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# Geological Survey of Canada Open File 2860 (Parts of NTS 105A)

## Canada - Yukon Mineral Resource Development Cooperation Agreement (1991-1996)

### REGIONAL LAKE SEDIMENT AND WATER GEOCHEMICAL RECONNAISSANCE DATA SOUTHEASTERN YUKON

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Natural Resources  
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development agreement

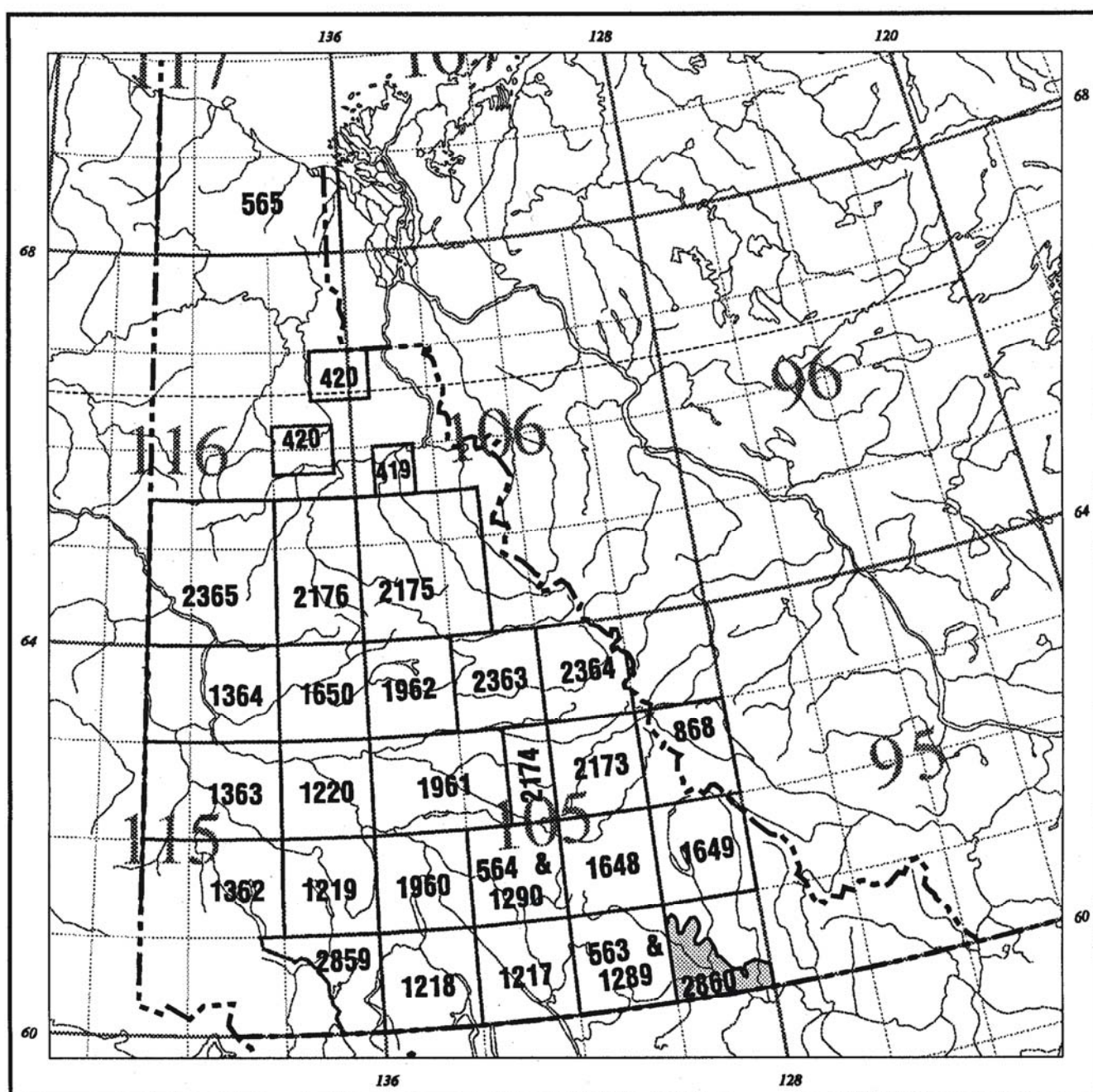
Contribution to Canada - Yukon Mineral Resource Development Cooperation Agreement (1991-1996),  
a subsidiary agreement under the Canada - Yukon Economic Development Agreement

