



**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7309**

**MANITOBA GEOLOGICAL SURVEY
OPEN FILE OF2013-2**

**Regional lake sediment geochemical data, Kasmere Lake–
Nueltin Lake area, Manitoba (NTS 64-K, 64-N, 64-O)**

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GSC Open File 7309

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Introduction

New analytical data for 62 elements resulting from the reanalysis of 1,198 lake sediment samples collected from the Kasmere Lake – Nueltin Lake area, northern Manitoba, in 1975 are presented in this joint Geological Survey of Canada (GSC) and Manitoba Geological Survey (MGS) open file release. Field observations and analytical data originally reported in GSC Open File 321 (GSC, 1976a), GSC Open File 322 (GSC, 1976b) and GSC Open File 323 (GSC, 1976c) are included in a separate digital file within this report. These data represent a subset of samples from 3,157 lake sediment samples originally collected in 1975 and published in GSC Open Files 321, 322 and 323. Over 18,000 lake sediment samples from northern Manitoba collected between 1975 and 1991 are currently stored in a GSC archive facility in Ottawa.

The area shown in Figure 1 was sampled in 1975 under the Federal Uranium Reconnaissance Program and splits of all samples have been archived at GSC. Funds for the reanalysis of archive samples were made available under the Geo-Mapping for Energy and Minerals (GEM) Program of Natural Resources Canada (NRCan) and the Manitoba Far North Geomapping Initiative of the MGS. The GEM Program is a 5-year investment by the Government of Canada in geoscience information leading to the discovery of new energy and mineral resources in Canada. GEM is delivered at the federal level by NRCan and the Polar Continental Shelf Project (PCSP). The major focus is to attract and guide effective private sector investment in large areas of Canada's North by providing new public geoscience information. The GEM Minerals component is designed to raise the level of geoscience knowledge of Canada's North, with emphasis on the acquisition and rapid release of data for mineral exploration and land-use planning. Supported by geochemical and geophysical information, multidisciplinary teams (federal, territorial/provincial, university-based collaborators and students) are targeting areas with high potential for base and precious metals, diamonds and rare metals.

The Manitoba Far North Geomapping Initiative of the MGS, in partnership with NRCan and universities, focuses on the southeast margin of the Archean Hearne craton in Manitoba, with the goal of furthering the understanding of the nature, evolution and mineral potential of one of the principal geological building blocks of Manitoba's Precambrian shield north of 58°N. The initiative applies integrated bedrock and surficial geological mapping and is aimed at developing effective mineral exploration tools for various terrain types in drift covered areas.

Reanalysis of archive lake sediment samples provides data for more elements than was originally provided in 1976 as well as improved, lower detection limits for many elements, at approximately 5% of the cost of collecting new samples. Analytical results and field observations form part of a national geochemical database used for resource assessment, mineral exploration, geological mapping, and environmental studies. Sample collection, preparation procedures and analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the area, the year of collection or the analytical laboratory undertaking the analyses.

Regional Setting

The survey area lies within the Selwyn Lake Uplands, an ecoregion extending northwest from the Churchill River in Manitoba to the eastern margins of Great Slave Lake. Within Manitoba, the land slopes gently towards the Hudson Bay Lowland, dropping from about 500 m asl to 150 m asl. Summers are cool and winters very cold, with a mean summer temperature of 11° C and a mean winter temperature of -21.5° C. Mean annual precipitation ranges between 250 and 400 mm. This area is part of a tundra and boreal forest transition zone and is characterized by open stands of low, stunted black spruce with dwarf birch and Labrador tea, with a ground cover of lichen and moss. Although extensive and discontinuous throughout much of the ecoregion, within Manitoba permafrost is sporadic and discontinuous. Dystric Brunisols are the predominant soil type (Ecological Stratification Working Group, 1995).

Regional bedrock geology

The bedrock geology of far northwest Manitoba was mapped by the MGS in the mid-1970s (Weber et al., 1975), and served as the base for MGS' 1:250k Bedrock Geology Compilation Map Series including NTS sheets 64-N and 64-O (Manitoba Industry, Trade and Mines, 2000, 2001). As part of MGS' Far North Geomapping Initiative, detailed bedrock mapping was undertaken in the Misty Lake (Kremer et al., 2010a, b) and Snyder Lake areas (Kremer et al., 2011), the latter in conjunction with surficial geological mapping (Trommelen, 2011). This most recent mapping, together with work carried out in 2006 in the Kasmere and

