especially for the platinum group), even if the overall geology is well defined. A case in point is a recent platinum exploration program in Montana, in an area where the overall geology had previously been well defined by work over a period of more than 30 years. It took another 6 years of detailed specific surface work before underground exploration sampling and development work could be undertaken. The result of these years of geological study and development work was the

successful location of an approximately 10 foot-thick band of rock bearing about one half ounce of platinum group elements per ton of rock. This 10 foot thick band of platinum bearing rock occurs within a 20,000 thick layered rock unit of known appropriate geologic environment. This represents an exploration target of about 0.0016% platinum in the 10 foot ore zone, which in turn represents a target zone of one two-thousands (1/2,000) of the entire rock unit. This entire rock unit, incidentally, had only been recognized as such, and further as a potential favorable platinum host, after extensive previous geologic study.

By comparison, potential chromium bearing ore horizons make easier exploration targets, because the chromium content must be of much higher grade (20%-40% Cr_2O_3) as well as considerably larger in volume, to represent an economic deposit. Float boulders with this grade of chromium mineralization have been reported in creek beds cutting ultramafic rock units in the western Brooks Range, suggesting that significant volumes may be found in bedrock. Similarly, minor but geochemically anomalous amounts of platinum have been discovered, associated with these rocks,

suggesting again that the bedrock may contain platinum bearing horizons.

These relationships remain to be investigated with any degree of thoroughness in this region, together with the possibilities regarding the other elements likely to be associated (i.e., nickel, cobalt, copper).

4. The Brooks Range granites, which are frequently very silicic, have not been explored systematically. However, where they have been sampled, geochemically highly anomalous zones as well as mineralized areas have been found featuring tin, tungsten, lead, zinc, copper, fluorine, molybdenum, and uranium minerals. Although the individual values found thus far are not, in themselves, of economic importance, they are highly significant as guides to indicate zones for further prospecting, as well as suggesting the types of deposits to be sought. For example, the tin values found in this area are similar to those peripheral to zones of active tin mining elsewhere in the world. Therefore, the tin potential of these granitic rocks in the western Brooks Range ought to be explored further. Similarly, the tungsten

values are geochemically anomalous in some areas where granites have intruded limestone. The "tactite" alteration zones that ~~were~~ have been found and investigated in the Brooks Range are as large as some of those found in the tungsten mining districts at Bishop, California and Cantung, N.W.T., Canada -- the two major primarily tungsten districts in North America. Only a very limited extent of the total contact length between granites and limestones has been explored where this mineralization is found in the Brooks Range. The total length of this contact zone is many (10's) of miles long at the Arrigetch pluton alone (several major plutons are known in the area) , but not more than several thousand feet of the contact has been prospected in detail -- and that was selected on the basis of widespaced regional geochemical sampling.

The extent of other types of mineralization associated with the several major granitic plutons which are exposed throughout an extensive portion of the study region remains to be ascertained. Further, geologic evidence indicates that hidden portions of these granitic plutons

underlie an additional, as yet undetermined portion of the entire region. This latter type of geologic environment is one in which it is quite likely that conditions conducive to the formation and deposition of ore-forming materials have existed during and subsequent to the formation of the granitic rocks. The closest analogy seems to be that of similar geologic settings and relationships throughout the entire Cordilleran region of North and South America, of which the Brooks Range is presumably the northernmost portion. A considerable proportion of the mineral resources upon which the national economy has been dependent has been (and still is) derived from the Cordilleran region in the United States. It would seem somewhat shortsighted to ignore the potential for similar circumstances in this region of similar geology in the Brooks Range of Alaska.