Contribution à l'Entente de coopération Canada Yukon sur l'exploitation minière (1991-1996),  
entente auxiliaire négociée en vertu de l'Entente Canada Yukon de développement économique

**Yukon**  
Government

Canada

**NATIONAL GEOCHEMICAL RECONNAISSANCE  
LAKE SEDIMENT AND WATER GEOCHEMICAL DATA  
YUKON 1994  
GEOLOGICAL SURVEY OF CANADA OPEN FILE 2860  
PARTS OF NTS 105A**



**National Topographic System reference and index to adjoining  
geochemical reconnaissance surveys**

Open File 2860 represents a contribution to the Canada-Yukon Mineral Resource Development Cooperation Agreement (1991-1996), a subsidiary agreement under the Canada-Yukon Economic Development Agreement. This project was managed by the Geological Survey of Canada.

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# GSC OPEN FILE 2860

## REGIONAL LAKE SEDIMENT AND WATER GEOCHEMICAL DATA

### YUKON NTS 105A

#### INTRODUCTION

Open File 2860 presents analytical and statistical data for 35 elements in lake sediments from 205 sample sites in Yukon Territory. Loss-on-ignition in sediments, and uranium, fluoride, and pH values in waters from these sites are included in this report. Open File 2860 contains geochemical data from an area in the southeastern part of the territory sampled in 1993 under the Canada - Yukon Mineral Resource Development Cooperation Agreement (1991-1996).

The reconnaissance surveys were managed by the Geological Survey of Canada.

Regional geochemical surveys have been carried out by the GSC in Yukon since 1976. A total of 28 open files have been published or are in publication, covering approximately 331 930 km<sup>2</sup>. Areas surveyed, with associated open file numbers, are shown in Fig. 1. Fig. 2 shows cross-Canada coverage. Data from all open files are available on 3.5 or 5.25 inch diskettes and in the original published form.

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, 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

P.W.B. Friske coordinated the activities of contract and GSC staff.

Contracts were let to the following companies for sample preparation, original analyses and/or reanalyses and were managed by Geological Survey of Canada staff as follows:

Collection: *GSC Staff*

Preparation: Bondar-Clegg & Company Limited  
Gloucester, Ontario  
*J.J. Lynch (GSC)*

Analysis: Becquerel Laboratories  
Mississauga, Ontario

Cantech Laboratories Inc.  
Calgary, Alberta

Bondar-Clegg & Company Limited  
Gloucester, Ontario

*J.J. Lynch (GSC)*

M. McCurdy edited open files and coordinated open file production.

H. Gross provided computer processing support.

C.C. Durham, S.J. Day, S. Carberry, and R. Balma provided technical assistance.

#### DESCRIPTION OF SURVEY AND SAMPLE MANAGEMENT

Helicopter-supported sample collection was carried out during the summer of 1993. Lake sediment and water samples were collected at an average density of one sample per 27.25 km<sup>2</sup> throughout the 5 587 square kilometres covered by the survey.

Samples were arranged in groups (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 placed in two non-adjacent sample vials). Finally, each group included a control reference sample. The functions of these samples are described in the section titled, Presentation and Interpretation of Gold Data. Field observations were recorded on standard forms used by the Geological Survey of Canada (Garrett, 1974).

Site positions were marked on 1:50 000 scale NTS maps in the field and later digitized at the Geological Survey of Canada in Ottawa to obtain Universal Transverse Mercator (UTM) coordinates. The dominant rock types in the lake catchment basins were identified on appropriate geological maps used as the bedrock geological base on NGR maps.

