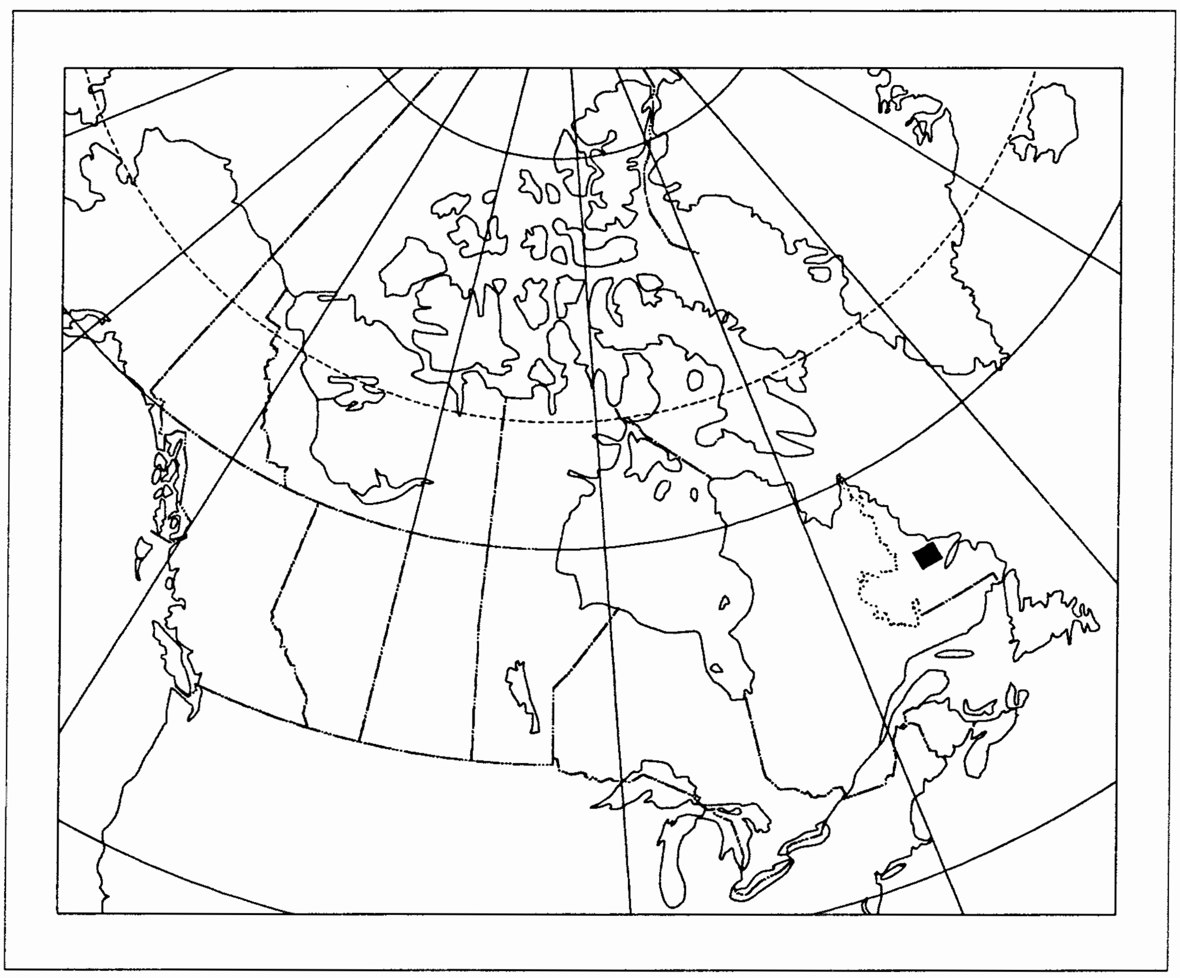
GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

GEOLOGICAL SURVEY OF CANADA OPEN FILE 2645
(NTS 13K)

CANADA - NEWFOUNDLAND COOPERATION AGREEMENT ON MINERAL DEVELOPMENT (1990-1994)