5. High grade sulfide (primarily copper) mineralization associated with sedimentary carbonate rocks (dolomite and limestone of the "Baird Group" and equivalents). The geologic relationships demonstrate that these rocks represent an ancient marine environment, much of which involved areas of

"carbonate build-up" (i.e., "reefs" and similar settings). The well known deposits at Ruby Creek ("Bornite"), on (d)(1) lands, may well be representative of a geologic setting not uncommon at the time, and one which was quite widespread geographically as well. Rocks of similar type, age, and depositional environments have been shown to occur across a considerable portion of the (d)(2) lands in the western Brooks Range. It might be logically inferred, by analogy with the Ruby Creek deposits, that similar geological environments elsewhere in the region might be associated with similar types of mineralization. Such has been found to be the case. Although little detailed work has been done, several other areas of mineralization of this type have been discovered within the (d)(2) lands. More thorough investigation of those portions of the region known to contain rocks of this association would be indicated. There do seem to be definite, predictable relationships which decidedly enhance the exploration potential for this type of mineral deposit within this region.

6. High grade gold associated with small quartz veins, some containing up to 2 and more ounces

of gold per ton, have been mined, principally in the Chandalar area, since the early 1900's. Here the quartz veins occur in schists and phyllites. The gold mineralization consists primarily of the native metal plus lesser amounts associated with sulfides and sulfarsenides, thus permitting the recovery of most of the gold with ~~relatively simple and~~ proven metallurgical procedures.

The best developed veins are approximately 200 feet long and these have been followed to depths of 200 feet, but the geology and mineralization appear to continue below this depth. The actual extent of these zones remains to be explored.

These high grade zones have been most actively mined in the Chandalar area, but regionally the vein gold mineralization is known to extend west to Wiseman and possibly into the western Brooks Range (d)(2) lands.

An economic mining feasibility study conducted on a hypothetical deposit of this type shows that a small high grade gold deposit, if located in the western Brooks Range, could be mined

profitably at a gold price of about $140/oz. -- approximately the price of gold at the present time.

7. The possibility of large low grade gold deposits in the western Brooks Range is suggested by results of analyses for the gold content of some samples collected by geologists of the State Survey.

These gold bearing rocks were collected on random traverses through areas where streams are known to contain fine grain placer gold, thus the gold in the rock samples probably represents the "mother lode" which is the source of the gold that is found in the creeks. Rocks from two areas contained approximately 0.1 oz. gold per ton of rock. These could be near ore grade in more southerly locations, if modern methods of gold leaching were to be used for extracting the precious metal. Given the superficial knowledge of the geology and the wide, non-systematic sampling, the areas where these gold bearing rock samples were taken are attractive target zones for further exploration. The mineralization appears to be disseminated within the rocks, rather than confined to structures such as

veins. This presents the possibility that large tonnages could be delineated for modern, low unit cost mining methods. The metallurgy for treating these types of ores has been proven at existing operations elsewhere.

The extent of the surface distribution of mineralized gold bearing rock can be delimited in part by identifying areas of previous placer mining. Several large, isolated, separate zones of past placer gold mining activity have been outlined in this area.

In addition to gold in bedrock, it is well known that in the Lower 48 states, many of the presently active base metal mining districts had their origins as placer gold districts. The gold serves as a geochemical guide or "halo" around the base metal deposits. In the western Brooks Range, gold is known to be present with the massive zinc-copper deposits in the Ambler district.

8. Placer gold prospecting was the major contributor leading to the exploration and settlement by the white man of many areas of the Alaskan interior.

The western Brooks Range was no exception to this common stage in the history of pioneering of the New World. Reliable reports show that placer gold mining was going on in the western Brooks Range as early as 1901. Rumored earlier activity has also been reported. The main exploration effort received its impetus from the Klondike discoveries in the Yukon Territory, Canada. Whatever the date of the first prospector coming to this area might have been, placer gold mining and small mining settlements were in existence long before any government survey personnel began investigations of these regions.

The placer mining has been intermittent and widespread since the main influx of prospectors in the early 1900's through today. Production from these deposits has been small, with the operations generally being one man or small partnerships. Equipment was small in comparison to the major dredging operations at Nome, Fairbanks, or the Klondike. The known placer deposits, though small, are frequently rich enough to provide employment and a satisfactory return to prospectors and others with an interest in the development of mineral resources. The major gold placer

operation in the western Brooks Range appears to have been at Klery Creek where small scale dredging operations continued intermittently in the 1940's, 1950's, and early 1960's. Other placer activities include operations at Lucky Six Creek, Ningoyak Creek, Nigikpalvgururvak Creek, and Salmon River.

