REGIONAL GEOCHEMICAL RECONNAISSANCE

INTERPRETATION OF DATA FROM NONACHO LAKE - EAST ARM OF GREAT SLAVE LAKE REGION, DISTRICT OF MACKENZIE

Y.T. MAURICE

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Critical Readers

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GENERAL INTRODUCTION

Geochemical data are an essential component of the comprehensive geological description of any area or country. This paper is one of a series of overviews on the geochemistry of regions of Canada.

The Geological Survey of Canada commenced regional surveys involving systematic geophysical measurements in 1949, with an aeromagnetic survey covering 30 000 km^2. By 1961 such regional geophysical surveys had expanded towards national coverage through a jointly funded Federal-Provincial program.

GSC first experimented with regional geochemical surveys in the late 1950s and continued up to the early 1970s. As a result of this work, the value of such surveys was established, methods were perfected, and the importance of sample collection and analytical controls was recognized[1]. The commencement of a large scale national program of regional geochemical surveys then waited upon the availability of funding. This opportunity arose with the energy crisis of 1973, which led to the Federal-Provincial Uranium Reconnaissance Program. This program was initiated with the support of the 1974 Annual Conference of the Provincial Ministers of Mines, and it commenced in 1975 with an expected life of 10 years. Costs for work within the provinces were shared between the Federal and Provincial governments, whilst the Federal government was wholly responsible for the cost of work in the Territories.

Between 1975 and 1979, when the Uranium Reconnaissance Program was terminated by the Federal government for economic reasons, work took place in seven provinces and all the Territories. During this period approximately 900 000 km^2 in different parts of Canada were covered by geochemical surveys. The areas covered were selected according to a variety of criteria. Work in each of the provinces was conducted through a joint Federal-Provincial management committee. Since the funds available (approximately $1.25 million per year for geochemistry) were not large in relation to the magnitude of the task, blanket coverage was not possible. Areas for geochemical surveys were selected partly on the basis of suspected exploration potential, as indicated by existing mineral occurrence and geological information, and partly to demonstrate the applicability of geochemistry in a variety of terrains.

[1] These general considerations have been described by Cameron and Hornbrook (in Exploration for Uranium Ore Deposits, International Atomic Energy Agency, Vienna, 1976, p. 241-264) and Coker, Hornbrook and Cameron (in Geophysics and Geochemistry in the Search for Metallic Ores; Geological Survey of Canada, Economic Geology Report 31, 1979, p. 435-478).

INTRODUCTION GÉNÉRALE

Les données géochimiques sont essentielles à la description détaillée de la géologie de n'importe quel pays ou région. Le présent document fait partie d'une série d'aperçus sur la géochimie régionale du Canada.

La Commission géologique du Canada a commencé en 1949 à effectuer des levés régionaux, dont la cueillette systématique de données géophysiques, par un levé aéromagnétique couvrant 30 000 km^2. En 1961, ces levés géophysiques régionaux ont été étendus à tout le Canada en vertu d'un programme fédéral-provincial à frais partagés.

La CGC a exécuté ses premiers levés géochimiques régionaux à la fin des années 50 et poursuivi ses activités dans ce domaine jusqu'au début des années 70. Ces travaux ont permis d'établir la valeur de ce type de levés, de mettre au point les méthodes et de montrer l'importance de l'échantillonnage et de la vérification des résultats d'analyses[1]. La mise en oeuvre d'un vaste programme national de levés géochimiques régionaux a dû attendre que les fonds requis deviennent disponibles. L'occasion attendue s'est manifestée au moment de la crise de l'énergie en 1973, phénomène responsable de la mise sur pied du Programme fédéral-provincial de recherche pour l'uranium. Ce programme a été lancé avec l'appui de la conférence de 1974 des Ministres provinciaux des mines, et mis en oeuvre en 1975 avec une durée prévue de dix ans. Les frais engagés dans les provinces ont été partagés entre les gouvernements fédéral et provinciaux, bien que le gouvernement fédéral ait assumé entièrement le coût des travaux exécutés dans les territoires.

Entre 1975 et 1979, lorsque le gouvernement fédéral a mis fin au Programme de recherche pour l'uranium pour des raisons économiques, des travaux avaient été exécutés dans sept provinces et les deux territoires. Au cours de cette période, une superficie d'environ 900 000 km^2 répartie dans différentes régions du Canada a fait l'objet de levés géochimiques. Les régions couvertes ont été choisies en fonction de divers critères. Dans chaque province, les travaux ont été exécutés par l'entremise d'un comité de gestion fédéral-provincial. Étant donné que les fonds disponibles (environ 1,25 million de dollars par année pour la géochimie) n'étaient pas considérables par rapport à l'ampleur de la tâche, une couverture complète n'a pas été possible. En ce qui concerne les levés géochimiques, les régions ont été choisies, d'une part, parce qu'elles étaient susceptibles de renfermer des gisements de minéraux, tel qu'indiqué par les venues minérales connues et les données géologiques disponibles et, d'autre part, afin de démontrer l'applicabilité de la géochimie à différents types de terrains.

[1] *Ces considérations d'ordre général ont été décrites par Cameron et Hornbrook (dans Exploration for Uranium Ore Deposits, Agence Internationale de l'Énergie Atomique, Vienne, 1976, pp. 241-264) et par Coker, Hornbrook et Cameron (dans Geophysics and Geochemistry in the Search for Metallic Ores; Geological Survey of Canada, Economic Geology Report 31, 1979, pp. 435-478).*

Following on the termination of the Uranium Reconnaissance Program in 1979 most of the participating provinces indicated their interest in continuing the surveys in their areas of jurisdiction under other financial arrangements. These have varied from year to year and from province to province. They range from mostly provincial funding in British Columbia and Ontario, to wholly federal funding as in Newfoundland. Since 1979 the Geological Survey of Canada has conducted one federally funded survey in the Territories (Nahanni, Yukon). As far as possible, the areas surveyed have coincided with NTS sheet boundaries in order to facilitate eventual national compilations. Most of the regional geochemical survey work has been undertaken by contractors. Sample collection, sample preparation, and different types of analytical services have been performed by separate organizations. Twelve companies have taken part in these operations. The Geological Survey of Canada has been responsible throughout for overall co-ordination, compilation and checking of data. Commencing in 1976, all data (66 different sets) have been released on GSC Open File under the title of National Geochemical Reconnaissance, and this term has been commonly used in related published literature.

This paper is one of a series which has three main aims: to serve as a reminder of the extent to which geochemical reconnaissance data are available for various parts of the country; to make general comments upon the relationship between the observed surficial geochemistry and the general and economic geology of various regions; and to provide specific examples showing how these geochemical data may be interpreted. Although the prime purpose of the geochemical surveys is as a guide to mineral exploration, the same data are of value to environmentalists, and in populated areas to agriculturalists and health authorities.

Regional geochemistry is based either on the sampling of lakes, wherever they are sufficiently abundant to permit one sample to be taken every $12\ km^2$, or in mountainous areas on the sampling of streams, at a similar site density. In special circumstances, where additional funding has been available, more detailed sample densities have been employed. At each site both sediment and water is collected. Sediment samples have been routinely analyzed for U, Zn, Cu, Pb, Ni, Co, Mo, Ag, Mn and Fe, and loss on ignition. In some areas Ba, W, Sn, As, Sb, V and Hg have also been determined. All waters have been analyzed for U, and commonly for F. From 1976 onwards pH measurements have been made on all water samples.

En 1979, une fois terminé le Programme de recherche pour l'uranium, la plupart des provinces qui y avaient participé se sont dites intéressées à poursuivre les levés dans les régions placées sous leur compétence, en utilisant d'autres arrangements financiers. Ces derniers ont varié d'année en année et d'une province à l'autre. Ils vont du financement provenant surtout du gouvernement provincial, comme c'est le cas en Colombie-Britannique et en Ontario, jusqu'au financement issu entièrement du gouvernement fédéral, tel qu'à Terre-Neuve. Depuis 1979, la Commission géologique du Canada a exécuté dans les territoires (Nahanni, au Yukon) un levé financé par le gouvernement fédéral. Dans la mesure du possible, on a fait coïncider les régions à l'étude avec les feuilles de cartes du SNRC en vue de faciliter une éventuelle compilation des données pour tout le Canada. La plupart des levés géochimiques régionaux ont été exécutés par des entrepreneurs privés. Plusieurs organismes se sont chargés du prélèvement et de la préparation des échantillons, ainsi que des différents services d'analyse. Douze sociétés ont pris part à ces activités. La Commission géologique du Canada a assumé l'entière responsabilité de la coordination, de la compilation et de la vérification de tous les résultats. À partir de 1976, toutes les données (66 séries différentes) ont été publiées dans le dossier public de la CGC intitulé <<National Geochemical Reconnaissance>>, et cette appellation a été couramment utilisée dans les publications concernant le sujet.

Le présent document fait partie d'une série qui a trois objectifs principaux: de rappeler à quel point sont disponibles, pour diverses parties du pays, les données géochimiques de reconnaissance; de présenter des commentaires d'ordre général en ce qui concerne la relation entre la géochimie de surface et la géologie générale et la géologie économique, dans diverses régions; et de fournir des exemples précis montrant comment les données géochimiques peuvent être interprétées. Bien que le but premier des levés géochimiques soit la recherche de minéraux, ils peuvent aussi servir aux environnementalistes et, dans les régions habitées, aux agronomes et aux services d'hygiène.

Les levés géochimiques régionaux sont fondés sur l'échantillonnage des lacs, là où ceux-ci sont assez nombreux pour permettre la ceuillette d'un échantillon à tous les $12\ km^2$ *ou, dans les régions montagneuses, sur l'échantillonnage des cours d'eau, à intervalles semblables. Lorsque des fonds additionnels étaient disponibles par suite de circonstances spéciales, on a utilisé un réseau d'échantillonnage aux mailles plus étroites. À chaque station d'échantillonnage, on a receuilli des sédiments et de l'eau. Les échantillons de sédiments ont été systématiquement analysés afin d'en évaluer la teneur en U, Zn, Cu, Pb, Ni, Co, Mo, Ag, Mn et Fe, et on a déterminé la perte au feu. Pour certaines régions, on a également dosé le Ba, le W, le Sn, l'As, le Sb, le V et le Hg. Tous les échantillons d'eau ont été analysés afin de déterminer la présence de l'uranium, et souvent, du fluor. À partir de 1976, on a déterminé le pH de chaque échantillon d'eau.*

For the regional surveys, sample collection and sample preparation procedures, analytical methods and repeatability of results have all been tightly specified and controlled. This has been done in order to obtain consistent data between different areas, between work undertaken in successive years, and between results from different analytical laboratories. In this way, the results can eventually become part of the national geochemical reconnaissance data base, providing maps which have sufficient reliability to be used as an essential component of resource assessment, mineral exploration and geological mapping.

It is not the intention of this series of overview papers to seek to identify every anomalous feature and determine its cause. This is only possible where there have been comprehensive follow-up investigations. Each of these must involve detailed field and laboratory work tailored to each anomaly. Only a very small percentage of the many anomalies which are present in the data have been investigated systematically by the Geological Survey of Canada or provincial agencies because of the limited human and material resources available to conduct such work. The major effort of examining anomalies has been undertaken by industry, but only in a small percentage of cases, where there have been discoveries of commercial interest, do such results become known and documented.

Different styles have been adopted in preparing the separate parts of this series of overview papers. This reflects upon the quantity of complementary information available, and other circumstances outside the control of individual authors. This series will achieve its aim if, by drawing attention to the wealth of data that are now available, it stimulates investigations that will lead to new discoveries of both scientific and economic importance.

A.G. Darnley
Director
Resource Geophysics and Geochemistry Division

En ce qui concerne les levés régionaux, les méthodes de prélèvement et de préparation des échantillons, les méthodes d'analyse et la répétabilité des résultats, ont toutes été étroitement vérifiées et décrites en détail. Cette initiative avait pour but de s'assurer de l'uniformité des données provenant de différentes régions, de travaux s'échelonnant sur plusieurs années successives et de résultats d'analyses émanant de différents laboratoires. De cette façon, les résultats pourront éventuellement s'incorporer à l'ensemble des données géochimiques de reconnaissance du Canada en fournissant des cartes ayant un degré de fiabilité suffisant pour être utilisées à titre d'éléments essentiels dans l'évaluation des ressources, la recherche de minéraux et la cartographie géologique.

Le but de cette série d'aperçus n'est pas d'identifier toutes les anomalies ni d'en déterminer la cause. Cela ne peut se faire qu'aux endroits où l'on a procédé à des études complémentaires approfondies. Chacune de ces études doit comprendre un examen détaillé sur le terrain et en laboratoire adapté à chaque anomalie. Seul un très faible pourcentage des nombreuses anomalies qui existent dans les données a été systématiquement examiné par la Commission géologique du Canada ou par des organismes provinciaux parce que les ressources humaines et matérielles disponibles pour ce genre d'activité sont restreintes. Le secteur industriel a fourni le principal effort dans la tâche d'examiner les anomalies, mais c'est seulement dans un nombre limité de cas, c'est-à-dire à l'occasion de découvertes présentant un intérêt commercial, que ces travaux ont été publiés et documentés.

Les diverses parties de cette série d'aperçus ne présentent pas toutes le même style. Cela tient à la quantité de renseignements complémentaires disponibles et à d'autres circonstances indépendantes de la volonté des différents auteurs. Cette série atteindra son but si, en attirant l'attention sur la quantité de données qui est actuellement disponible, elle accélère la poursuite d'études susceptibles de mener à de nouvelles découvertes présentant un intérêt scientifique et économique.