In Ottawa, field dried samples were air-dried and crushed: particle reduction was accomplished using a ceramic puck mill. The minus 80 mesh (177 micron) fraction was obtained and used for subsequent analyses. At this time, control reference and blind (analytical) 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.

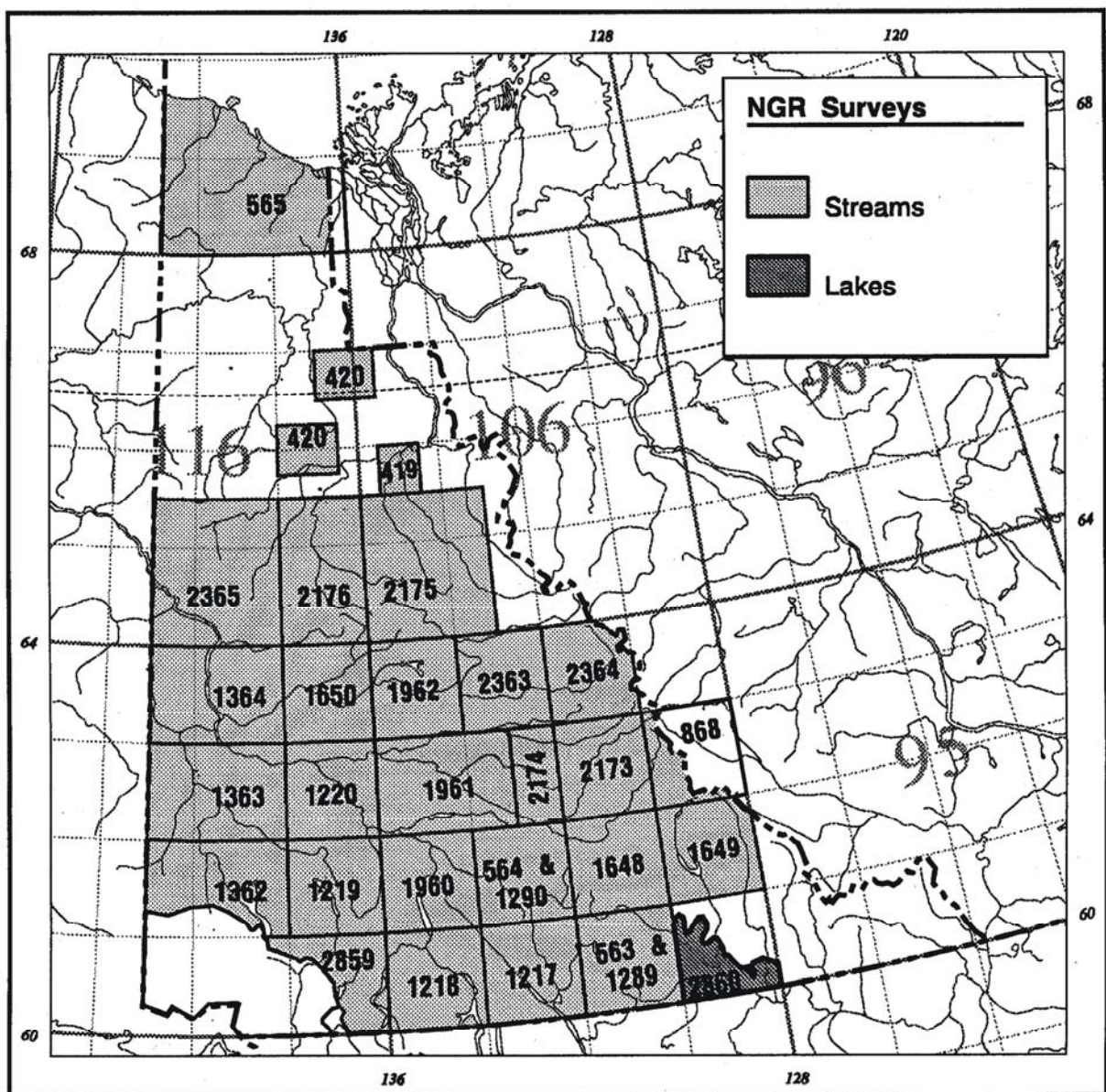


Fig. 1. Areas of Yukon covered by geochemical surveys, showing current GSC open file numbers.

