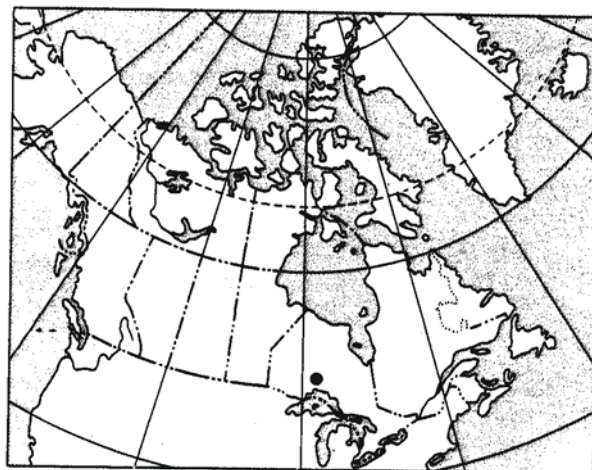


GEOLOGICAL SURVEY OF CANADA OPEN FILE 2177
(parts of NTS 42E, 42L and 52H)
CANADA – ONTARIO MINERAL DEVELOPMENT AGREEMENT (1985 – 1990)

**REGIONAL LAKE SEDIMENT AND WATER
GEOCHEMICAL RECONNAISSANCE DATA,
CENTRAL NORTHERN ONTARIO**



INDEX MAP

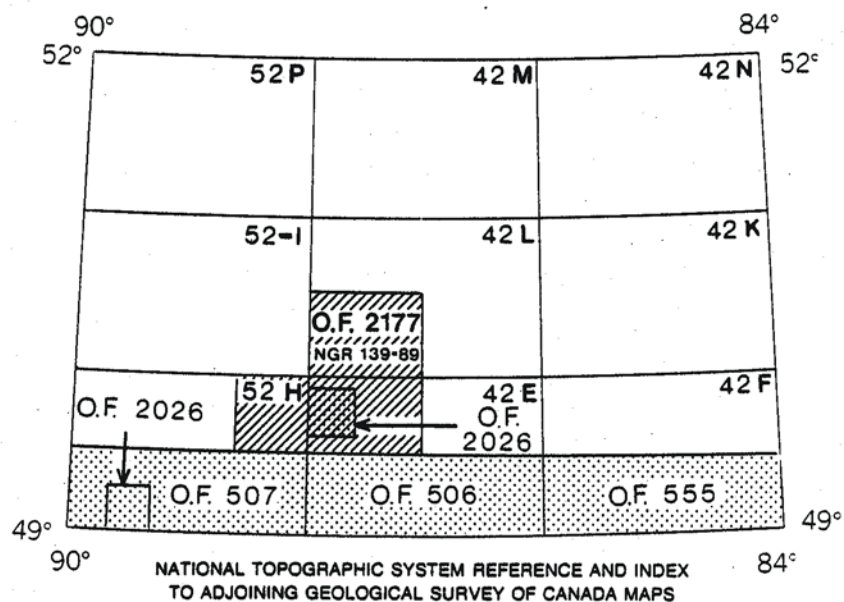
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1990: National Geochemical Reconnaissance Lake Sediment and Water Data, Central Northern Ontario (parts of NTS 42E, 42L and 52H) Geological Survey of Canada Open File 2177

July, 1990

**NATIONAL GEOCHEMICAL RECONNAISSANCE
LAKE SEDIMENT AND WATER GEOCHEMICAL DATA
ONTARIO 1990
GEOLOGICAL SURVEY OF CANADA OPEN FILE 2177, NGR 139-1989
Parts of NTS 42E, 42L and 52H**



Open File 2177 represents a contribution to the Canada – Ontario Mineral Development Agreement (1985-1990), a subsidiary agreement under the Economic and Regional Development Agreement. This project was funded and managed by the Geological Survey of Canada.

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**REGIONAL LAKE SEDIMENT AND WATER GEOCHEMICAL DATA, ONTARIO 1990,
GSC OPEN FILE 2177, NGR 139-1989; PARTS OF NTS 42E, 42L AND 52H**

INTRODUCTION

Open File 2177, covering an area east of Lake Nipigon in central northern Ontario, was sampled in 1989 as part of the Canada - Ontario Mineral Development Agreement. Open File 2177 contains the results of analyses of lake sediments and waters from this area for 42 elements plus loss-on-ignition. Corresponding waters were analysed for uranium, pH, fluoride, alkalinity, calcium and magnesium.