REGIONAL LAKE SEDIMENT AND WATER GEOCHEMICAL RECONNAISSANCE DATA CENTRAL LABRADOR



Friske, P.W.B., McCurdy, M.W., Gross, H., Day, S.J., Lynch, J.J., Durham, C.C. (1993): National Geochemical Reconnaissance Lake Sediment and Water Data, Central Labrador (NTS 13K); Geological Survey of Canada Open File 2645

17 June 1993

Energy, Mines and Resources, Canada — Energie, Mines et Ressources, Canada

Canada

NATIONAL GEOCHEMICAL RECONNAISSANCE

LAKE SEDIMENT AND WATER GEOCHEMICAL DATA

NEWFOUNDLAND 1993

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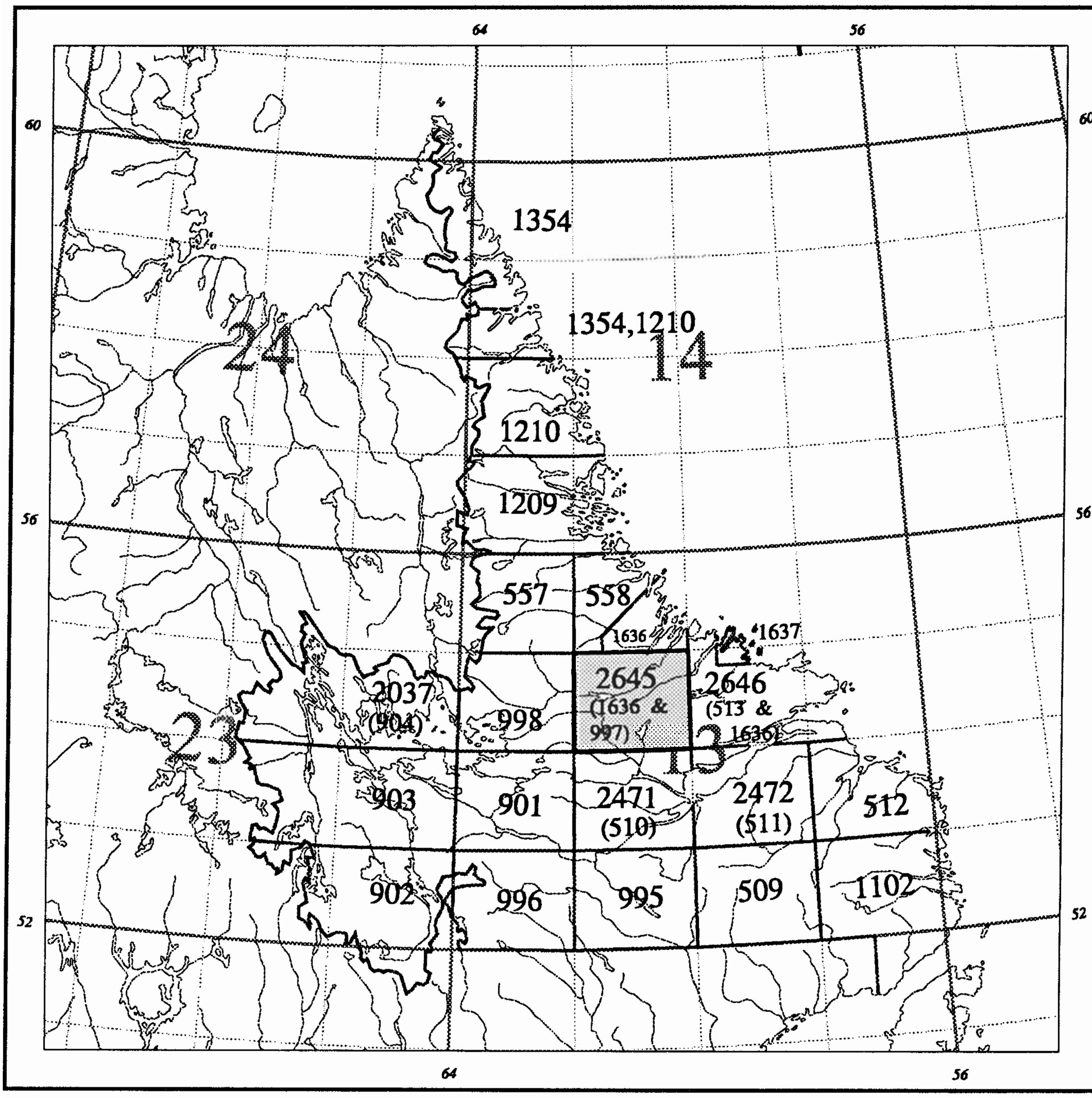
NTS 13K



National Topographic System reference and index to adjoining geochemical reconnaissance surveys

Open File 2645 represents a contribution to the Canada - Newfoundland Cooperation Agreement on Mineral Development (1990-1994), a subsidiary agreement under the Economic and Regional Development Agreement. This project was managed by the Geological Survey of Canada.