As an aside, one of the main problems in exploring these areas, even as late as the 1940's, involved the transportation of equipment from the settlements to the areas of mineral discovery and attempted exploitation. In some cases, this was accomplished by the use of dogs, in teams of 40 or more. Drilling machinery and all support equipment reportedly was brought to the Salmon River by this method, where the equipment was subsequently reassembled for use.

INVENTORY OF KNOWN MINERALIZED AREAS IN THE WESTERN BROOKS RANGE

Mineral showings have been prospected for and staked in this area, and probably many more have been investigated but not staked in the vast land areas in the western Brooks Range presently being considered for permanent

withdrawal from mineral entry. The more recent activities have been recorded in the technical literature or other public documents. The results of much of the early work in this region were never recorded. These locations as well as their pertinent information have been lost with the passing of the prospector(s) involved. Similarly, many occurrences and deposits noted in the early work have not been relocatable since the initial discovery took place before adequate maps were available upon which to plot the deposits. Information regarding likely discoveries may exist in company data and files which have never been made public; little of this type of data has been made available for inclusion in the present summary.

An indication of the mineral resources in the Brooks Range region under consideration can be gleaned from publicly available data. Five sources that were readily available are:

(1) The Miscellaneous Field Studies Maps published by the U.S. Geological Survey. These compilations of the Metallic Mineral Resources Map show nine general areas of mineralization on the Western Brooks Range (d)(2) lands.

(2) The U.S. Bureau of Mines Open File Report 20-73, a compilation of publicly available data mainly the State of Alaska Kardex file and data on mineralized areas from personal knowledge and published reports - indicates that at least 57 separate zones of mineralization are present in the (d)(2) lands, including those located by 378 placer claims and 626 lode claims.

(3) A recent map by the Kennecott Copper Corporation, prepared using public and privately available data, shows 38 known zones of mineralization in the (d)(2) lands in the western Brooks Range. These 38 zones include one coal occurrence, 14 base metal occurrences, nine gold occurrences, and 14 placer (primarily gold) occurrences.

(4) More recent work for the U.S. Bureau of Mines (1975, 1976) compiled general zones of known or reported mineralizations. Several additional zones have been brought to the Bureau's attention since then. Evaluation of the actual ~~locate~~ number will be difficult and time-consuming, at best, because the early prospectors who made most of the original discoveries are now gone; more recently the region has been withdrawn from

prospecting, hence, no new knowledge will be forthcoming from continuing exploration/prospecting activities, as would otherwise be the normal sequence of events.

(5) Several new occurrences have been located by persons in government employ during the course of various other types of work.

RESULTS OF THE 1975-1976 BUREAU OF MINES WORK

The Bureau of Mines work in the western Brooks Range includes the contracted library, field, and compilation work, and in-house data gathering on both metallic and non-metallic deposits. The mineral economics work reviews the ~~possible types of mineral~~ present on the withdrawn lands commodities and their possible contribution to the national mineral ~~consumption~~ requirements. Economic mining feasibility studies show the potential of deposits that might be found in the western Brooks Range.

Metallic Mineral Resources

Twenty-eight general areas which contain 45 separate local zones of mineralization have been delineated. The following five tables (1-5) summarize the results of this investigation. Of the twenty-eight areas investigated:

(2) - Circled Numbers Correspond to Numbers of Mineral Sites in USGS OFR 77-168C Map