Directeur
Division de la géophysique et de la géochimie appliquées
A.G. Darnley

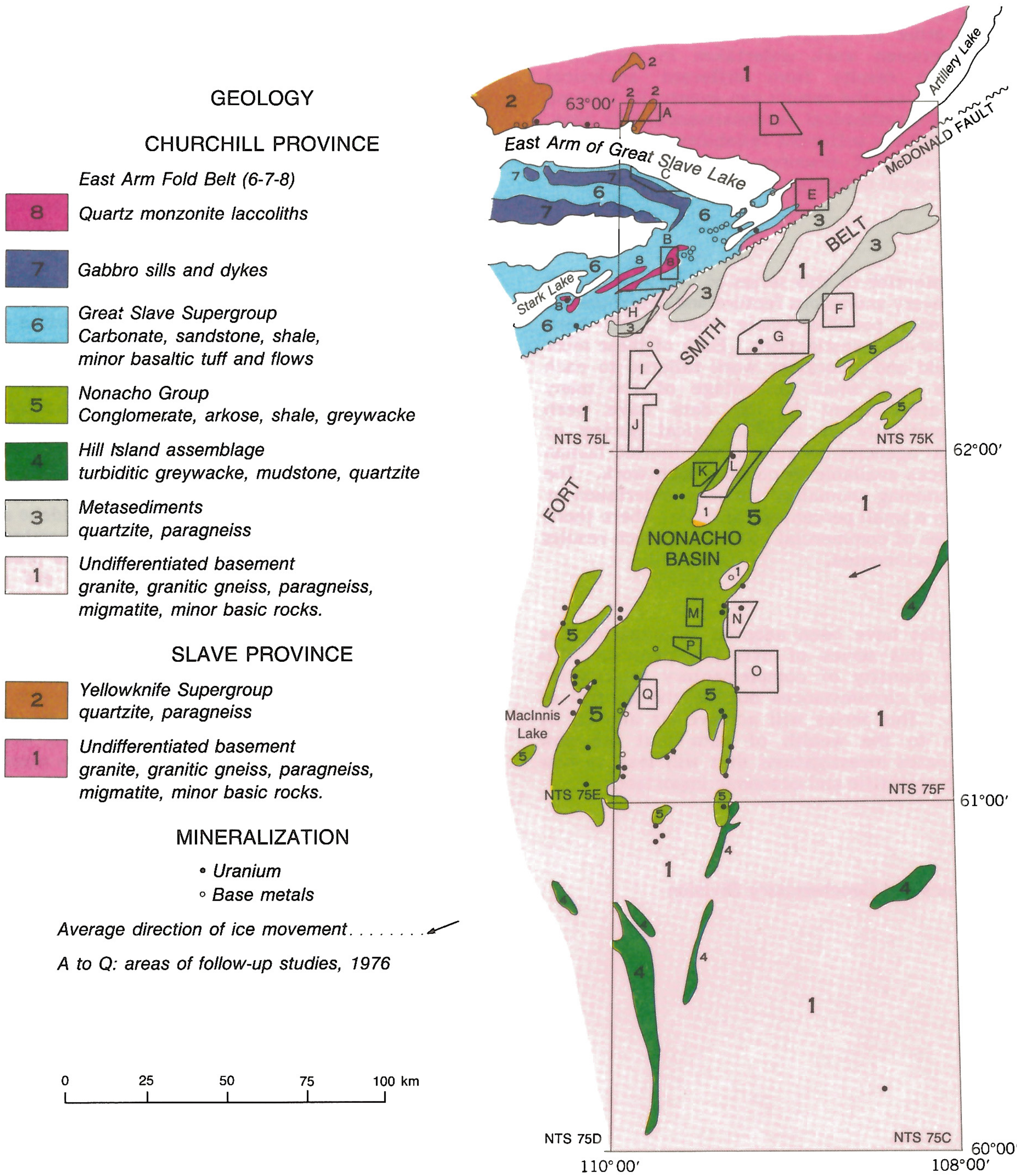

Figure 1. Geology, mineral occurrences and location of 1976 follow-up areas (A to Q). A transparent overlay of Figure 1 is in the pocket, at rear.

REGIONAL GEOCHEMICAL RECONNAISSANCE: INTERPRETATION OF DATA FROM NONACHO LAKE – EAST ARM OF GREAT SLAVE LAKE REGION, DISTRICT OF MACKENZIE

Abstract

Results of a regional geochemical reconnaissance lake sediment survey of 34 670 km² of Precambrian Shield in the Nonacho Lake – East Arm of Great Slave Lake region, are interpreted at 1:2 000 000 scale. A moving average technique was used to compile the data with the effect of reducing the signal from local features and emphasizing regional trends.

The most prominent geochemical pattern is a 80 km long string of multielement anomalies along the northeastern extension of the Fort Smith Belt. These anomalies are related to a megacrystic granite (U), sulphidic metasediments (Cu, Mo, Pb, U) and an unmapped basic or ultrabasic body (Ni, Co, As) that may be related to a strong positive gravity anomaly. The intensity of the geochemical anomalies suggests a high potential for various types of mineralization.

The widespread occurrence of copper and other metalliferous mineralization in the East Arm Fold Belt is regarded as a favourable indicator for the presence of economic mineral deposits. Low levels of Cu, Zn and Hg in the lake sediments of that region are explained in terms of lower metal mobility due to an alkaline environment and/or a more restricted distribution of these metals in the country rock.

To the north of the East Arm, in the Slave Province, strong base metal (Cu, Ni, Co, As, Zn, Pb, Hg) and U-Mo anomalies are associated with Yellowknife Supergroup metasediments and coarse grained granitic rocks respectively. The occurrence of base metal anomalies near the north shore of the East Arm, where sulphide-bearing quartz veins occur, is suggestive of undiscovered sulphide mineralization. The U-Mo-bearing granites may have been a source of U for deposits in the East Arm Fold Belt.

The surficial geochemistry of the Nonacho Basin was influenced by the spread of glacial till from the east. However, an increase in the concentration of U in lake sediments near the margins of the basin reflects the distribution of uranium mineralization. Geochemical patterns over the granitoid basement east of the Nonacho Basin indicate relatively high levels of U, Pb, and Mo, and to a lesser extent, Zn and Cu.

Résumé

Les résultats d'une étude de reconnaissance géochimique régionale des sédiments lacustres, dans une zone de 34 670 km² du Bouclier précambrien dans la région du lac Nonacho et du bras est du Grand Lac des Esclaves, sont interprétés à l'échelle de 1/2 000 000. L'utilisation d'une technique de moyenne mobile pour compiler les résultats a eu pour effet d'atténuer les signaux associés aux éléments géologiques locaux et de faire ressortir les tendances régionales.

L'agencement géochimique prédominant est une chaîne d'anomalies composées de multiples éléments qui longe, sur 80 km, le prolongement nord-est de la zone de Fort Smith. Les anomalies sont liées à un granite à gros cristaux (U), à des roches métasédimentaires sulfurées (Cu, Mo, Pb, U) et à un massif basique ou ultrabasique non cartographié (Ni, Co, As) qui pourrait être relié à une forte anomalie gravimétrique positive. L'intensité des anomalies géochimiques donne lieu de croire à la présence fort probable de divers types de minéralisations.

La présence répandue de minéralisations de cuivre et d'autres métaux dans la zone de plissements du bras est du Grand Lac des Esclaves est un indice favorable à la présence de gisements économiques. Les faibles teneurs en Cu, en Zn et en Hg des sédiments lacustres de cette région s'expliquent par une faible mobilité des métaux due à un milieu alcalin ou à une répartition plus limitée de ces métaux dans la roche encaissante.

Au nord du bras est, dans la province des Esclaves, de fortes anomalies en métaux communs (Cu, Ni, Co, As, Zn, Pb, Hg) et en U et en Mo sont associées respectivement à des sédiments métamorphisés du supergroupe de Yellowknife et à des roches granitiques à gros grain. Leur présence près de la rive nord du bras est, où l'on retrouve des filons de quartz minéralisés en sulfures, porte à croire que les anomalies sont aussi reliées à des gîtes de sulfures jusqu'ici inconnus. Les granites renfermant de l'U et du Mo pourraient être à l'origine de l'uranium que l'on trouve dans les gîtes de la zone de plissements du bras est.

La mise en place d'un till glaciaire provenant de l'est a eu un effet sur la géochimie de surface du bassin Nonacho. Une augmentation de la concentration d'U dans les sédiments lacustres, à proximité des marges du bassin, concorde toutefois avec la répartition de la minéralisation de cet élément. Les agencements géochimiques au-dessus du socle granitoide à l'est du bassin Nonacho, indiquent une teneur élevée de ces roches en U, en Pb et en Mo et dans une certaine mesure, en Zn et en Cu.

INTRODUCTION

The area discussed in this paper is located in the west-central part of the Churchill Province and includes a small segment of the southeastern part of the Slave Province. It comprises basement rocks from the two provinces as well as Proterozoic Nonacho sediments and the eastern extremity of the Proterozoic East Arm Fold Belt.

The area, bounded by latitude 60 and 63°N and longitude 108 and 110°W, comprises NTS map areas 75C, F and K, representing a total surface area of about 34 670 km² (Fig. 1).

The geochemical reconnaissance survey of this entire area was carried out in 1975 and consisted of sampling centre-lake sediments at a density of 1 sample per 13 km² using a float-equipped helicopter. A total of 2690 samples were collected and analyzed for U, Cu, Pb, Zn, Ni, Co, Mo, As, Ag, Hg, Fe, Mn and loss on ignition. The results were published by Hornbrook et al. (1976). Details of the analytical techniques used are given in the Appendix.

Surveys carried out at a later date in other areas included the sampling of near-surface lake waters, but lake waters were not collected in the present area. As a result, a number of parameters considered important for the interpretation of the geochemical data are not available; these include pH, conductivity (as an estimate of the total dissolved solids), bicarbonate, and certain readily soluble elements such as U and F. Limited water data were obtained in 1976, however, during follow-up studies on some of the anomalies outlined during the reconnaissance. This follow-up work was designed primarily to evaluate the U anomalies and was carried out in areas A to Q shown in Figure 1. The work consisted of sampling waters and sediments from all lakes and ponds (indicated on 1:50 000 scale topographical maps) within areas A-Q accompanied by limited ground traversing. The procedure and results are described in more detail elsewhere (Maurice, 1976a, 1977, 1979).

Acknowledgments

Sample collection was carried out under contract to Trigg, Woollett and Associates of Edmonton and the chemical analyses, to Chemex Labs. Ltd. of Vancouver and Atomic Energy of Canada Ltd., Commercial Products Division, Ottawa. E.H.W. Hornbrook directed Geological Survey of Canada activities in the geochemical reconnaissance program and supervised sample collection. J.J. Lynch supervised the analyses. Data monitoring and compilation was carried out by R.G. Garrett and N.G. Lund. The production of the coloured element distribution maps was co-ordinated by W.B. Coker and D.J. Ellwood. D.J. Ellwood also prepared the computer plotting package (APPMAP) and provided much appreciated guidelines that led to the final format. S.M. Roscoe, S.S. Gandhi, and R.M. Laramée provided pertinent data on mineral occurrences. The writer thanks H.H. Bostock and W.D. Goodfellow for reviewing the manuscript and Gwendy E.M. Hall who is co-ordinating the series of overviews on regional geochemistry.

PHYSIOGRAPHY AND GEOLOGY

Apart from the East Arm region, which presents a rugged and picturesque topography, the terrain is characterized by a monotonous succession of low rocky hills separated by lakes and slow-flowing streams. The land rises abruptly south of the McDonald Fault escarpment to an average elevation of 400 to 450 m in areas of basement rocks and to about 350 m in the Nonacho basin. Within the East Arm basin, the mean elevation is between 200 and 250 m, but locally reaches over 400 m, with vertical cliffs several hundred metres above the level of Great Slave Lake which stands at 156 m.

The rocks are generally well exposed in the western half of the area where the Quaternary cover is thin. In the east, however, thick morainal deposits and eskers mask the outcrop in many areas. The direction of glaciation is fairly consistent throughout the area at between 100 and 120° towards the southwest.

Topographic and geological features make it convenient to subdivide the area into five regions: 1) Slave Province; 2) East Arm Fold Belt; 3) Fort Smith Belt; 4) Nonacho Basin; 5) Churchill basement east and south of Nonacho Basin.

Slave Province

The area included in the Slave Province is located north of the McDonald Fault and contains rocks of units 1 and 2 (Fig. 1). The rocks of the Slave Province are Archean and have undergone metamorphism during the Kenoran Orogeny (2.5 Ga); they may also have suffered some effects from the Hudsonian Orogeny (1.7 Ga) which deformed the rocks to the south in the Churchill Province.

Within the survey area the rocks belonging to the Slave Province are largely granitic gneisses and granite plutons (unit 1) some of which may be synorogenic. In the northwest corner of the area (area A, Fig. 1) there are two small patches of metasediments, mostly paragneisses belonging to the Archean Yellowknife Supergroup (unit 2). These units are metamorphosed to lower amphibolite facies but parts show granitization with an intermixing of migmatites, granites and pegmatites. All rocks in this northwest area show intense rusty weathering and small gossans occur along fractures within the granites.

East Arm Fold Belt

The rocks of the East Arm Fold Belt, known as the Great Slave Supergroup and described by Hoffman et al. (1977), form an unmetamorphosed succession of conglomerates, sandstones, shales and carbonates mixed with basaltic and rhyolitic lava flows that are penetrated by basic and intermediate intrusives. Sedimentation and igneous activity took place during Early to Late Aphebian and include both marine and nonmarine sequences. Only the northeastern end of this 250 km long belt lies within the present study area.

The intrusive rocks include a number of porphyritic quartz monzonite laccoliths (unit 8, Fig. 1) composed essentially of plagioclase, hornblende, biotite and quartz (Hoffman et al., 1977; Gandhi and Prassad, 1982). Inclined gabbro sills (unit 7, Fig. 1) up to several hundred metres thick form cliffs exhibiting columnar jointing. These are the youngest rocks of the Great Slave Supergroup, postdated only by the north-northwest-trending vertical Mackenzie diabase dyke swarm found throughout the region.

According to Hoffman et al. (1977), deposition of the supergroup took place in an aulacogen the structure of which is complicated by postdepositional faulting and nappe tectonics.

Fort Smith Belt

The Fort Smith Belt is a north-trending zone of gneisses and intrusive rocks situated to the west and southwest of the Nonacho Basin in NTS 75D and E, described by Charbonneau (1980) and Bostock (1981, 1982). Similar rocks are situated south of the McDonald Fault and north of the Nonacho Basin, suggesting that the belt curves towards the northeast into NTS 75K (Fig. 1). This part of the belt, however, is largely unmapped.

The main unit in the Fort Smith Belt is a megacrystic granite batholith which intrudes older metasediments and intrusives (Bostock, 1981). In NTS 75D and E this rock corresponds to a magnetic low shown in blue in Figure 2. This low appears to thin out between rocks of higher magnetic susceptibility after adopting a northeast orientation subparallel to the McDonald Fault. In NTS 75K the magnetic low becomes imperceptible but small discrete bodies of megacrystic granite, similar to the main unit of the Fort Smith Belt, occur along this trend. Maurice and Plant (1979) have described one such body within area G (Fig. 1).