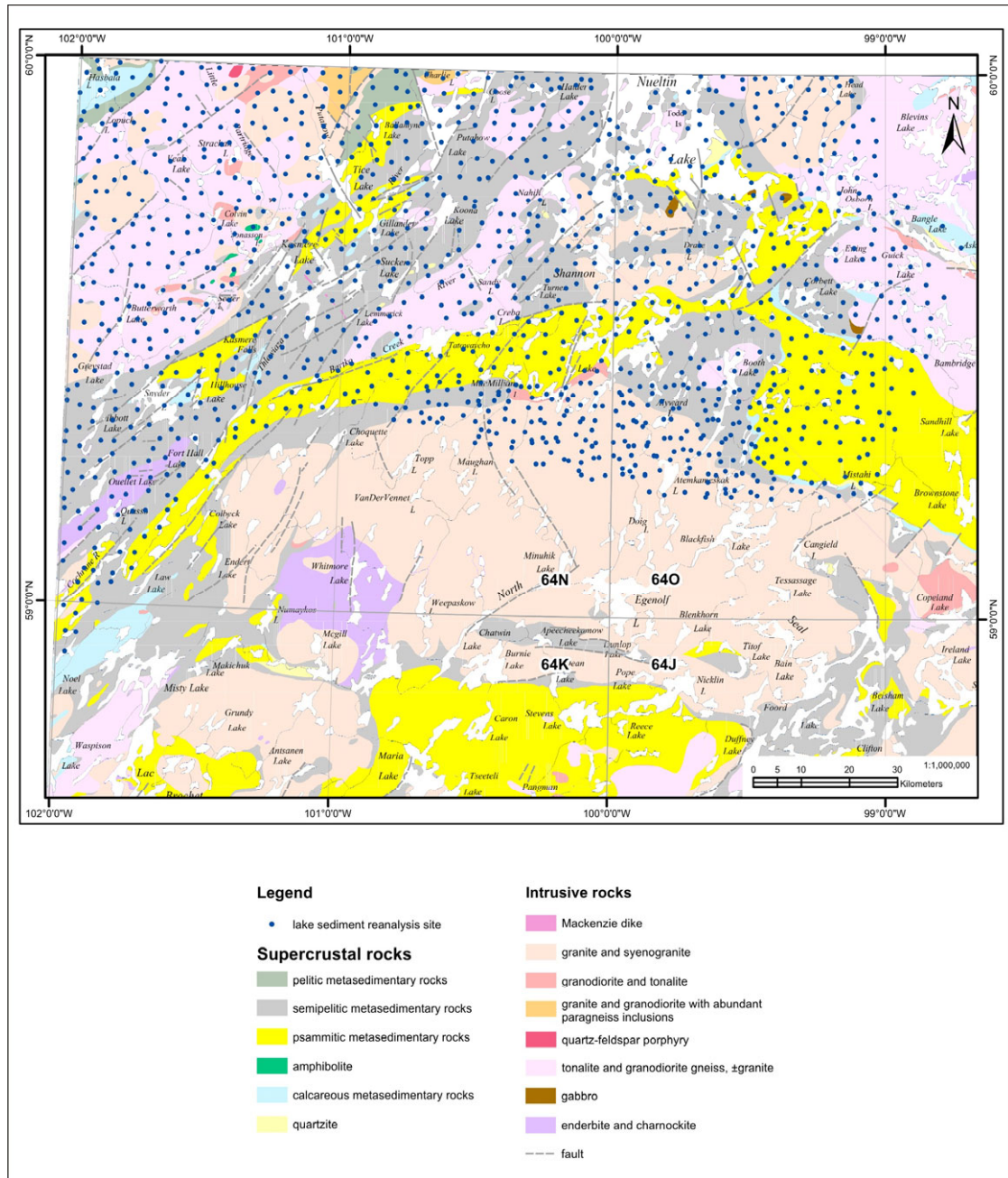


Figure 1. Map of northwest Manitoba with simplified bedrock geology background (modified after Manitoba Industry, Trade and Mines, 2000, 2001) and legend showing locations of lake sediment samples collected in 1975 and reanalyzed for this report.

Putahow lakes area (Anderson and Böhm, 2006; Böhm and Anderson, 2006a, b; Matile, 2006), has not yet been integrated in the simplified bedrock geology shown in Figure 1.

Much of the study area lies in the Wollaston Domain of the Western Churchill Province. The Wollaston Domain comprises Paleoproterozoic rift, passive margin and foreland sedimentary sequences (collectively termed the Wollaston Supergroup), which overlie and are infolded with Neoarchean basement rocks of the southeastern Hearne craton margin (Kremer et al., 2011, and references therein). The Wollaston Domain experienced significant tectonothermal reworking during the Trans-Hudson orogeny. Suites of Paleoproterozoic felsic intrusive rocks were emplaced before, during and after terminal collision of the Trans-Hudson orogeny, and range from small plugs and sills to larger bodies and batholiths.

