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

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Geological Survey of Canada Open File 3293

## REGIONAL STREAM SEDIMENT AND WATER GEOCHEMICAL DATA SOUTHEASTERN YUKON

(Parts of NTS 95D and 105A)

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Natural Resources  
Canada

Ressources naturelles  
Canada



Canada-Yukon economic  
development agreement

Contribution to Canada - Yukon Mineral Resource Development Cooperation Agreement (1991-1996),  
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entente auxiliaire négociée en vertu de l'Entente Canada-Yukon de développement économique

**Yukon**  
Government

Canada

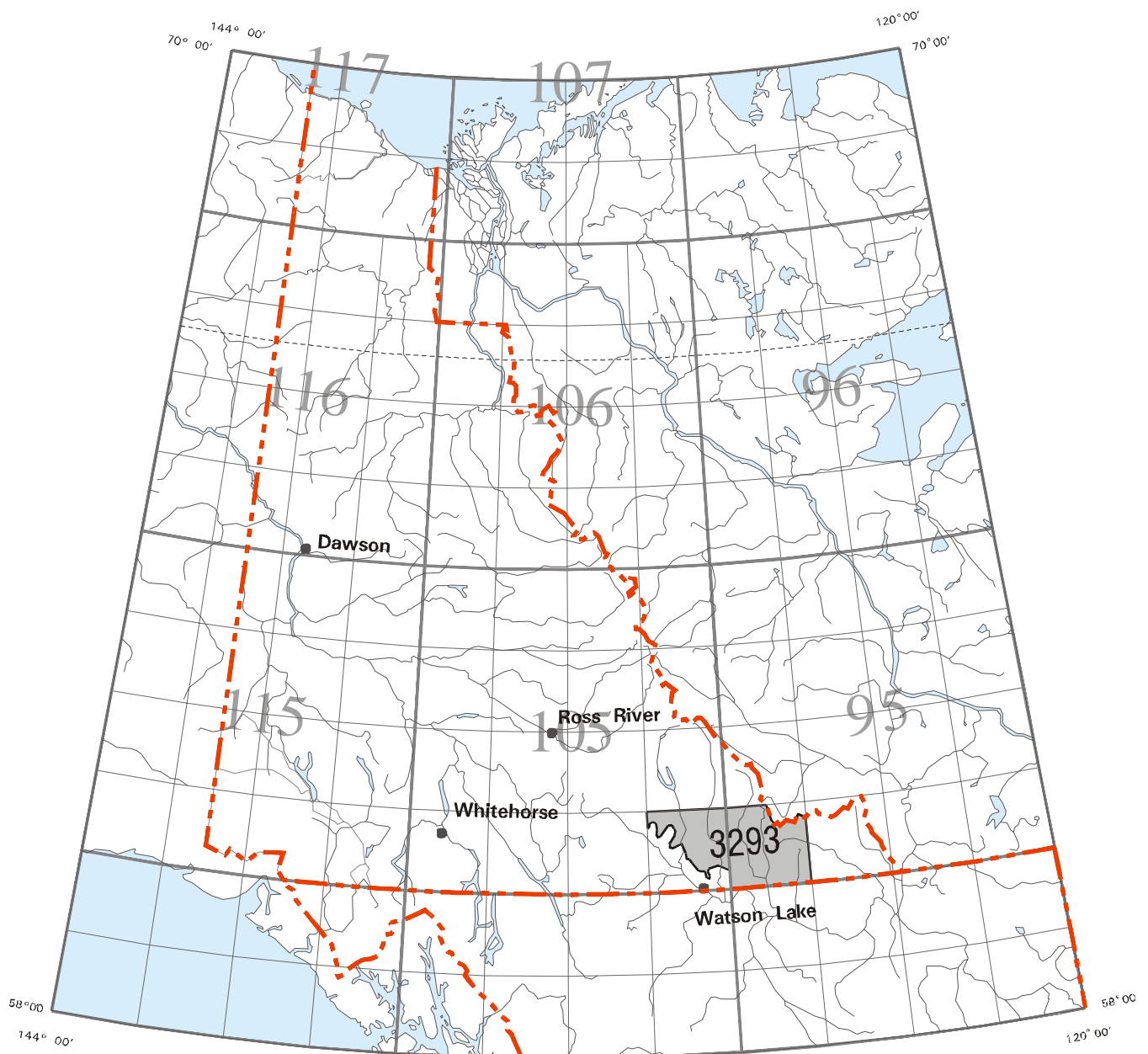
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# NATIONAL GEOCHEMICAL RECONNAISSANCE STREAM SEDIMENT AND WATER GEOCHEMICAL DATA SOUTHEASTERN YUKON

1996

GEOLOGICAL SURVEY OF CANADA OPEN FILE 3293  
PARTS OF NTS 95D and 105A

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Open File 3293 represents a contribution to the Canada - Yukon Mineral Resource Development Cooperation Agreement (1991-1996).

