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DEPARTMENT OF ENERGY, MINES AND RESOURCES

Geological Survey of Canada

EVALUATION OF THE REGIONAL MINERAL POTENTIAL
(NON-HYDROCARBON)
OF THE WESTERN ARCTIC REGION

Economic Geology Subdivision
Regional and Economic Geology Division

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GEOLOGICAL SURVEY OF CANADA

OPEN FILE REPORT 492

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(A report prepared for the Committee for Original Peoples' Entitlement on behalf of Inuvialuit Nunangat, the native people of the western Canadian Arctic)

Preface

In connection with land claim negotiations on behalf of the Inuvialuit Nunangat, the native people of the western Canadian Arctic, the Committee for Original Peoples' Entitlement (COPE), requested that the Department of Energy, Mines and Resources provide it with an evaluation of the mineral potential of the region to which the Inuvialuit claim land rights. This region extends from longitude 110°W to longitude 141°W and its irregularly-shaped southern boundary lies mainly between latitudes 68°N and 69°N.

The task of preparing the non-hydrocarbon part of the appraisal was assigned to the Economic Geology Subdivision of the Geological Survey. A consultant retained by COPE met with members of the Economic Geology Subdivision on 19 May, 1977 to explain the nature of the request and provide a map delineating the boundaries of the area concerned. To meet schedules for initial use of the report, the Geological Survey requested the Subdivision to complete it by 3 June, 1977.

The report considers 17 commodities ranging from base metals to aggregate (construction) materials, with principal attention devoted to lead and zinc. Small-scale maps illustrate the distribution of mineral occurrences and outline areas that are considered to be relatively favourable, in comparison with the rest of the region, for the occurrence of lead, zinc, copper and uranium.

In this large region mineral discoveries are sparse and geological information is generally at only a reconnaissance level. Because of these factors, and because of the short time available in which to make the evaluations, this report can only be considered a preliminary qualitative assessment of this Arctic region.

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INTRODUCTION

by G.B. Leech

This report on the potential of the Western Arctic Region to contain non-hydrocarbon mineral commodities is best read with an understanding of the general premises of mineral resource appraisal.

Evaluation of potential for undiscovered mineral resources is basically a process of considering the geology of the study area in the light of a world-wide data base of information about the nature and occurrence of mineral deposits. The confidence that can be placed in the evaluation is closely tied to the quality of the information available on the study area.

Most mineral commodities occur in more than one type of deposit, some of which contain a mixture of commodities. Most deposit types occur characteristically in particular geological environments and have characteristic relationships to their host rocks. Therefore the process of evaluating the mineral potential of an area involves analyzing the geological information in terms of the presence or absence of the geological features believed favourable to the existence of each major deposit type in turn.

The two main sources of geological information are geological mapping and the results of prior mineral exploration. The fact that a geological map or report is available for a region does not necessarily mean that the information required for mineral resource evaluation is available, because, especially in reconnaissance mapping of the type done in the Arctic, inconspicuous details that are important from the mineral point of view may not have been recorded. Because mineral deposits are almost always smaller in size than hydrocarbon "pools", the detail of information required is accordingly greater. The second source of information, exploration for metals, is relatively sparse in the Western Arctic.

The more sparse the information the more the dependence on the personal judgments of those called upon to make evaluations. The geologists of the Economic Geology Subdivision of the Geological Survey of Canada have each had several years' experience in their commodity specialties but the reader of this report should bear in mind that the evaluation for each commodity discussed in this report essentially represents only one geologist's opinion.

Evaluations such as this can only be qualitative, not quantitative, and are subject to improvement as new information becomes available.

GEOLOGICAL FRAMEWORK OF THE WESTERN ARCTIC REGION

by D.F. Sangster

The study region includes two main areas, the Arctic Islands and the northern fringe of the continental mainland. Within these areas, four main geological provinces have been recognized. (Fig. 1). The known mineral occurrences in the Western Arctic region are shown on Fig. 2.

1. Central Stable Region

In terms of land mass, by far the largest part of the Western Arctic Region is underlain by the Central Stable Region, which can be further divided into two portions; the central Precambrian core and the Interior Platform. The central Precambrian core comprises the Minto Inlier or Arch on Victoria Island, the Brock Inlier on the mainland, and the Cape Lambton Inlier on southern Banks Island. The Precambrian core (central portion) is flanked by strata of the northern part of the Interior Platform of western Canada.

Rocks of the Minto Inlier (Arch) are mainly limestone, sandstone, siltstone, shale and gypsum-anhydrite. These sedimentary rocks are overlain by volcanic rocks consisting primarily of basalt flows and pyroclastics. The Precambrian rocks, particularly the sediments, are intruded by gabbroic sills and dykes that are also presumed to be of Precambrian age. Similar Precambrian sediments occur in the Brock Inlier and are also intruded by gabbroic sills and dykes. Volcanic rocks are, however, apparently absent in Brock Inlier.

The Interior Platform of the Central Stable Region consists mainly of undisturbed Paleozoic sedimentary rocks; younger (Mesozoic) rocks are preserved only on the western margin. The Paleozoic strata flanking the Minto and Brock Inliers range in age from Cambrian to Devonian. Cambrian basal sandstone occurs along the fringes of these Inliers; however, its thickness is variable and it is discontinuous due to deposition on a surface of local relief. The sandstone is overlain by Ordovician and Silurian dolomite and limestone. These

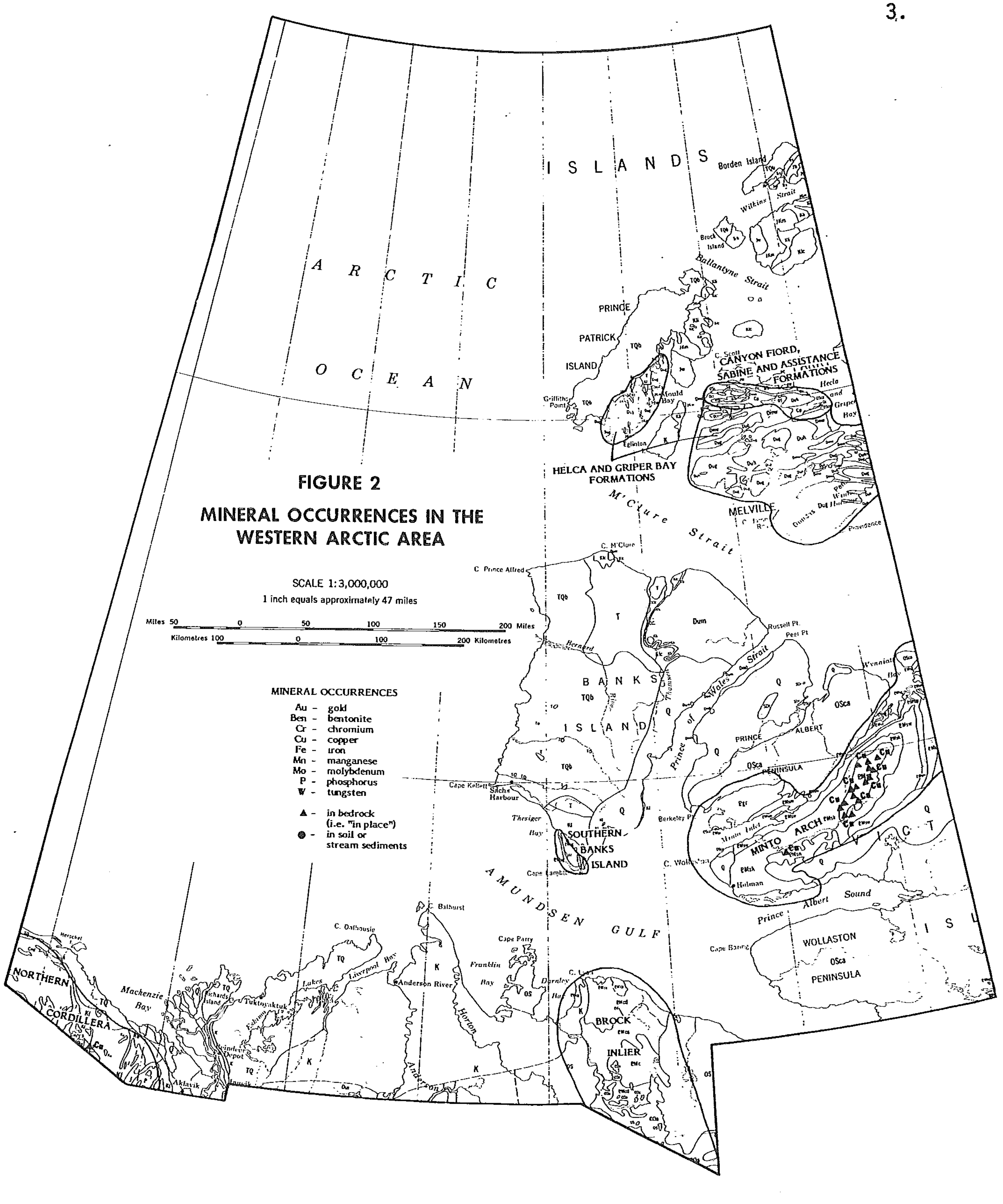
FIGURE 2
MINERAL OCCURRENCES IN THE WESTERN ARCTIC AREA
SCALE 1:3,000,000
1 inch equals approximately 47 miles
Miles 50 0 50 100 150 200 Miles
Kilometres 100 0 100 200 Kilometres
MINERAL OCCURRENCES
Au - gold
Ben - bentonite
Cr - chromium
Cu - copper
Fe - iron
Mn - manganese
Mo - molybdenum
P - phosphorus
W - tungsten
▲ - in bedrock (i.e. "in place")
● - in soil or stream sediments
ARCTIC OCEAN
ISLANDS
Borden Island
Wilkins Strait
Brock Island
Ballantyne Strait
PRINCE PATRICK ISLAND
CANYON FIORD, SABINE AND ASSISTANCE FORMATIONS
Mould Bay
Griffiths Point
Eglinton
HELCA AND GRIPER BAY FORMATIONS
M'Clure Strait
MELVILLE
C. M'Clure
C. Prince Alfred
BANKS ISLAND
Russell Pt.
Peel Pt
Prince of Wales Strait
PRINCE ALBERT PENINSULA
Cape Kellett
Sachs Harbour
Thesiger Bay
SOUTHERN BANKS ISLAND
Berkeley Pt
MINTO ARCH
Holman
Prince Albert Sound
AMUNDSEN GULF
C. Bathurst
C. Dalhousie
Cape Parry
Franklin Bay
Darnley Bay
WOLLASTON PENINSULA
NORTHERN CORDILLERA
Herschel
Mackenzie Bay
Tuktoyaktuk
Liverpool Bay
Anderson River
Horton
BROCK INLIER
Aklavik