The reconnaissance survey was undertaken by the Geological Survey of Canada in conjunction with the Ontario Ministry of Northern Development and Mines.

Analytical results and field observations are used to build a national geochemical data base for resource assessment, mineral exploration, geological mapping and environmental studies. Sample collection and preparation procedures and analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the area, the year or the analytical laboratory.

CREDITS

E.H.W. Hornbrook directed the survey.

P.W.B. Friske coordinated the operational activities of contract and Geological Survey of Canada staff.

Contracts were let to the following companies for sample preparation and analysis and were managed by the following staff of the Regional Geochemical Studies section:

Collection:	Sial Geopysique Ltd. Montreal, Quebec E.H.W. Hornbrook M.W. McCurdy
Preparation:	Golder Associates Ottawa, Ontario J.J. Lynch
Analysis:	Bondar-Clegg and Company Ottawa, Ontario Chemex Labs North Vancouver, British Columbia J.J. Lynch

M. McCurdy edited open files and coordinated production.

A.C. Galletta managed the digital geochemical data and provided computer processing support.

The personal computer data base and software programs used for data entry, verification, processing and presentation in the publication of reports were designed and programmed by Harry Gross, Geochemical Data Manager for the Exploration Geochemistry Subdivision.

Sample location and gold value maps were plotted by Canada Lands Data Systems staff at Environment

Canada, Hull, Quebec. Symbol-trend maps were prepared by GSC staff.

Pat Doyle, C.C. Durham and Rob Phillips provided technical assistance.

DESCRIPTION OF SURVEY AND SAMPLE MANAGEMENT

Helicopter-supported sample collection was carried out during the summer of 1989. Lake sediment and water samples were collected at an average density of one sample per 8 square kilometres throughout the 8 400 square kilometres of the central northern Ontario survey.

Sample site duplicate samples were routinely collected in each analytical block of twenty samples.

Field observations were recorded on standard forms used by the Geological Survey of Canada (Garrett, 1974).

The sample site positions were marked on appropriate 1:50 000 scale NTS maps in the field. These maps were digitized at the Geological Survey in Ottawa to obtain the sample site UTM coordinates.

In Ottawa, field dried samples were air-dried crushed, ball-milled and sieved. The minus 80 mesh (177 microns) fraction was used for subsequent analyses. At this time, control reference and blind duplicate samples were inserted into each block of twenty sediment samples. For the water samples, only control reference samples were inserted into the block. There were no blind duplicate water samples.

The sample site coordinates were checked as follows: a sample location map was produced on a Calcomp 1051 drum plotter using the digitized coordinates; the original sample location map produced in the field was then overlain with the Calcomp map; the two sets of points were checked for coincidence. The dominant rock types in the catchment basins were identified on appropriate geological maps used as the bedrock geological base on NGR maps.

Thorough inspections of the field and analytical data were made to check for any missing information and/or gross errors.

Quality control and monitoring of the geochemical data was undertaken by a standard method used by the Exploration Geochemistry Subdivision at the Geological Survey of Canada.

ANALYTICAL PROCEDURES

Instrumental Neutron Activation Analysis (INAA)

The weighed sample (generally 10 to 40 g) is irradiated epithermally for 20 minutes in a neutron flux with an approximate density of 1 x 10¹¹ neutrons/cm²/second. Counting begins seven days after irradiation. The counting time is somewhat variable (6 to 11 minutes) and is matrix dependent. Counting is done on a germanium-lithium co-axial counter. The counting data is

accumulated on a VAX computer and is subsequently converted to concentrations. Numerous international reference samples are irradiated with each batch of routine samples. Elements determined by INA analyses include: Na, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Zr, Mo, Ag, Cd, Sn, Sb, Te, Cs, Ba, La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, Ta, W, Ir, Au, Th, and U. The sample weight is also reported. Data for Zn, Se, Zr, Ag, Cd, Sn, Te, and Ir are not published because of inadequate detection limits and/or precision.