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# GSC OPEN FILE 3293

## REGIONAL STREAM SEDIMENT AND WATER DATA SOUTHEASTERN YUKON Parts of NTS 95D and 105A

### INTRODUCTION

Open File 3293 presents analytical and statistical data for 36 elements in sediments from 1 117 stream sites in Yukon. Loss-on-ignition in sediments and uranium, fluoride, and pH values in waters from these sites are included in this report. Open File 3293 contains geochemical data from an area in the southeastern part of the territory sampled in 1995 under the Canada - Yukon Mineral Resource Development Cooperation Agreement (1990-1995).

The reconnaissance surveys were managed by the Geological Survey of Canada in conjunction with the Department of Indian Affairs and Northern Development, Whitehorse, Yukon.

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.

Regional geochemical surveys have been carried out by the GSC in Yukon since 1976. A total of 29 open files have been published or are in publication, covering approximately 348 260 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.

### CREDITS

P.W.B. Friske directed the survey, coordinating the activities of contract and Geological Survey of Canada staff.

Contracts were let to the following companies for sample collection, preparation, and analysis:

Collection:	McElhanney Consulting Services Vancouver, British Columbia
Preparation:	Bondar-Clegg & Company Ottawa, Ontario
Analysis:	CanTech Laboratories, Inc. Calgary, Alberta
	Becquerel Laboratories, Ltd. Mississauga, Ontario

S.W. Adcock developed the computer programs for handling the data shown in Sections A and B.

M. McCurdy edited open files and coordinated production.

C.C. Durham and S. Carberry provided technical assistance.

### DESCRIPTION OF SURVEY AND SAMPLE MANAGEMENT

Sediments and waters were collected during the summer of 1995. Sample sites were distributed over the 16 330 km<sup>2</sup> survey area at an average of one sample per 14.6 km<sup>2</sup>.

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 in Ottawa to obtain Universal Transverse Mercator (UTM) coordinates. The dominant rock types in the stream 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 sieved through a minus 80 mesh (177 micron) screen before milling in ceramic-lined puck mills. 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.