Table 1.- Mineralization associated with sedimentary host rocks

NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
1.(1) Red Dog (7)	T 31 N, R 18 W DeLong Quad (Mtns)	Zinc, lead, barite, and silver	Stratiform sedimentary (volcanogenic?)	5 types of mineralization recognized. Sed. rocks - cherts, shales, carbonates, tuffs. Mississippian-Permian-Triassic(?)	Mineralization is widespread, 9000'x3500'. Average about 3% Pb, 5% Zn, 1 oz Ag.
2. Color anomalies (3,4,5,6)	several DeLong Mtns. quad	- - - - - - - - - - - - - Potentially similar to Red Dog - - - - - - - - - - -			
3. Omar (3)	T 24 N, R 10 W Baird Mtns. quad	Copper	Fracture filling & breccia zones	High grade Cu veins in Paleozoic carbonate rocks	Possible manifestation of another Ruby Creek. Mineralization over 9000'x3500'
4. Frost (4)	T 24 N, R 9 W Baird Mtns. quad	Zinc, barite, lead	Stratiform? Syn-sedimentary	Paleozoic sedimentary rocks.	Mineralization found along at least 5000' strike length. Many geological fractures similar to Red Dog.
5 (17) Temby	T 25 N, R 4 W Baird Mtns. quad	Copper	Quartz veins with minor Cu sulfides	Paleozoic clastic rocks	1.5% Cu assay by USGS.
6 (15) Hub Mtn.	T 25 N, R 4 W Baird Mtns. quad	Copper	Quartz calcite vein with to 6" chalcopyrite & malachite	Paleozoic dolomite host	1.1% Cu & 0.35% Cu in two samples taken about 1000' apart, possibly on same structure
7. (14) Chevron	T 29 N, R 5 W Baird Mtns. quad	Copper	Quartz vein 100' long, 6' thick	Paleozoic clastic sediments	0.37% Cu
8. Salmon River	TP 26, 27 N R 5, 6 W Baird Mtns Quad	Copper, lead, and placer gold	Quartz vein float with copper	Paleozoic clastics	Two sample (float) analyses one 2%+ and about 0.8% Cu. Claims staked for Cu. One claim staked for Pb. Placer claims. Systematic placer sampling did not lead to any production. ~~7'x5'x2' quartz boulder assayed 0.48% Cu.~~

Table 1.- Mineralization associated with sedimentary host rocks, Continued

NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
9. Agashashok River (4)	T 26 N, Rs 11, 12 N Baird Mtns. quad	Copper	Quartz vein with chalcopyrite	Paleozoic carbonates with local graphitic phyllites	7'x5'x2' quartz boulder assayed 0.48%
10 (E) Kav Copper	T 28 N, R 9 E Ambler River quad	Copper	Quartz carbonate veinlets w/minor chalcopyrite, malachite, azurite, fracture filling.	Devonian carbonate and clastic sedimentary rocks	Minor 2"-4" small randomly distributed quartz carbonate veinlets
11 (1) Ningoyak Creek	T 28, 29 N Ts 10, 11, 12 W Ambler River quad	Copper, placer gold	Quartz veining w/ chalcopyrite and pyrite	Paleozoic clastics, phyllites	High grade 0.44% Cu. Main vein about 1', ~~flat~~ rest smaller. Limited areal distribution.
12. ~~Kaiagluk~~ Kutarlak Creek	T 23, 24 N R 12, 13 E	Zinc	Quartz vein with pyrite	Devonian sed. clastics and carbonates	Geochem only
13. Ipning River ~~8-20~~	T 24, 25 N, R 16 E Survey Pass quad	Copper, zinc, gold, molybdenum	Geochem high	Paleozoic seds. Skajit Formation. Pyritic graph.	High background(?)
14. Iyahuna Creek ~~8-21~~	T 24, 25 N, R 16 E Survey Pass quad	Zinc	Geochem high	Paleozoic seds. Skajit Formation. Pyritic graph	High background(?)
15. Mt. Papiok ~~8-23~~	T 25 N, R 17 E Survey Pass quad	Lead, zinc, molybdenum	Geochem highs	Devonian clastics and carbonates. Pyritic graph	High background(?)
16. Walker Lake ~~8-24~~	T 19,20, 21 N R 19, 20, 21 E Survey Pass quad	Zinc, copper, lead, gold, silver	Geochemical samples	Ambler Paleozoic schist belt rocks. Volcanics.	High, possibly widespread Au, on strike from massive zinc-copper sulfides.
17. Sheep Creek ~~8-27~~ Wiseman quad	T 32 N, R 20 W	Copper	Pods, lenses and conformable	Paleozoic carbonates	Highest value 5700 ppm in a rock sample.
18. Tobin Mtn. ~~8-28~~ Wiseman quad	T 33 N, R 18 W	Zinc	Geochem	Paleozoic carbonaceous clastic sediments w/variable amounts of pyrite.	Geochem only to date