units, in turn, are overlain by middle Devonian carbonates and Upper Devonian siltstones, sandstones and shales.

Mesozoic rocks consist of a few hundred feet of Lower Cretaceous non-marine sandstones, locally containing minor coal seams, overlain by a greater thickness of marine shales. Cenozoic rocks in the Central Stable Region are represented by a predominantly non-marine sequence of sandstones, siltstones and shales, again containing local coal beds.

2. Innuitian Orogen Region

Lower to Middle Paleozoic carbonates and shales dominate the southeastern portion of this region. Parts of the Middle and Upper Devonian sequence consist of non-marine clastics and mayrepresent a deltaic progradation in this area. These rocks are overlain with marked unconformity by mainly non-marine red sandstones and conglomerates of Pennsylvanian age deposited in relatively small basins that were partly or intermittently isolated. Disconformably or unconformably overlying the Pennsylvanian strata, the Permain is represented by marine sandstone, limestone and evaporites (gypsum, anhydrite). Mesozoic rocks of the Innuitian Orogen Region consist of marine and non-marine sand, sandstone and shale. Parts of the Lower Cretaceous sandstones contain coal.

3. Arctic Coastal Plain

The Arctic Coastal Plain is a narrow strip of land of low relief that borders the Western Arctic Region (mainland and islands) on the northwest. It is presumed to be continuous with the offshore Arctic Continental Shelf and is underlain by unconsolidated gravel, sand and silt with woody detritus. On the mainland part, the Mackenzie Delta lies within the Arctic Coastal Plain.

4. Cordillera

The northern part of the Cordilleran Orogen underlies the southwest Western Arctic Region. This geologically - complex area contains rocks ranging in age from Precambrian to Cenozoic and that are mainly structurally deformed.

Relevant to this report is that it also contains the northernmost extension of the metallogenically important lithologies that contain known base metal deposits farther to the south. The area is also significant because it contains the only known granitic intrusions of the Western Arctic Region. Rocks of this nature that intrude sediments of varied lithologies - as they do in the Cordilleran portion of the Region - have long been of metallogenic interest.

MINERAL POTENTIAL OF THE WESTERN ARCTIC REGION

Lead (Pb) and Zinc (Zn)

by D.F. Sangster

The Western Arctic Region was evaluated for its Pb-Zn potential in terms of four major deposit-types and one minor type known to contain exploitable concentrations of these metals elsewhere in the world. The four major deposit-types are stratiform or stratabound and may be characterized in terms of their host-rock lithologies: 1. volcanic-hosted; 2. shale-hosted; 3. carbonate-hosted; 4. sandstone-hosted. The fifth (minor) deposit-type considered is that of hydrothermal veins or replacement deposits adjacent to granitic intrusions. The following assessment of the study area is discussed in terms of these five Pb-Zn "environments".

1. Volcanic-hosted.

The major area of volcanic rocks in the study area is within the Minto Arch of Victoria Island. Descriptions of these volcanic rocks (Thorsteinsson and Tozer, 1962) were studied to assess their Pb-Zn potential. The rocks appear to consist almost entirely of amygdaloidal basalt; submarine, calc-alkaline volcanic lithologies that are generally considered more "favourable" for volcanic-hosted Pb-Zn deposits appear to be missing. Basalts intercalated with shales are known to contain zinc-bearing sulphide bodies elsewhere in the world but significant thicknesses of shale appear to be lacking in the volcanic formations of Minto Arch. Consequently, the potential for viable lead- and zinc-bearing deposits in these volcanic rocks appears to be minimal.

2. Shale-hosted.

In assessing the area for shale-hosted stratiform deposits, two main geological features were sought, namely: a) the presence of a thick succession of black, marine shales; and b) the presence of penecontemporaneous faults (growth faults) in the shale succession. With the possible exception of the Lower Paleozoic Road River and Hare Indian formations (Yorath et al., 1969) on the mainland, strata with these features were not recognized in the study area. However, since penecontemporaneous faults would probably be missed in reconnaissance mapping, the presence of appropriate lithologies in the formations noted above in Areas A and B (Fig. 3) suggests some Pb-Zn potential for these areas.

Where shale-hosted Pb-Zn deposits occur elsewhere in Canada and the world, average grades of currently-exploitable deposits range from 10% to 20% combined Pb-Zn. Consequently, deposits of this type could be an attractive exploration target in this area.

3. Sandstone-hosted.

Much of the study area, in particular the Arctic Islands, is underlain by sandstones, grits and conglomerates of various kinds but which are largely non-marine. In the assessment of these sandstones, two major criteria were sought, namely: a) proximity of the sandstones to metamorphic or igneous basement; and b) their deposition in a low-latitude environment. Two formations were judged to fulfill these criteria, unit 10(a) and the Glenelg Formation (Thorsteinsson and Tozer, 1962), both on Victoria Island (Areas D and E, Fig. 3), and their presumed equivalents on the mainland (Area C, Fig. 3) (Yorath et al., 1969).

Where such deposits are exploited elsewhere in the world, average grades range between 4% and 8% Pb with little or no zinc.