The megacrystic granite is a cataclastic rock composed essentially of pink to grey potassium feldspar megacrysts in a medium grained matrix consisting of potassium feldspar, quartz, sericite, biotite, and plagioclase. Accessory minerals include spinel, monazite, zircon, apatite, fluorite, ilmenite, garnet and cordierite. The batholith contains numerous and commonly large inclusions of metasediments, chiefly a banded paragneiss with pelitic, quartzitic and calc-silicate zones referred to as the Tsu Lake gneiss by Bostock (1981, 1982). These inclusions display extensive rusty weathering and in some areas, zones rich in iron sulphides have developed

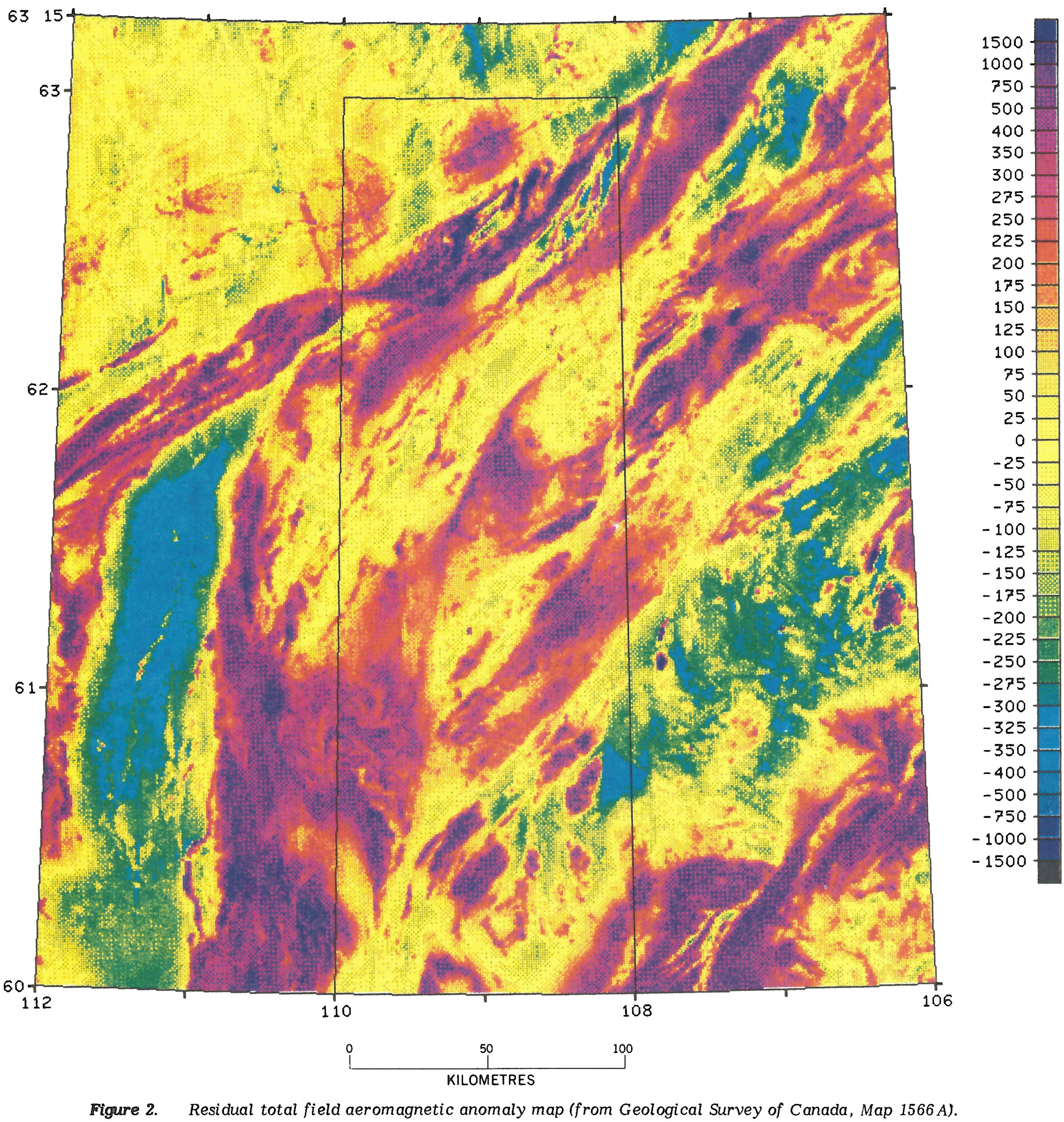

Figure 2. *Residual total field aeromagnetic anomaly map (from Geological Survey of Canada, Map 1566A).*

into gossans. Similar rocks occur in close association with the megacrystic granite bodies in NTS 75K (Maurice and Plant, 1979). Bostock (1981) gives a minimum age for the emplacement of the intrusion at 1944 ± 16 Ma based on zircons from the central part of the batholith. He suggests an Archean age for the Tsu Lake gneiss based on data from similar rocks in northern Alberta (Nielsen et al., 1981).

Rocks of high magnetic susceptibility situated south of the McDonald Fault (Fig. 2) correspond to an undifferentiated mylonitized gneissic complex. Within this complex, zones of metasediments and metavolcanics similar to Yellowknife Supergroup rocks have been mapped and are shown as unit 3 in Figure 1. According to Reinhardt (1969), mylonitization is related to an early period of movement along the McDonald Fault system.

Nonacho Basin

The Nonacho Basin is an intermontane basin filled with some 12 000 m unmetamorphosed fresh water clastic sediments (L. Aspler, personal communication, 1982). The main rock types are polymictic conglomerates, arkoses, shales and greywackes. Most units are thought to be fluvial but turbidite facies in the finer sediments suggest deeper depositional environments in parts of the basin. Gentle folding has imparted a longitudinal (NE-SW) strike to the rocks with dips generally varying from 45 to 60° (Henderson, 1937).

According to Bostock (1982), deposition of the Nonacho sediments likely coincided with uplift in the Fort Smith Belt. He describes mylonite zones, which reflect the initial upward pulse in the Fort Smith Belt, that appear to predate deposition of the Nonacho sediments, and intrusive relationships between the Nonacho sediments and granite bodies that are genetically related to later phases of the Fort Smith intrusive event.

Bostock (1982) further suggests that the Hill Island assemblage (unit 4, Fig. 1), which is exposed to the south of the Nonacho Basin and which has been equated to the Tazin (Archean) of northern Saskatchewan by Mulligan and Taylor (1969), is in fact part of the Nonacho Group. His arguments are based on lithological similarities, intrusive relationships with younger rocks of the Fort Smith Belt, and grade of metamorphism.

Churchill basement east and south of Nonacho Basin

This region, which occupies most of NTS 75C and the southeastern half of NTS 75F, over half of the area covered by the reconnaissance geochemical survey, is the least known. Mulligan and Taylor (1969) have described the rocks of this region as a mixture of granitic gneiss, paragneiss and granite with minor mafic rocks of Archean or Proterozoic ages. On the basis of limited ground traversing in areas N, O, and Q (Fig. 1), the writer suggests a similarity between these rocks and the granite gneiss with minor and interleaved paragneiss of Archean age described by Bostock (1982) in the northeastern part of NTS 75D. In area N (Fig. 1) the writer found outcrops of albite-bearing pegmatites and boulders of sodaclase diorite (Maurice and Plant, 1979) containing an unusual assortment of minerals (see Mineralization) suggesting that there may be important alkaline intrusions in the area.

MINERALIZATION

There are no known economic mineral deposits within the study area but there are numerous occurrences of both radioactive minerals and base metals (Fig. 1).

Sulphide-bearing quartz veins and stringers occur sporadically along the north shores of the East Arm. One such occurrence is located south of area A (Fig. 1) and consists of disseminated chalcopyrite in quartz-carbonate veins that intersect granitic gneiss. A string of mineralized occurrences containing chalcopyrite with minor bornite, chalcocite, and native copper with Au and Ag values also occurs in quartz-carbonate veins along a northeast-trending fault within the East Arm Fold Belt. This mineralization is hosted by carbonates as well as shales and sandstones and is quite extensive with reported Cu contents often exceeding 1%.

A major U occurrence explored by adit in the 1950s, is located within a monzonitic laccolith (unit 8, Fig. 1) near Stark Lake. It consists of coarse grained uraninite associated with magnetite, apatite and actinolite with minor amounts of carbonates, copper sulphides and pyrite (Badham, 1978; Gandhi and Prassad, 1980a, 1982). The laccolith is located about 17 km west of the western boundary of the survey area, but large bodies of similar rock occur in NTS 75K. These have not yet been found to be mineralized but could provide interesting exploration targets. The East Arm Fold Belt is also known to contain radioactive minerals associated with sandstones. Two occurrences of this type are located in arkoses close to the McDonald Fault, southwest of area E (Fig. 1).

In the Fort Smith Belt, radioactive minerals are associated with the megacrystic granite body in area G (Fig. 1). Uraninite and thorian monazite occur in dyke-like mafic bands, a few centimetres thick and several metres in length, that appear to intrude the megacrystic granite. The mafic bands are composed mostly of biotite (60%), quartz (20%) and garnet (10%) with accessory ilmenite, zircon, rutile, apatite, fluorite, sphalerite, pyrite, pyrrhotite, galena and chalcopyrite. Although maximum radioactivity is encountered within these mafic bands, the megacrystic granite is anomalously radioactive throughout and several outcrops have been found with coatings of secondary U minerals.

Northeast of area I (Fig. 1), veins ranging from 2 to 30 cm in width and containing fluorite, massive galena, molybdenite, minor chalcopyrite and pyrite occur in what has been described as a metamorphosed granite (Padgham et al., 1975). One vein exceeds 100 m in length.

In the central part of the Fort Smith Belt, to the west of the study area, Charbonneau (1980) and Burwash and Cape (1981) report radioactive occurrences that are similar to those occurring in area G. From the same area Bostock (1982) describes an occurrence of arsenopyrite and chalcopyrite in amphibolite associated with biotite granodiorite, and two molybdenite occurrences, one in a breccia in contact with Tsu Lake gneiss and the other in a pegmatite dyke cutting garnet-bearing gneiss. Bostock and Thompson (1983) also report several scheelite occurrences associated with granites in the same region. These minerals could occur in the northeastern part of the Fort Smith Belt (NTS 75K) in view of the geological similarities between the southeastern and northeastern parts of the belt.

Within the Nonacho Basin there are several occurrences of radioactive minerals, but there are a greater number of occurrences within basement rocks adjacent to the basin. All of the basement occurrences, with the exception of the one in area N (Fig. 1) and most of those occurring in the overlying Nonacho sediments, are associated with fractures or shear zones. U mineralization is generally accompanied by intense chloritization and small quantities of sulphides (chalcopyrite and galena are common). Fracture-controlled radioactive occurrences near MacInnis Lake (Fig. 1) were also found to be enriched in Au and Bi (Maurice and Plant, 1979; Gandhi and Prassad, 1980b). Whether the overall proximity of the