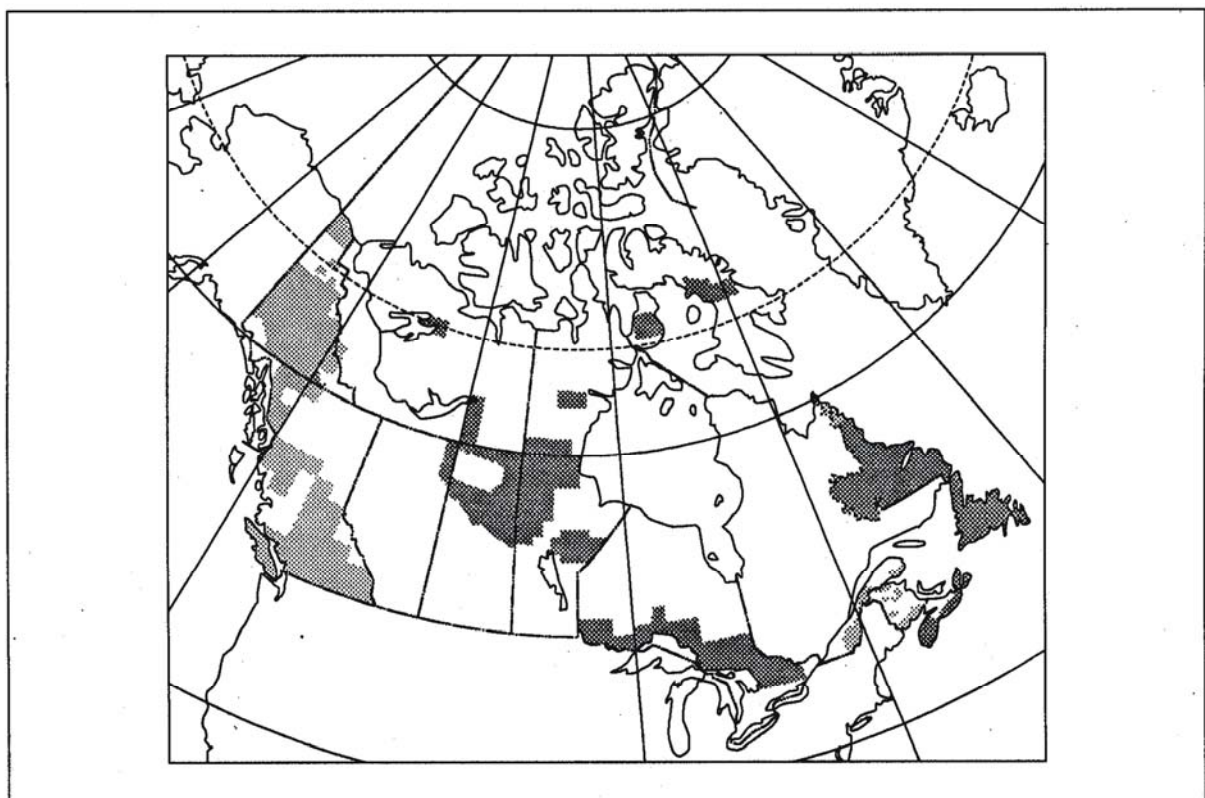


Fig. 2. Drainage surveys to National Geochemical Reconnaissance standards.

Analytical data from labs were monitored for reliability with standard methods used by the Applied Geochemistry Subdivision at the GSC.