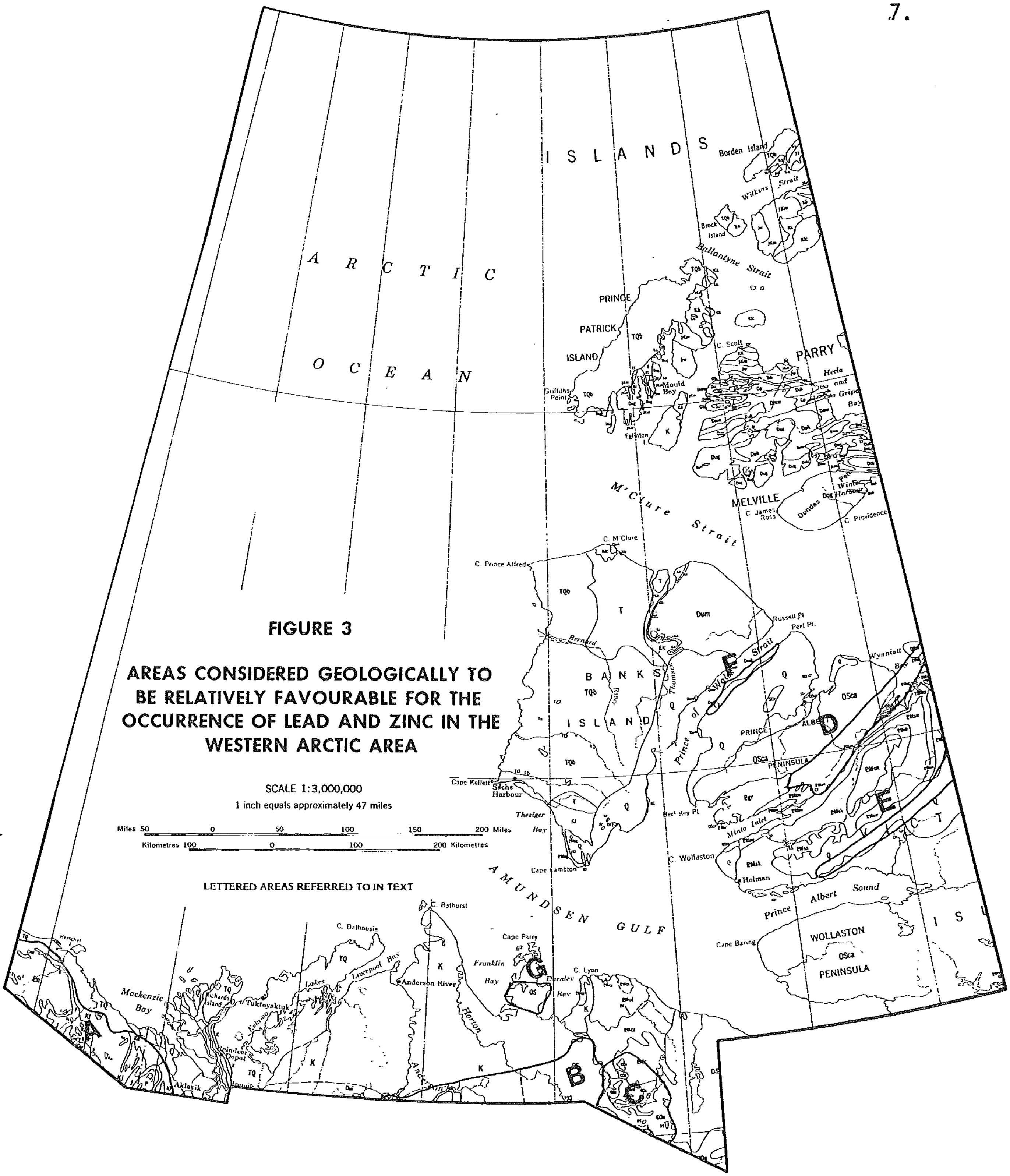

FIGURE 3

AREAS CONSIDERED GEOLOGICALLY TO BE RELATIVELY FAVOURABLE FOR THE OCCURRENCE OF LEAD AND ZINC IN THE WESTERN ARCTIC AREA

SCALE 1:3,000,000

1 inch equals approximately 47 miles

Miles 50 0 50 100 150 200 Miles

Kilometres 100 0 100 200 Kilometres

LETTERED AREAS REFERRED TO IN TEXT

4. Carbonate-hosted.

Carbonate rocks are probably the most likely lithology to contain attractive deposits of lead and/or zinc. In assessing the relative potential of the various carbonate units exposed in the map-area, three "metallotects"[1] were sought, namely: a) that the carbonates be dolomite; b) proximity to a carbonate-to-shale facies change and/or c) proximity to an unconformity or disconformity.

Within the study area, the Blue Fiord Formation of Middle Devonian age fulfills the second criterion. Miall (1976, p. 53) has drawn attention to the major carbonate-shale facies change between the Blue Fiord carbonate and the Orksut shale on Banks Island and he comments on the significance of this facies change to the lead-zinc potential of the region. The position of this facies change is illustrated by Miall (1976) in his Fig. 9. In assessing this facies change in terms of Pb-Zn, three features should be noted: a) fluorite, a common gangue mineral of carbonate-hosted Pb-Zn, has been noted in Blue Fiord carbonate on southern Banks Island at a depth of 6400 feet in a borehole (Miall, 1976, p. 69); b) Thorsteinsson and Tozer (1962, p. 53) quote an earlier report stating that "garnets" were found in Blue Fiord carbonate on Princess Royal Islands, the position of the carbonate-shale facies boundary shown by Miall. These "garnets" are almost assuredly red sphalerite, the ore mineral of zinc; c) galena has been reported in Blue Fiord carbonate on eastern Melville Island (Tozer and Thorsteinsson, 1964, p. 225). Although this latter locality is outside the study area, its presence contributes to the over-all assessment of Blue Fiord carbonate. Two negative features must also be noted in such an assessment: a) outcrop of the Blue Fiord is limited to a small area on northwestern Victoria Island (Area F) and b), Blue Fiord carbonate is normally limestone whereas dolomite is the more common host for carbonate-hosted lead-zinc deposits elswhere in the world. Nevertheless, the area of Blue Fiord limestone must be credited with a small, but real, potential

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[1] Geological characteristics or features that may have influenced the formation of mineral deposits.

for Pb-Zn mineralization.

Other areas considered to have potential to contain carbonate-hosted type of lead-zinc mineralization are Areas B and G (Fig. 3). Here, rocks of Cretaceous age lie with profound unconformity on lower to mid-Paleozoic rocks and, where these underlying rocks are carbonate, the area must be viewed as possible Pb-Zn "country". In Areas B and G the Cretaceous is reported to lie unconformably on carbonates of the Bear Rock, Ronning, and Hume Formations of mid to early Paleozoic age (Yorath et al., 1969).

Carbonate-hosted lead-zinc deposits normally range in average grade from 4% to 10% combined Pb-Zn. Grades at Arvik Mines Ltd., Little Cornwallis Island, averaging about 20% lead and zinc, must be regarded as abnormal; the deposit is one of a very small group of deposits of this kind in the world with substantial tonnages of such high-grade material.

5. Hydrothermal (vein and replacement) deposits.

Deposits of this type, as a group, tend to be small and high-grade relative to the previous four types but often have the added benefit of containing attractive silver grades, mostly in the form of sulphosalts or argentiferous galena. These deposits are most common in the immediate vicinity of felsic (granitic) intrusions. Rocks of this nature are known to occur in Area A (Fig. 3) and hence this area must be considered to have potential to contain Pb-Zn deposits of this type.

Conclusions

1. This assessment of the potential of the Western Arctic Region to contain lead-zinc mineralization of the five types previously discussed has identified seven areas considered to have higher potential to contain such mineralization than the remainder of the Western Arctic Region not so identified. Of these seven areas, however, Area A (Fig. 3) is considered to have the highest potential to contain Pb-Zn mineralization *of any kind*. This is largely because A is an area of

complex geology and contains the extreme northern extension of carbonates and shales that, to the south, host lead-zinc deposits. The only known granitic intrusions of the study area are also in Area A and therefore it is potentially favourable for hydrothermal-type deposits.

2. In evaluating the Pb-Zn potential of the region in terms of exploitation, cognizance must be taken of the fact that the average grades mentioned are those of deposits which are, or were, exploited elsewhere on a large scale. All deposit-types discussed are known to contain small high-grade portions which, under proper circumstances in the Western Arctic Region, could support a small "cottage" mining operation. Thus, although average grades might be discouraging from the point of view of large-scale exploitation, discovery of small, high-grade deposits might provide the basis for a local small-scale mining venture with minimum disruption of the environment.

3. Although lead-zinc and hydrocarbons are known to occur together in the same carbonate formations elsewhere in the world, this lead-zinc report has been prepared without the benefit of a companion oil and gas assessment. Insofar as the latter may identify favourable carbonate reservoir formations, these same formations, if and where they outcrop in the Western Arctic Region, should be re-evaluated for their Pb-Zn potential.

4. This lead-zinc assessment, based as it is on a minimum of geological information and prepared without personal knowledge of the area, should best be viewed as an attempt to draw attention to those areas which seem to be the most obviously favourable in the light of the various criteria discussed.