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GSC OPEN FILE 2645
REGIONAL LAKE SEDIMENT AND WATER GEOCHEMICAL DATA, LABRADOR NTS 13K

INTRODUCTION

Open File 2645 contains data for gold and 25 other elements obtained by re-analyzing lake sediments collected in 1983 from 954 sites in central Labrador. Original analytical data selected from Open File 997 (published in 1983) for 15 elements plus loss-on-ignition in sediments, and uranium, pH and fluoride values in concomitant waters, are also included in this open file.

The original reconnaissance survey was carried out by the Geological Survey of Canada (GSC) in conjunction with the Newfoundland Department of Mines and Energy under the terms of the Canada - Newfoundland Cooperative Mineral Program (1982-1984). Open File 1636, published in 1989, included reanalysis data for part of NTS 13K (Fig. 1), and was funded under the Canada-Newfoundland Mineral Development Agreement (1984-1989). Analyses of remaining archive samples for Open File 2645 were undertaken under the Canada - Newfoundland Cooperation Agreement on Mineral Development (1990-1994).

Analytical results and field observations are used to build a national geochemical data base for resource assessment, mineral exploration, geological mapping and environmental studies. Figure 2 shows coverage across Canada. 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 under the reanalysis program.

E.H.W. Hornbrook directed the original survey.

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

Collection (1983):	Marshall Macklin Monaghan Toronto, Ontario *E. Hornbrook, N.G. Lund (GSC)*
Preparation (1983):	Golder Associates Ottawa, Ontario *J.J. Lynch (GSC)*
Analysis (1983):	Chemex Labs Vancouver, British Columbia Acme Analytical Laboratories Toronto, Ontario *J.J. Lynch (GSC)*
Analysis (1988):	Bondar-Clegg and Company Ottawa, Ontario *J.J. Lynch (GSC)*
Preparation (1992):	Bondar-Clegg & Company Ottawa, Ontario *J.J. Lynch (GSC)*
Analysis (1992)	Becquerel Laboratories Mississauga, Ontario *J.J. Lynch (GSC)*

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

H. Gross and S.W. Adcock provided computer processing support.

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

DESCRIPTION OF SURVEY AND SAMPLE MANAGEMENT

Helicopter-supported sample collection was carried out during the summer of 1983. Lake sediment and water samples were collected at an average density of one sample per 15.1 km^2 throughout the 14,413 square kilometres covered by the 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).

Site positions were marked on 1:250 000 scale NTS maps in the field and later digitized at the Geological Survey 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, crushed and ball-milled. The minus 80 mesh (177 micron) fraction was obtained and 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. Additional lake sediment material required for INAA analyses was taken from archive storage. Particle reduction was accomplished using a ceramic puck mill.

Analytical data from labs were monitored for reliability with standard methods used by the Applied Geochemistry Subdivision at the Geological Survey of Canada.

