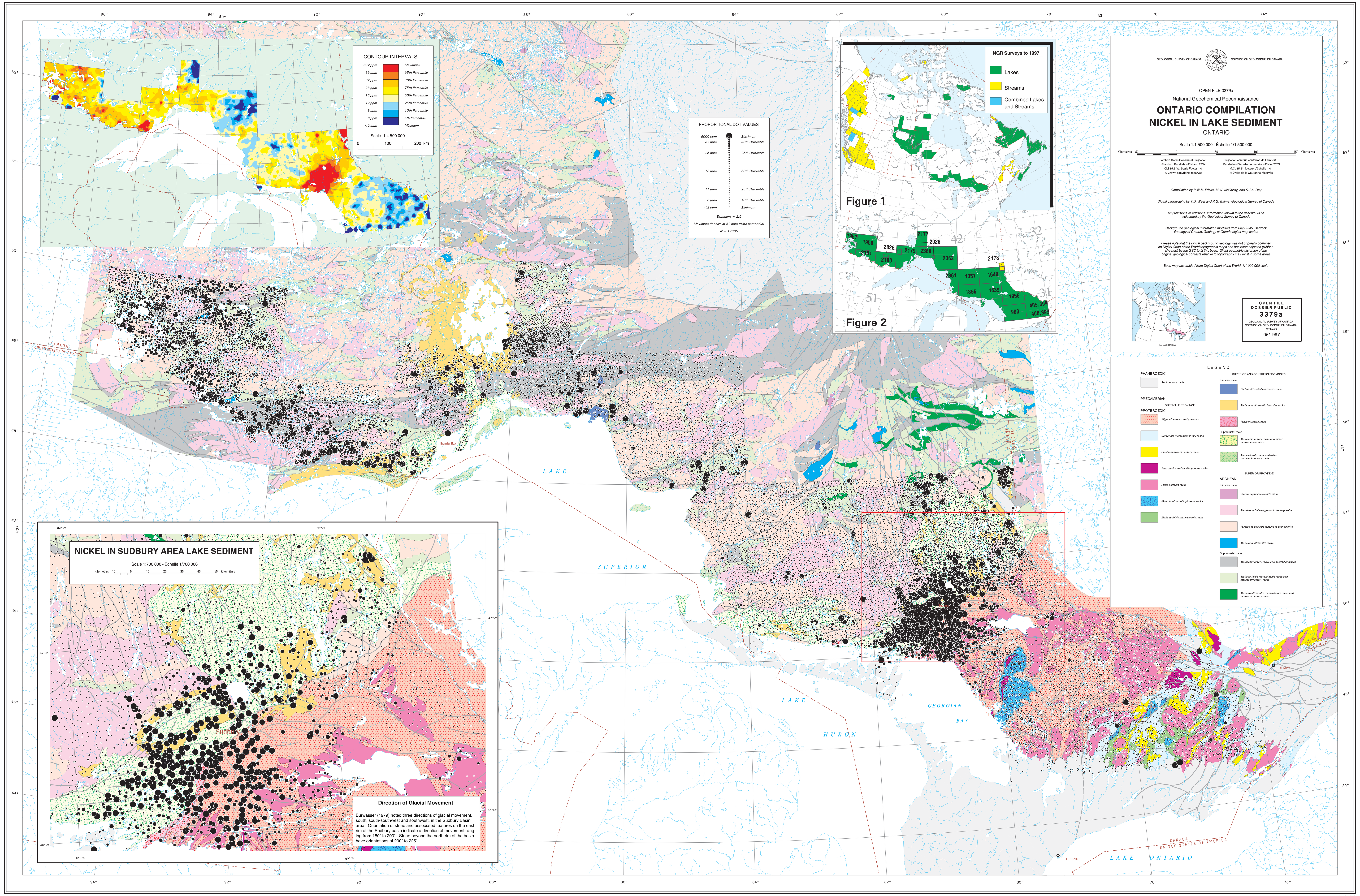
Natural Resources Canada / Ressources naturelles Canada


CONTOUR INTERVALS
Scale 1:4 500 000
PROPORTIONAL DOT VALUES
NGR Surveys to 1997
Lakes
Streams
Combined Lakes and Streams
Figure 1
Figure 2
NICKEL IN SUDBURY AREA LAKE SEDIMENT
Scale 1:700 000 - Échelle 1/700 000
Direction of Glacial Movement
Burwasser (1979) noted three directions of glacial movement, south, south-southwest and southwest, in the Sudbury Basin area. Orientation of striae and associated features on the east rim of the Sudbury basin indicate a direction of movement ranging from 180° to 200°. Striae beyond the north rim of the basin have orientations of 200° to 225°.
LEGEND
LAKE SUPERIOR
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
CANADA
UNITED STATES OF AMERICA
TORONTO

GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

OPEN FILE 3379a

National Geochemical Reconnaissance

ONTARIO COMPILATION NICKEL IN LAKE SEDIMENT

ONTARIO

Scale 1:1 500 000 - Échelle 1/1 500 000

Kilometres 50 0 50 100 150 Kilomètres

Lambert Conic Conformal Projection
Standard Parallels 49°N and 77°N
CM 85.5°W, Scale Factor 1.0

Projection conique conforme de Lambert
Parallèles d'échelle conservée 49°N et 77°N
M.C. 85.5°, facteur d'échelle 1,0

Compilation by P.W.B. Friske, M.W. McCurdy, and S.J.A. Day

Digital cartography by T.D. West and R.G. Balma, Geological Survey of Canada

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

Background geological information modified from Map 2545, Bedrock Geology of Ontario, Geology of Ontario digital map series

Please note that the digital background geology was not originally compiled on Digital Chart of the World topographic maps and has been adjusted (rubber-sheeted) by the GSC to fit this base. Slight geometric distortion of the original geological contacts relative to topography may exist in some areas

Base map assembled from Digital Chart of the World, 1:1 000 000 scale

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INTRODUCTION

Large areas of Canada have been covered by stream and lake surveys carried out under the National Geochemical Reconnaissance (NGR) program. The goal of this program is to establish and maintain a nationally consistent database of field and analytical data derived from drainage sediment and water samples. Toward this end, systematic surveys have been conducted since 1973. To date (1997), more than 200 surveys have been completed to NGR standards, representing over 190 000 sites covering 2.3 million km^2 throughout Canada (Figure 1). These were carried out mainly by the Geological Survey of Canada, either independently or in cooperation with provinces and territories, under various funding arrangements.

Consistent methods of sample collection, sample preparation and chemical analysis developed and employed at the GSC are the hallmark of NGR surveys (Friske and Hornbrook, 1991). Geochemical surveys carried out by the GSC or provincial/territorial agencies, shown in Figure 1, fulfil these criteria and qualify as NGR surveys.

At present, data for each NGR survey are available in hard copy and digital form. However, to simplify access to such a substantial collection of diverse information, a digital database is being created using Microsoft ACCESS software. As entry of large contiguous blocks of data (e.g. all Labrador lake sediment and water data) is completed, geochemical maps and reports are being produced that display and summarize the data. The aim of this second generation of publications is to increase awareness of NGR data and enhance applications not only to mineral exploration but in other areas as well, such as public health and environmental studies.

This map summarizes the distribution of nickel from 17 935 lake sites in Ontario sampled between 1976 and 1989. Figure 2 shows the individual open files that make up the Ontario compilation. Detailed, site-specific information is available in these open files.

SURVEY METHODOLOGY

A detailed description of the NGR survey methodology is given in Friske and Hornbrook (1991). Below is a brief summary, with particular reference to the Ontario lake sediment and water surveys.

Sample Collection

Sample collection is carried out by a two-person sampling crew in a helicopter mounted on floats. An ideal sample comes from a lake less than 5 km^2 in size and greater than 3 metres deep, with a single central basin that is the focus of drainage in the area around the sample site.

Sediment is collected from a centre-lake profundal basin using a hollow-pipe, bottom-valve sampler (85 cm long x 10 cm diameter) attached to an external winch and rope system mounted on the fuselage of the helicopter. Generally, the full length of the sampler penetrates into the bottom sediment and the sample represents a 30 to 35 cm section from several tens of centimetres below the sediment-water interface. However, if relatively clastic-rich material is encountered, the sampler may not penetrate its full length, and some surface material is included. The ideal sample material is an organic-rich sediment (*gyttja*), commonly a greenish-brown to grey thixotropic gel, but clay, marl and/or sandy samples may also be encountered. At each site, field observations such as lake size, lake depth and local relief are recorded.

Lake waters are routinely collected at all lake sediment sites. Rectangular wide-mouth polyethylene bottles (250 ml) are used to sample water from depths of 20 cm or more below the surface of the lake. The inclusion of suspended materials is avoided as much as possible.

Sample Preparation and Analysis

Lake sediment samples are initially field-dried. Sample preparation for lake sediments consists of crushing the fully dried sample into small (5 mm or less) fragments, followed by further reduction in ceramic mills. Any material not milled or used in the analytical procedures is put into long-term storage.