Before irrevocable decisions are made on the use of land in the Western Arctic Region , it is recommended that serious consideration be given to examining the identified Pb-Zn areas in terms of the various geological characteristics alluded to in the text. For example, having identified the Blue Fiord Formation on Victoria Island as a potential Pb-Zn bearer, it would be logical to determine: a) if there are other areas in which this Formation exists; b) if more detailed mapping would change the boundaries shown in Thorsteinsson and Tozer (1962); c) if the Formation is, in fact, mostly limestone as these authors state or whether their observations were influenced by their desire to locate fossils, which are best preserved in limestone rather than dolomite?, and d) if the "garnets" on Princess Royal Islands are really garnets or whether this is the first recorded zinc locality in the Western Arctic Region?

Barite

by D.F. Sangster

Because barite is a component of drilling mud used in oil and gas exploration, a local source of this commodity could be useful. Although no barite occurrences have been reported in the Western Arctic Region, large deposits of this commodity do occur in sedimentary rocks of the northern Canadian Cordillera south of the study area. These deposits, which are stratiform in nature, occur principally in upper Paleozoic basinal shales. Lesser deposits are found in shelf carbonates of early to mid-Paleozoic age.

Upper Paleozoic basinal shales are essentially lacking in the Western Arctic Region, and the probability of barite occurring in this region is lessened accordingly. However, Paleozoic carbonates occur in some portions of the Region. To a large degree the geologically favourable areas for carbonate-hosted barite coincide with those for carbonate-hosted lead and zinc. Thus, if barite is to be found in the Western Arctic Region, it is considered likely that it will occur in Areas B, F and G shown on the lead-zinc resources map (Fig. 3).

Uranium

by V. Ruzicka

No uranium deposit is known in the study region and only a limited amount of reconnaissance work for uranium has been conducted locally by exploration companies, among which Acquitaine Company of Canada Ltd. and Uranerz Exploration and Mining Ltd. have been most active.

The study region contains several favourable areas that might host uranium deposits. The areas considered most favourable are indicated on Figure 4.

Area 1 includes a part of the Cordillera and its foreland in northern Yukon Territory and adjacent northwestern part of the District of Mackenzie (Norris et al., 1963; Jeletzky, 1975). This area contains geological environments favourable for:

1. Sandstone-type deposits that might be spatially associated with unconformities and confined to porous, continental sandstones containing carbonaceous matter. The relatively most favourable unconformities appear to be the Permo-Carboniferous and Jurassic-Cretaceous ones.

2. Orthomagmatic-type deposits. Uranium could be associated with the high-level granite intrusions. However, distribution of these bodies is apparently very restricted.

3. Deposit types in which uranium is paragenetically associated with molybdenum, tungsten or gold and which are apparently related to contact aureoles of granitic intrusions and are perhaps partly reworked. Such deposits are known in the Bohemian Massif in Europe (Ruzicka, 1971).

Area 2, the Peel Plain (Yorath et al., 1975), contains Cretaceous and Tertiary sediments that might host uranium mineralization because: a) they are continental, and b) they may contain bituminous material that could trap uranium.

Area 3 consists of the Coppermine Arch and overlying Cretaceous sediments (Frazer, 1964; Balkwill and Yorath, 1970a,b). Uranium mineralization could occur here in an environment that is lithologically similar to the Paleohelikian Hornby Bay Group where uranium occurs at

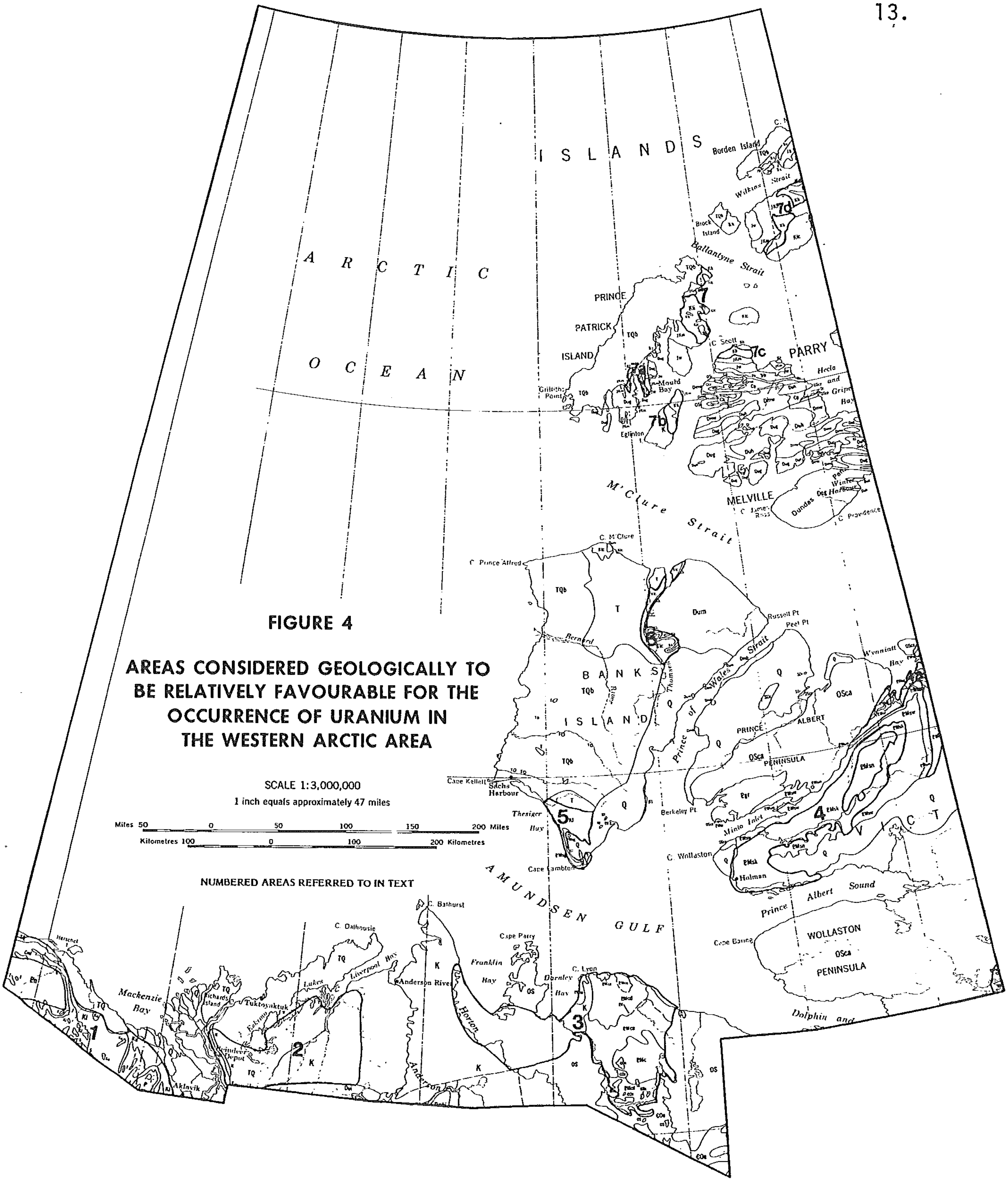

FIGURE 4

AREAS CONSIDERED GEOLOGICALLY TO BE RELATIVELY FAVOURABLE FOR THE OCCURRENCE OF URANIUM IN THE WESTERN ARCTIC AREA

Dismal Lakes, south of the study area. The Cretaceous sediments contain lignite and coal beds that might provide traps for uranium dissolved in waters derived from Precambrian rocks of the Canadian Shield. Almost no exploration for uranium has been conducted here and no uranium occurrences are known in this area.

Area 4, the Minto Arch (Thorsteinsson and Tozer, 1962, 1970) contains Precambrian (Proterozoic) sediments and volcanics associated with evaporites of the Shaler Group. The Glenelg Formation of this Group contains prominent uranium geochemical anomalies in the southeast part of Victoria Island (south of the study area). In the Minto Arch the Glenelg Formation, containing continental sediments, occurs beneath both the Reynolds Point Formation containing limestone and sandstone and the Minto Inlet Formation containing anhydrite that could be a source of uranium-bearing brines. Thus the geological environment may have been favourable for the supergene processes active in the concentration of uranium mineralization.

Area 5 consists of the southern margin of Banks Basin and adjacent Precambrian rocks of the Minto Arch. An environment similar to that in Area 4 might host uranium deposits and might also serve as a source for uranium mineralization in Cretaceous continental sediments derived from it.

Area 6 encompasses the northern part of Banks Basin (Thorsteinsson and Tozer, 1970). Cretaceous continental sediments of the Isachsen Formation might be more favourable for sandstone-type uranium mineralization than the overlying marine shales of the Christopher Formation. A depositional environment consisting of a closed channel sealed by the overlying shale might be a favourable trap for the concentration of uranium.