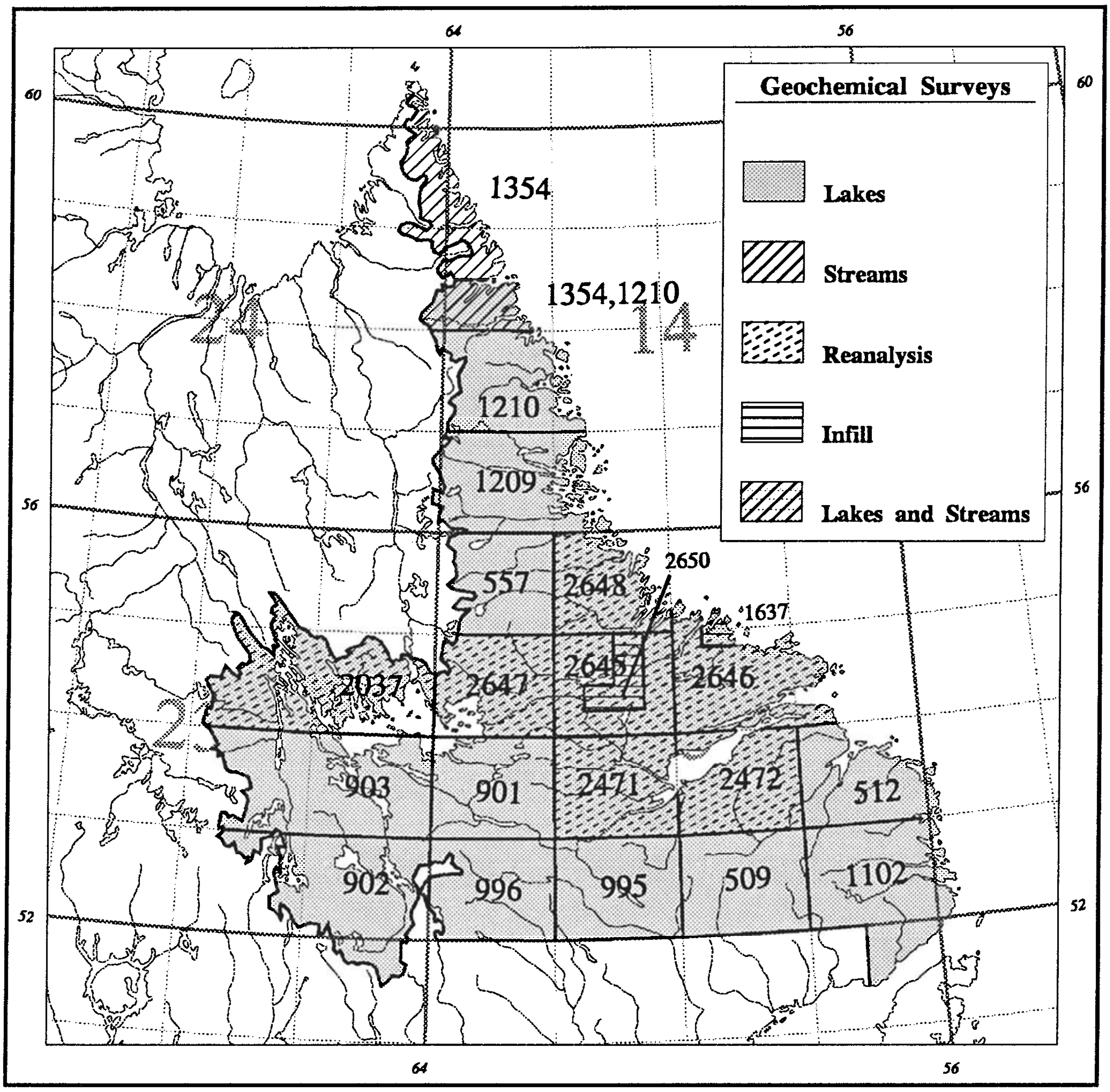

Fig. 1. Areas of Labrador covered by geochemical surveys, showing current GSC open file numbers.

