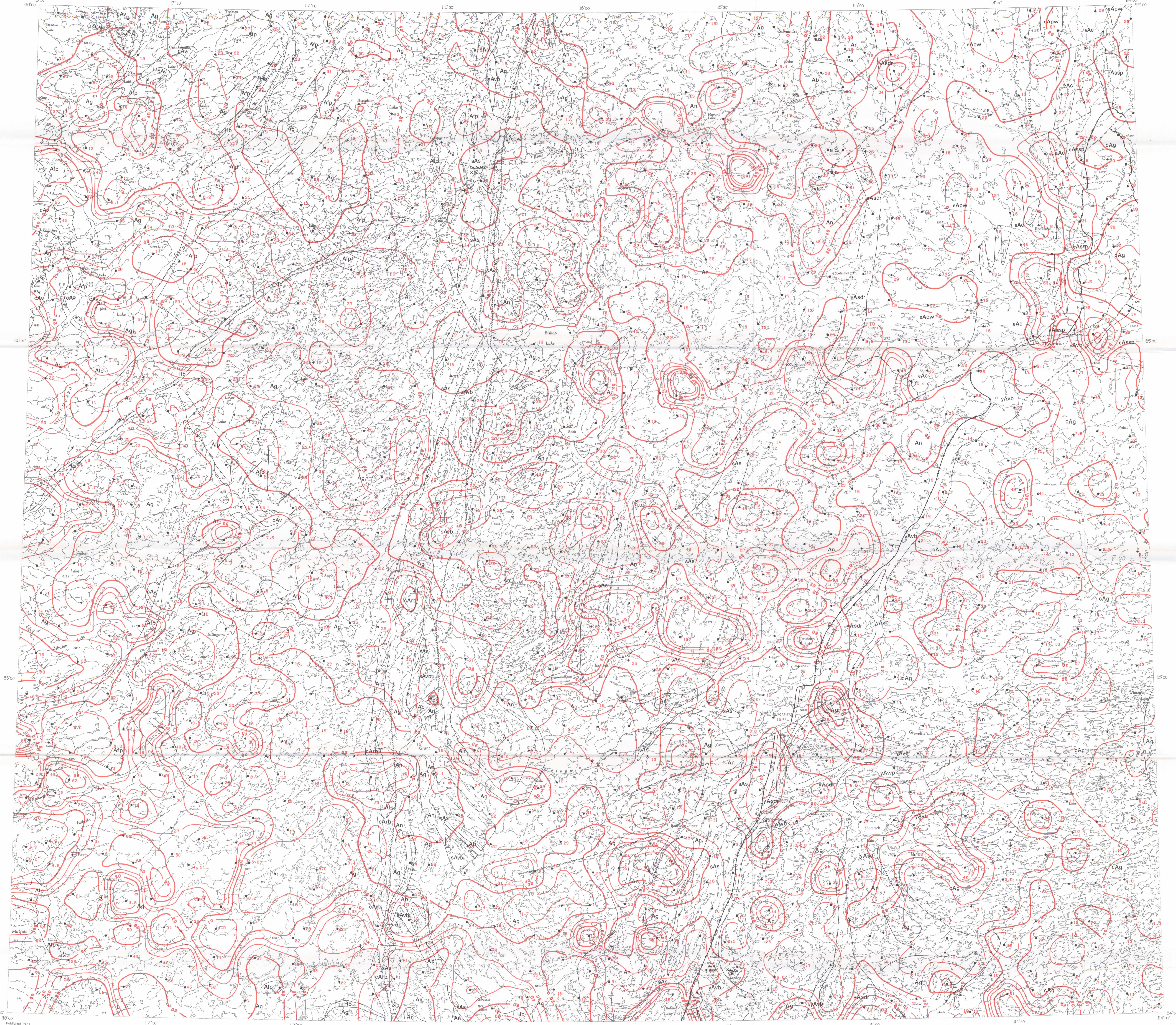
GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

PRELIMINARY SERIES



LEGEND

PROTEROZOIC

HADRYNIAN

Hb	Gabbro sheets, sills

APHEBIAN

Afp	Felsite porphyry
Ag	Granodiorite, diorite, quartz diorite
An	Migmatite, granitic gneiss

CAMERON BAY GROUP

cAv	Intermediate porphyritic flow, tuff, agglomerate
cArb	Red arkose, conglomerate, shale
Ab	Gabbro, diorite

SNARE GROUP

sAvb	Basalt, tuff, minor chert
sAs	Quartzite, dolomite, siltstone, shale

EPWORTH GROUP

eApw	RECLUSE FORMATION: argillite, shale, greywacke
eAc	ROCKNEST FORMATION: dolomite
eAssp	ODJICK FORMATION: sandstone, shale, argillite, andesite
eAsdr	Metamorphosed Epworth Group