Area 7, containing the Pennsylvanian to Cretaceous continental sediments of the western part of Sverdrup lowland, might host uranium mineralization despite the apparent distance from granitic source rocks and the absence of diapiric structures that are considered favourable for uranium mineralization. For example, the Isachsen Formation comprises sandstone, shale, conglomerate and coal and is locally covered by basaltic effusives. A similar combination has yielded uranium in some parts of the world, one explanation being that uranium is precipitated from acid solutions when these meet waters that have become alkaline by percolation through basalt. The potential for uranium mineralization in this area should be regarded as low, but the possibility that uranium concentrations might exist in such environment cannot be excluded.

Copper

by. R.V. Kirkham

Little is known about the distribution of copper in the Western Arctic Region. Minimal exploration for copper has been done and the geology is known only in a reconnnaissance manner but the limited information available suggests that this region probably has a relatively low potential for copper deposits. Nevertheless, because the area is so large and includes such a diverse assemblage of rocks, it could conceivably contain copper deposits that might eventually be exploitable. This report represents an attempt to outline some broad areas that contain geological features favourable for the occurrence of copper (Fig. 5).

The distribution of known copper occurrences is shown on Figures 2 and 5. Most of these occurrences are extremely minor and have no economic potential. The ones on Victoria Island are primarily native copper and/or chalcocite which occur in discordant structures that cut the Precambrian Natkusiak flood basalts of the Minto Arch (Thorsteinsson and Tozer, 1962). Similar occurrences are found in the Coppermine River area, Northwest Territories, Seal Lake area in Labrador, in Keweenawan lavas around Lake Superior and in other parts of the world. In most of these areas even the best of such discordant occurrences tend to be relatively small deposits of marginal grade (a few hundred thousand to a few million tons of 1% to 4% Cu). Nevertheless, the large and important conformable native copper deposits of the Keweenaw Peninsula of Michigan occur in this general type

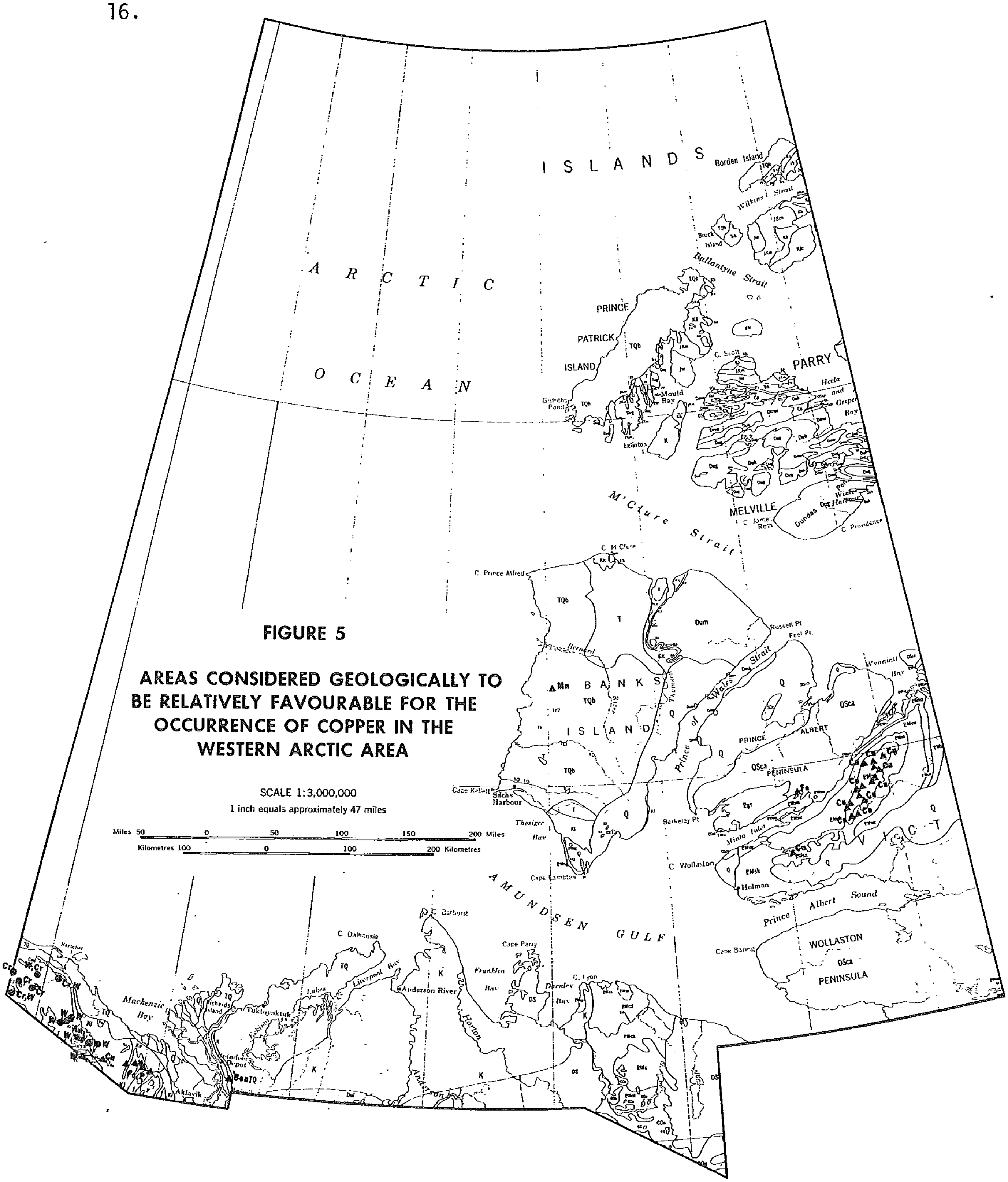

FIGURE 5

AREAS CONSIDERED GEOLOGICALLY TO BE RELATIVELY FAVOURABLE FOR THE OCCURRENCE OF COPPER IN THE WESTERN ARCTIC AREA

of geological environment and even though no conformable occurrences have been discovered on Victoria Island there is a remote chance that such deposits might occur in the Natkusiak basalts.

If any large, important copper deposits are found in the Western Arctic Region they will probably be of a sedimentary type. Areas with rocks that might have some potential for such deposits are outlined on Figure 5. These include the Precambrian and lower Paleozoic rocks of the Brock Inlier (Balkwill and Yorath, 1970), Minto Arch and a small area on the southern tip of Banks Island (Thorsteinsson and Tozer, 1962), and the Canyon Fiord, Sabine Bay and Assistance Formations on Melville Island (Tozer and Thorsteinsson, 1964). The large area on Melville Island underlain by the Devonian Hecla Bay and Griper Bay Formations (Tozer and Thorsteinsson, 1964) conceivably also has some small potential for copper deposits.

The Cordilleran region in the southwest part of the study area is geologically complex (Norris et al., 1963). It might have potential for sedimentary as well as other types of copper deposits but until more is learned about this area, its copper potential will remain largely unknown.

Even though areas with some potential have been outlined in Figure 5, it should be emphasized that the region as a whole probably has a very low potential for exploitable copper deposits.

Molybdenum

by R.V. Kirkham

No molybdenum occurrences are known in the Western Arctic Region and, judging from available geological information, most of the region probably has little if any potential for molybdenum. The only area which might conceivably contain exploitable molybdenum deposits is the northern part of the Yukon, where tungsten-bearing granitic intrusions are known (Norris et al., 1963).

Nickel

by O.R. Eckstrand

No nickel occurrences have been reported in the Western Arctic Region, and the potential for nickel sulphide deposits appears to be low.

There could be limited potential for nickel deposits in the late Precambrian Minto Arch on Victoria and Banks Islands. Diabase-gabbro sills (Christie, 1964) intrude formations of the Shaler Group (Thorsteinsson, R. and Tozer, E.T., 1962), two of which (Minto Inlet and Kilian Formations) contain gypsum and anhydrite-rich beds. This is similar to the geological setting for the Noril'sk nickel-copper deposits (the largest in U.S.S.R.) and for large low grade copper-nickel deposits associated with the Duluth Complex, Minnesota. In both of the latter there is evidence that mafic magmas have incorporated sulphur from footwall rocks to form nickel-copper sulphide concentrations toward the base of sill-like intrusions. However the Minto Arch sills are virtually undifferentiated whereas the Noril'sk intrusions are highly differentiated in a manner that is considered responsible for concentrating the sulphides into exploitable deposits. The copper-nickel-bearing basal part of the Duluth complex is only weakly to moderately differentiated, but low grade renders these deposits economically marginal. Similar grades in the Western Arctic would be of little economic interest.