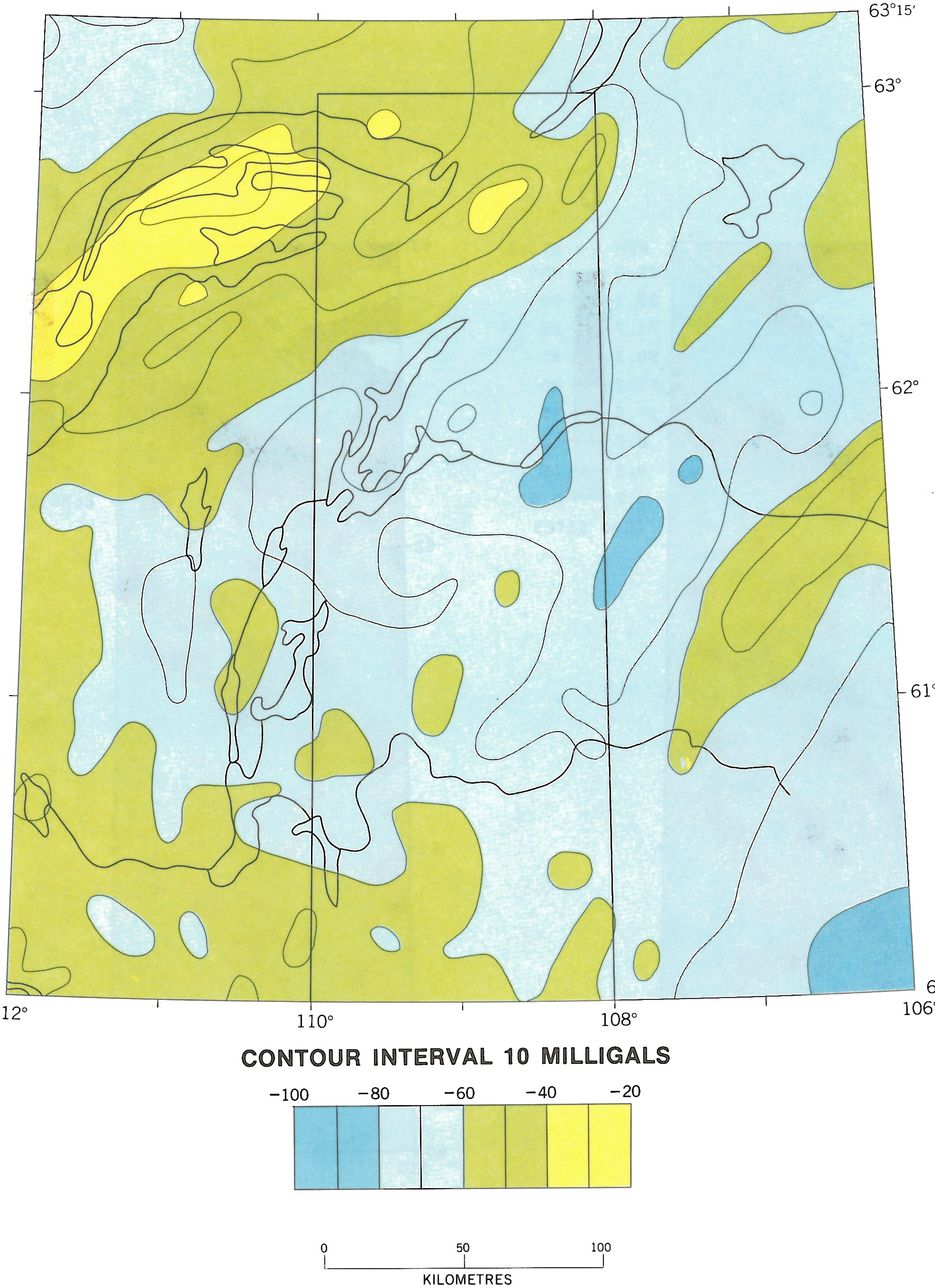

Figure 3. *Bouguer gravity anomaly map (from Earth Physics Branch Map 80-1).*

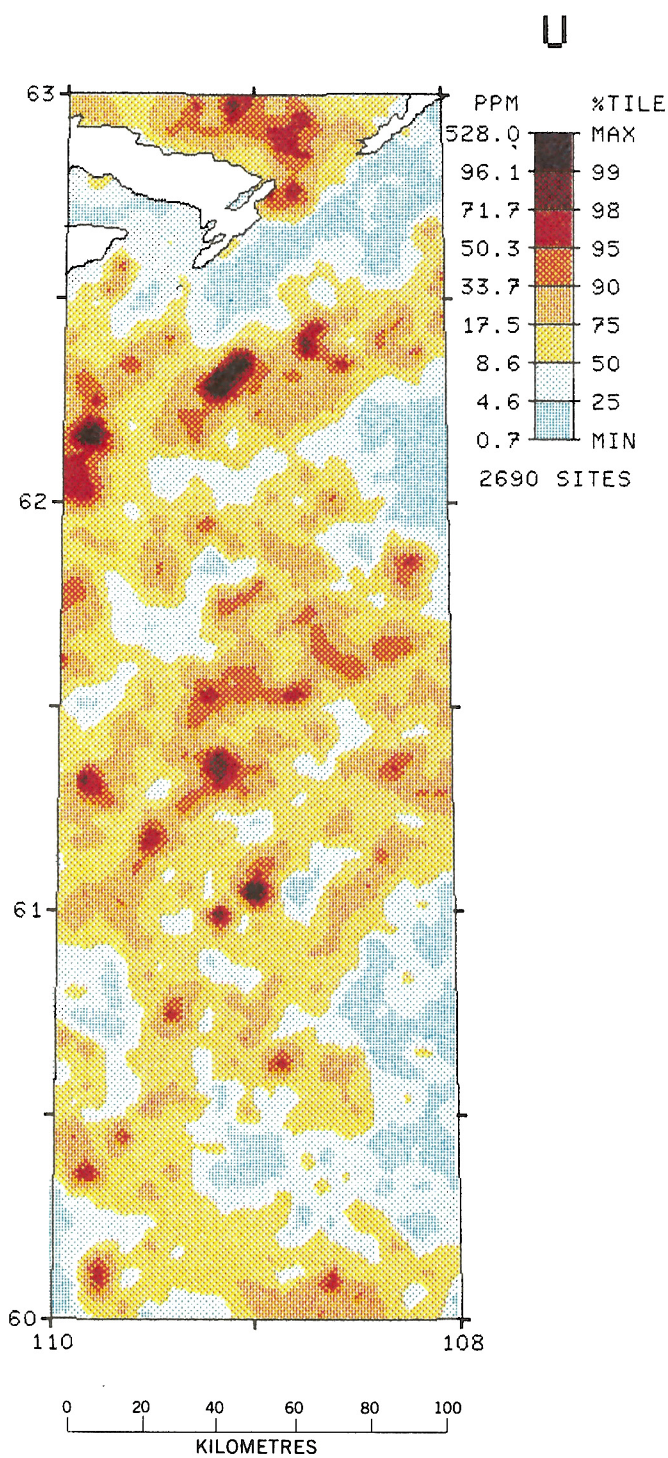

Figure 4. *Distribution of uranium in lake sediments.*

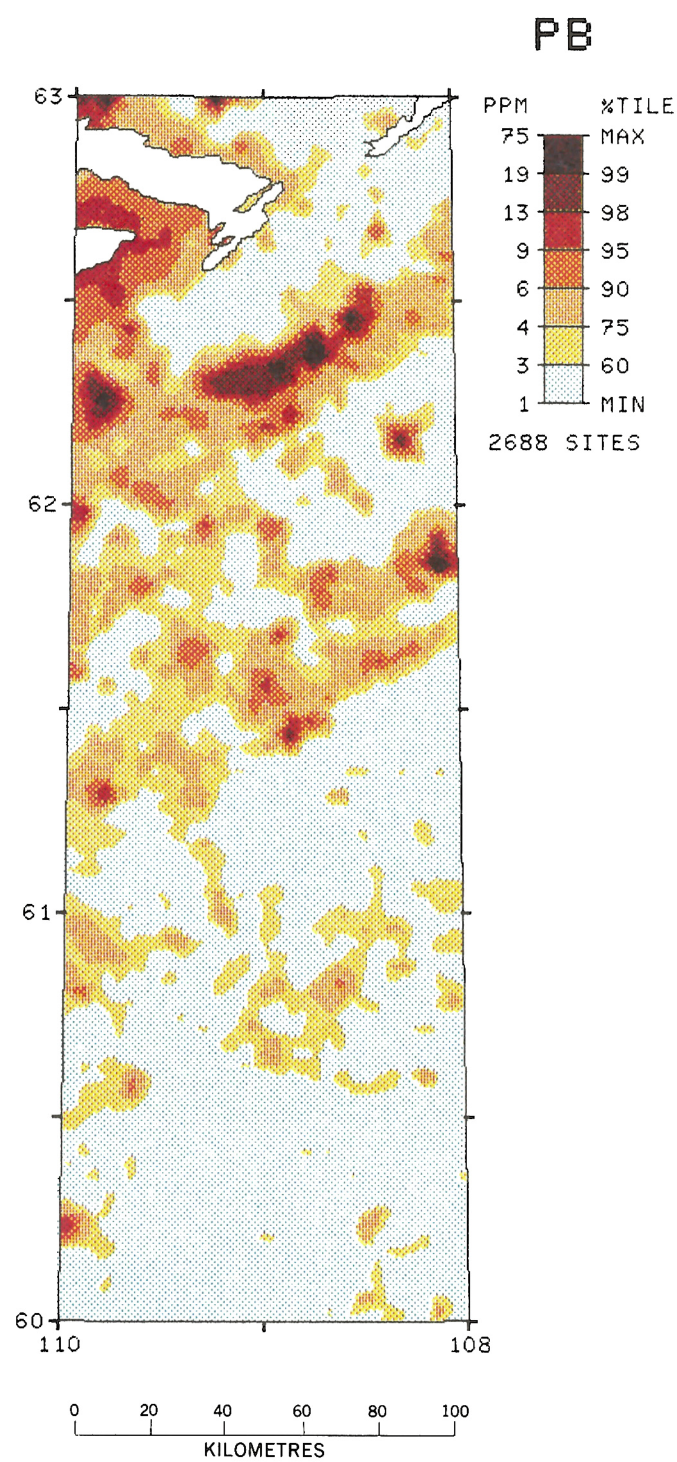

Figure 5. *Distribution of lead in lake sediments.*

radioactive fractures in the basement to the Nonacho sediments reflects a genetic link or simply more intense and successful prospecting, is unclear. The basement rocks that are mineralized in this manner are varied but often they tend to be of the basic type (amphibolite and gabbro).

Two radioactive occurrences within Nonacho sediments are stratiform. Southwest of area K (Fig. 1), stratiform uraninite occurs with pyrite in a greenish-grey to pink siltstone. Near the southeastern shore of MacInnis Lake, uranothorite and thorian monazite, along with cassiterite, native gold and unidentified Nb and Ta minerals occur in paleoplacers within basal quartz-rich conglomerates and arkoses (Maurice and Plant, 1979; Maurice, 1984).

The radioactivity within area N is due to disseminated pitchblende generally associated with epidote in albitic diorite. Only boulders of this material have been reported to date but these occur near exposures of pegmatites containing large crystals of yttrocolumbite (Y, U, Ti, Fe) (Nb, Ta) O_4 (Maurice and Plant, 1979). Although most mineral occurrences within and around the Nonacho Basin contain both radioactive minerals and sulphides, a few occurrences comprise only base metals. The largest is located west of area P (Fig. 1) in a basement inlier and consists of a 125 m long by 6 m wide quartz vein and other smaller veins containing weakly disseminated to massive bornite, chalcopyrite, sphalerite and galena with Au and Ag (McGlynn, 1971; Thorpe, 1972). North of area N, also in a basement inlier, Mo and Cu occur in what has been described as an intermediate volcanic tuff (S.M. Roscoe, personal communication, 1982). Molybdenite is also found with uraninite in a quartz-rich shear zone in basement rocks near the northwest corner of area L.

SAMPLING METHODOLOGY FOR LAKE SEDIMENTS

Lake sediment samples were collected according to instructions, specifications and conditions provided by the Geological Survey of Canada in contract with an experienced survey firm. The area was sampled at an average density of one sample per 13 km^2 using a GSC-developed, torpedo-shaped, sampling apparatus with a winch and rope mounted on the outside on the fuselage of a helicopter. Sites were located in the centre-lake profundal basins, away from the shoreline. An ideal lake would be 1 to 5 km^2 in surface area, at least 3 m deep and constitute an active part of the drainage system in a 13 km^2 grid cell. Lakes too small to be shown on a 1:250 000 scale NTS map were not sampled. With the top several centimetres of sediment from the sediment-water interface washed out of the core barrel during retrieval of the sampling apparatus, the remaining material collected was generally an organic-rich sediment, commonly a greenish-brown to grey thixotropic gel. Samples with a dominant sand-gravel component or totally organic peat from swampland were discarded. High wet strength paper bags, approximately 10x15x15 cm with a double fold top and water resistant glue were used to contain the sediment samples.

Each sampling crew consisted of a pilot, a navigator and note-taker in the front of the cabin with the pilot, and a third member sitting aft who operated the winch from an outside float-mounted platform to collect the lake sediment sample. All crew members were in constant communication through an intercom system. An average rate of 15 sample sites per hour was achieved while sampling on traverse. The overall survey sampling rate depended on the ferry time to and from traverses and logistics of positioning gas caches. The basic sample design incorporated a field and blind duplicate and a control reference sample in every analytical block of twenty samples, to monitor and control sampling and analytical variance.

GEOCHEMICAL INTERPRETATION

Regional trends

The distribution of the elements in the lake sediments of the survey area are shown at the scale of 1:2 000 000 in Figures 4 to 15. Figure 16 shows the location of the individual samples.

Table 1 gives, for each element, the arithmetic mean of all lake sediment samples collected by the Geological Survey of Canada in the Canadian Shield (41 144) up to the end of 1981. These data may be useful in comparing element concentrations in the lakes in the study area with average values for lakes in the Canadian Shield. Care should, however, be taken when using these values to establish whether the rocks of an area are enriched or depleted in a given element in comparison to the Shield because the relation between the geochemistry of lake sediments and surrounding rocks is dependent upon a series of factors which vary from place to place.

The main source of trace elements in lake sediments is bedrock and surficial materials such as till and soil. Variations in their chemical composition generally exert a greater influence on the geochemical pattern of a region than mineralization. The patterns that can be directly attributable to mineralization are for the most part very subtle even at 1:250 000 scale which is normally used to interpret these data for mineral exploration purposes. Furthermore, in the preparation of the 1:2 000 000 scale maps for this publication, a moving average technique was used to interpolate irregularly spaced data to a regular grid for which the unit cell is 3200 m^2. This technique involved weighting using an inverse distance function ($1/d^3$) applied to the nearest five data points. The effect of this moving average is to filter out minor irregularities in the data and emphasize the broader scale or regional features. Despite these attenuating factors, large economic deposits undergoing weathering would be expected to produce significant anomalies.

Although the data are best interpreted in terms of the 5 geological subdivisions defined previously, a few regional trends are noteworthy. For example, the Ni distribution (Fig. 8) seems to indicate that the survey area is made up of several crustal blocks with different concentrations of Ni. A northern block stands out as being higher in Ni in contrast to a central and perhaps also a southern block both lower in Ni. Furthermore, the Ni pattern cuts across and is apparently unaffected by major geological boundaries such as the McDonald Fault or the unconformity that limits the Nonacho Basin. The longitudinal (NE-SW) structural orientation of the

Table 1. Arithmetic mean for selected elements for all regional geochemical reconnaissance lake sediment samples collected by the Geological Survey of Canada in the Canadian Shield to the end of 1981 (41 144 samples except Hg = 29 174 samples)

Zn	- 99.7 ppm	Ag	- 0.12 ppm
Cu	- 33.8 ppm	As	- 2.65 ppm
Pb	- 5.4 ppm	U	- 9.84 ppm
Ni	- 19.5 ppm	Hg	- 61.9 ppb
Co	- 9.3 ppm	Mn	- 495.3 ppm
Mo	- 3.6 ppm	Fe	- 2.415%

Note: less than 2% of the values used in this compilation are below the detection limit of the analytical method except for Pb(25%), Mo(30%), Ag(80%), and As(50%). One half (½) the detection limit was used when concentration was less than or equal to the detection limit (see Appendix).