Surficial Geology

Earlier regional 1:250 000 scale mapping (Dredge et al., 1982; Nixon et al, 1982 and Richardson et al., 1982) and till sampling surveys (Dredge et al. 1986) during the 1970's provide the regional surficial geological framework for the study area. This work was part of a 1:500 000 scale map compilation for northwestern Manitoba by Dredge et al. (1986). Subsequent geochemical re-analyses of the till samples was completed to provide a more comprehensive suite of elements data (Dredge and Pehrsson, 2006; Dredge and McMartin, 2007). The regional geomorphologic context is provided by Trommelen and Ross (2010). Recently, more detailed surficial geological mapping and till sampling has been carried out in the Kasmere-Putahow lakes (Matile, 2006) and the Snyder lake areas (Trommelen, 2011a,b). Models for deglaciation and the northern extent of proglacial lakes in northwestern Manitoba are presented by Klassen, (1983), Dredge et al, (1986), Dyke and Dredge, (1989), Dyke et al, (2003; 2005) and Dyke (2004).

Northernwestern Manitoba was repeatedly covered by the Laurentide Ice Sheet (LIS) and its precursors throughout the Quaternary Period and likely remained ice covered throughout the entire Wisconsin glacial stage (Dyke et al, 2002). The regional ice flow is to the south-southwest indicating that during the Late Wisconsin, the ice advanced from the Keewatin Sector of the LIS from a dispersal centre located in central Nunavut. (Prest et al., 1968; Prest, 1984). Evidence of earlier ice flow directions is also present in the area (Dredge et al., 1986; Trommelen, 2010) (Figure 2).

While much of the regional topographic aspects of the region are related to the underlying bedrock structure and rock type, the present day landscape is predominantly a product of glaciation. Most of the study area is drift covered – less than 2 percent of the region is rock outcrop (Dredge et al, 1986). Where evident, the regional bedrock structure typically coincides with the main ice-flow which has enhanced the bedrock ridges and eroded sub-parallel linear lake basins (Trommelen, 2010).

Sandy to bouldery till (glacial diamicton) is the prominent surface material, followed by organic deposits/wetlands, glaciofluvial sediments (eskers and esker complexes) and scattered sandy glaciolacustrine deposits (Figure 2). Belts of streamlined terrain (crag and tails, drumlinoid ridges and fluting) are interspersed with bouldery flat to hummocky till plains. The streamlined terrain is oriented parallel to the regional ice flow direction. In adjacent areas, ribbed moraine (till ridges) and intervening lakes form an east–west fabric normal to the ice flow direction (Trommelen and Ross, 2010). Major south to southwest- trending esker systems and/or meltwater corridors dissect the till landforms and occur approximately every 15-20 km laterally with numerous smaller tributary eskers in between (Dredge et al., 1986; Matile, 2006). Landforms within these distinctive features are up to 30m high and some systems continue for up to 100km (Dredge et al., 1986; Matile, 2005; Trommelen, 2010)

The region was likely ice free around 8.2 Ka C14 BP (Dyke et al., 2003). While there is evidence of small short lived proglacial lakes scattered throughout, only the southernmost part of the study area was likely inundated by the northwestern extent of Lake Agassiz. This region is characterized by muskeg interspersed with fine grained lake sediments (Dredge et al., 1986).