The area of nickel potential shown on Figure 6 includes the Minto Inlet, Wynniatt, Kilian and Natkusiak Formations; i.e. those formations that contain gypsum and anhydrite, or overlie them, and were intruded by gabbro-diabase sills.

Iron, Manganese and Phosphate

by G.A. Gross and C.R. McLeod

Richardson Mountains

Cretaceous sediments consisting of interbedded black shale, sandy shale and siderite are exposed in the

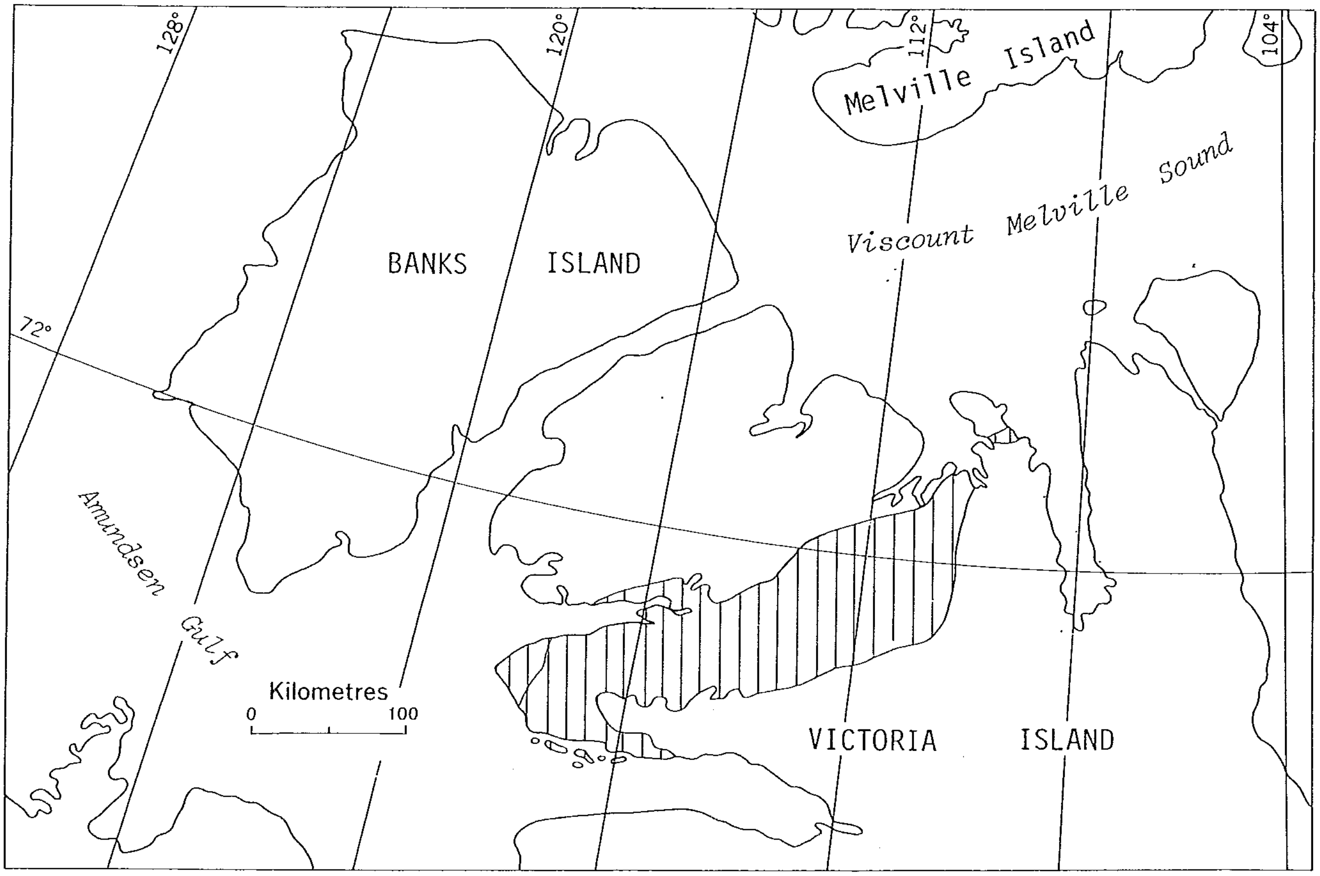

Figure 6. Area considered geologically to have some possible potential for the occurrence of nickel in the western Arctic area.

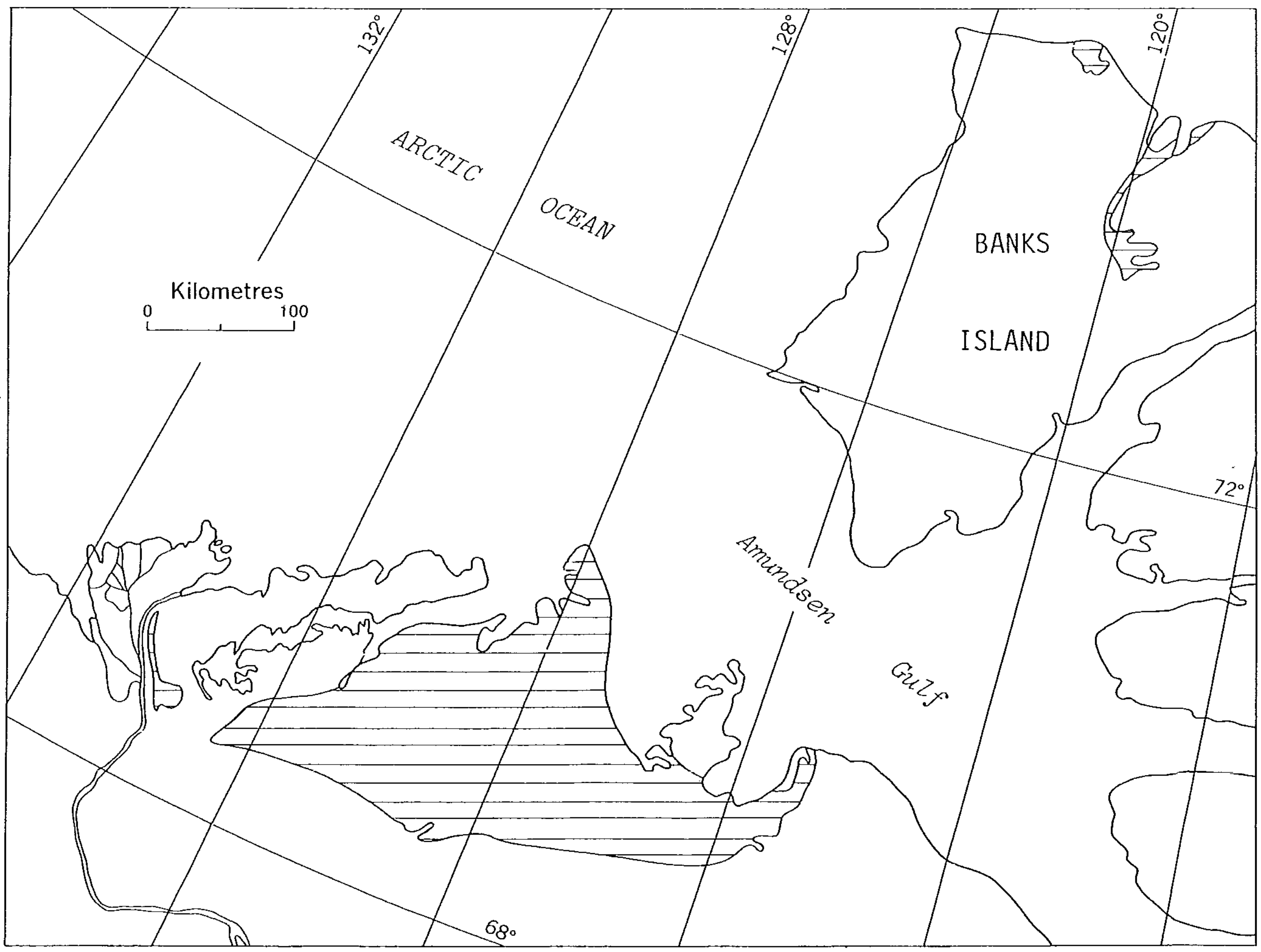

Figure 7. Areas possibly underlain by "bentonitic shales".

northern part of the Richardson Mountains along Cache Creek, Fish River, Boundary Creek, and Rapid River, between latitude 68°25' and 68°35' (Young, 1972, 1973). Sections containing numerous siderite beds range in thickness from 500 to 1500 feet and contain 15% to 20% iron and 1.5% to 3% phosphorus, with some individual layers containing as much as 14% to 20% P_2O_5.