ARCHEAN

Ag	Quartz diorite, quartz monzonite, granodiorite, granite. In part porphyritic
An	Granite gneiss, migmatite, mixed gneisses involving Yellowknife rocks
cAg	Complex of plutonic granitic rocks that may be, in part, older than Yellowknife Supergroup

YELLOWKNIFE SUPERGROUP

yAwp	Greywacke, shale
yAsdr	Cordierite-andalusite bearing knotted schist and other metamorphic equivalents of yAwp
yAvb	Intermediate to basic lava, tuff, agglomerate, and undifferentiated acidic volcanic rocks

Boundary between Bear and Slave geological provinces
Fault, observed or assumed
Mineral prospect showing principal element(s)
Lake sample site and metal concentration (sediment sieved to minus 250 mesh)
Lake sample site and metal concentration (sediment sieved to minus 100 mesh)
Geochemical concentration contours as ppm

MINERALS

Asbestos	asb	Molybdenum	Mo
Bismuth	Bi	Nickel	Ni
Cobalt	Co	Silver	Ag
Copper	Cu	Thorium	Th
Gold	Au	Uranium	U
Lead	Pb	Zinc	Zn

Geology after unpublished map compiled by J. C. McGlynn, 1971

Field work by R. J. Allan, E. M. Cameron, C. C. Durham, R. Benson, R. Colley, B. Cumming, G. Lund, D. Mann, C. Pride, G. Thomas and R. Worobuk

Analyses by J. J. Lynch, R. Horton, W. H. Nelson, W. Alexander and A. Martineau

Marginal notes by R. J. Allan and E. M. Cameron

Geochemical contours and metal concentration numbers drawn by computer drum plotter

Geological cartography by the Geological Survey of Canada

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

Base-map assembled by the Geological Survey of Canada from maps published at the same scale by the Army Survey Establishment R. C. E. in 1961, 1962

Copies of the topographical maps covering this map-area may be obtained from the Canada Map Office, 615 Booth Street, Ottawa, Ontario K1A 0E9

Mean magnetic declination 1972, 36°31' East, decreasing 6.7' annually. Readings vary from 36°55' in the SE corner to 36°42' in the NW corner of the map area

Elevations in feet above mean sea-level

MARGINAL NOTES*

Lake Sediment Geochemistry The use of lake sediments as an aid to mineral exploration and geological mapping within the Canadian Shield is based on two principal concepts of their origin. The first is that the detrital portion of a fine-grained lake sediment is a good composite sample of the rocks in the vicinity of the lake. In perhaps a majority of cases, the material forming the sediment has passed through an intermediate stage as a component of locally derived tills or other glacial sediments before being transported to the lake. The second concept is that the fine-grained particles of the sediment are an excellent medium for the sorption of metal ions released during the weathering of nearby sulphide ore deposits or similar mineralization. Most of the known sulphide deposits in the Bear-Slave survey area show moderate to high degrees of oxidation.

At the wide, reconnaissance, sampling interval used, it is unlikely that many samples will be taken from lakes within the limits of the secondary dispersion halo of a single ore deposit. However, country containing such deposits may be defined by the trace element dispersion from the much more extensive non-economic mineralization that is often associated with economic deposits. Similar trace metal patterns may also be derived from mineralization that is not associated with ore deposits or from rock units of unusual chemical composition.

Lake Sediment Sampling The lake sediment samples were collected by post-hole auger from a helicopter. The were taken near the edge of the lake in water 3 to 8 feet deep. They comprise approximately the top 8 inches of sediment, less the surface layer. Of the variety of sediment types that may occur in lakes, the type of sample sought was of clay to silt grade and low in organic material.

Sample Preparation and Analysis The sediment samples were dried, then sieved to minus 250 mesh to give a powder suitable for analysis. A few coarse samples were sieved to minus 100 mesh, then ball-milled. Nickel was analyzed by direct-reading emission spectrometry. The technique summarized below has been described by Timperley, Horton and Lynch, (1973).

A 100 mg sediment sample was mixed with buffer composed of 1 part Na_2CO_3 and 7 parts graphite and containing Pd and In as internal standards. The sample mixture was packed in 3/16" preformed anodes. These were burned in a D. C. arc enclosed in a chamber, through which there was a flow of oxygen-argon. The arc burned at 5 amps for 10 sec. and 15 amps for 50 sec. An 8K minicomputer terminated measurement of the Ni 3415 line after volatilization of this metal was complete, but prior to development of excessive background. The minicomputer converted the accumulated light energy of the Ni line to ppm Ni in real time using calibration curves derived from standards. Background corrections were made and Pd 3421 served as an internal standard. A control standard was run after every tenth sample. For 254 replicate analyses of a lake sediment sample containing 36.8 ppm Ni a standard deviation of 4.4 ppm was obtained. This is equivalent to a coefficient of variation of 12%.