Table 2.- Placer Gold Areas

	NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
1	Klery Creek	T 21 N, R 8 W Baird Mtns. quad	Gold	Placer		Also tungsten. Previous Au producer. Last operated 1960's.
2.	Salmon River		See #8 on Table 1			
3.	Nigikpaivaupurvak Creek	T 27 N, R 13 E Survey Pass quad	Gold	Placer		One man placer operation

Table 3.- Zones of mafic and ultramafic rocks

NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
1.22 Avan River	Ts 31-34 W, R 13-16 W DeLong & Misheguk Mtn. quads	Chromium, platinum	Mafic-ultramafic	Possibly layered intrusive but present consensus is that it's Alpine type, pending further study.	Potential also for Ni, Co, Cu
2.23 Misheguk Mtn.	T 33 N, Rs 10, 11 W Misheguk Mtn. quad	Chromium	Mafic-ultramafic	Possibly layered intrusive but present consensus is that it's Alpine type, pending further study.	Potential also for Ni, Co, Cu.
3.24 Maiyumerak Mtns.	Ts 27, 28 N, Rs 14-16 W Baird Mtns. quad	Chromium	Mafic-ultramafic	Possibly layered intrusive but present consensus is that it's Alpine type, pending further study.	Potential also for Ni, Co, Cu

Table 4.- Mineralized zones related to granitic intrusives

NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
1. Kaluich Area	T 25 N, R 3 E Ambler River quad	Lead, zinc, copper fluorine	Mineralized contact zone	Leucocratic granitoid body intruding Paleozoic siltstones and carbonates.	About 5 square mile area w/high Pb, Zn, Sn, F, Cu. (0.2% Pb over 100'x7') 1% Pb in a soil sample.
2. Shishaksninovik Pass	T 24 N, R 11 E Ambler River quad	Lead, zinc, molybdenum	Mineralized contact zone and intrusive	Granite intrudes clastic and carbonate Paleozoic sediments. Complex pluton, several granitic phases.	Float samples contain over 2% Zn and 1.6% Pb with about 3 oz Ag. Mo, W, Sn, U in stock itself.
3. Tupik Creek (Ikpikpak Pluton)	T 24 N, R 17 E Survey Pass quad	Lead, zinc	Skarn zone with geochemically high values.	Mineralized contact zone. Complex intrusive, several granitic phases.	To 7350 ppm Cu, 30 ppm (about 1 oz) Ag. Also Cu, Mo in skarn. Several zones of iron oxide staining along contact. Also Sn, W, in geochem values.
4. Arrigetch Peaks	Ts 23, 24 N. P 21, 22 E Survey Pass quad	Copper, zinc, tungsten	Tactite skarn zones	Granite in limestone contact. Complex pluton with several granitic phases.	One zone 450' long w/ 0.45% Cu, 0.2% Zn, w/minor W.

Table 5.- Other reported mineralization investigated

NAME	LOCATION	COMMODITY	TYPE	GEOLOGY	NOTES
1.29 Nantu[illegible] Mtn.	T 24 N, R 26 E Survey Pass quad	Zinc, silve[illegible]	Float	Paleozoic sediments (Sk[illegible]) at contact of granite. [illegible] quart[illegible] zones of [illegible] stain[illegible] from oxidized pyrite in sedi[illegible]	Source of mineralized float not found. Also high Mo & Au in rocks.