The existence of an NGR sample archive allows the GSC to take full advantage of improvements and developments in the field of analytical chemistry, and since 1976 Ontario lake sediments have been analyzed and reanalyzed for a considerable range of elements. In all areas shown in Figure 2 data are available for Ag, As, Co, Cu, Fe, loss-on-ignition, Mo, Mn, Ni, Pb, U, and Zn. Open files shown in Figure 2 with numbers above 2000 include data for As, Au, Ba, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Sm, Ta, Tb, Th, U, W, and Yb. In addition, fluorine, mercury, vanadium and cadmium data exist for some areas. All water samples were analyzed for U, F, and pH. Calcium, magnesium and total alkalinity data are available for some areas. Analytical procedures are a combination of Instrumental Neutron Activation analysis (INAA), atomic absorption spectrometry (AAS), and specific techniques. Data for the elements determined and the methods used are included in individual open files for each area (Fig. 2).

Nickel data are available for all samples. The analytical procedure used to determine nickel concentrations in lake sediments is similar for all samples. A 1.0 gram sample is placed in a test tube; 6 ml of a 3:1 mixture of 4M HNO_3 and 1M HCl are added and the solution is allowed to stand overnight at room temperature. After digestion, the test tube is immersed in a water bath at room temperature, brought up to 90 degrees C, and held at this temperature, with periodic shaking, for two hours.

At this point, sample solutions are diluted to 20 ml with metal-free water and mixed. Nickel, copper, lead, zinc, cobalt, silver, manganese, iron and cadmium are then determined by AAS using an air-acetylene flame. The detection limit for nickel is 2 ppm. Although this is a 'partial' extraction, studies have shown that for lake sediments this procedure is very nearly a 'total' extraction for many trace metals, including nickel (Davenport et al., 1992; Lynch, 1990).

Quality Control

One of the most important characteristics of NGR surveys is the structure of the sampling routine. Each block of 20 consecutive field numbers consists of 17 routine field samples, a field duplicate sample, a blind (analytical) duplicate sample and a control reference sample. The field duplicate sample is a separate sample collected at one of the 17 routine sites, at the discretion of the sampling team. One number, always the first in a block of 20 (i.e. 001, 021, 041, etc.) is reserved for a blind duplicate. The sample preparation laboratory splits a sample in the block, preferably one of the field duplicate samples, and places one of the splits into the blind duplicate position. A randomly pre-selected number within a block of 20 is reserved for a control reference sample. Control reference samples are lake or stream sediments with well-established analytical values.

Field duplicates, blind duplicates and control reference samples are incorporated in every block of 20 samples, and are used to monitor and control sampling and analytical variance. As a result of stringent quality control and consistency of analytical methods over time, it is possible to generate a regional compilation for nickel without any significant boundary effects between the different surveys. A 10 ppm nickel value from a lake sediment analyzed in 1976 is directly comparable to a 10 ppm nickel value determined in 1989, not only from Ontario, but from any NGR lake sediment survey across Canada.

Data Presentation

Relative concentrations of nickel in Ontario drainage sediments are illustrated with two types of graphic images created using ARC/INFO geographic information system (GIS) software. The smaller contour plots represent smoothed surfaces depicting broad regional trends in the nickel data. Actual values of nickel concentrations at specific sites are represented with proportional dot plots. Proportional dot plots display more detailed information and indicate the location of anomalous values. This style of presentation also facilitates the use of the bedrock geology as a background, allowing easy visual evaluation of the relationship between geology and nickel distribution.

Contour plots were created using the IDW (inverse distance weighting) and FILTER functions within ARC/INFO. Nickel data were converted to log_{10} values, and interpolated to a 1.0 km^2 grid surface from the irregularly spaced sample sites. The data were then further smoothed with the FILTER function, which passes a 3 X 3 filter over the grid. The 'low' option was used, which results in 9 values being weighted equally to calculate a new value for each grid cell. This filter was passed over the grid 6 times. The 1.0 km^2 cells were then assigned colours based on cell values to create contour maps. Proportional dot plots were created using the SPOTSIZE function. The maximum spot diameter corresponds to the value of the 98th percentile (67 ppm for lakes). Sites with values greater than or equal to the 98th percentile are represented by circles with the maximum diameter. The smallest diameter corresponds to the minimum value, set to 1 ppm (one-half detection limit). Values between the minimum and maximum correspond to diameters fitting an exponential curve $y=x^{2.5}$.

Percentile values shown for the contour map and the proportional dot map may differ. Weighted distance averages for grid cells determined from log_{10} values were used to calculate percentiles for the contour map, whereas element concentration data from each site were used in the calculation of percentiles for the proportional dot map.

The underlying bedrock geology is a generalized version of the Ontario Geological Survey Earth Resources and Land Information System digital 1:1 000 000 scale Bedrock Geology of Ontario. The original 60 units were reduced to 23 to facilitate data presentation, with emphasis placed on combining similar rock types.