Atomic Absorption Spectroscopy (AAS) and Other Analyses

For the determination of Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Cd, and As a 1 g sample is reacted with 6 mL of a mixture of 4M HNO₃ and M HCl in a test tube overnight at room temperature. After digestion, the test-tube is immersed in a hot water bath at room temperature and brought up to 90° C and held at this temperature for 2 hours with periodic shaking. The sample solution is then diluted to 20 mL with metal-free water and mixed. Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe and Cd are determined by atomic absorption spectroscopy using an air-acetylene flame. Background corrections are made for Pb, Ni, Co, Ag, and Cd.

Arsenic is determined by atomic absorption using a hydride evolution method wherein the hydride (AsH₃) is evolved and passed through a heated quartz tube in the light path of an atomic absorption spectrophotometer. The method is described by Aslin (1976).

Molybdenum and vanadium are determined by atomic absorption spectroscopy using a nitrous oxide acetylene flame. A 0.5 g sample reacts with 2.5 mL concentrated HNO₃ at 90° C for 30 minutes. At this point 0.5 mL concentrated HCl is added and the digestion continues at 90° C for an additional 90 minutes. After cooling, 8 mL of 1250 ppm Al solution are added and the sample solution diluted to 10 mL before aspiration.

Mercury is determined by the Hatch and Ott procedure with some modifications. The method is described by Jonasson *et al.* (1973). A 0.5 g sample is reacted with 20 mL concentrated HNO₃ and 1 mL concentrated HCl in a test tube for 10 minutes at room temperature prior to 2 hours of digestion with mixing at 90° C in a hot water bath. After digestion, the sample solutions are cooled and diluted to 100 mL with metal-free water. The Hg present is reduced to the elemental state by the addition of 10 mL of 10% w/v SnSO₄ in M H₂SO₄. The Hg vapour is then flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrophotometer. Absorption measurements are made at 253.7 nm.

Loss-on-ignition is determined using a 500 mg sample. The sample, weighed into 30 mL beaker, is placed in a cold muffle furnace and brought up to 500° C over a period of 2 -3 hours. The sample remains at this temperature for 4 hours and then allowed to cool to room temperature for weighing.

Uranium is determined using a neutron activation method with delayed neutron counting. A detailed description of the method is provided by Boulanger *et al.* (1975). In brief, 1 gram sample is weighed into a 7 dram polyethylene vial, capped and sealed. The irradiation is

provided by the Slowpoke reactor with an operating flux of 10¹² neutrons/sq cm/sec. The samples are pneumatically transferred from an automatic loader to the reactor, where each sample is irradiated for 60 seconds. After irradiation, the sample is again transferred pneumatically to the counting facility where after a 10 second delay the sample is counted for 60 seconds with six BF₃ detector tubes embedded in paraffin. Following counting, the samples are automatically ejected into a shielded storage container. Calibration is carried out twice a day as a minimum, using natural materials of known uranium concentration.

Antimony is determined in lake sediments as described by Aslin (1976). A 500 mg sample is placed in a test tube; 3 mL concentrated HNO₃ and 9 mL concentrated HCl are added and the mixture is allowed to stand overnight at room temperature. The mixture is heated slowly to 90° C and maintained at this temperature for at least 90 minutes. The solution is cooled and diluted to 10 mL. A 400 µL aliquot of this test solution is removed and diluted to 10 mL with 1.8 M HCl. The antimony in an aliquot of this dilute solution is then determined by hydride evolution-atomic absorption spectrometry.

Fluorine is determined in lake sediments as described by Ficklin (1970). A 250 mg sample is sintered with 1 g of a flux consisting of two parts by weight sodium carbonate and one part by weight potassium nitrate. The residue is then leached with water. The sodium carbonate is neutralized with 10 mL 10% (w/v) citric acid and the resulting solution is diluted to 100 mL with water. The pH of the resulting solution is then measured using a fluoride ion electrode. Standard solutions contain sodium carbonate and citric acid in the same quantities as the sample solution.

Water Analyses

Fluoride in lake water samples is determined using a fluoride electrode. Prior to measurement an aliquot of the sample is mixed with an equal volume of TISAB II buffer solution (total ionic strength adjustment buffer). The TISAB II buffer solution is prepared as follows: to 50 mL metal-free water add 57 mL glacial acetic acid, 58 g NaCl and 4 g CDTA (cyclohexylene dinitrilo tetraacetic acid). Stir to dissolve and cool to room temperature. Using a pH meter, adjust the pH between 5.0 and 5.5 by slowly adding 5 M NaOH solution. Cool and dilute to one liter in a volumetric flask.