## **ANALYTICAL PROCEDURES**

### **Instrumental Neutron Activation Analysis (INAA)**

Weighed and encapsulated samples are packaged for irradiation along with internal standards and international reference materials. Samples and standards are irradiated together with neutron flux monitors in a two-megawatt pool-type reactor. After a seven day decay period, samples are measured on a high resolution germanium detector. Computer control is achieved with a Microvax II computer. Typical counting times are 500 seconds. Elements determined by INAA include: Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cs, Eu, Fe, Hf, Ir, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Sn, Ta, Tb, Te, Th, U, W, Yb, Zn, and Zr. The sample weights are also reported. Data for Ag, Cd, Ir, Mo, Ni, Se, Sn, Te, Zn, and Zr 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, and Cd, a 1 g sample is reacted with 6 mL of a mixture of 4M HNO<sub>3</sub> and M HCl in a test tube over night 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.

Molybdenum and vanadium are determined by atomic absorption spectroscopy using a nitrous oxide acetylene flame. A 0.5 g sample is reacted with 1.5 mL concentrated HNO<sub>3</sub> 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 degrees C and held at this temperature for 30 minutes with periodic shaking. At this point, 0.5 ml concentrated HCl is added and the digestion continued 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 HNO<sub>3</sub> 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 10% w/v SnSO<sub>4</sub> in M H<sub>2</sub>SO<sub>4</sub>. 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.

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 fluoride in 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 litre 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 analyzer. 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 microlitres 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 microlitre aliquots of either 55 or 550 ppb U are used). All readings are taken against a sample blank.

Table 1 provides a summary of analytical data and methods.

## COMPARISON OF DATA PRODUCED BY TWO METHODS

The data listed in II-1 to II-18 allows users to make a comparison of data generated by two different analytical methods for a couple of elements. Before attempting such a comparison some caution should be exercised.

The 'wet chemistry' data for Co and Fe were obtained by AAS using a partial extraction (HNO<sub>3</sub> and HCl). The data for these elements obtained by INAA produces 'total' data. Hence, the 'wet chemistry' data will likely be somewhat lower than the INAA data.

## PRESENTATION AND INTERPRETATION OF GOLD DATA

The following general discussion reviews the format used to present the gold 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 gold in nature and the resultant difficulties in obtaining and analyzing samples which reflect the actual concentration level at a given site.

Samples that have gold values that are statistically above approximately the 90th percentile, or those with LOI values below 10%, are normally analyzed again in accordance with standard NGR procedures. There will be no repeat data published in Open File 2860 however, as insufficient material remained after the initial neutron activation analyses. The correct interpretation of gold geochemical data from regional stream sediment or lake sediment surveys requires an appreciation of the unique chemical and physical characteristics of gold and its mobility in the surficial environment. Key properties of gold that distinguish its geochemical behaviour from most other elements (Harris, 1982) include:

- 1) Gold occurs most commonly in the native form which is chemically and physically resistant. A significant proportion of the metal is dispersed in a micron-sized particulate form, and the high specific gravity of gold results in a heterogeneous distribution, especially in stream sediment and clastic-rich (low LOI) lake sediment environments. In organic-rich fluvial and lake sediments, gold distribution appears to be more homogeneous.
- 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 in 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 or depleted in the surficial environment. Hence, a major problem facing the geochemist is to obtain a representative sample. In general, in areas where concentrations of gold in sediments are low, and/or grain sizes of the gold present relatively high, proportionally larger samples are required 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 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 and analytical variance;
  - (c) analysis of a second subsample (blind duplicate) from one sample to measure and control short-term precision or analytical variance.