The siderite occurrences are of little interest as an iron resource because of their low grade, the intimate admixture of clay and phosphate minerals and their remote location. It is technically feasible to produce iron from this material but the processing methods are complicated and costly and involve high energy consumption.

The abnormally high amount of phosphate associated with the siderite beds may be an indication of phosphate resources in this sequence of rocks but no samples of a quality and grade suitable for fertilizer raw materials have been reported. The phosphate is known to occur as apatite and in phosphatic silicate minerals. Some of the occurrences of phosphatic silicate material contain exotic assemblages of minerals that are in demand for museums and by collectors and the area may possibly sustain a small industry for the supply of mineral specimens in the future.

The sequence of rocks containing siderite and black shale represents sedimentary fillings of trenches and grabens in a highly faulted euxinic marine environment and is of considerable general metallogenetic significance. Mudstones containing abnormal amounts of copper, zinc, lead and precious metals may be present in this rock succession but significant occurrences are not known at present.

According to Young et al., (1976) the bedded ironstone and shale facies of the Albian flysch facies are distributed over the Cache Creek High and westward through the area where the above named exposures were examined. Possible occurrences of other metalliferous mudstone could be associated with the ferruginous facies of the Albian stage sediments.

Victoria Island

On Victoria Island a bed of oolitic hematitic ironstone about 10 feet thick occurs at the head of Minto Inlet in Cambrian rocks (Thorsteinsson and Tozer, 1962, p. 39). It is unlikely to be of any significance as an iron resource; however, it may be of interest as a decorative stone or of use in handcrafted stone work.

Banks Island

A manganiferous zone is associated with a disconformity in the Cretaceous succession on Banks Island (Miall, 1974). The zone in which manganiferous carbonate and oxide spherulites are dispersed is about 40 feet thick where intersected at a depth of about 3150' in a bore hole, about 20 feet thick at a depth of about 2350' in a second hole, but yielded only traces in a third hole. A surface exposure of the zone occurs at the north end of the island (Miall, pers. comm.). The known material does not approach commercial grade but manganese concentrations may be present elsewhere at this stratigraphic position.

Other Occurrences

There are numerous reports of concretions and beds containing phosphorous, iron and manganese in the descriptions of Jurassic and Cretaceous sections throughout the region. Ferruginous and manganiferous cement in sandstone on Eglington Island imparts a metallic lustre to some beds. These occurrences are of geological interest but have little if any economic significance.

Bentonite

by P. Moyd

Bentonitic shales of Lower Cretaceous age are widely distributed, mainly in the southwest Central Stable Region, in thicknesses of up to 800'. Limited test results to date have not indicated deposits of economic interest. However, the formation is so widespread and has been studied so little from the bentonite standpoint that it would be imprudent to evaluate its resource potential on the basis of present information.

Bentonite has had various definitions through the years, but for commercial purposes it is now defined as a material consisting essentially of montmorillonite clay minerals, regardless of origin or occurrence. Although bentonite has many uses, its most important use in the Western Arctic Region would be for drilling muds. For this purpose, the bentonite must be of exceptionally good quality, of the high-swelling sodium type, and conform to specifications that are quite rigid. To be exploitable, high-quality horizons must be present in discrete beds that are readily separable since beneficiation procedures have not proved successful. Bentonitic beds are common throughout the world, but can be mined successfully in relatively few places. This is especially true of the drilling-mud quality material (Patterson and Murray, 1975).

Shales of upper Lower Cretaceous age containing variable amounts of bentonitic material occur widely in the Central Stable Region (Aitken et al., 1969; Balkwill and Yorath, 1970; Yorath et al., 1975). Until 1975 these shales were known simply as "Bentonitic Shale" or "Bentonitic Zone". In 1975, the name Horton River Formation was given to these beds in the Franklin Bay area and they were correlated with the Christopher Formation of Banks Island (Yorath et al., 1975). The "Bentonitic Zone" is described as a monotonous succession of dark gray to black, soft, plastic bentonitic shales, containing numerous rusty brown- and orange-weathering ironstones. It attains local thicknesses of up to 800' thick but it is not present everywhere. It overlies the Lower Cretaceous "Silty Zone" with apparent conformity and is disconformably overlain by the "Bituminous zone", also of Lower Cretaceous age.

Only one drilling program for bentonite has been conducted, although the zone has been intersected in many wells. In 1971, Trans-Canada Resource Ltd. of Vancouver, drilled four holes to a maximum depth of 137' on a 205-claim block covering an area of about 60 sq. km in the Mackenzie Delta, on the west side of Noell Lake about 24 km north of Inuvik (Padgham, 1975). Analyses of the drill cores showed only about 1% montmorillonite, and no discrete beds of bentonite even though the contained microfossils proved that it was indeed the "Bentonite zone" (Trans-Canada Resources, 1971).

X-ray diffraction analyses of samples from the Anderson River area showed only 22-30% chlorite and montmorillonite, of the low-swelling types (Yorath et al., 1975).

Although the above results are negative, because of the great extent of the formation there might possible be bentonite of better quality elsewhere.

Aggregate Materials

Construction materials are an important mineral resource, especially in a terrain as ecologically sensitive as that of the Arctic. For the mainland part of the study area (west of longitude 127°), areas that contain significant amounts of granular aggregate material and areas of bedrock suitable for aggregate are shown on Figure 8. For southern Banks Island, areas containing these materials are delineated on Figure 9.

OTHER COMMODITIES

by G.B. Leech

Chromium

Chromite has been identified in stream sediments in the Cordilleran region near the Alaska boundary (localities are shown on Figure 2) (Norris et al., 1963). Chromite is a resistant mineral and can travel for considerable distances from its bedrock sources. These sources have not been identified but are most likely to be ultramafic rocks, some of which almost certainly occur in the extreme southwest corner of the study area. Nevertheless the area's potential for exploitable chromite resources is probably low.

Chromite is commonly disseminated throughout its hostrock, so its presence in stream sediments is not evidence of the existence of exploitable deposits. Even if a large concentration existed, its usefulness would depend on its chrome/iron ratio; the quality of the chromite found in the streams is unknown and the Canadian Cordillera