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The authors wish to thank Robert Garrett for providing the cumulative frequency plots and many useful ideas incorporated into the open file. Phil Thurston of the Ontario Geological Survey, in addition to reviewing the generalized geological base, also provided several helpful suggestions. Thanks are expressed to C.E. Dunn for critically reviewing the publication.

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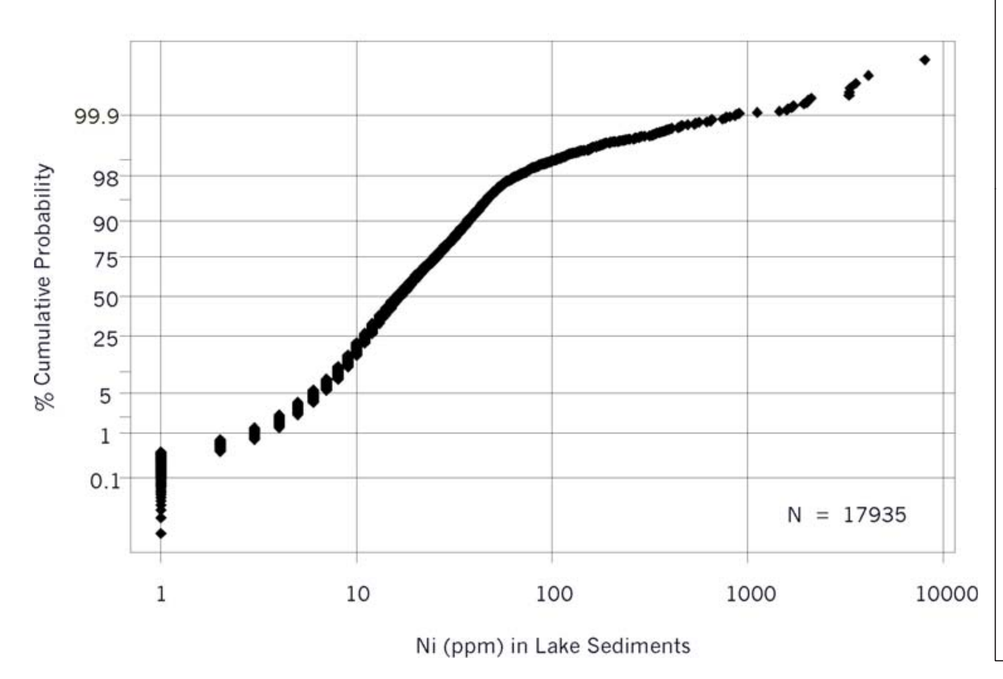
CUMULATIVE PROBABILITY PLOT



SUMMARY STATISTICS FOR SELECTED ELEMENTS

	As	Cu	Hg	Ni	Pb	U	Zn
Lake sediments							
Number of Values	17 925	17 935	13 814	17 935	17 935	17 937	17 935
Detection Limit	1	2	10	2	2	0.2	2
Units	ppm	ppm	ppb	ppm	ppm	ppm	ppm
Analytical Method	AAS	AAS	CV-AAS	AAS	AAS	NADNC	AAS
Mean	1.9	37.8	119	24.1	9.3	5.7	108
Std Deviation	12.9	54.4	198	97.6	42	14.4	77.2
Median	1	29	110	16	6	2.5	100
Minimum Value	<1	<2	<10	<2	<2	<0.2	4
5th Percentile	***<1***	***10***	***35***	***6***	***<2***	***0.8***	***42***
10th Percentile	<1	14	47	8	2	1.1	56
25th Percentile	<1	20	70	11	3	1.6	77
50th Percentile	***1***	***29***	***110***	***16***	***6***	***2.5***	***100***
75th Percentile	2	42	150	25	11	4.9	129
90th Percentile	3	64	195	37	19	11.4	161
95th Percentile	***5***	***85***	***222***	***46***	***26***	***20.1***	***188***
98th Percentile	9	124	260	67	37	37.8	226
Maximum Value	1 140	3 030	21 000	8 000	5 300	994.2	7 000

AAS - *atomic absorption spectrometry*
Grav - *gravimetric*
CV-AAS - *cold vapour / atomic absorption spectrometry*
NADNC - *neutron activation / delayed neutron counting*

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Friske, P.W.B., McCurdy, M.W., and Day, S.J.A.
1997: National Geochemical Reconnaissance - Ontario compilation: distribution of nickel in 17 935 lake sediment samples, Ontario.
Geological Survey of Canada, Open File 3379a, scale 1:1 500 000.

Canada