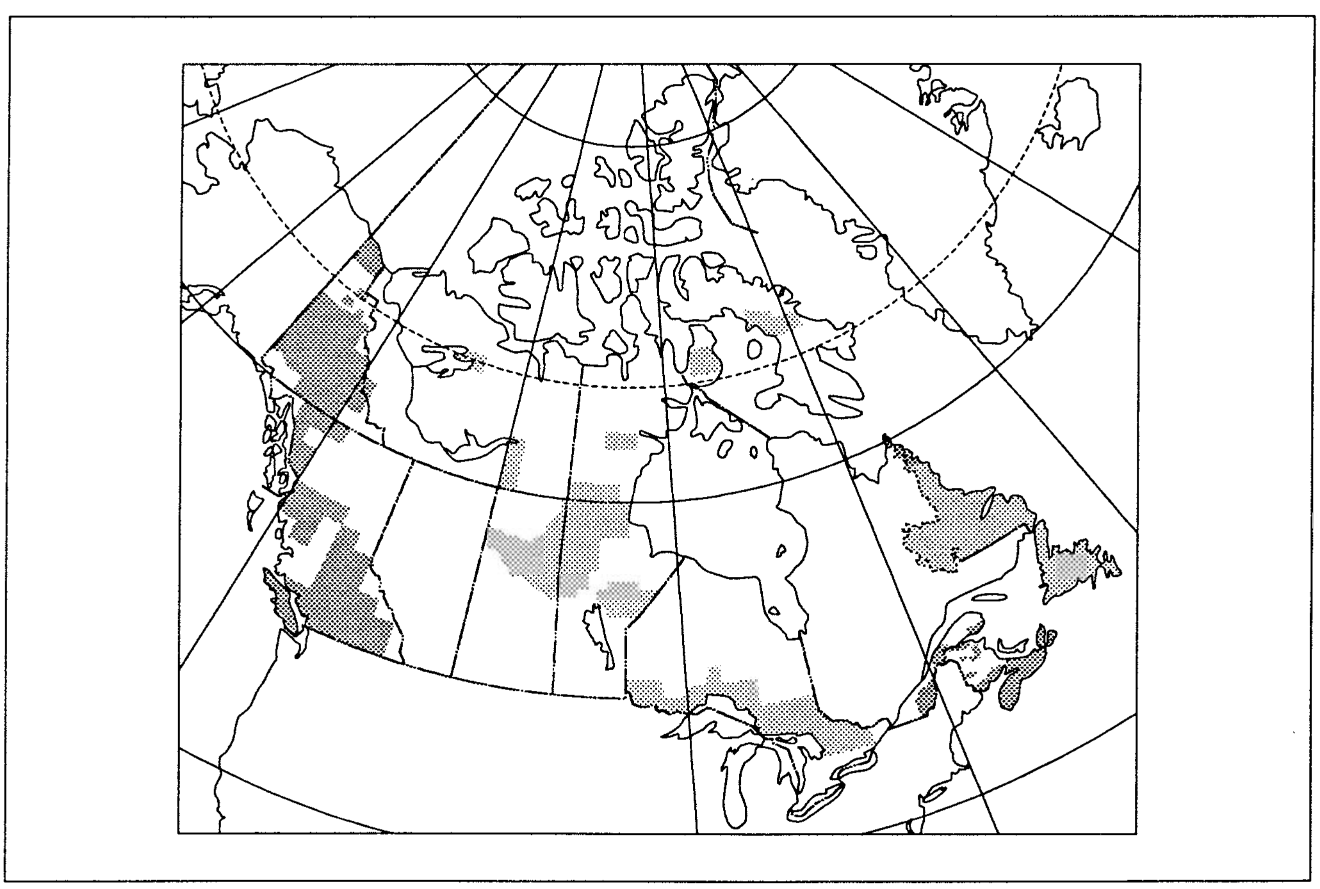

Fig. 2. Drainage surveys to National Geochemical Reconnaissance standards.

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, 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 was reacted with 6 ml of a mixture of 4M HNO_3 and M HCl 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 degrees C and held at this temperature for 2 hours with periodic shaking. The sample solution was then diluted to 20 ml with metal-free water and mixed. Zn, Cu, Pb, Ni, Co, Ag, Mn and Fe were determined by atomic absorption spectroscopy using an air-acetylene flame. Background corrections were made for Pb, Ni, Co, Ag, and Cd.

Arsenic was determined by atomic absorption using a hydride evolution method wherein the arsenic was evolved as AsH_3 and passed throught a heated quartz tube in the light path of an atomic absorption spectrophotometer.

Molybdenum and vanadium were determined by atomic absorption spectroscopy using a nitrous oxide acetylene flame. A 0.5 g sample was reacted with 1.5 ml concentrated HNO_3 at 90 degrees C for 30 minutes. At this point 0.5 ml concentrated HCl was added and the digestion continued at 90 degrees 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 gram sample was reacted with 20 ml concentrated HNO_3 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 degrees 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% w/v $SnSO_4$ in M H_2SO_4. 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 degrees 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.