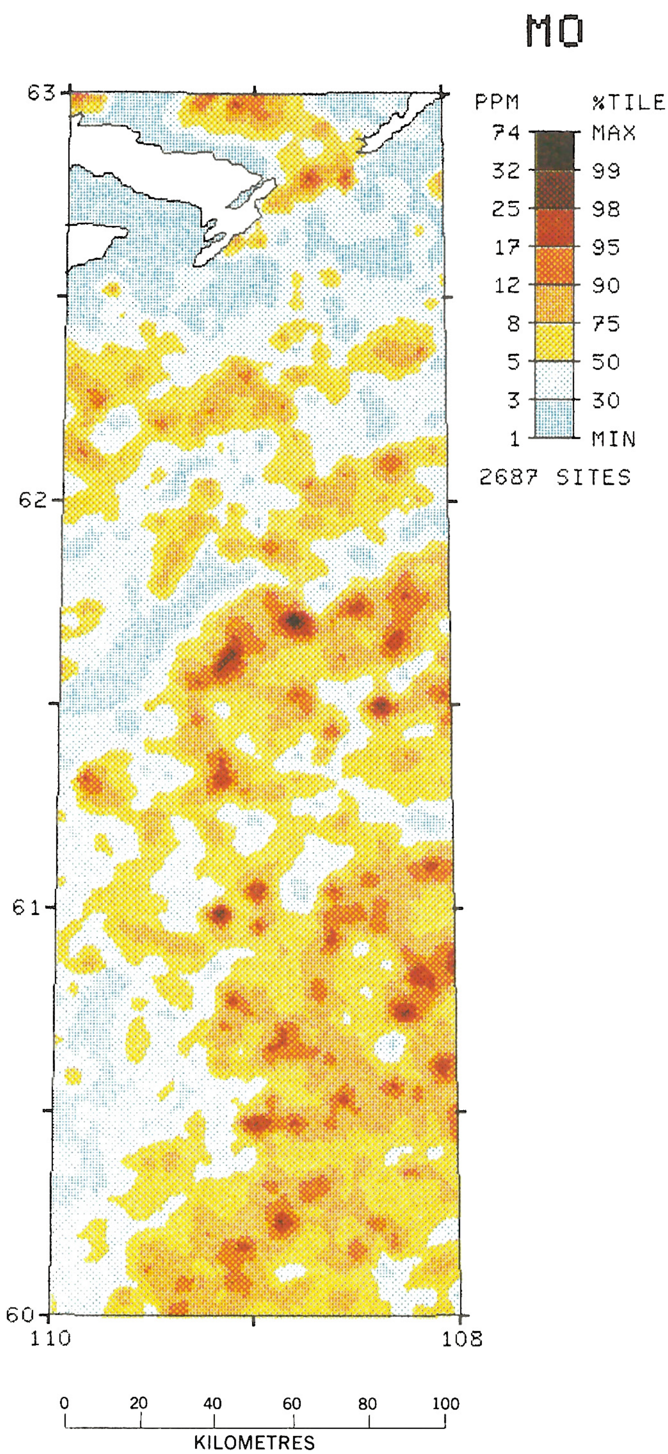

Figure 6. *Distribution of molybdenum in lake sediments.*

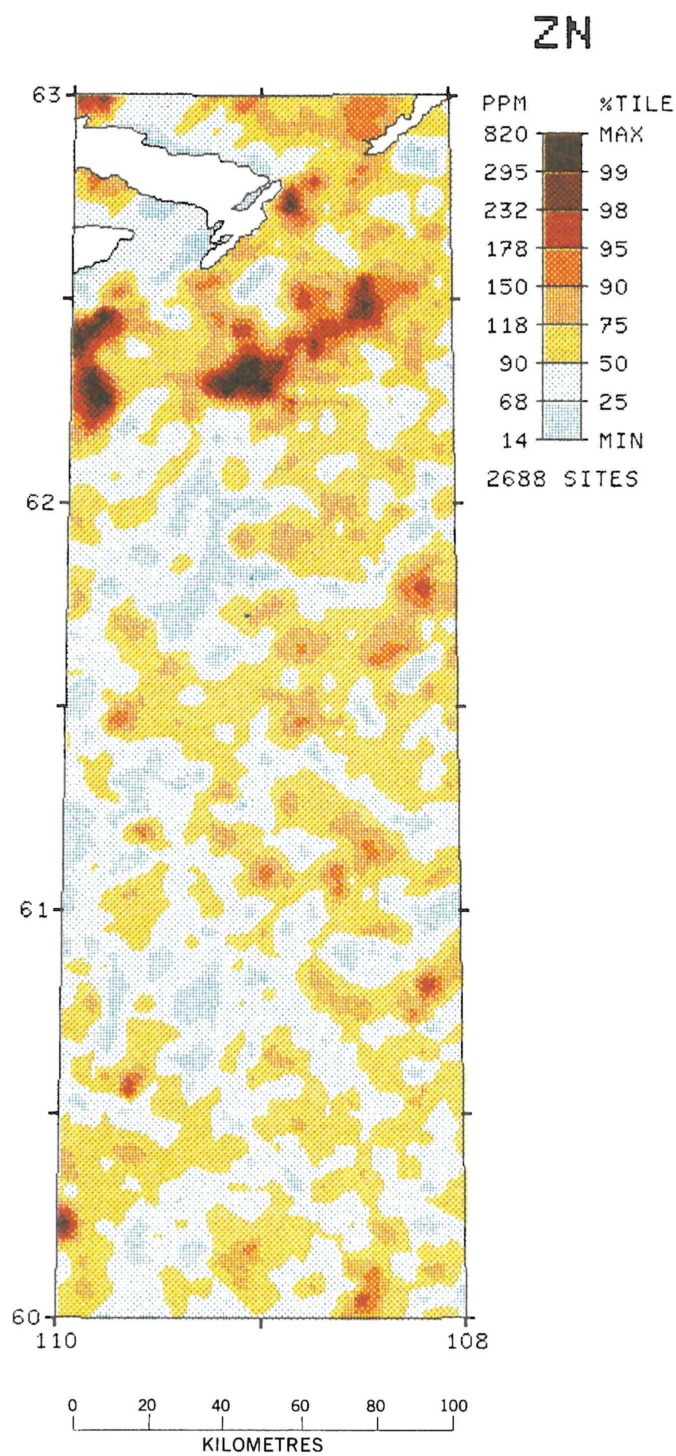

Figure 7. *Distribution of zinc in lake sediments.*

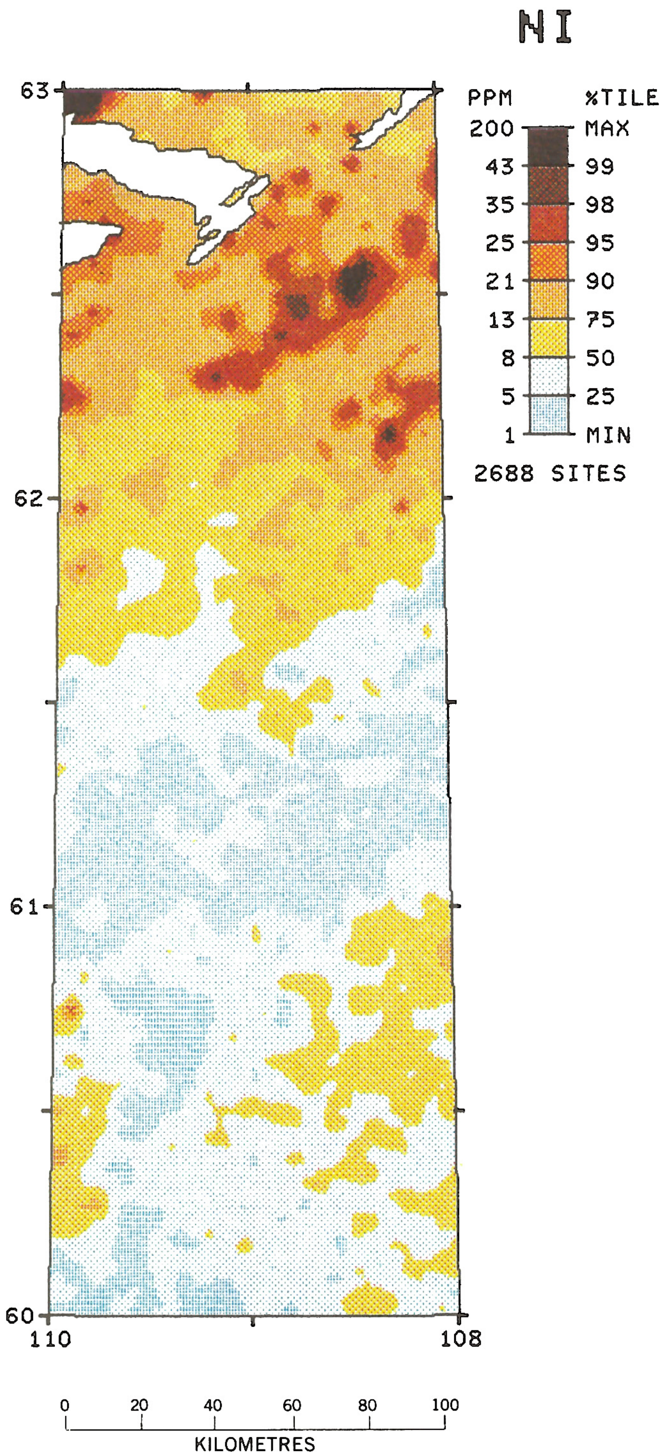

Figure 8. Distribution of nickel in lake sediments.

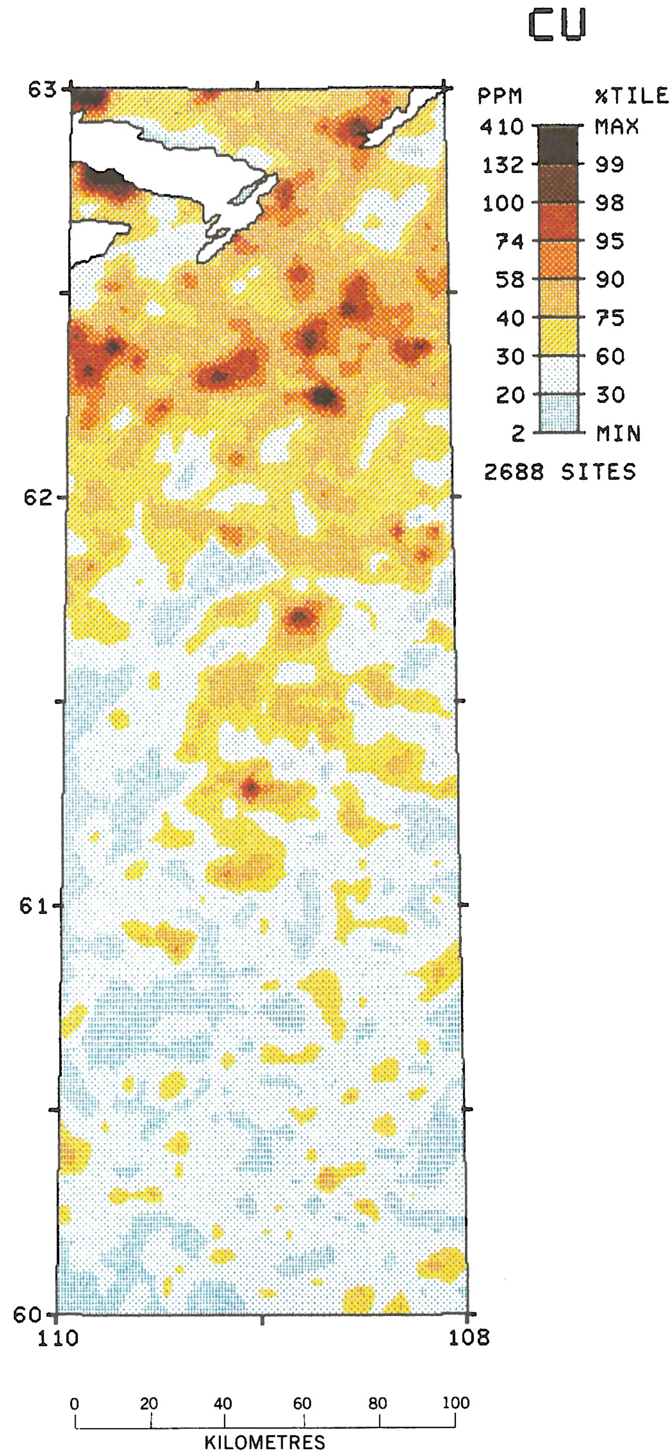

Figure 9. Distribution of copper in lake sediments.