Nickel in Rocks and Ores of the Survey Area During the 1971 orientation survey (Allan, Cameron and Durham, 1972) lake sediment samples were collected from a number of areas within the Bear and Slave Provinces. A selection of the data for these lake sediments is given below as an aid to the interpretation of the levels on this map-sheet. Nickel was determined in the less than 250 mesh fraction after an HNO_3-HCl attack. Nickel values given on this sheet are total contents and are likely to be higher than the values from the orientation survey.

Geological Province	Area	Number Samples	Arithmetic Mean	Median	Geology*
Slave	Indin Lake	35	35	32	Sediments; volcanics, mainly basic; minor acidic volcanics.
	High Lake	31	32	28	Volcanics; sediments.
	Harding Lake	8	28	29	Granites; minor sediments.
	Muskox Lake	11	46	50	Basic volcanics; sediments.
	Hackett River	28	24	16	Acidic volcanics; siliceous sediments.
Bear	Bode Lake	12	23	18	Granodiorite.
	Terra Mine	39	34	34	Volcanics, mainly basic; sediments.
	Muskox Intrusion	12	185	132	Ultramafics, minor gneisses.

* Rocks listed in decreasing order of expected effect on lake sediments.

The lake sediments with the highest nickel content come from the area of the ultramafic, layered, Muskox Intrusion. It is unlikely that such levels will occur in the Bear-Slave Operation area because there are no known large bodies of ultramafic rock. The dimensions and the nickel content of this intrusion are such that high nickel contents were detected in lake sediments to the west, the direction of ice flow. However, copper levels were relatively low. Because nickel sulphide mineralization of the Shield is often associated with copper sulphides, coincident anomalies for these two elements are more favorable exploration targets. In the Slave Province, there were lower but sharp, nickel anomalies at Hackett River and High Lake. At High Lake, rock analyses for nickel showed the presence of scattered mineralization. At both locations, it was suspected that the small, sharp nickel anomalies in lake sediments were due to preferential leaching of nickel from sulphides in the metasomatized rocks near the volcanic vents. At Hackett River, nickel was found to be relatively low in an ore sample (47 ppm Ni in a sample containing 27% Zn) and also low in the sediment from the lake adjacent to the deposit. This sediment sample contained 1419 ppm Zn, 140 ppm Pb, 624 ppm Cu and 32 ppm Ni. Lake sediments overlying acidic volcanic areas are low in nickel, those overlying basic rocks are generally high. For example, the sediments from lakes in the siliceous volcanic-sedimentary area at Hackett River are low in nickel, whereas those from the basic volcanic and sedimentary area at Muskox Lake (note not Muskox Intrusion) are high. Although data on the levels of nickel in the rocks from the orientation survey areas is not available, it is apparent from the above that nickel in lake sediments reflects major geological variations. Also, considering the relative levels of other elements in the lake sediments and rocks of these areas, it is likely that the nickel contents given in the table above for lake sediments are comparable with the mean nickel content of the rocks in each area.

In the Bear Province, nickel along with copper mineralization is found in showings in the Hepburn metamorphic belt in the northeast corner of Sheet 1. This is associated with a gabbroic unit and with a northeast-trending fault. Nickel arsenides are also one of the constituents of the epigenetic uranium and silver veins of the Bear Province. In the Slave Province, nickel mineralization is found in showings in the basic volcanics of the Yellowknife Supergroup. As noted above, it appears that nickel sulphides are present as the metasomatized rocks around the massive sulphide deposits of this province. Nickel is one of the elements in the hierarchy of indicators for such deposits, as outlined in marginal notes for zinc, lead and copper.

Nickel in the Surficial Environment Nickel is found in nature in the divalent form. When in solution it is moderately mobile and is probably transported in the ionic form as $[Ni(H_2O)_6]^{2+}$. It may travel considerable distances in this form, but is precipitated in neutral to alkaline environments as the hydroxide or is co-precipitated with iron hydroxides.