Table 1. Summary of Analytical Data and Methods

ELEMENT		DETECTION LEVEL		METHOD
<u>SEDIMENTS:</u>				
Ag	Silver	0.2	ppm	AAS
As	Arsenic	0.5	ppm	INAA
Au	Gold	2	ppb	INAA
AuWt	Sample Weight	0.01	g	-
Ba	Barium	50	ppm	INAA
Br	Bromine	0.5	ppm	INAA
Cd	Cadmium	0.2	ppm	AAS
Ce	Cerium	5	ppm	INAA
Co	Cobalt	2	ppm	AAS
Co	Cobalt	5	ppm	INAA
Cr	Chromium	20	ppm	INAA
Cs	Cesium	0.5	ppm	INAA
Cu	Copper	2	ppm	AAS
Eu	Europium	1	ppm	INAA
F	Fluorine	40	ppm	ISE
Fe	Iron	0.02	pct	AAS
Fe	Iron	0.2	pct	INAA
Hf	Hafnium	1	ppm	INAA
Hg	Mercury	5	ppb	CV-AAS
La	Lanthanum	2	ppm	INAA
LOI	Loss-on-ignition	1.0	pct	GRAV
Lu	Lutetium	0.2	ppm	INAA
Mn	Manganese	5	ppm	AAS
Mo	Molybdenum	2	ppm	AAS
Na	Sodium	0.02	pct	INAA
Ni	Nickel	2	ppm	AAS
Pb	Lead	2	ppm	AAS
Rb	Rubidium	5	ppm	INAA
Sb	Antimony	0.1	ppm	INAA
Sc	Scandium	0.2	ppm	INAA
Sm	Samarium	0.1	ppm	INAA
Ta	Tantalum	0.5	ppm	INAA
Tb	Terbium	0.5	ppm	INAA
Th	Thorium	0.2	ppm	INAA
U	Uranium	0.2	ppm	INAA
V	Vanadium	5	ppm	AAS
W	Tungsten	1	ppm	INAA
Yb	Ytterbium	1	ppm	INAA
Zn	Zinc	2	ppm	AAS
<u>WATERS:</u>				
F-W	Fluoride	20	ppb	ISE
PH	Hydrogen ion activity	-	-	GCM
U-W	Uranium	0.05	ppb	LIF

- AAS

CV-AAS

GCM

GRAV

INAA

ISE

LIF
- atomic absorption spectrometry

- cold vapour / atomic absorption spectrometry

- glass Calomel electrode and pH meter

- gravimetry

- Instrumental Neutron Activation Analysis

- ion selective electrode

- laser-induced fluorescence



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 an analogous 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 preceding the analytical data for each sample site.

## REFERENCES

- Clifton, H.E., Hunter, R.E., Swanson, F.J., and Phillips, R.L.** (1969) Sample size and meaningful gold analysis; U.S. Geological Survey Professional Paper 625-C.
- Ficklin, W.H.** (1970) A rapid method for the determination of fluoride in rocks and soils, using an ion selective electrode; U.S. Geol. Surv. Paper 700C, pp. 186-188.
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- Godfrey, J.D.** (1986) Geology of the Precambrian Shield of northeastern Alberta (NTS 74M and 74L N 1/2); Alberta Research Council Map EM180.
- 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, Geological Survey of Canada Paper 79-1A, pp. 361-365.
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- 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.
- Wheeler, J.O. and McFeely, P. (comp.)** (1991) Tectonic Assemblage Map of the Canadian Cordillera and adjacent parts of the United States of America; Geological Survey of Canada, Map 1712A, scale 1:2 000 000.