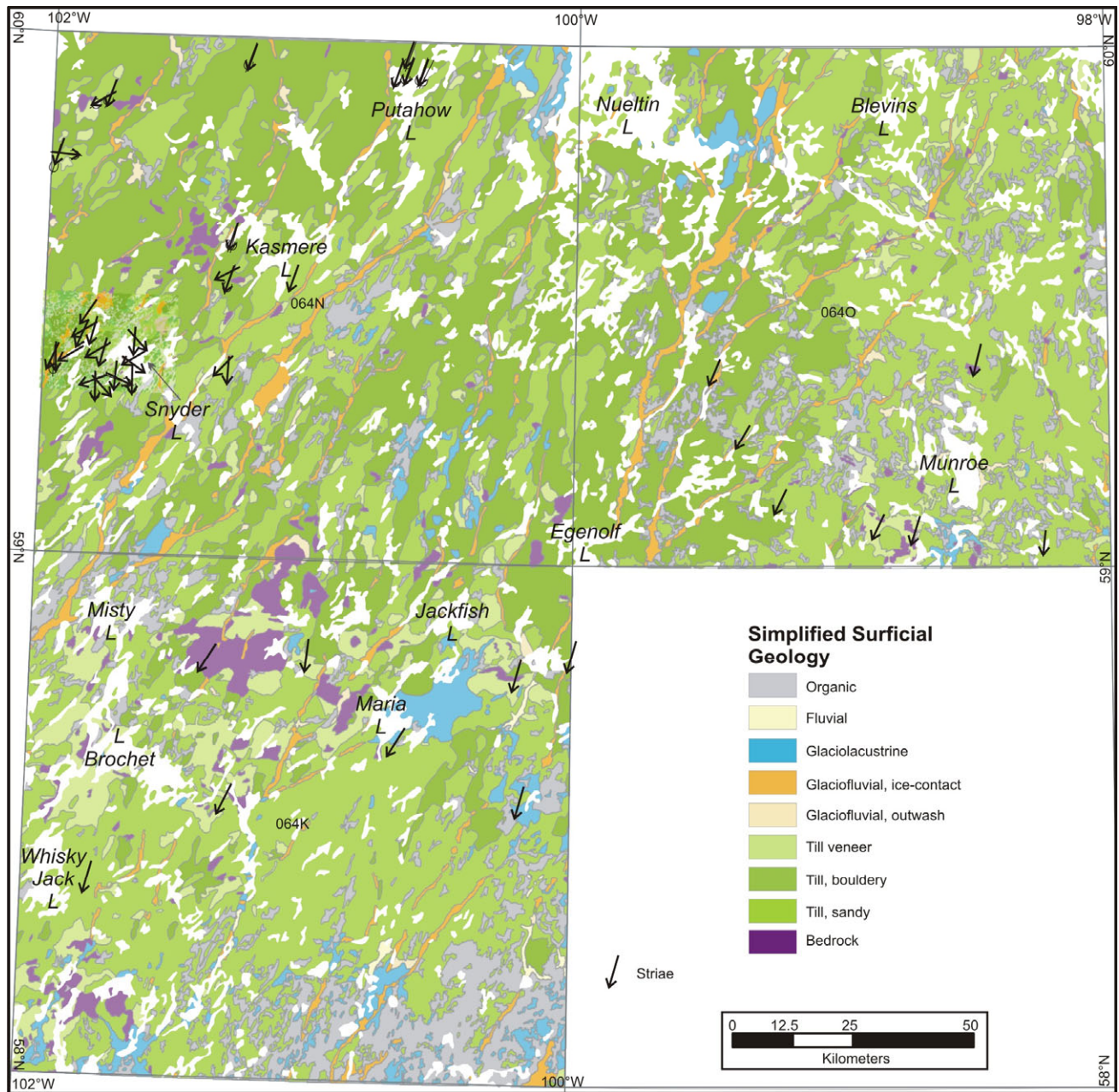


Figure 2. Generalized surficial geology map for study area, northwestern Manitoba (Matile and Keller, 2006a, 2006b; Matile, 2006; Trommelen, 2011).

Description of Survey and Sample Management

Original lake sediment samples were collected during the summer of 1975 and data for 12 elements released in 1976 in three GSC open files (321, 322, and 323). The 1,198 sample sites from which sediments were reanalyzed for this report, shown in Figure 1, are distributed throughout an approximate area of 15,200 km² at an average density of one sample per 12.7 km².

A bottom-valve, hollow-pipe sampler was used to collect approximately one kilogram of wet lake sediment. Field observations for each site were recorded on standard forms used by the GSC (Garrett, 1974). At GSC laboratories in Ottawa, field-dried samples were air-dried and sieved through a minus 80 mesh (177 micron) screen before milling in ceramic-lined puck mills. Typically, one kilogram of the organic gel, the preferred collection material, yielded about 50 g of material for analysis. After milling, control reference and blind duplicate samples were inserted into each block of twenty sediment samples. For quality control purposes, the original samples were arranged in groups (consecutively-numbered blocks) of twenty. Each group of twenty contained site duplicate samples, that is, two samples from a single site; the group also contained an analytical duplicate sample pair (a single site sample split and assigned two non-consecutive sample numbers). Finally, each group included a control reference sample. Before publication, thorough inspections of the field and analytical data were made to check for any missing information and/or analytical errors. A more detailed description of collection and quality control methods used by the GSC for lake sediment samples can be found in Cook and McConnell (2001). Samples selected for reanalysis were removed from the GSC archive facility in Ottawa and shipped to commercial labs for reanalysis. Within these reanalysis suites, the above-described pattern of distribution of quality control samples was maintained, with the exception that new control reference standards replaced the original ones inserted in 1975.

Quality assurance/quality control measures for the reanalysis of the data by Inductively Coupled Plasma Emission Spectroscopy/Mass Spectrometry (ICP-ES/MS) were carried out by the Applied Geochemistry section staff at the GSC.