(1) 18 host base metal mineralization in sedimentary rocks; (2) three are placer gold areas; (3) three are areas of ultramafic rock - all of which have some chrome - one has a known associated platinum in a placer and all three have potential for copper, cobalt, and nickel mineralization; (4) four are partly mineralized granites and associated rocks; and (5) one area of reported lead-zinc mineralization, but no bedrock source, was also found. Mineralization in the Salmon River area includes placer gold ~~and~~ as well as lead, zinc copper and is thus listed twice in the above categories.

These 28 investigated areas are ~~only 28~~ 45 of 61 specific zones & reported mineralized that were identified for possible follow-up in 1975 and 1976. Since then, other specific areas have been brought to the Bureau's attention. Other more general areas of apparent interest for regional exploration have been identified by recent geological and geochemical field work by government agencies.

Non-metallic Mineral Resources

The amount of information that is available on non-metallic minerals in this region is considerably less than for the metallic minerals. In addition to uranium known to be associated with at least one of the granitic plutons, oil shales have been located at least at two sites, geologic projections suggest that one or more horizons of phosphate

deposits may cross onto (d)(2) lands from the NPRA along the north flank of the Brooks Range, and small jade mining operations exist in the Cosmos and Jade Hills on immediately adjacent (d)(1) lands. In the past, modest amounts of asbestiform minerals have been produced from this region during periods of compelling national need.

The barite associated with several of the metallic occurrences discussed previously remains to be fully evaluated as a resource of decided interest and potential, particularly in the context of present and likely future petroleum exploration and development activities in northern Alaska.

Neither the economic significance nor the possible relationship(s) to the national resource requirements can be inferred for any of these resources from the meager data on hand.

Mineral ~~Resources~~ Commodities

The mineral exploration and resource evaluation work in the western Brooks Range has been very superficial, but several types of base and precious metal mineralization have been outlined. Within these recognized zones, at least 13 specific commodities of potential national interest

are known to be present. The potential contribution to the national mineral requirements of these commodities will not be known until detailed exploration can be carried out. Analysis of the requirements for these commodities in terms of national consumption can be assessed, based on known annual national consumption, production, secondary recovery, and import requirements. Of the 13 commodities tabluated (table 6) only two -- copper and molybdenum -- are produced in sufficient quantity not to require imports to meet present national annual requirements. The annual domestic production of other commodities generally is much less than the annual domestic consumption. For some nationally critical commodities such as chrome, there is virtually no domestic production; in fact, in this instance Rhodesia and the U.S.S.R. are the primary world producers, which underscores the critical nature of this particular material in the national context.

Future requirements for metal commodities are projected to increase, and because of the high labor rates, together with decreasing areas remaining on public ground where exploration and mining can be undertaken at acceptable costs, we are forced to assume that the domestic production will lag, and that increased imports of metals will be needed to take up the gap between domestic requirements and domestic production.

Table 6.- U.S. 1976 commodity consumption, production, and source data*

	COMMODITY	CONSUMED	PRODUCED		IMPORTED	EXPORTED
			PRIMARY	SECONDARY		
1.	Barite 1/	1,830,000	1,129,000	-	750,000	47,000
2.	Chromium 1/	518,000	withheld	50,000	1,200,000	230,000
3.	Copper 1/	2,350,000	1,610,000	360,000	860,000	280,000
4.	Fluorite 1/	1,169,000	1,000,000	-	900,000	1,000
5.	Gold 2/	4,300,000	1,030,000	2,500,000	2,000,000	2,000,000
6.	Lead 1/	1,412,000	610,000	670,000	215,000	40,000
7.	Molybdenum 3/	57,000,000	113,000,000	-	2,100,000	63,000,000
8.	Platinum Group 2/	2,440,000	18,000	190,000	2,890,000	550,000
9.	Silver 2/	171,700,000	34,000,000	49,100,000	77,800,000	15,800,000
10.	Tin 4/	71,800	withheld	16,500	53,000	1,900
11.	Tungsten 3/	14,499,000	6,000,000	-	5,400,000	1,450,000
12.	Uranium 1/	10,700	12,600	none	2,800	2,200
13.	Zinc 1/	1,310,000	480,000	57,000	790,000	4,000