Fluorine was determined as described by Ficklin (1970). A 250 mg sample was sintered with 1 gram of a flux consisting of two parts by weight sodium carbonate and one part by weight potassium nitrate. The residue was then leached with water. The sodium carbonate was neutralized with 10 ml 10% (w/v) citric acid and the resulting solution was diluted to 100 ml with water. The pH of the solution should range from 5.5 to 6.5. The fluoride content of the test solution was measured using a fluoride ion electrode. Standard solutions contained sodium carbonate and citric acid in the same quantities as the sample solution.

Uranium was determined using a neutron activation method with delayed neutron counting. A detailed description of the original method is provided by Boulanger et al.(1975). In brief, a 2 gram sample was irradiated for 10 seconds in the Triga reactor located at Washington State University. The operating flux was 8×10^{13} neutrons/cm^2/second. After irradiation, the samples were transferred to the counting facility where, after a 10 second delay, each sample was counted for 10 seconds. Calibration was carried out twice a day or as required. One standard was analysed after every 20 samples.

Water Analyses

Uranium in waters was 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, G.E.M., 1979) was added to produce the uranyl pyrophosphate species, which fluoresces when exposed to the laser. Since organic matter in the sample could cause unpredictable behaviour, a standard addition method was used. Further, the reaction of uranium with Fluran may either be delayed or sluggish; for this reason an arbitrary 24 hour time delay between the addition of the Fluran and the actual reading was incorporated into this method. In practice, 500 µl Fluran solution was added to a 5 ml sample and allowed to stand for 24 hours. At the end of this period, fluorescence readings were made with the addition of 0.0, 0.2, and 0.4 ppb uranium. For samples with higher concentrations, the additions were 0.0, 2.0, and 4.0 ppb uranium (20 µl aloquots of 55 or 550 ppb U were used). All readings were taken against a sample blank.

Hydrogen ion activity (pH) was measured with a Broadley-James combination electrode and a Model 404 Orion specific ion meter.

Fluoride in lake water samples was determined using an Orion fluoride electrode and a Model 401 Orion specific ion meter. Prior to measurement, an aliquot of the sample was mixed with an equal volume of a TISAB (total ionic strength adjustment buffer).

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-78 allows users to make a comparison of data generated by two different analytical methods for a number of elements. Before attempting such a comparison some caution should be exercised.

1. The original data for Ni, Co, As, Mo, and Fe were obtained by AAS using a partial extraction (HNO_3 and HCl). The data for these elements obtained on re-analysis are by INAA, which produces 'total' data. Hence, the original data will likely be somewhat lower than the INAA data.

2. The data for U were derived by a 'total' method, both originally and on re-analysis.

3. The sample preparation for the original analyses differed from the preparation employed for the re-analysis. Originally, a portion of the collected sample was prepared. Prior to re-analysis all of the remaining original sample was prepared and bottled. As a result, most of the original data were obtained from a different split of the unprepared sample than that which was used for re-analysis. Disagreement between original and re-analyzed data for some elements might be attributed to heterogeneity of the two different splits used for the two analyses.

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 2645 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 fluviatile 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 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 and analytical variance;

Table 1. Summary of Analytical Data and Methods

ELEMENT		DETECTION LEVEL		METHOD
SEDIMENTS:				
Ag	Silver	0.2	ppm	AAS
As	Arsenic	1	ppm	HY-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	10	ppb	AAS
La	Lanthanum	2	ppm	INAA
LOI	Loss-on-ignition	1	pct	GRAV
Lu	Lutetium	0.2	ppm	INAA
Mn	Manganese	5	ppm	AAS
Mo	Molybdenum	2	ppm	AAS
Mo	Molybdenum	1	ppm	INAA
Na	Sodium	0.02	pct	INAA
Ni	Nickel	2	ppm	AAS
Ni	Nickel	10	ppm	INAA
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
U	Uranium	0.5	ppm	NADNC
V	Vanadium	5	ppm	AAS
W	Tungsten	1	ppm	INAA
Yb	Ytterbium	2	ppm	INAA
Zn	Zinc	2	ppm	AAS
WATERS:				
F-W	Fluoride	20	ppb	ISE
pH	Hydrogen ion activity	-	-	GCM
U-W	Uranium	0.05	ppb	LIF

AAS	- atomic absorption spectrometry
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

(c) analysis of a second subsample (blind duplicate) from one sample to measure and control short-term precision or analytical variance.