Analytical Procedures (2010)

ICP-ES/MS

For the determination of 62 elements listed in Table 1, a one-gram sample was leached with 6 ml of a mixture of HCl, HNO₃, and distilled, deionized water (2:2:2 volume to volume ratio) at 95° C for one hour. The sample solution was diluted to 20 ml and analysed by inductively coupled plasma emission spectroscopy on a Jarell-Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin-Elmer Elan instrument. Analyses were carried out at Activation Laboratories, Limited, Ancaster, Ontario using the 'ICP+ICP/MS Ultratrace 2' package (Activation Laboratories (Canada) Limited, 2013).

Element	Detection Limit	Units of Measurement	Analytical Method	Element	Detection Limit	Units of Measurement	Analytical Method
Ag	0.002	ppm	AR-MS	Mo	0.01	ppm	AR-MS
Al	0.01	pct	AR-MS	Na	0.001	pct	AR-MS
As	0.1	ppm	AR-MS	Nb	0.1	ppm	AR-MS
Au	0.5	ppb	AR-MS	Nd	0.02	ppm	AR-MS
B	1	ppm	AR-MS	Ni	0.1	ppm	AR-MS
Ba	0.5	ppm	AR-MS	P	0.001	pct	AR-ES
Be	0.1	ppm	AR-MS	Pb	0.01	ppm	AR-MS
Bi	0.02	ppm	AR-MS	Pr	0.1	ppm	AR-MS
Ca	0.01	pct	AR-MS	Rb	0.1	ppm	AR-MS

Element	Detection Limit	Units of Measurement	Analytical Method	Element	Detection Limit	Units of Measurement	Analytical Method
Cd	0.01	ppm	AR-MS	Re	0.001	ppm	AR-MS
Ce	0.1	ppm	AR-MS	S	0.001	pct	AR-ES
Co	0.1	ppm	AR-MS	Sb	0.02	ppm	AR-MS
Cr	0.5	ppm	AR-MS	Sc	0.1	ppm	AR-MS
Cs	0.02	ppm	AR-MS	Se	0.1	ppm	AR-MS
Cu	0.01	ppm	AR-MS	Sm	0.1	ppm	AR-MS
Dy	0.001	ppm	AR-MS	Sn	0.05	ppm	AR-MS
Er	0.1	ppm	AR-MS	Sr	0.5	ppm	AR-MS
Eu	0.1	ppm	AR-MS	Ta	0.05	ppm	AR-MS
Fe	0.01	pct	AR-MS	Tb	0.1	ppm	AR-MS
Ga	0.02	ppm	AR-MS	Te	0.02	ppm	AR-MS
Gd	0.1	ppm	AR-MS	Th	0.1	ppm	AR-MS
Ge	0.1	ppm	AR-MS	Ti	0.01	pct	AR-ES
Hf	0.1	ppm	AR-MS	Tl	0.02	ppm	AR-MS
Ho	0.1	ppm	AR-MS	Tm	0.1	ppm	AR-MS
In	0.02	ppm	AR-MS	U	0.1	ppm	AR-MS
K	0.01	pct	ICP-MS	V	1	ppm	AR-MS
La	0.5	ppm	AR-MS	W	0.1	ppm	AR-MS
Li	0.1	ppm	AR-MS	Y	0.01	ppm	AR-MS
Lu	0.1	ppm	AR-MS	Yb	0.1	ppm	AR-MS
Mg	0.01	pct	ICP-MS	Zn	0.1	ppm	AR-MS
Mn	1	ppm	ICP-MS	Zr	0.1	ppm	AR-MS

parts per million (ppm)
per cent (pct)
parts per billion (ppb)

Table 1. Elements Determined by ICP-ES/MS Reanalysis of Archive Lake Sediment Samples.

Analytical Procedures (1976)

Atomic Absorption Spectroscopy (AAS) and Other Analyses

For the determination of Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, and Cd, a 1 g sample was reacted with 3 ml concentrated HNO₃ in a test tube overnight at room temperature. After digestion, the test tube was immersed in a hot water bath at room temperature and brought up to 90° C and held at this temperature for 30 minutes with periodic shaking. One ml of concentrated HCl was added and heating continued for another 90 minutes. The sample solution was then diluted to 20 ml with metal-free water and mixed. Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe and Cd were determined by AAS using an air-acetylene flame. Background corrections were made for Pb, Ni, Co, Ag, and Cd.

Molybdenum was determined by AAS using a nitrous oxide acetylene flame. A 0.5 g sample was reacted with 1.5 ml concentrated HNO₃ in a test tube overnight at room temperature. After digestion, the test tube was immersed in a hot water bath at room temperature and brought up to 90° C and held at this temperature for 30 minutes with periodic shaking. At this point, 0.5 ml concentrated HCl was added and the digestion continued at 90° C for an additional 90 minutes. After cooling, 8 ml of 1250 ppm Al solution were added and the sample solution diluted to 10 ml before aspiration.