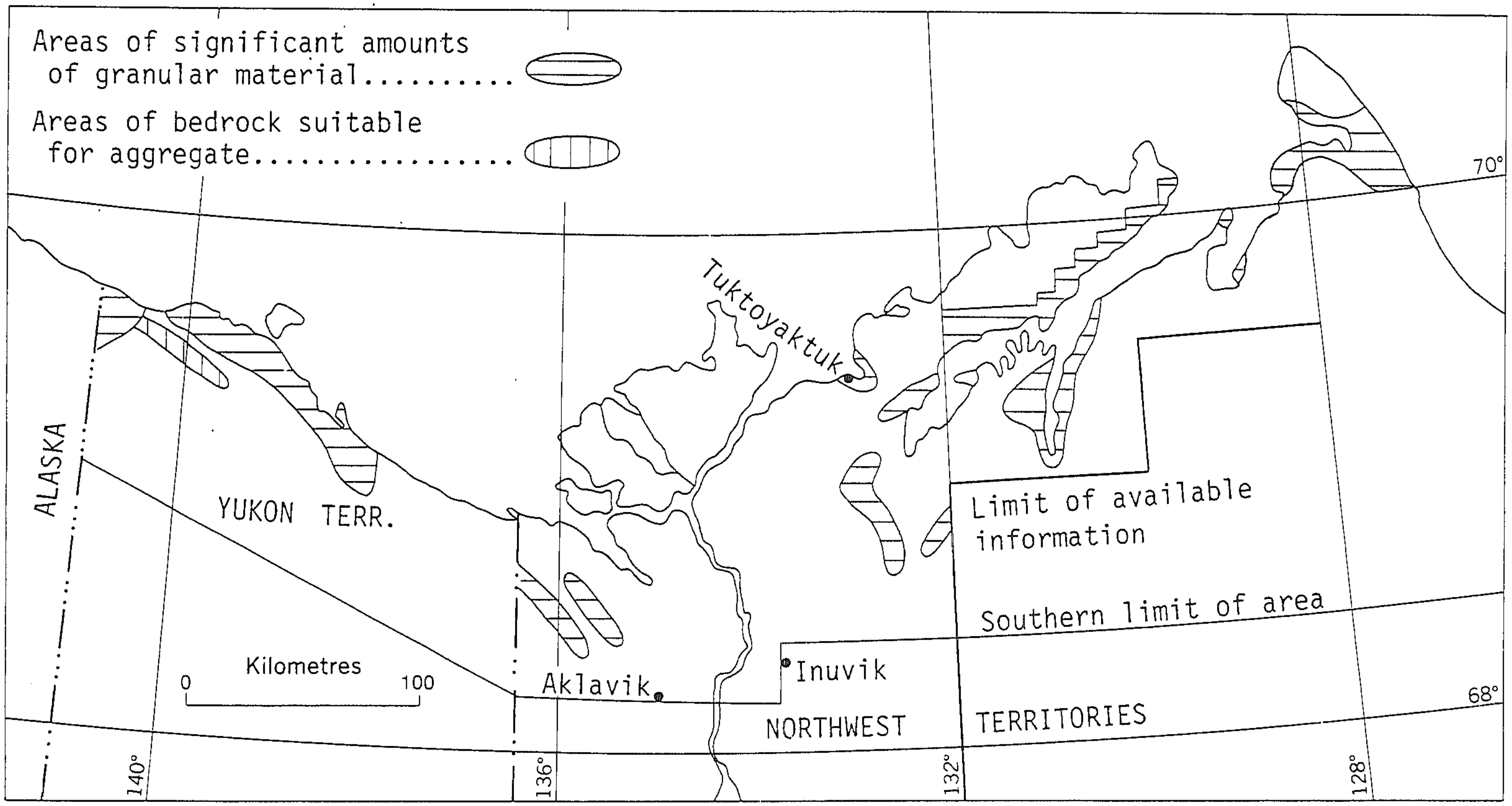

Figure 8. Areas of significant amounts of granular materials and bedrock areas suitable for aggregate, Arctic Coastal Plain region.

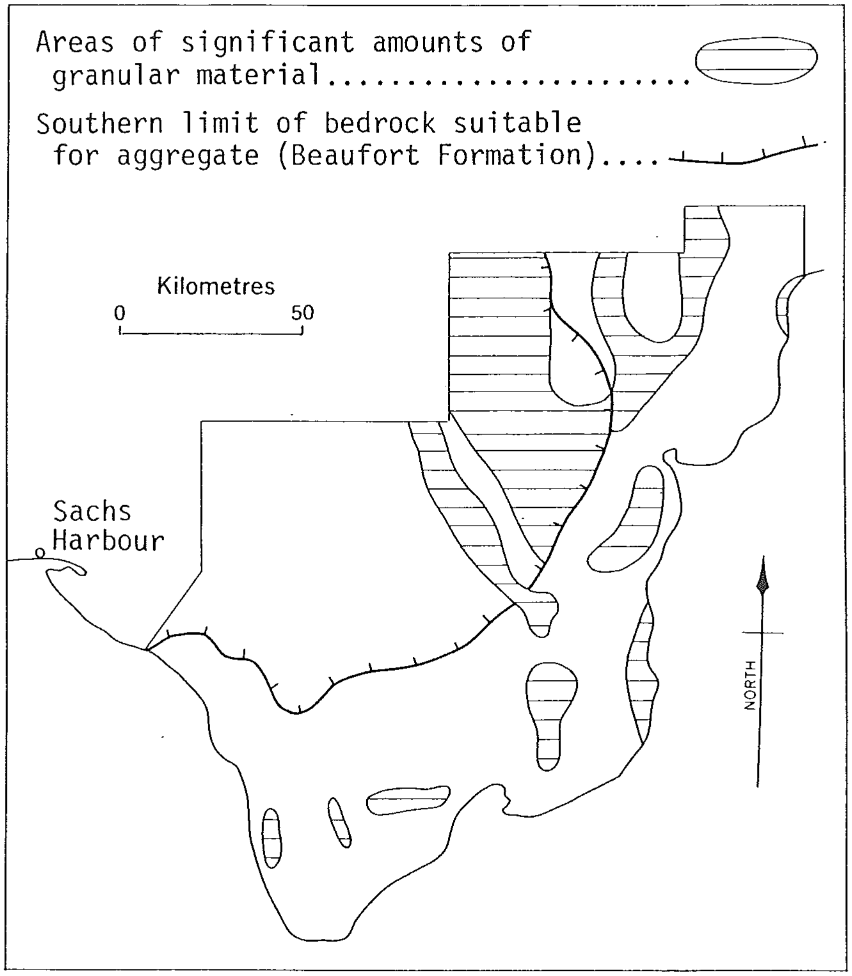

Figure 9. Areas of significant amounts of granular materials and bedrock areas for aggregate, southern Banks Island.

seems singularly poor in such concentrations. Stream sediments themselves (placer concentrations) are not mined for chromite anywhere in the world.

Diamonds

The southeastern part of the study area is part of a "stable region". In some parts of the world diamonds occur in diatreme breccias (kimberlite) that intrude stable regions, especially those diatremes related to linear zones of uplift or other "activation" of the stable region. If such zones are identified in or trending toward the study area this possibility, though remote, should not be eliminated.

Evaporites

Gypsum, anhydrite and possibly salt, of more than one geological age, occur in the Western Arctic Region. Gypsum and anhydrite are exposed on Victoria Island and underlie extensive areas.

On Victoria Island the gypsum and anhydrite are part of the Late Precambrian Shaler Group. They comprise more than half of the Minto Inlet Formation, whose thickness varies from about 300 feet to 1200 feet, and characterize the lower member of the Kilian Formation (Thorsteinsson, R. and Tozer, E.T., 1962).

On the mainland, gypsum and anhydrite are components of the Saline River Formation that occurs at depth beneath much of the study area east of the Mackenzie Delta but they are probably inaccessible for practical purposes.

On Melville Island evaporites of Ordovician age (Baumann Fiord and Bay Fiord Formations) may occur at great depth beneath most of the area south of Hecla and Griper Bay. Salt may be present. Farther north, evaporites of Carboniferous age (Otto Fiord Formation) may occur, also at great depth, beneath the south part of Mackenzie King Island.

In regions where salt occurs the presence of potash is a possibility.

Gold

Gold has been found in sediments in streams in the Cordillera in the southwest part of the study area. This region has some potential for placer mining, particularly for small operations.

Carving Stone

Soapstone and carveable stone of other types should be considered in an analysis of the total mineral resources of the Western Arctic Region. The possibly suitable material includes a considerable range of altered igneous rocks and sedimentary rocks and actual suitability must be established by tests. Thus these materials are beyond the scope of the present report. The Cordilleran region, where traces of chromite have been found, might be a source of soapstone and, less likely, jadeite.

Tungsten

Small amounts of scheelite, a tungsten material, have been found in the Cordilleran part of the study area. Only one of the occurrences shown on Figure 2 is in bedrock, the others are transported material in stream sediment and soil samples (Norris et al., 1963). The localities where granitic rocks intrude sedimentary rocks are favourable for the occurrence of vein type tungsten deposits and perhaps other types. Vein type deposits are commonly small. Farther south in the Cordillera, important deposits of skarn type occur where granitic rocks intrude limey strata of Cambrian age. Equivalent strata are not known to occur in the study area but any combination of limey rocks and granite in the area is potentially favourable for tungsten-bearing skarns.

CONCLUSION

This report indicates the areas in which mineral commodities are more likely to occur, if they occur at all. It also indicates, for various commodities, the type or types of deposits that are most likely to occur in each area. This is an important consideration, because the exploitability of a commodity depends importantly on the deposit type in which it occurs.

Although certain areas are designated as being relatively more favourable for the occurrence of given commodities than the remaining areas, this must not be interpreted to mean that the latter cannot contain mineral deposits. A discovery in one of them should trigger a re-evaluation of them.

Three areas, namely the Cordilleran part of the study area, the "Brock Inlier" and its surroundings east and south of Darnley Bay and the "Minto Arch" athwart Victoria Island reappear repeatedly in the commodity discussions and related maps. Thus these areas are relatively favourable from more than one standpoint.

Areas designated as relatively favourable on the basis of only one deposit type may have fewer chances of containing deposits. However, a second important consideration, besides the number of deposits, is the expected value of a discovery, which depends to a large degree on the deposit type anticipated. Because of the paucity of information, a strict ordering of the areas according to their relative potential for mineral deposits is not possible at this time. The designations of relative areal potentials should be re-evaluated when more information becomes available.

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