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 analogous gold response due to natural variability may be lacking. Once an anomalous area has been identified, field investigations should by 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 by 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

Aslin, G.E.M. (1976) The determination of arsenic and antimony in geological materials by flameless atomic absorption spectrophotometry; Journal of Geochemical Exploration, Vol. 6, pp. 321-330.

Boulanger, A., Evans, D.J.R. and Raby, B.F. (1975) Uranium analysis by neutron activation delayed neutron counting; Proceedings of the 7th Annual Symposium of Canadian Mineral Analysts, Thunder Bay, Ontario, September 22-23, 1975.

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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Garrett, R.G. (1974) Field data acquisition methods for applied geochemical surveys at the Geological Survey of Canada; Geol. Surv. Can. Paper 74-52.

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.

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	13K
SAMPLE ID	Remainder of sample number: Year . . . . Field crew . . . . Sample sequence number	 83 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: HELIKIAN/APHEBIAN **Grenville Province**	
	metaquartzite, schistose grit and conglomerate, sheared felsic porphyry, greenstone, chlorite-epidote schist, quartz-sericite shist	HAGS
	garnetiferous biotite-quartz-feldspar paragneiss	HAGP
	paragneiss, granitoid gneiss, minor quartzite and marble	HUGP
	intermediate to basic gneiss, amphibolite	HUGB
	Churchill Province quartzite, conglomerate, arkose, shale, phyllite, basalt, mafic pyroclastics, greenstone, chlorite schist, limestone	NWHS,VNHW,NHWK
	Nain Province intermediate to acidic volcanics, feldspathic quartzite	PHLE, UPHE
	conglomerate, quartzite, slate, siliceous dolomite, chert, and arkose	APE3
	feldspathic quartzite, conglomerate, argillite, basic volcanics . . .	APE2,VAE2
	slate, argillite, siltstone, quartzite, greywacke, dolomite, and basalt	APE1,VAE1
	ARCHEAN Grenville Province granitic gneiss, amphibolite, acidic intrusives	ARCG
	Nain Province mafic schists, greenstone, metasediments, amphibolite, ultrabasic intrusions	AREV
	granitic and granodioritic gneiss, migmatite, granulite, amphibolite	AREG
	INTRUSIVE ROCKS CAMBRIAN AND EARLIER diabase dykes	NH18
	HELIKIAN diabasic olivine gabbro; intermediate and ultramafic intrusives	NH17
	gabbro, norite, and diabase sills	NH16
	granite to granodiorite, massive to poorly foliated, porphyritic in part	NH15
	adamellite suite: adamellite, monzonite, syenite, granodiorite, granite	PH13
	anorthosite suite: anorthosite, anorthositic gabbro, leucotroctolite	PH11
	APHEBIAN granite, quartz monzonite, granodiorite, quartz diorite	APH7
	well foliated feldspar-quartz-hornblende-biotite granitic gneiss, chlorite-epidote-quartz-feldspar gneiss, amphibolite, migmatite	APH5

FIELD RECORD	DEFINITION	TEXT CODE
LAKE AREA	The area of the water body sampled:	
	Pond	pond
	1/4 to 1 square kilometre	.25-1
	1 to 5 square kilometres	1-5
	greater than 5 square kilometres	>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	Low
	Medium	Med
	High	Hi
SAMPLE CONT.	Contamination; human or natural:	
	None	-
	Work	Wo
	Camp	Ca
	Fuel	Fu
	Gossan	Go
SAMPLE COLOUR	Sediment sample colour; up to two colours may be selected:	
	Tan	Tan
	Yellow	Yellow
	Green	Green
	Grey	Grey
	Brown	Brown
	Black	Black
SUSP MATL	Suspended matter in water:	
	None	-
	Heavy	Heavy
	Light	Light
Miscellaneous	Refers to missing data in any field	*
	no sample material for analysis	ns
	parts per million	ppm
	parts per billion	ppb
	percent	pct
	weight (of sample)	Wt
	gram	g