Mercury was determined by the Hatch and Ott procedure with some modifications. The method is described by Jonasson *et al.* (1973). A 0.5 g sample was reacted with 20 ml concentrated HNO₃ and 1 ml concentrated HCl in a test tube for 10 minutes at room temperature prior to two hours of digestion with mixing at 90° C in a hot water bath. After digestion, the sample solutions were cooled and diluted to 100 ml with metal-free water. The Hg present was reduced to the elemental state by the addition of 10 ml 10% weight per volume (w/v) SnSO₄ in 1 M H₂SO₄. The Hg vapour was then flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrophotometer. Absorption measurements were made at 253.7 nm.

Loss-on-ignition was determined using a 500 mg sample. The sample, weighed into a 30 ml beaker, was placed in a cold muffle furnace and brought up to 500° C over a period of two to three hours. The sample was held at this temperature for four hours, then allowed to cool to room temperature for weighing.

Arsenic was determined by a colorimetric method using silver diethyldithiocarbamate. Sample material was digested by heating a 1 g sample with 20 ml of 6M HCl at 90°C for 1.5 hours. Arsenic in the reaction solution was converted to arsine, which was evolved and then complexed with silver diethyldithiocarbamate. The intensity of the colour of the complex was determined with a spectrophotometer. Colorimetric measurements were made at 520 nm.

Uranium was determined using a neutron activation method with delayed neutron counting. A detailed description of this method is provided by Boulanger *et al.* (1975). In brief, a 1 g sample was weighed into a 7-dram polyethylene vial, capped and sealed. The samples were pneumatically transferred from an automatic loader to a 'Slowpoke' reactor, where each sample was irradiated for 60 seconds in an operating flux of 10¹² neutrons/cm²/sec. After irradiation, the samples were transferred to a counting facility where, after a ten second delay, each sample was counted for 60 seconds with six BF3 detector tubes embedded in paraffin. Following counting, samples were ejected into a shielded storage container.

Element	Detection Limit	Units of Measurement	Analytical Method
Ag	0.2	ppm	AAS ¹
As	1.0	ppm	COL ²
Co	2	ppm	AAS
Cu	2	ppm	AAS
Fe	0.02	pct	AAS
Hg	10	ppb	CV-AAS ³
LOI	1.0	pct	GRAV ⁴
Mn	5	ppm	AAS
Mo	2	ppm	AAS
Ni	2	ppm	AAS
Pb	2	ppm	AAS
U	0.5	ppm	NADNC ⁵
Zn	2	ppm	AAS

- 1) Atomic Absorption Spectrometry (AAS)
- 2) Colorimetric (COL)
- 3) Cold vapour Atomic Absorption Spectrometry (CV-AAS)
- 4) Gravimetric methods (GRAV)
- 5) Neutron activation – delayed neutron counting (NADNC)

Table 2. Summary of original elements determined and methods used.

Format of Data Files

Field observations and analytical data are presented in an Excel® spreadsheet file included with this report: **Appendix 2 GSC OF 7309 MGS OF2013-2 FIELD and ANALYTICAL DATA.xls**. There are three worksheets in this file:

<u>Worksheet</u>	<u>Contents</u>
Field Observations	site-specific field observations including sample location coordinates (geographic, NAD 83)
Original Data -1975	AAS and specific methods analytical data for samples collected in 1975
Reanalysis–ICP-2010	ICP-ES/MS reanalysis data for lake sediment samples

Brief descriptions of the field headers used in the ‘Field Data’ worksheet can be found in Appendix 1 at the end of this report.

Quality Control for Geochemical Data

Reliability (Trueness, Accuracy and Precision) of analytical data returned from commercial laboratories was determined by incorporating 72 field duplicate (FD) pairs within the sampling protocol, and including 39 analytical duplicate (AD) pairs, 26 standard reference material (SRM) samples, and 13 control reference material (CRM) samples within the sample suite submitted to the labs. Analytical data for control reference standards, analytical and field duplicates, and blanks are included with this report in **Appendix 3 GSC OF 7309_MGS OF2013-2 QUALITY CONTROL.xls**.

Data quality was evaluated in a four-step process using standard reference materials to evaluate trueness, control reference materials to evaluate accuracy, analytical duplicate samples to evaluate analytical precision, and field duplicates to carry out Analyses of Variance (ANOVA) in order to assess fitness-of-purpose (‘Are differences between sample sites real?’) for mapping.