TABLE 2. Field Observations Legend

FIELD RECORD	DEFINITION	TEXT CODE
MAP	National Topographic System (NTS): lettered quadrangle (1:250 000 or 1:50 000 scale) Part of sample number	105A
SAMPLE ID	Remainder of sample number: Year ..... Field crew ..... Sample sequence number .....	93 1 001-999
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
ZN	Zone (7 to 22)	
UTM	Universal Transverse Mercator (UTM) Coordinate System; digitized sample location coordinates.	
EASTING	UTM Easting in metres	
NORTHING	UTM Northing in metres	
ROCK UNIT	Major rock type of catchment area: <b>CENOZOIC</b> <b>Tertiary and Quaternary</b> alkali basalt and peralkaline trachyte-comendite shield volcanoes; alkali olivine basalt cones with lherzolite nodules; flows and tuffs; nonmarine..... <b>Palaeogene</b> shale, siltstone, sandstone, conglomerate, local lignite, marl and dacitic volcanics; nonmarine ..... <b>PALAEOZOIC</b> <b>Devonian - Triassic</b> variably sheared, ophiolite-like assemblage of oceanic, alkalic to transitional pillowed basalt, tuff, breccia, serpentinitized peridotite and gabbro, radiolarian chert, argillite and volcanic clastics; marine..... <b>Devonian - Mississippian</b> westerly-derived, chert-pebble conglomerate, chert-quartz sandstone, pebbly mudstone, blue-black siliceous shale, locally containing barite, brown shale, alkaline trachyte and rhyolite flows, breccia, tuff, pillow basalt and breccia; chert and limestone; marine and nonmarine ..... <b>Upper Proterozoic - Triassic</b> sheared conglomerate with lenses of Upper Triassic limestone and sandstone and clasts of gneissic granites and metamorphic rocks and Upper Triassic and Paleozoic carbonate; Pennsylvanian and Permian carbonate, and chloritic quartz grit; Lower Mississippian felsic metavolcanics, dark grey phyllite and quartzite, and older micaceous feldspathic quartzite, schist, marble; all variably mylonitized; marine ..... <b>Cambrian - Devonian</b> resistant dolomite, limestone, and local sandstone interbedded with recessive red, green, and grey shale and detrital carbonate that together form several carbonate-shale grand cycles. These pass westward into offshore shale, siltstone and thin-bedded carbonate with minor alkalic tuff, breccia and amygdaloidal basalt of Cambrian, Cambro-Ordovician, Silurian, and Devonian ages but mainly of Ordovician age; marine .....	TQE  PgTS   DTrS  DME   PTrNK   CDR/CDRC

FIELD RECORD	DEFINITION	TEXT CODE
ROCK UNIT (continued)	<b>Upper Proterozoic - Lower Cambrian</b> upper unit: blue-grey, apple-green and maroon slate with minor siltstone and sandstone; lower unit: interbedded graded sequence of sandstone, locally conglomeratic, and shale with limestone in upper part; marine ..... shallow-water crossbedded orthoquartzite, feldspathic quartzite, locally graded-bedded quartzite, quartz-pebble conglomerate, mafic flows, breccia and tuff overlain by interbedded quartzite, siltstone, shale, and limestone with archeocyathid reefs; metamorphic equivalents; marine..... <b>PRECAMBRIAN</b> <b>Upper Proterozoic</b> graded-bedded assemblage of interbedded quartz-feldspar grit, sandstone, siltstone and shale, commonly maroon and green; diamictite in Rocky Mountains, limestone in upper part, local greenstone flows, breccia and tuff, and metamorphic equivalents; marine .....	PCH   PCGC   uPWC
ROCK AGE	Predominant age of rock type in catchment area: Tertiary and Quaternary ..... Palaeogene ..... Devonian – Triassic ..... Devonian – Mississippian ..... Upper Proterozoic – Triassic ..... Cambrian – Devonian ..... Upper Proterozoic - Lower Cambrian ..... Upper Proterozoic .....	63 57 40 29 97 09 08 04
LAKE AREA	The area of the water body sampled: Pond ..... 1/4 to 1 square kilometre ..... 1 to 5 square kilometres ..... greater than 5 square kilometres .....	pond .25-1 1-5 >5
LAKE DEPTH	Distance in meters from the surface of the lake to the bottom .....	0 - 99
TERRAIN RELIEF	Relief of lake catchment basin: Low ..... Medium ..... High .....	Low 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 .....	Tan Yellow Green Grey Brown Black
SUSPEND MAT'L	Suspended matter in water: None ..... Heavy ..... Light .....	- Heavy Light

FIELD RECORD	DEFINITION	TEXT CODE
Miscellaneous	Refers to missing data in any field ..... no sample material for analysis ..... parts per million..... parts per billion..... percent ..... weight (of sample) ..... gram.....	* ns ppm ppb pct Wt g