* data from "Commodity Data Summaries, 1977"

1/ short tons
2/ troy ounces
3/ pounds
4/ long tons

Economic Considerations Related to Mining | Cup

In an effort to determine the feasibility of developing economically some of the types of deposits which could be expected to be found in the western Brooks Range, preliminary financial analyses were made of four deposit types that have been found on or near the (d)(2) lands and which, on geologic grounds, also may be present on the (d)(2) lands. These are:

1. lead-zinc-barite deposits in sedimentary ~~[illegible]~~ environments;
2. high grade zinc-copper deposits in metamorphosed volcanic rocks;
3. high grade copper deposits in carbonate rocks; and
4. high grade gold vein deposits.

It was assumed that a surface rail transportation network would be made available by either a government agency, such as the Alaska Railroad, or other transportation company. Sufficient tonnages of metal sulfide concentrates apparently would not be generated by the known base metal deposits to recapture the capital costs for building this system. The operating and capital costs could be recovered if large coal deposits such as those on the North Slope of the Brooks Range were

brought into production. With such a main line system available, tie-in spur lines could be built to the metal mining operations. Some of the high grade zinc-copper deposits could be economically viable at today's metal prices if such a transportation system were presently available.

The postulated small underground high grade gold mine operations, while perhaps of limited national significance, give not only an indication of possible viability of small company operations in these remote areas, but they also provide some indication as to the possible economic viability of other small operations that may produce products of high unit value, such as uranium, tungsten, or other commodities. For the gold mine as proposed in the Bureau of Mines study, a price of near $140 per ounce would be required for a profit of 20% discounted cash flow rate of return on the investment.

This economic feasibility study did not evaluate small high grade prospects that can be operated by a few men, perhaps as working partnerships, etc.; these cannot be costed out by accepted standard methods. Their measure of success is that they can operate and provide enough return to satisfy those involved.

The derived price for major revenue contributing elements has been calculated for the existing operation for possible operating mine models in the Brooks Range, with the price of the lesser revenue-contributing metals fixed at existing prices at the time of the costing.

~~SOME~~ CONSIDERATIONS REGARDING MINERALS EXPLORATION IN WESTERN THE BROOKS RANGE

The approximately 19,200,000 acres in the western Brooks Range under the four proposed land classification schemes are highly varied in topography and physiography, as well as very complex geologically. Surface features vary from the muskegs and swamps of the Selawik Lowlands, to the broad open Noatak River Valley, to the rugged Arrigetch Peaks. In this region, exploration methods and costs will vary depending in large part on the various aspects of topography and geology. Mountainous areas are generally more successfully explored, partly because the rocks are more exposed, providing partial "cross sections" of some rock units, thus facilitating a three-dimensional view of some of the geologic relationships. The flat tundra and bog covered areas, where little or no bedrock is exposed and which may be covered by hundreds of feet of overburden, complicate exploration and thus increase costs.

The individual prospector was successful in finding the more obvious surface outcroppings of mineral deposits. Deposits below the surface without any surface leads can only be found by extensive detailed geological, geophysical, and geochemical work. To date (1976) only surface showings (and most likely not all of these) have been located in the Brooks Range. The era of sophisticated exploration has not yet arrived in this region, except for local follow-up on specific zones of known or projected surface mineralization.

Exploration costs vary widely depending on the terrain, target, methods selected, type of deposit sought, and geology. The ranges of exploration costs have been computed for regional, detailed reconnaissance, and specific targets, for various exploration systems, and compared on a per square mile basis.