Tables 1 through 5 (Worksheets ‘Trueness’, ‘Accuracy’, ‘AD Precision’, ‘ANOVA (FD)’ in **Appendix 3 GSC OF 7309_MGS OF2013-2 QUALITY CONTROL.xls** can be used to estimate the quality of analysis for elements found in Tables 1 and 2 of this document. Elements are grouped based on their position in the Periodic Table.

‘Trueness’

‘Trueness’ of analytical data was evaluated by inserting Canadian Certified Reference Lake Sediments LKSD-1 and LKSD-4 at random locations throughout the northwest Manitoba sample suite. LKSD-1 is a combination of lake sediments from two lakes located in central Ontario (Brady Lake, 31M and Joe Lake, 31F). Sediment from three lakes, Big Gull Lake (31C) in Ontario and Key Lake and Seahorse Lake (74H) in Saskatchewan, were combined to make up LKSD-4 (Lynch, 1990).

In Tables 1 and 2 of Appendix 3 (‘Trueness’), means and standard deviations (MEAN \pm SD) for control reference standards LKSD-1 and LKSD-4, for which provisional values have been published by Lynch (1990, 1999) are shown. Lower detection limits (LDL), standard deviation (SD) and Relative Standard Deviation (RSD) for elements determined by ‘partial’ and total methods from repeated analyses of reference standards LKSD-1 and LKSD-4 are listed. Relative Standard Deviation (RSD), expressed as a percentage, facilitates comparison of the repeatability of elements measured in different units and varying means (Reimann *et al.*, 2008). RSD is independent of both the magnitude of the data and the units. Accepted values in square brackets are derived from unpublished data ($n \geq 40$) collected from recent projects at the GSC.

Almost all analytical results for 62 elements in LKSD-1 and LKSD-4 received from a commercial lab fall within one standard deviation of published or accepted values for the means. Elements with possible analytical problems, indicated by RSD values greater than 25 per cent, are shown in bold red type. However, a relatively high RSD, reflecting poor analytical repeatability, could also be an indication that results are close to the detection limit for elements such as Be, Ge and Te in LKSD-1 and W, Re, In and Ge in LKSD-4.

Accuracy

The accuracy of analytical results received from commercial laboratories, in the sense of an absence of bias, or 'drift' over time, was monitored by inserting one internal standard at 13 random locations throughout the sample suite of 1,198 routine samples. The internal standard material consists of stream sediments from a creek near Dawson City, YT, collected, dried, sieved and homogenized for use at the GSC. Results for each element are shown in Table 3 of Appendix 3 ('Accuracy').

Analytical data for the internal standard 'Bonanza Creek' are included with this report and can be used to create 'x-charts', by plotting the 'Sequence' (first column) against the elemental value. Trends caused by instrumental drift or obvious deviations can usually be detected in these diagrams (Reimann *et al.*, 2008). Elements with an RSD exceeding 25% are marked in bold red type and are generally associated with values near the lower detection limit.

Precision

Precision is considered in terms of the closeness of agreement between analytical duplicate samples analyzed by the same method, i.e. independent test results obtained using the same equipment within short intervals of time on duplicate samples. In order to provide an estimate of precision for each element, the squared difference between two analytical duplicates was calculated for $N = 39$ duplicate pairs. The sum of these values was divided by the number of samples ($(2*N) = 78$) to estimate a measure of variability (variance). Standard Deviation was then obtained by calculating the square root of this variance (Garrett, 1969). The resulting numerical estimates of precision are shown in Table 5 in Appendix 2 ('AD Precision') represented by the Relative Standard Deviation, where the Standard Deviation is divided by the overall mean of the samples and multiplied by 100 to obtain a percentage (Reimann *et al.*, 2008). Elements (or analytes) are grouped based on their position in the Periodic Table. Included with the element or analyte and method of analysis are the Lower Detection Limit (LDL), the percentage of data below the Lower Detection Limit (% Below LDL), the Range and the Mean. This information provides context for the estimate of Precision in the last column of Table 5.

Elements with precisions poorer than 25%, marked in bold red type in Table 4, Appendix 2, tend towards generally low concentrations in samples, as indicated by the Range, the Mean and the percentage of data below the detection limit. Such is the case for the elements Hf, Re, Au, In, Se, Ge, Sb and Te. Results for Au are also affected by the particulate nature of gold ('nugget effect') and should be considered accordingly.

Analysis of Variance (ANOVA)

Precision and accuracy are 'external' criteria against which geochemical survey data are evaluated. In order to establish that these data are 'fit for purpose,' an Analysis of Variance (ANOVA) is required (Reimann *et al.*, 2008). Results from two types of ANOVA are shown in this report. Appendix 3, Table 5 ('ANOVA (FD)') shows results from an ANOVA undertaken on field duplicate pairs collected throughout the Northwest Manitoba survey.