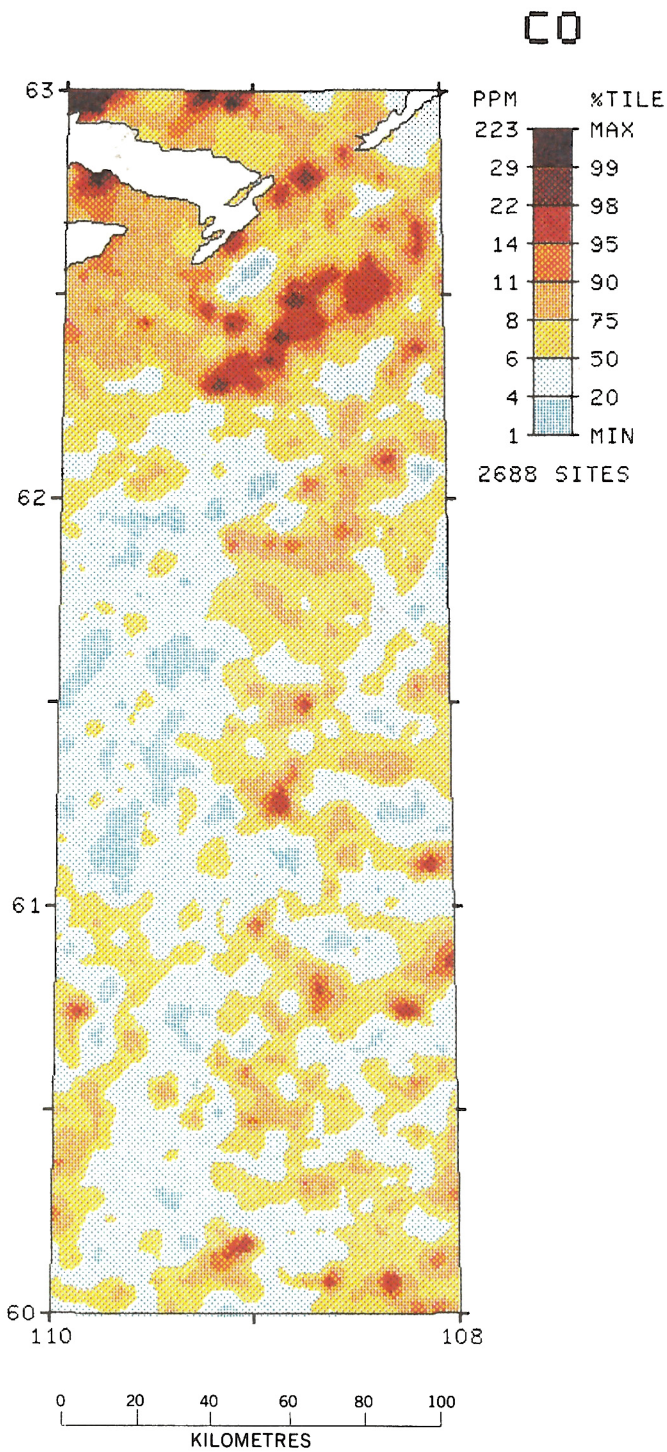

Figure 10. *Distribution of cobalt in lake sediments.*

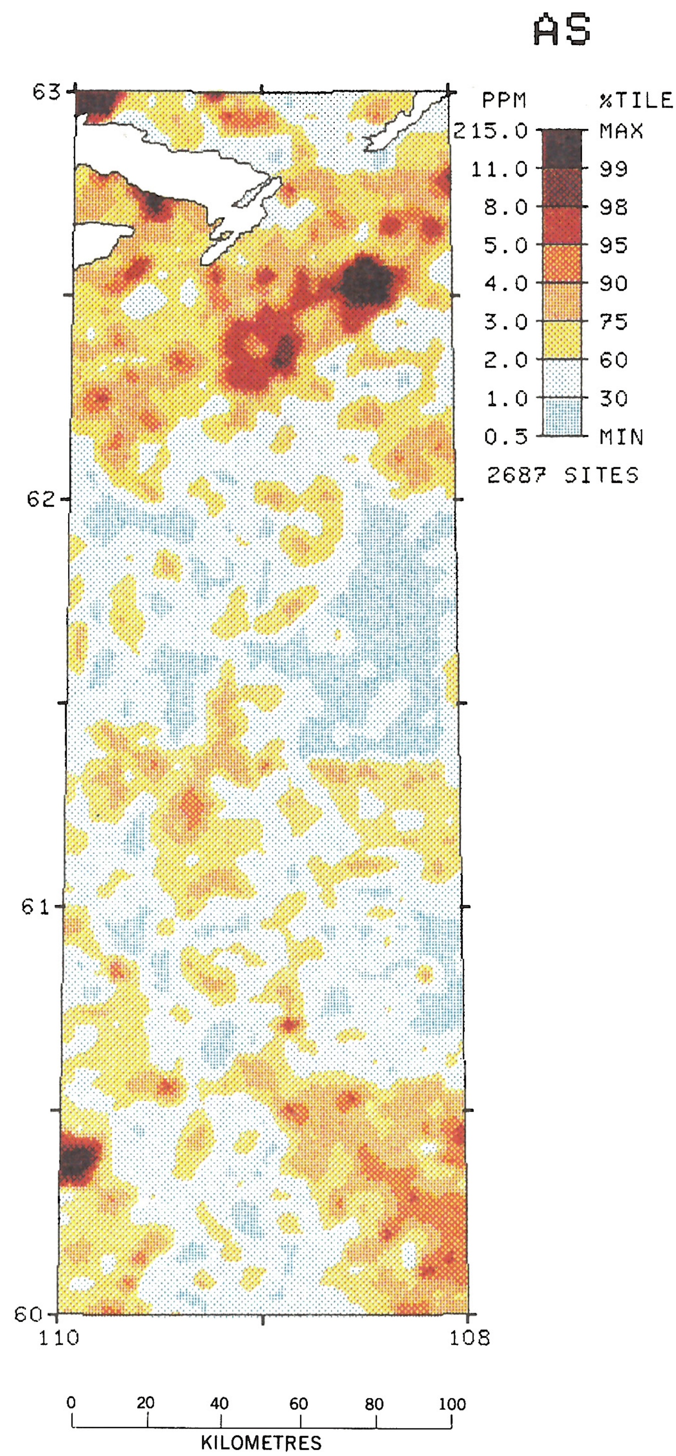

Figure 11. *Distribution of arsenic in lake sediments.*

rocks within the Nonacho Basin offers no explanation for the apparent higher Ni content in the northern part of the basin relative to the southern part. Instead, this pattern probably reflects a degree of geochemical blending caused by glaciation. Glacial till originating from a Ni-deficient granitic terrane to the east appears to have depressed the Ni content of lake sediments in the central part of the Nonacho Basin and a Ni-enriched till, originating from a Ni-enriched terrane in the northern sector, may have the opposite effect in the northern part of the basin. However, in the northern part of the area, glaciation does not appear to have played a major role in shaping the geochemical pattern; this will become clear later.

Higher concentrations of Pb, Zn, Cu, Co and As (Fig. 5, 7, 9, 10 and 11) are displayed in the northern part of the area but none shows as sharp a contrast between the northern and central sectors as Ni. Mo (Fig. 6) is more concentrated in the central and southern blocks. The Pb pattern (Fig. 5), perhaps better than any of the other elements, parallels the NE-SW direction of glaciation. However, the influence of glacial dispersion on the orientation of geochemical anomalies is difficult to evaluate because the structural direction, shown on the aeromagnetic map (Fig. 2), is essentially parallel to the direction of glaciation in most of the area.

Anomalies in the Slave Province

Anomalies in the Slave Province fall into two major categories:

1. Base metals anomalies (Cu, Ni, Co, As, Zn, Pb, Hg) associated with rusty weathering paragneisses of the Yellowknife Supergroup and other metasediments locally mixed with gabbroic rocks. The latter are common near the north shore of the southern tip of Artillery Lake where Ni, Cu and Hg are especially high (Fig. 8, 9 and 12).
2. U-Mo associated with coarse grained, white to pale grey granites.

The metasediments that are associated with type 1 anomalies are generally closely related and are commonly found as inclusions in granitic rocks that produce type 2 anomalies. This results in base metal and U anomalies often being almost coincident, as is the case in area E and to a lesser extent in areas A and D (Fig. 1). In area A, ground observations have shown that the granites often contain sulphide concentrations along fractures, resulting in small gossans at the surface. Because of surface oxidation the sulphides are not visible on the outcrops but the strength of the base metal anomalies in nearby lake sediments suggests that a substantial amount of base metals must be present in this area.

The pale granites are generally from 2 to 10 times more radioactive than normal granites, with maximum radioactivity associated with the coarser grained varieties. Minor secondary U minerals were encountered in the areas of highest radioactivity within area D (Fig. 1). These granites are not in themselves interesting exploration targets but they could have been an important source of U for the formation of sedimentary U deposits in the East Arm Fold Belt.

Anomalies in the East Arm Fold Belt

The gabbro sills in the East Arm Fold Belt (unit 7, Fig. 1) show sharp geochemical contrast with the surrounding sedimentary rocks. Zn, Cu, Co, As and Hg (Fig. 7, 9, 10, 11 and 12) are strongly enhanced over the gabbro in area C (Fig. 1) where the sill is wide enough to enclose several small lakes. These anomalies probably reflect the composition of the basic rocks although the high concentration of some of the elements, particularly Cu could indicate the presence of sulphides.

The distributions of Pb, Ni, Co, and As (Fig. 5, 8, 10, and 11) are uniform over the sedimentary rocks of the Great Slave Supergroup (unit 6, Fig. 1) and, except for Pb, their concentrations approximate the average values for the Canadian Shield (Table 1). Pb is about twice the average Shield value of 5.4 ppm. Other elements including Zn, Cu and Hg (Fig. 7, 9 and 12) are low over the sedimentary rocks of the East Arm when compared to the average for the Shield and to the northern sector as a whole. This is interesting inasmuch as significant Cu mineralization occurs in that area (Fig. 1). A low Cu mobility due to the alkaline calcareous environment of the East Arm[1] may partly explain the low Cu levels in the lake sediments near the mineralization but, as low as this mobility may be, it is not lower than that of Pb (Mann and Deutscher, 1980). Yet, the concentration of Pb is relatively high in the lake sediments of the East Arm. This probably reflects differences in the distribution of the two elements in the country rock. Although Cu attains high concentrations in some fractures, its concentration in the country rock is probably low and that of Pb high, compared to average Shield rocks. The added effect of a high pH environment would probably require that the concentration of Pb be substantially higher in the rocks of the East Arm than in the average Shield rocks in order to produce the high Pb background observed in the lake sediments. Unfortunately, there are no bedrock analyses available that could substantiate these assumptions.

U is generally depleted in the East Arm Fold Belt despite the fact that this region contains sandstone-hosted U deposits. These occurrences, however, are epigenetic, probably related to sources outside the sedimentary basin. Thus, the mineralizing processes were selective, possibly controlled by aquifers, and did not widely affect the rocks of the basin. Weak U anomalies may be observed near the mineralization in sandstones near the McDonald Fault. Other U anomalies are associated with the monzonitic laccoliths (unit 7, Fig. 1). Ground work in area B (Fig. 1) suggests that the U enhancement in that area derives from a more elevated background concentration of U in the laccoliths rather than from a deposit.

Anomalies in the Fort Smith Belt

A strong multielement geochemical anomaly extending some 80 km in a NE direction occurs in the central and eastern portion of the belt. The rocks causing this anomaly are plugs of megacrystic granite enclosed in ferruginous metasediments. Analyses of rocks collected in area G (Fig. 1) indicate that the granite is particularly anomalous in U and Th while the metasediments are enriched in Cu, Mo, Pb, U and Th. In addition, mafic bands within the megacrystic granites contain Cu, Pb and Zn sulphides, U and Th minerals (see Mineralization) and elevated concentrations of Mo, Nb, F, Zr and REE (Maurice and Plant, 1979). Neither Ni nor Co seem to be enriched in the granites or the metasediments, suggesting that there may yet be another rock type in the area supplying these elements to the surface environment to account for high concentrations of these elements, as well as As, in the lake sediments of that region (Fig. 8, 10 and 11). This, as yet unmapped rock, may be a basic or ultrabasic intrusive and could be related to a strong positive Bouguer gravity anomaly detected in that general area (Fig. 3). Hornal and Boyd (1972) have inferred the eixstence of a large body of basic or ultrabasic rocks under the East Arm Fold Belt to account for the positive gravity anomaly to the west of the survey area (Fig. 3) and have speculated that it may have been the feeder for ultramafic intrusive rocks and the gabbro sills found throughout the East Arm. A similar body, perhaps akin to the one under the East Arm, may exist under the Fort Smith Belt. The centre of the gravity anomaly is situated in the mylonites, the high

[1] The pH of 19 lakes on sedimentary rocks within area B (Fig. 1) averaged 8.4

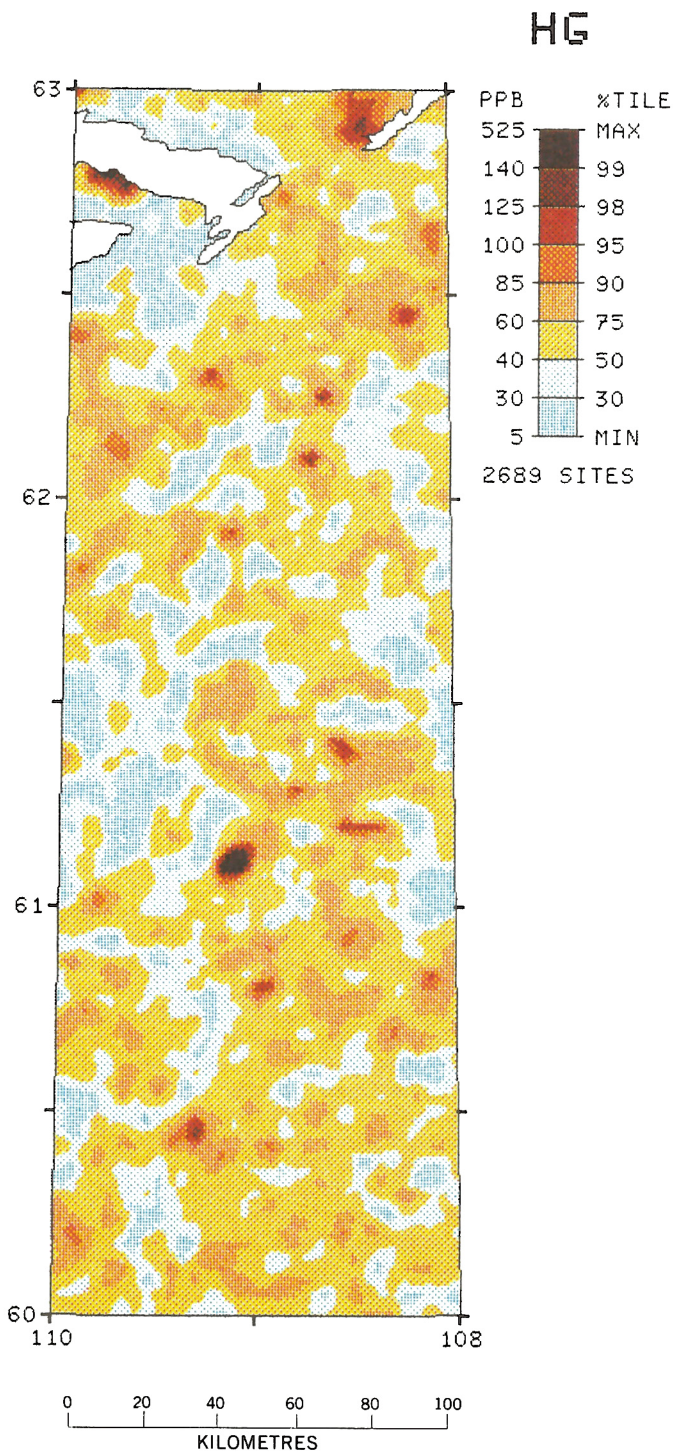

Figure 12. Distribution of mercury in lake sediments.