Hydrogen ion activity (pH) is measured with a combination glass-calomel electrode and a pH meter.

Uranium in waters is determined by a laser-induced fluorometric method using a Scintrex UA-3 uranium analyser. A complexing agent, known commercially as Fluran and composed of sodium pyrophosphate and sodium monophosphate (Hall, 1979) is added to produce the uranyl pyrophosphate species which fluoresces when exposed to the laser. Since organic matter in the sample can cause unpredictable behaviour, a standard addition method is used. Further, the reaction of uranium with Fluran can be delayed or sluggish; for this reason an arbitrary 24 hour time delay between the addition of the Fluran and the actual reading is incorporated into this method. In practice, 500 µL of Fluran solution are added to a 5 mL sample and allowed to stand for 24 hours. At the end of this period fluorescence readings are made

with the addition of 0.0, 0.2 and 0.4 ppb U. For high samples the additions are 0.0, 2.0 and 4.0 (20 µL aliquots of 55 or 550 ppb U are used). All readings are taken against a sample blank.

Alkalinity in waters is determined by titrating a 25 mL aliquot of the sample with 0.02 N H₂SO₄ using a Corning combination 135 pH meter. The end point is pH 4.5.

Detection level = 1 ppm.

Calcium and magnesium in waters are determined by atomic absorption spectroscopy. The sample solution contains 1000 µg/mL lanthanum. Potassium acts as an ionization buffer and lanthanum as the releasing agent.

Table 1 provides a summary of analytical data and methods.

PRESENTATION AND INTERPRETATION OF GOLD DATA

The following discussion reviews the format used to present the Au geochemical data and outlines some important points to consider when interpreting this data. This discussion is included in recognition of the special geochemical behaviour and mode of occurrence of Au in nature and the resultant difficulties in obtaining and analyzing samples which reflect the actual concentration level at a given site.

To correctly interpret Au geochemical data from regional stream sediment or lake sediment surveys requires an appreciation of the unique chemical and physical characteristics of Au and its mobility in the surficial environment. Key properties of gold that distinguish its geochemical behaviour from most other elements include (Harris, 1982):

- (1) Gold occurs most commonly in the native form which is chemically and physically resistant. A significant proportion of the metal is dispersed in micron-sized particulate form, and the high specific gravity of gold results in heterogeneous distribution, especially in stream sediment and clastic-rich (low LOI) lake sediment environments. Gold distribution appears to be more homogeneous in organic-rich fluvial and lake sediments.
- (2) Gold typically occurs at low concentrations in the ppb range. Whereas gold concentrations of only a few ppm may represent economic deposits, background levels encountered from stream and centre-lake sediments seldom exceed 10 ppb, and commonly are near the detection limit of 2 ppb.

These factors result in a particle sparsity effect wherein very low concentrations of gold are heterogeneously enriched in the surficial environment. Hence, a major problem facing the geochemist is to obtain a representative sample. In general, areas where concentrations of gold in sediments are low, and/or grain sizes of the gold present relatively high require proportionally larger samples to reduce the uncertainty between subsample analytical values and actual values. Conversely, as actual gold concentrations increase or grain size decreases, the number of gold particles to be shared in random subsamples increases and variability of results decreases (Clifton *et al.*, 1969; Harris, 1982).

The limited amount of material collected during the rapid, reconnaissance-style regional surveys and the need to analyze for a broad spectrum of elements, precludes the use of a significantly large sample weight for the gold analyses. Therefore, to obtain representative samples, grain size is reduced by sieving and ball milling of the dried sediments.

The following control methods are currently employed to evaluate and monitor the sampling and analytical variability which are inherent in the analysis of gold in geochemical media:

- (1) For each block of 20 samples:
 - (a) random insertion of a standard reference sample to control analytical accuracy and long-term precision;
 - (b) collection of a field duplicate (two samples from one site) to measure sampling variance;
 - (c) analysis of a second subsample (blind duplicate) from one sample to measure and control short-term precision.
- (2) For both stream and lake sediments, routine repeat analyses on a second subsample are performed for all samples having values that are statistically above approximately the 90th percentile of the total data set.
- (3) For lake sediments only, a routine repeat analysis on a second subsample is performed on those samples with LOI values below 10%, indicating a large clastic component. Ongoing studies suggest that the gold distribution in these samples is more likely to be variable than in samples with a higher LOI content.