However, most nickel is probably transported mechanically, either in primary silicates or in silicates formed during weathering. The primary ferromagnesian minerals of igneous rocks that contain nickel may be converted during weathering to complex nickel-bearing layer silicates. Factor analyses of the data for 24 major and trace elements from Sheet 1 showed that a high proportion of the total variance for nickel, cobalt, chromium, vanadium, iron and magnesium is contained in the most significant common factor. This factor contains approximately one-half of the total variance of the data set. Preliminary X-ray diffraction and microscopic examination of samples with heavy loadings, showed that this factor is correlated with ferromagnesian minerals in the samples. Further work may, however, show that it is more complex than being a simple "ferromagnesian mineral" factor. Nevertheless, as a working hypothesis it may be expected that most, but not all, of the variation of nickel across the map-sheets is due to changes in the ferromagnesian mineral content of the sediments. This, in turn, is related to the content of such minerals in the rocks and tills of each lake drainage basin.

Predominantly mechanical transport of nickel has been demonstrated in two nickel-rich areas underlain by permafrost. Nickel was found to be concentrated in the coarse (plus 250 mesh) fractions of lake sediments that overlie an ultramafic intrusion containing only minor nickel sulphides (Allan and Crook, 1972). Nickel was not detected in lake waters in this area. The reverse was true for sediments from an area of nickel sulphide-bearing ultramafic sills. Here nickel was readily detected in lake waters and was concentrated in the fine (minus 250 mesh) fraction of the sediments. In the latter case, the high nickel levels were accompanied by high values for copper.

Considering the above, it may be possible to detect, in lake sediments, nearby weathering nickel sulphides by considering the anomalous nickel areas in relation to (1) the levels of the other elements present in ferromagnesian minerals; and (2) the levels of other elements, e.g. Cu that could accompany the nickel in sulphides.

Nickel that is transported mechanically will be subject in the lake environment to variations due to particle sorting. For such reasons an attempt was made to collect samples from similar bottom environments and of similar size grade as outlined above under Lake Sediment Sampling. Analyzing a constant sieve fraction of the sediment also helps to reduce variations of this type.

Nickel in Lake Sediments, This Sheet As is the case for many metals studied during this work, nickel is somewhat more abundant in lake sediments from the Proterozoic Bear Province than from that portion of Sheet 1 underlain by Archean rocks of the Slave Province. In the latter region, nickel is generally less than 20 ppm and many areas contain 10 ppm or less. Within the Bear Province the majority of lake sediments contain more than 20 ppm Ni. There are few anomalous areas in Sheet 1 and there are none of a magnitude that would indicate the presence of an extensive, nickel-rich ultramafic rock unit. As indicated above, most of the variation in nickel distribution is probably related to variations in ferromagnesian mineral and layer silicate distribution in the survey area.

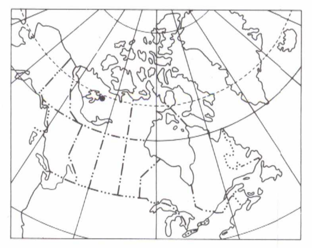
The most obvious anomaly for nickel is to the north of Exmouth Lake and east of Acasta River. High chromium and iron levels are also found in this area which is underlain by sediments of the Snare Group. This and other scattered highs in the Hepburn metamorphic belt are probably related to the ferromagnesian mineral content of the underlying rocks.

In the northwest, there are higher nickel values adjacent to the Terra Mine silver area. This area along with others in the Great Bear Batholith is known to contain nickel arsenides in epigenetic vein mineralization.

Further fractionation and analyses of the lake sediments will locate the site of the nickel in the samples. The source of this nickel in rocks and tills of lake drainage basin will only be resolved by follow-up sampling of these materials.

* Geological Survey Paper 72-50, contains a detailed description of the experimental basis for lake sediment sampling in the Shield; the geology and metallogeny of the region; the organization, methods, and costs of the sampling operation; the methods of sample analysis and the references for the articles quoted above.

Published 1973
Copies of this map may be obtained from the Geological Survey of Canada, Ottawa



MAP 14 - 1972

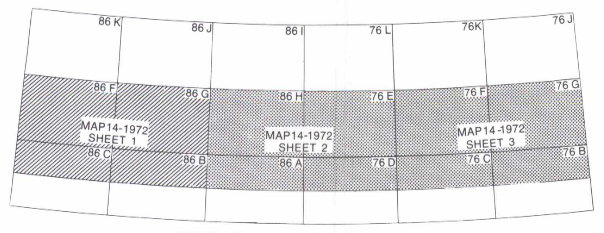
SHEET 1

NICKEL CONTENT OF LAKE SEDIMENTS
BEAR-SLAVE OPERATION

DISTRICT OF MACKENZIE

Scale 1:250,000

Miles 4 0 4 8 12 Miles
Kilometres 6 0 6 12 18 Kilometres



MAP 14 - 1972
SHEET 1
NICKEL
BEAR-SLAVE OPERATION
DISTRICT OF MACKENZIE