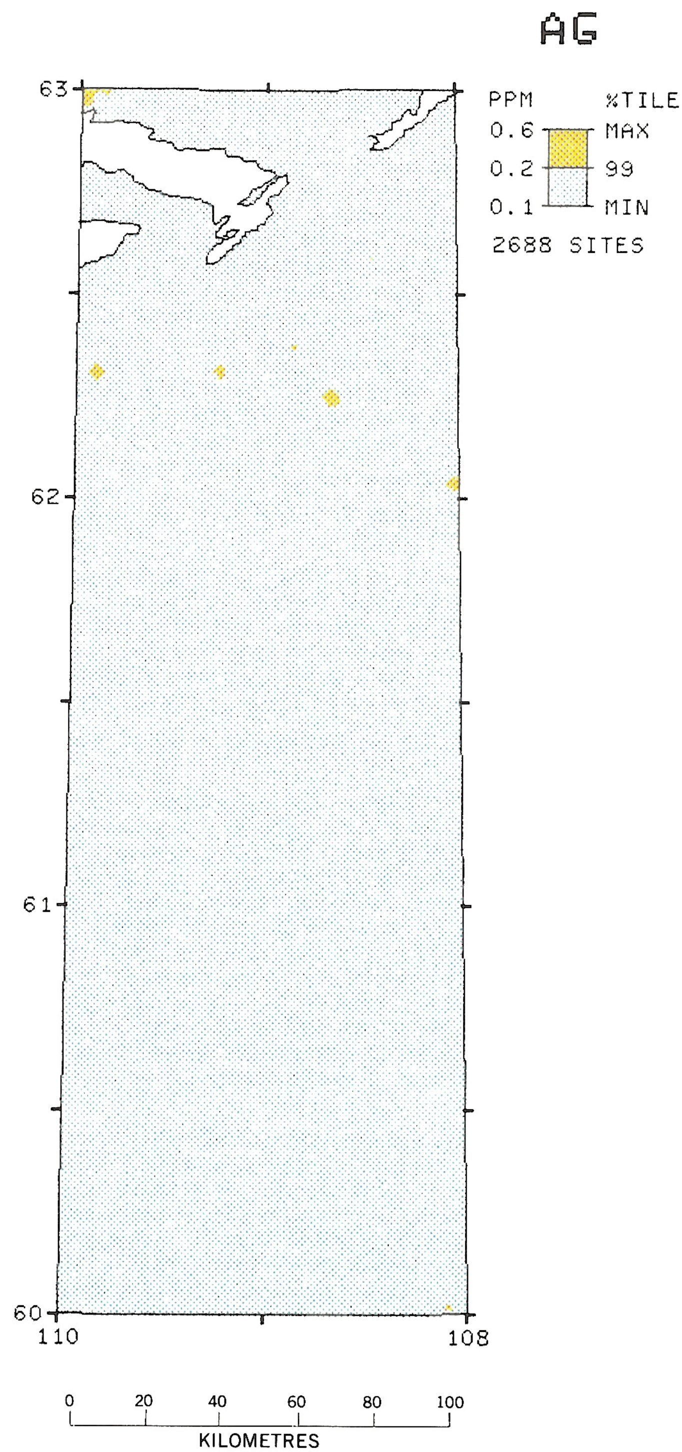

Figure 13. Distribution of silver in lake sediments.

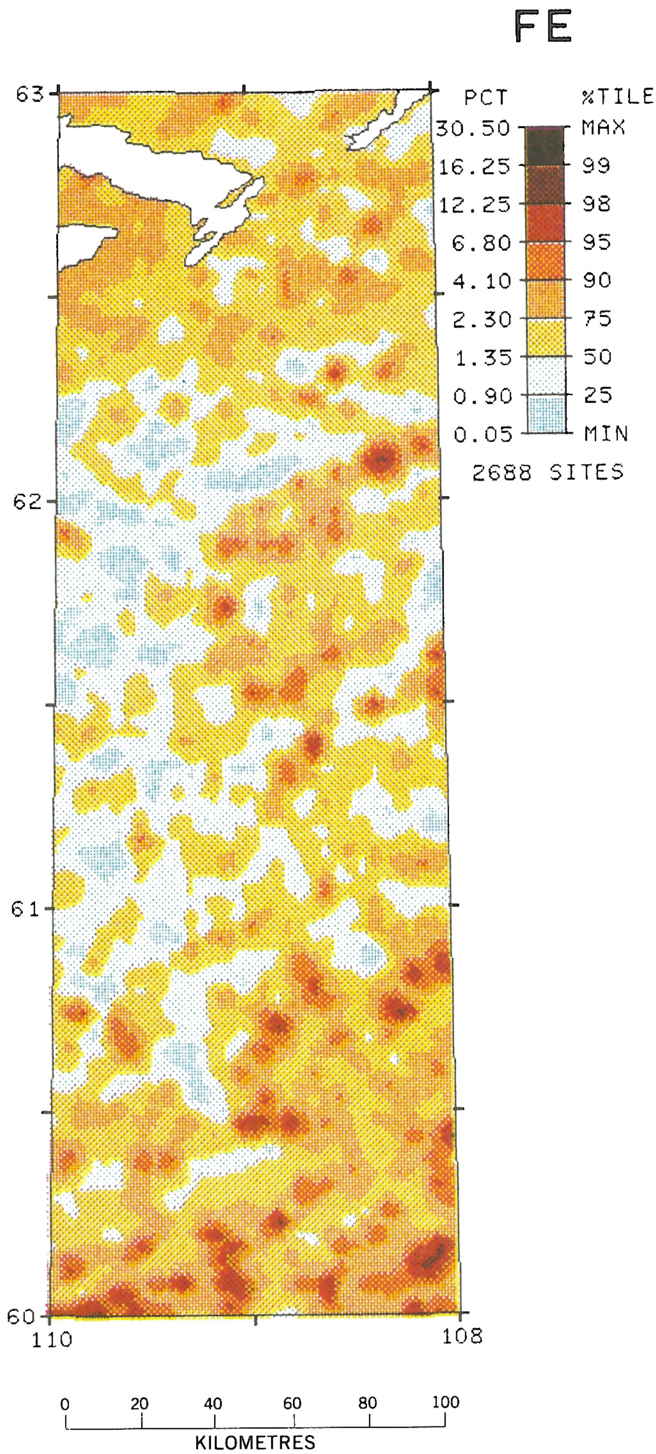

Figure 14. Distribution of iron in lake sediments.

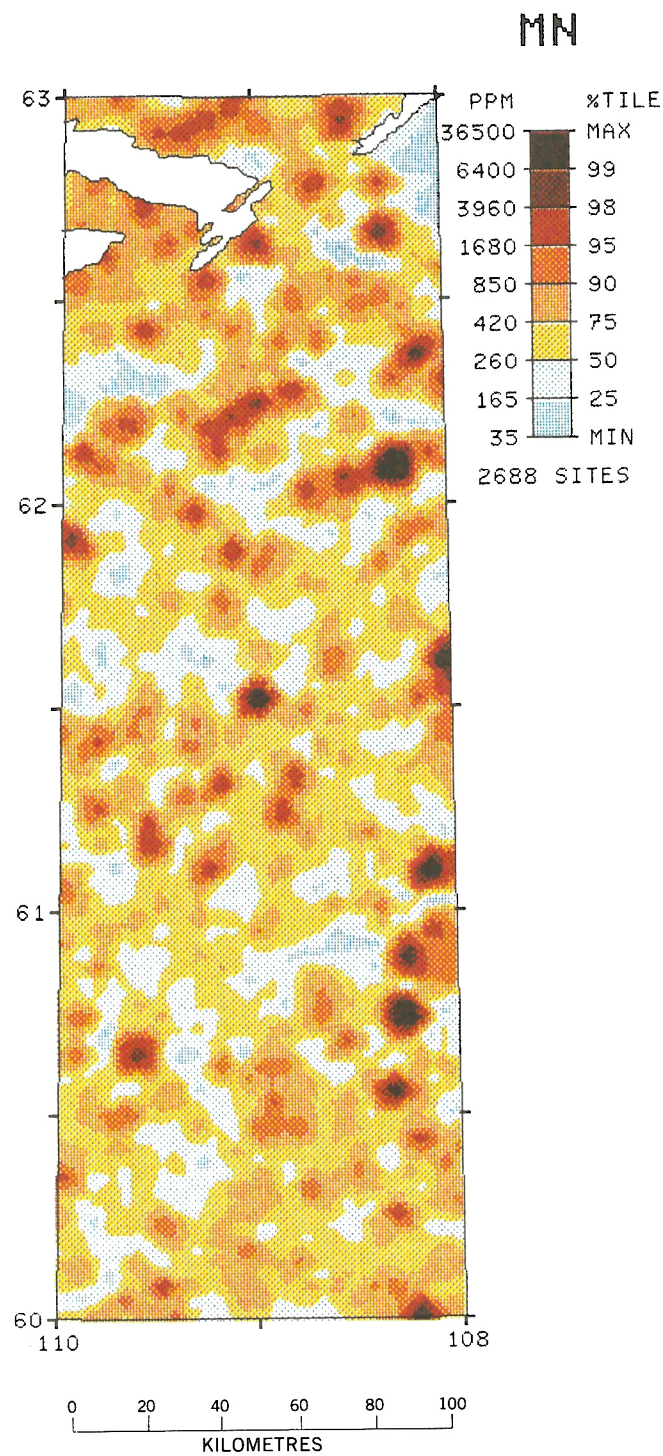

Figure 15. Distribution of manganese in lake sediments.

magnetic susceptibility zone south of the McDonald Fault (Fig. 2). It is interesting to note that those elements that have an affinity for basic rocks (e.g. Ni, Cu, Co and As) tend to be high within the mylonites (Fig. 8 to 11) while elements that do not have such an affinity (e.g. U, Pb, and Mo) are generally low (Fig. 4 to 6) despite their enhancement in the Fort Smith granites and metasediments. This geochemical contrast between various groups of metals that seemingly follows the geology also indicates that glaciation has not had as strong a blending effect in this area as is observed farther south (see Regional trends).

Similar rock assemblages, as described above, are probably responsible for Pb, Zn anomalies with minor U, Mo, Ni and As in area I and strong Cu, Zn anomalies in area H. The occurrence of massive galena-molybdenite-chalcopyrite veins near area I may provide proof that the metals from these rocks have occasionally been concentrated into deposits.

The strong U anomaly in the northern part of area J is probably caused by an isolated plug of megacrystic granite.

Anomalies in the Nonacho Basin

Compared with element abundances in lake sediments from other regions within the survey area and elsewhere in the Shield (Table 1), the sediments from the Nonacho Basin are generally low in Mo, Zn, Co, As, and Hg (Fig. 6, 7, 10-12). Ni and to a lesser extent Cu tend to be enriched in the northern part of the basin compared with the southern part (Fig. 8, 9). This has been interpreted as being due to the presence of Ni(Cu)-deficient glacial deposits over the southern part of the basin and/or Ni(Cu)-enriched glacial deposits over the northern part. Glacial till is likely also responsible for generally high levels of Pb (Fig. 5) within the Nonacho Basin, levels that, in some parts of the basin, are higher than would be expected from the lithology alone. The Pb content of this till probably originates from granitic rocks, not too distant from the basin, on its eastern side.

The distribution of U (Fig. 4) may also have been influenced by glacial dispersion but its higher concentration in the lakes along the margins of the basin seems to reflect the preferential distribution of U occurrences along the Nonacho-basement boundary. Mo (Fig. 6) behaves somewhat differently from the other elements in that it is low throughout the Nonacho Basin despite its relatively high concentrations over basement rocks to the east. The reason may be that the till is not supplying Mo to the lakes because of prevailing acidic conditions in the soil and till which renders Mo relatively immobile. On the other hand, more alkaline groundwaters may be more effective in leaching Mo from granitic basement rocks, leading to higher levels of this element in lakes over the basement (see Hansuld, 1967, for Mo stability fields).

There is a Zn anomaly with minor Cu in the central part of the basin to the north of the base metal occurrence situated to the west of area P. Studies of larger scale maps of that area indicate that this pattern does not derive directly from the exposed mineralization, although its proximity to this deposit and its Cu-Zn association could indicate undiscovered base metal sulphides buried below the surface.

Anomalies in the Churchill basement east and south of Nonacho Basin

As stated previously, this region is less well known geologically so that relationships between geochemical distribution and geology are more difficult to establish.

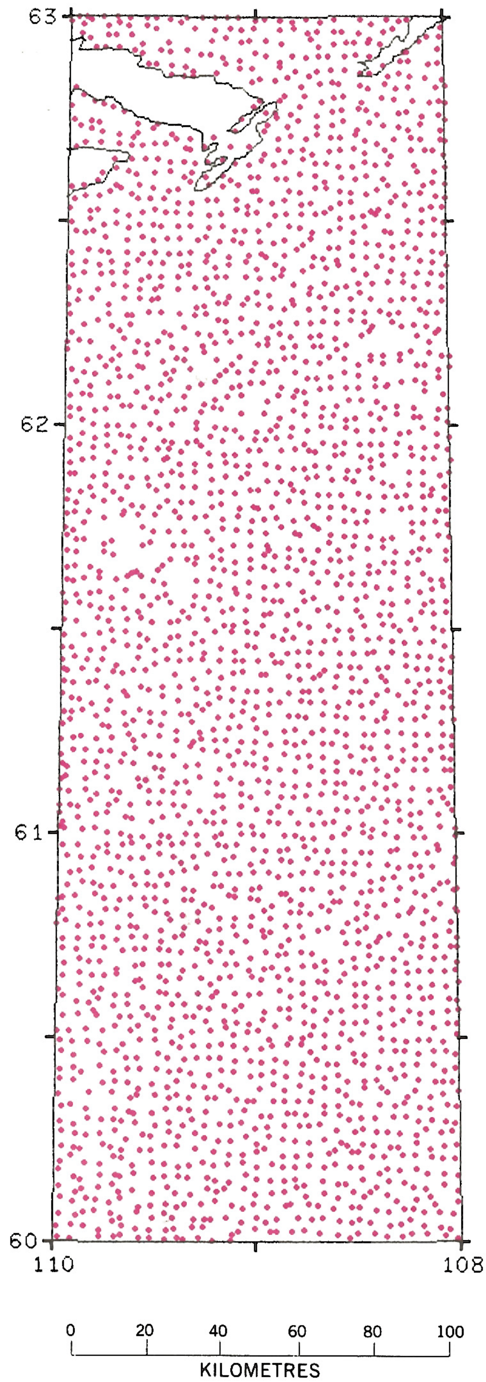

Figure 16. *Sample location map.*

One of the most prominent features is a wide northeasterly oriented band enriched in U, Pb and Mo with some Zn and Cu (Fig. 4-7, 9) which diagonally bisects NTS 75F. This association probably reflects granitoid rocks enriched in these elements and, although the geochemical pattern has likely undergone some reorientation and displacement due to glaciation, the source rocks are probably close to the anomalies. Topographic maps show that this area is well drained (relatively to the Nonacho Basin) so that a high proportion of the metals in the lakes were probably leached directly from the bedrock. As the pattern corresponds well with a magnetic high (Fig. 2), the rocks could also be magnetite-bearing. Ground work in areas N, O and Q failed to identify any specific rock type with these characteristics, but this is not conclusive as the ground traversing was far from exhaustive.