Field Duplicates

A one-way random effects model ANOVA was undertaken on each element in a set of 72 field duplicate pairs, representing one field duplicate within each block of 20 sequential sample numbers, to estimate, as a percentage, how much of the total variability is due to sampling and analysis ('within') of a lake and how much can be attributed to regional variability across the survey area ('between'). Results are shown in Table 5 of

Appendix 3 ('ANOVA (FD)'). Data were not log-transformed because in all but one case (Au), the range of observations did not exceed 1.5 orders of magnitude. The sampling variability was estimated from field duplicates using the 'anova2' function in the 'rgr' package running under the R system, a random effects ANOVA model estimating whether the combined sampling and analytical variability between duplicate pairs is significantly smaller than the variability between lakes (Garrett, 2012).

Evaluating Quality Control Data

Readers who wish to evaluate the quality of the geochemical data published in this report using the information provided in Appendix 3 are referred to two main sources. Descriptions of most of the methods used to generate the tables in Appendix 3 are found in Reimann et al. (2008). Users of 'R', a free environment for statistical computing and graphics are referred to Garrett (2012) for methods to display and analyze geochemical data.

Quality control data are presented in Appendix 3, in an Excel® spreadsheet file included with this report: **Appendix 3 GSC OF 7309_MGS OF2013-2 QUALITY CONTROL.xls**. There are seven worksheets in this file:

<u>Worksheet</u>	<u>Contents</u>
Trueness	Compares accepted values for two international reference standards with results from analysis of the Northwest Manitoba samples
Accuracy	Estimates repeatability using results from analyses of an internal standard
AD Precision	Provides an estimate of precision using analytical duplicate pairs
ANOVA (FD)	Simple pair ANOVA estimates proportion of total variability due to each of sampling and analysis
Control Reference Data	Analytical data used to estimate 'trueness' and accuracy
Analytical Duplicate Data	Analytical data used to estimate precision
Field Duplicate Data	Field duplicate data

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Appendix 1

Descriptions of Field Headings in Field Data Spreadsheet

UniqID – A 10-digit alphanumeric combination of the NTS Sheet (see below), two digits indicating the year of collection, a one-digit number identifying the collection party, and a three-digit sequential number from 1 to 999 identifying each individual sample in the order it was collected, e.g. 054L761002. This format is used to identify all National Geochemical Reconnaissance samples

NTS Sheet – National Topographic System 1:250,000 index reference, consisting of three numbers and one letter, e.g. 054L.

Year – a two digit number identifying the year in which a sample was collected, e.g. 76 (1976)

SampleNum – a combination of two-digits indicating the year of collection, the collection party identifier and the three digit number identifying the sample in the order it was collected (001 to 999). This number, preceded by the NTS Sheet within which the sample was collected, was originally used as the sample identifier for National Geochemical Reconnaissance samples.

RepStat – A one-digit number, either 0, 1 or 2, identifying samples as either routine samples (0), first sample collected in a field duplicate pair (1), or second sample in a field duplicate pair. Field duplicates are two samples collected from the same site.

Latitude (NAD83), Longitude (NAD83) – sample location in decimal degrees, North American Datum 1983.

Lake area – approximate area of the water body sampled

Pond –	less than 0.25 square kilometres
0.25 – 1.0 sq km	1.0 sq km - 1/4 to 1 square kilometre
1 – 5 sq km -	1 to 5 square kilometres
>5 sq km -	greater than 5 square kilometres

Lake Depth – the depth, in metres, below the water surface from which a sample of lake sediment was collected

Terrain Relief – relief of land immediately surrounding the lake sampling site

- Low - land is flat-lying, lake is often within or adjacent to swamp, bog, marsh or fen; drainage poor
- Medium – surrounding or adjacent land is hilly, usually treed, drainage is good
- High – mountainous terrain

Contamination – possible sources of anthropogenic or natural sediment contamination

- None - no apparent sources of human or natural contamination present
- Work – evidence of mining or industrial activity (past or present) within lake catchment basin
- Camp – signs of recreational activity, such as cottages, camps, docks, etc.
- Fuel – fuel barrels (empty or full) observed on land surrounding lake (or in lake)
- Gossan – signs of intensely oxidized, weathered or decomposed rock within the lake catchment basin

Sediment Colour – the colour of the wet sediment as observed by the collector at the site; more than one colour can be selected, e.g. Green Brown

Suspension – an indication of the presence of suspended material (clastic and/or organic) observed in surface waters at the lake sediment sampling site.

- None - visibility in water unrestricted by suspended material, i.e. water appears clear
- Light - some suspended material apparent, but visibility in surface water exceeds one metre
- Heavy - surface water appears cloudy, visibility one metre or less