The presentation of gold data, statistical treatment and the value map format are different than for other elements. Gold data listed in the open file may include initial analytical results, values determined from repeat analyses, together with sample weights and corresponding detection limits for all analyzed samples. The gold, statistical parameters and regional symbol-trend plots are determined using only the first analytical value. Gold values less than the detection limit are set to half that limit. On the value map, initial values are followed by a comma and a value obtained by a second analysis, where determined. Sample weights used can be found in the text. Following are possible variations in data presentation on a value map.

+ *	No data
+27	Single analysis
+27,14	Repeat analysis
+<1	Single analysis, less than detection limit

TABLE 1. Summary of Analytical Data and Methods

ELEMENT		DETECTION LEVEL		METHOD
<u>SEDIMENTS:</u>				
Zn	Zinc	2	ppm	AAS
Cu	Copper	2	ppm	AAS
Pb	Lead	2	ppm	AAS
Ni	Nickel	2	ppm	AAS
Co	Cobalt	2	ppm	AAS
Ag	Silver	0.2	ppm	AAS
Mn	Manganese	5	ppm	AAS
As	Arsenic	1	ppm	HY-AAS
Mo	Molybdenum	2	ppm	AAS
Fe	Iron	0.02	pct	AAS
U	Uranium	0.5	ppm	NADNC
Hg	Mercury	10	ppb	CV-AAS
F	Fluorine	20	ppm	AAS
V	Vanadium	5	ppm	AAS
Cd	Cadmium	0.2	ppm	AAS
Sb	Antimony	0.2	ppm	HY-AAS
LOI	Loss-on-ignition	1	pct	GRAV
Na	Sodium	0.02	pct	INAA
Sc	Scandium	0.2	ppm	INAA
Cr	Chromium	20	ppm	INAA
Fe	Iron	0.2	pct	INAA
Co	Cobalt	5	ppm	INAA
Ni	Nickel	10	ppm	INAA
As	Arsenic	0.5	ppm	INAA
Br	Bromine	0.5	ppm	INAA
Rb	Rubidium	5	ppm	INAA
Mo	Molybdenum	1	ppm	INAA
Sb	Antimony	0.1	ppm	INAA
Cs	Cesium	0.5	ppm	INAA
Ba	Barium	50	ppm	INAA
La	Lanthanum	2	ppm	INAA
Ce	Cerium	5	ppm	INAA
Sm	Samarium	0.10	ppm	INAA
Eu	Europium	1	ppm	INAA
Tb	Terbium	0.5	ppm	INAA
Yb	Ytterbium	2	ppm	INAA
Lu	Lutetium	0.2	ppm	INAA
Hf	Hafnium	1	ppm	INAA
Ta	Tantalum	0.5	ppm	INAA
W	Tungsten	1	ppm	INAA
Th	Thorium	0.2	ppm	INAA
U	Uranium	0.2	ppm	INAA
Wt	Weight	0.01	g	-
Au	Gold	2	ppb	INAA
<u>WATERS:</u>				
F-W	Fluoride	20	ppb	ISE
pH	Hydrogen ion activity	-	-	GCM
U-W	Uranium	0.05	ppb	LIF
Ca-W	Calcium	0.5	ppb	AAS
Mg-W	Magnesium	0.05	ppb	AAS
T-Alk	Total Alkalinity	1	ppm	TIT

- AAS
- atomic absorption spectrometry
- CV-AAS
- cold vapour (flameless) atomic absorption
- GCM
- glass Calomel electrode and pH meter
- GRAV
- gravimetry
- HY-AAS
- atomic absorption using hydride evolution
- INAA
- Instrumental Neutron Activation Analysis
- ISE
- ion selective electrode
- LIF
- laser-induced fluorescence
- NADNC
- neutron activation, delayed neutron counting
- TIT
- titration

In summary, geochemical follow-up investigations for gold should be based on a careful consideration of all geological and geochemical information, and especially a careful appraisal of gold geochemical data and its variability. In some instances, prospective follow-up areas may be indirectly identified by pathfinder element associations in favourable geology, although a complementary gold response due to natural variability may be lacking. Once an anomalous area has been identified, field investigations should be designed to include detailed geochemical follow-up surveys and collection of large representative samples. Subsequent repeat subsample analyses will increase the reliability of results and permit a better understanding of natural variability which can then be used to improve sampling methods and interpretation.