The eastern part of NTS 75C is characterized by noticeable enrichment in Mo, Ni, As and Fe (Fig. 6, 8, 11, 14). The rocks in this area are poorly exposed and the lakes are generally shallower and less organic. As a result they are more oxidizing and their sediments contain a greater proportion of hydrous iron oxides. Elements such as Mo, Ni and As are known to be widely scavenged by these oxides often resulting in anomalous concentrations.

SIGNIFICANCE FOR MINERAL EXPLORATION

The East Arm Fold Belt has many of the geological attributes that make it a favourable environment for the presence of economic base metal deposits not the least of which is the widespread occurrence of sizable Cu and other base metal showings throughout the fold belt (McGlynn, 1971). The absence of Cu anomalies in the lake sediments should not be regarded as an unfavourable sign as it may simply indicate a low Cu concentration in the country rock and/or the inability of this element to disperse from the deposits because of its low mobility in the prevailing alkaline environment. The above normal concentrations of Pb in the lakes of the East Arm are thought to reflect higher Pb concentrations in the country rock rather than Pb deposits. However, recent discoveries of quartz-carbonate veins containing abundant galena with sphalerite and chalcopyrite outside the study area at Artillery Lake, in rocks believed to correlate with the East Arm Supergroup (S.S. Gandhi, personal communication, 1984), may indicate a high potential for East Arm rocks to host such deposits in spite of the fact that there are presently no known Pb occurrences in the East Arm Fold Belt per se.

Economic deposits of U could also be expected in the East Arm Fold Belt but geochemical exploration should be conducted using surface and groundwaters rather than lake sediments. The carbonate environment, which characterizes the East Arm, renders U very soluble as it complexes with bicarbonate (Maurice, 1976b). Because of the occurrence of an important U prospect in a monzonitic laccolith near Stark Lake, these laccoliths and their immediate surroundings should be scrutinized. Gandhi and Prassad (1982) found no significant differences in the chemistry of mineralized and unmineralized laccoliths in the East Arm which suggests that they may be equally favourable hosts of mineralization.

The multielement anomalies associated with sulphidic metasediments both in the Slave Province and in the Fort Smith Belt should be examined closely. The strength of the anomalies indicate that large quantities of metals are present in these areas and it is possible that some may have been concentrated into economic deposits. The strong Ni, Co and As anomalies, which were tentatively linked to unmapped basic rocks, in turn related to the positive gravity anomaly in the northeastern part of the Fort Smith Belt, may be favourable for the occurrence of different types of mineralization. In the East Arm Fold Belt and adjacent crystalline basement, Badham (1978) describes occurrences of Ag, Ni-Co arsenides with variable amounts of Cu and U and points out that most are associated with basic or intermediate intrusive rocks. Such intrusives in the East Arm and adjacent regions should all be examined for these minerals particularly when they occur near positive gravity anomalies. The presence of anomalous Ni, Co, As, Cu, or Ag, or a combination of these elements in the lakes provides an additional clue to the presence of this type of mineralization. The As anomalies in the Fort Smith Belt should also be regarded as a sign of favourability for Au mineralization. Although gold has never been reported in the Fort Smith Belt, Au-bearing veins occur in basement rocks and Nonacho Group sediments in an area adjacent to the Fort Smith Belt, near MacInnis Lake (Maurice, 1984).

Judging from the large number of U occurrences along the margin of the Nonacho Basin, this region seems favourable for the occurrence of economic U deposits. The regional distribution of U in the lake sediments tends to confirm this. It may be that U is related to the unconformity separating the Nonacho sediments from the basement. If this is the case, a U-rich basement, such as occurs on either side of the basin, could be very significant.

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APPENDIX

ANALYTICAL METHODS FOR ANALYZING LAKE SEDIMENT SAMPLES

Zn, Cu, Pb, Ni, Co, Ag, Mn, and Fe

A 1 g sample is digested in 3 mL 16 M HNO_3 at 90°C for 30 minutes. 1 mL 12M HCl is added and the extraction continued for 90 minutes at 90°C. After cooling, the solution is diluted to 20 mL with deionized water, mixed and allowed to settle. The elements are determined by atomic absorption analysis using an air-acetylene flame with background correction for Pb, Ni, Co and Ag. Detection limits are: Zn = Cu = Pb = Ni = Co = 2 ppm; Ag = 0.2 ppm; Mn = 5 ppm; and Fe = 0.02%.

Mo

A 0.5 g sample is digested in 1.5 mL HNO_3 at 90°C for 30 minutes. 0.5 mL 12M HCl is added and the extraction continued for 90 minutes at 90°C. After cooling, 8 mL of 1250 $\mu g\ mL^{-1}$ Al solution is added, diluted to 10 mL with deionized water, mixed and allowed to settle. Mo is determined by atomic absorption using a nitrous oxide-acetylene flame. Detection limit = 2 ppm.

Hg

A 0.5 g sample is digested with 20 mL 16 M HNO_3 and 1 mL 12M HCl for 10 minutes followed by 2 hours at 90°C. After cooling, the sample solution is diluted to 100 mL with deionized water, mixed and allowed to settle. Hg vapour is formed by the addition of 10% (w/V) $SnSO_4$ in 1M H_2SO_4 and is flushed into a cell in the light path of an atomic absorption spectrophotometer where measurement is made at 253.7 nm. Detection limit = 10 ppb.

U

A 1 g sample is weighed into a polyethylene vial, capped and sealed. The irradiation is provided by a Slowpoke reactor with a flux density of 10^{12} neutrons $cm^{-2}\ s^{-1}$. The sample is pneumatically transferred from an automatic loader to the reactor where it is irradiated for 60 s. After a 10s delay, the sample is counted for 60s with 6 BF_3 detector tubes embedded in paraffin. Calibration is carried out twice daily using natural materials of known U concentration as standards. Detection limit = 0.2 ppm.

As

A 1.0 g sample is taken, 20 mL of 6M HCl added and the mixture heated for 1½ hours at 90°C. Arsenic is determined colorimetrically using silver diethyl dithiocarbamate and measurement made at 520 nm. Detection limit = 1 ppm.

LOI

A 0.5 g sample is weighed into a beaker, placed in a cold muffle furnace and the temperature raised to 500°C over a 2-3 hour period. The sample is maintained at 500°C for 4 hours, cooled and reweighed. Detection limit = 1.0%.

GEOLOGY

CHURCHILL PROVINCE

East Arm Fold Belt (6-7-8)

8	*Quartz monzonite laccoliths*
7	*Gabbro sills and dykes*
6	*Great Slave Supergroup* *Carbonate, sandstone, shale, minor basaltic tuff and flows*
5	*Nonacho Group* *Conglomerate, arkose, shale, greywacke*
4	*Hill Island assemblage* *turbiditic greywacke, mudstone, quartzite*
3	*Metasediments* *quartzite, paragneiss*
1	*Undifferentiated basement* *granite, granitic gneiss, paragneiss, migmatite, minor basic rocks.*

SLAVE PROVINCE

2	*Yellowknife Supergroup* *quartzite, paragneiss*
1	*Undifferentiated basement* *granite, granitic gneiss, paragneiss, migmatite, minor basic rocks.*

MINERALIZATION

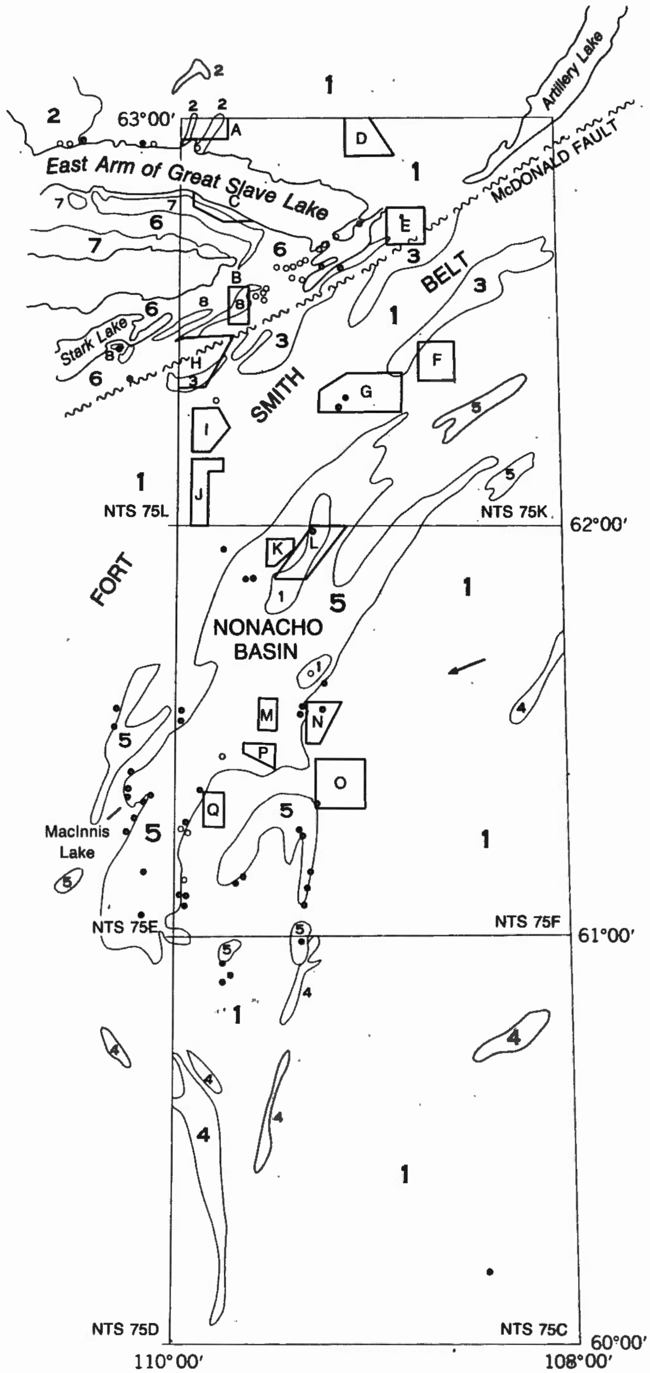
- • *Uranium*
- ◦ *Base metals*

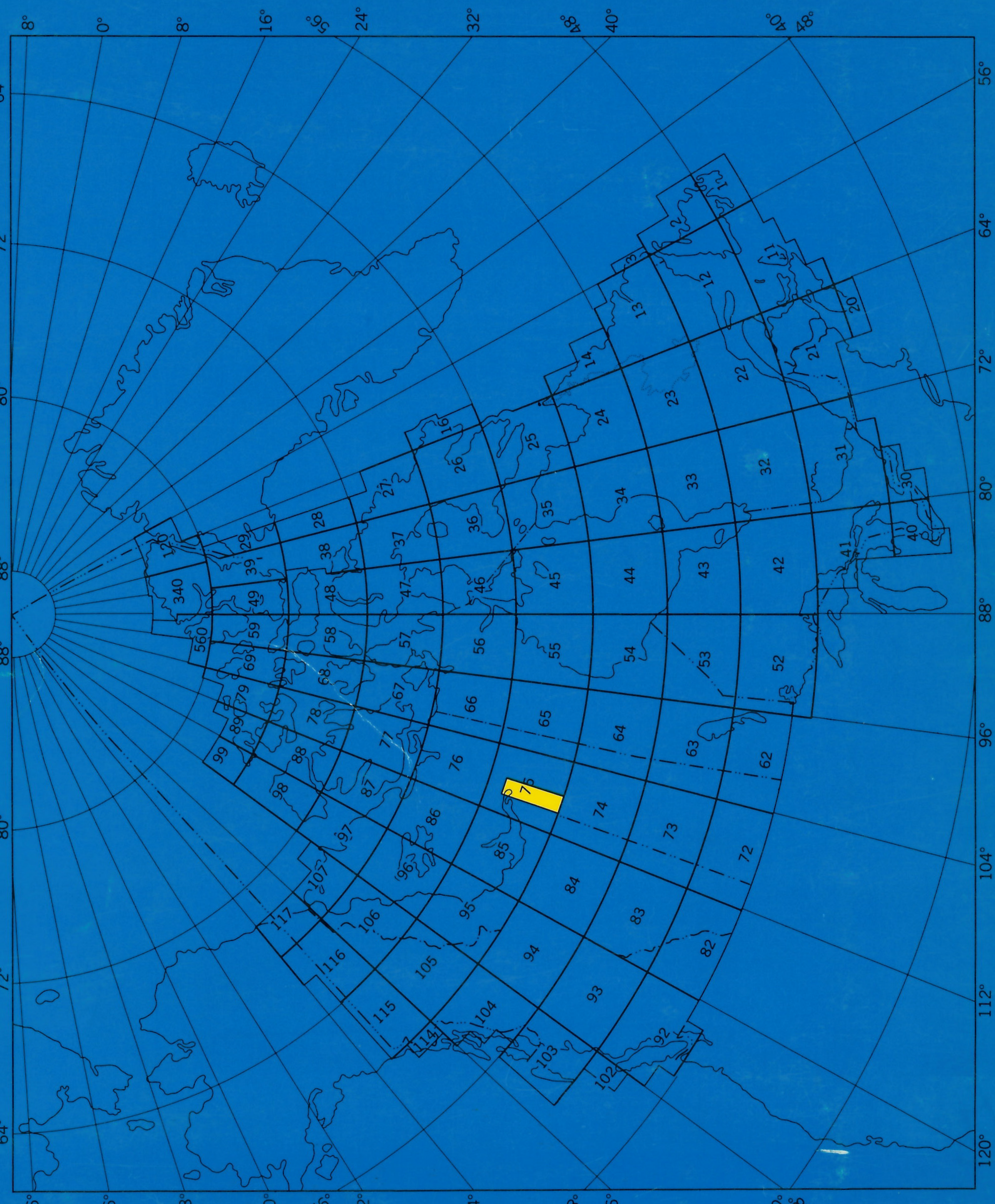
Average direction of ice movement .... ↙

A to Q: areas of follow-up studies, 1976

0 25 50 75 100 km

(To accompany Paper 84-12)





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