The conventional prospector with limited financial resources may spend little money over an exploration season, and only cover a small area, and this in a crude fashion. The costs for sophisticated modern exploration vary from less than $0.10 per square mile for pre-field office compilations for large areas to much more than $1,000 per square mile for detailed ground geophysical surveys. The expenditures, however, guarantee no success

but are an indication of the amount of expense that might be incurred for an extended program in selected areas.

Statistics on the results of exploration success (economically minable deposits were found) have been compiled by various authors, and selected examples from these give an indication of the time and cost required to find some mines. These show that in Canada, for every 1,000 experienced prospecting teams that go out every year, only five significant discoveries are made, and not all of these turn out to be profitable. It can be shown that the probability that all five prospects are ore bodies is three in 10,000. In other words, from all of the various prospects the 1,000 experienced exploration teams look at, only five of these are worthy of follow-up, and the odds for all five of these being ore bodies is three in 10,000. ~~Alternatively~~, the probability of all five being failures is 32.77%, or nearly one out of three. If each prospect has only a 1% chance of being a success, 461 consecutive failures may have to be gone through to find one success. This has been interpreted, although somewhat subjectively, to indicate that for a particular company to find a profitable mine requires 10 to 15 years of exploration, and expenditures of $10,000,000 to $15,000,000. To date, only one exploration and mining company has spent this kind of money in the Brooks Range. The odds of

finding additional significant prospects in the Brooks Range are very good because the region is virtually unexplored by modern methods. For economic reasons, of the prospects that have been found in the Brooks Range, none are yet mines although some might well have been, given more favorable circumstances and location.

A summary of possible costs attendant to successful exploration for either a Red Dog or Arctic Camp type deposit in the Brooks Range can be estimated (using 1964 costs) by updating published estimates. Three phases or proposed lengths of time required are shown below.

Type	Regional Appraisal	One Detailed Reconnaissance	Investigation of Target Area up to Development
Time	1-12 months	6-24 months	30-60 months
Costs	to $500,000	to $1,500,000	to $3,000,000 (without purchase)

This table is shown in 1964 dollars. The prospects considered therein were not in as remote a location as the Brooks Range, suggesting that the final derived cost in

this table could reasonably be increased by 20% or more to account for logistics and other costs. To date (1976), published information shows that in excess of $10,000,000 has been spent in the Ruby Creek area alone of the Brooks Range. This expenditure has resulted in a considerably clearer understanding of the geology and mineralization in this relatively restricted area, and in that context, ought to be construed as "money well spent", but it must be emphasized that no production of ore has taken place to date and, hence, no more tangible return on this investment has yet occurred.

Some other actual case history examples might also be cited. For example, the exploration in northern Manitoba, where the geology was not well known, leading to the discovery of the Thompson ore body (a major nickel mine on the world scale) was started in 1946, and the ore body was first drilled in 1956, some 10 years later. The total costs when sufficient drilling had proven sufficient ore to be present to justify going to production amounted to $10,000,000 (in 1956 dollars). Another example in a much less remote area in the United States, in an area where the regional geology was well known from many previous years of mapping, shows that from 1953 to 1964, $10,000,000 was spent for geologic investigations, exploration, and land acquisition in Missouri, leading to the discovery of a major mine.

A more recent cost example comes from Wisconsin, in a geologic setting in which ore had been found previously at a nearby location. Exploration started in 1970. Twenty-four blank prospects were drilled before copper and zinc mineralization was encountered in the 25th, in May of 1976. The exploration of the first 24 targets cost $2,000,000. This gives some indication of not only the time, but also the cost incurred in finding deposits in areas of relatively easy access and well known geology as compared to the areas of the Brooks Range under consideration, where only gross features of the geology are known, access is poor, and the field season for exploration also is limited.

These high costs need not be discouraging because with a great deal of good fortune, it is, of course, possible to find a significant deposit at lower cost. The above examples, however, are from companies looking for a specific commodity and size of deposit. In the course of looking for these large deposits, numerous small deposits, probably non-economic under the financial requirements of that particular company have also been found. These high costs, as presented here, are those for finding "significant" (on the national scale) mining operations.