FIELD DATA LEGEND

Table 2 describes the field and map information appearing on the following pages preceeding the analytical data for each sample site.

REFERENCES

- Aslin, G.E.M.** (1976) The determination of arsenic and antimony in geological materials by flameless atomic absorption spectrophotometer; *Journal of Geochemical Exploration*, Vol. 6, pp. 321-330.
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- Hall, G.E.M.** (1979) A study of the stability of uranium in waters collected from various geological environments in Canada; *in* *Current Research, Part A*, *Geol. Surv. Can. Paper 79-1A*, pp. 361-365.
- Harris, J.F.** (1982) Sampling and analytical requirements for effective use of geochemistry in exploration for gold; *in* *Levinson, A.A., Editor, Precious Metals in the Northern Cordillera*, proceedings of a symposium sponsored by the Association of Exploration Geochemists and the Cordilleran Section of the Geological Association of Canada, pp. 53-67.
- Jonasson, I.R., Lynch, J.J. and Trip, L.J.** (1973) Field and laboratory methods used by the Geological Survey of Canada in geochemical surveys; No. 12, *Mercury in Ores, Rocks, Soils, Sediments and Water*, *Geol. Surv. Can. Paper 73-21*.

TABLE 2. Field Observations Legend

FIELD RECORD	DEFINITION	TEXT CODE
MAP SHEET	National Topographic System (NTS): lettered quadrangle (1:250,000 or 1:50 000 scale) Part of sample number	042E, 042L or 052H
SAMPLE ID	Remainder of sample number: Year Field crew..... Sample sequence number.....	89 1 or 3 001-999
REP STAT	Replicate status; the relationship of the sample to others within the analytical block of 20: Routine regional sample First of field duplicate..... Second of field duplicate.....	00 10 20
UTM	Universal Transverse Mercator (UTM) Coordinate system; digitized sample location coordinates.	
ZN	Zone (7 to 22)	
EASTING	UTM Easting in metres	
NORTHING	UTM Northing in metres	
ROCK UNIT	Major rock type of catchment area: PRECAMBRIAN PROTEROZOIC mafic intrusive rocks: diabase dykes and sills; ultramafic dykes and sills..... Sibley Group (Pass Lake Formation): conglomerate, sandstone..... ARCHEAN unmetamorphosed felsic to intermediate intrusive rocks metamorphosed felsic to intermediate intrusive rocks metamorphosed migmatitic rocks metamorphosed felsic to intermediate subvolcanic intrusive rocks: including quartz and/or feldspar porphyry metamorphosed mafic to intermediate intrusive rocks: gabbro, norite; anorthosite to anorthositic gabbro; diorite, quartz diorite metamorphosed ultramafic rocks: peridotite, pyroxenite, serpentinite..... clastic metasediments..... chemical metasediments: magnetite chert ironstone, sulphide ironstone, carbonate ironstone, chert felsic to intermediate metavolcanics mafic and intermediate metaolcanics	PMI PSG AFI AMFI AMM AMFS AMMI ACU ACLM ACHM AFMV AMMV
ROCK AGE	Stratigraphic age of dominant rock type in catchment basin: Proterozoic Archean	04 02
LAKE AREA	The area of the water body sampled: Pond ¼ to 1 square kilometer..... 1 to 5 square kilometers greater than 5 square kilometers	pond .25-1 1-5 >5

FIELD RECORD	DEFINITION	TEXT CODE
LAKE DEPTH	Distance in metres from the surface of the lake to the bottom:	0 - 99
TERRAIN RELIEF	Relief of lake catchment basin: Low Medium..... High	Lo Med Hi
SAMPLE CONT.	Contamination; human or natural: None Work Camp Fuel..... Gossan	- Wo Ca Fu Go
SAMPLE COLOUR	Sediment sample colour; up to two colours may be selected: Tan Yellow..... Green Grey Brown..... Black	Tn Yl Gn Gy Br Bk
SUSP MATL	Suspended matter in water: None Heavy..... Light.....	- Hvy Lgt
Miscellaneous	Refers to missing data in any field.....	*