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

### 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



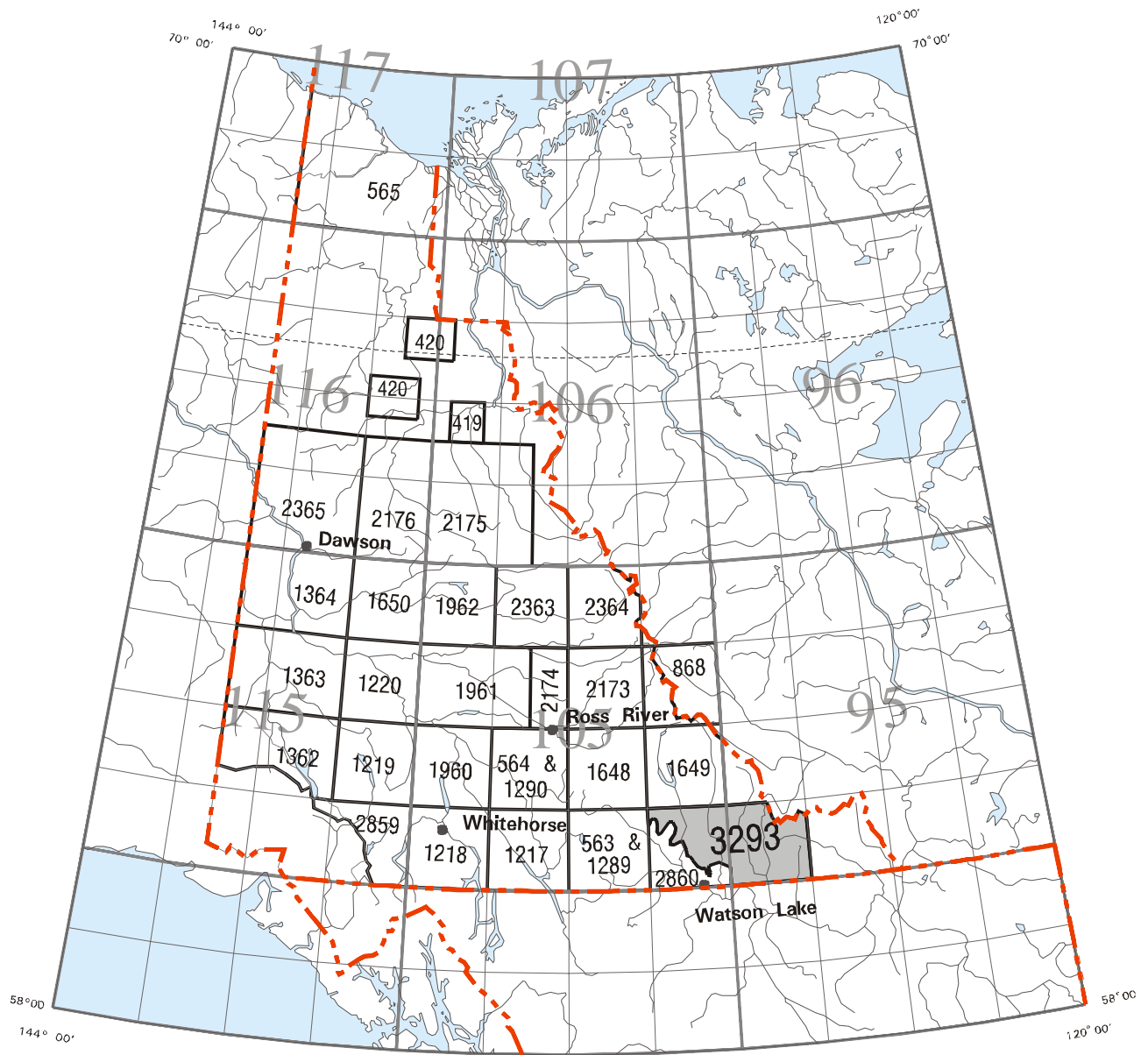


Fig. 1. Areas of Yukon covered by geochemical surveys, showing current GSC open file numbers.

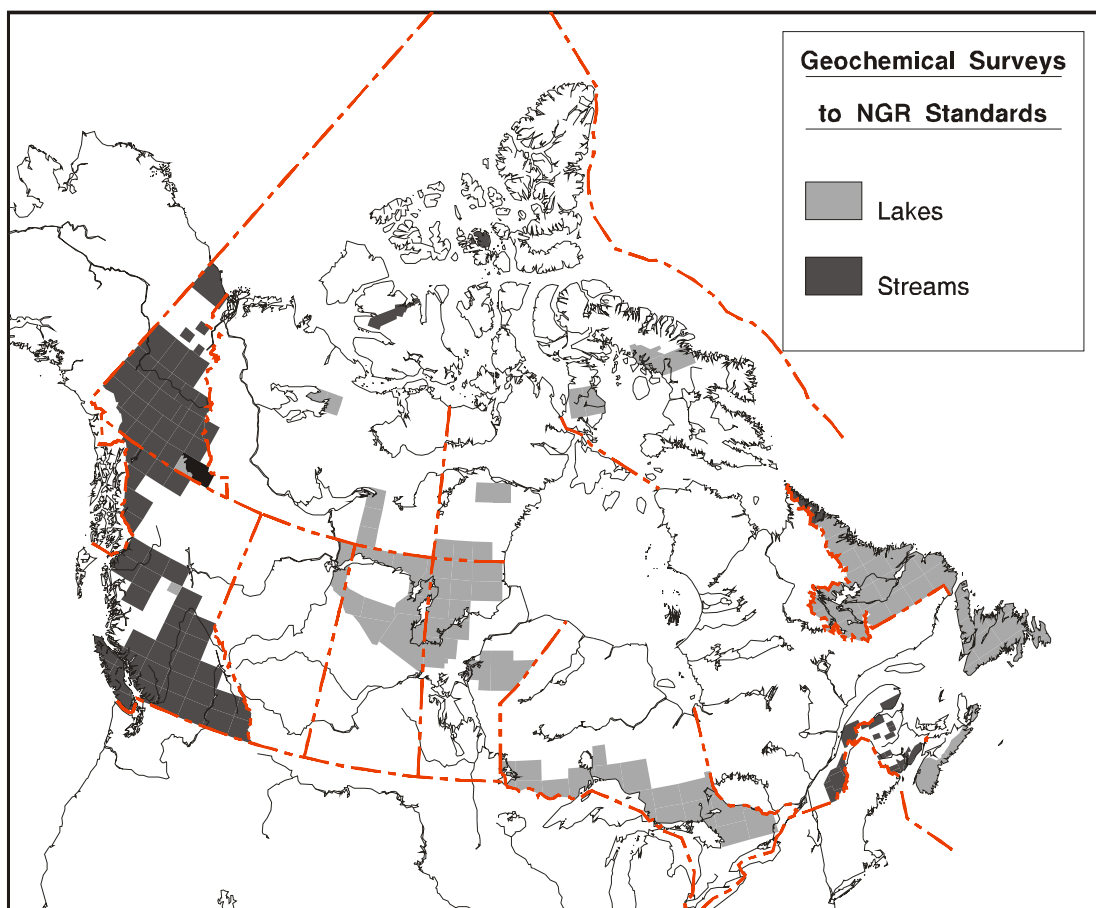


Fig. 2. Drainage surveys to National Geochemical Reconnaissance standards.

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 gram sample is reacted with 3 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° C and held at this temperature for 30 minutes with periodic shaking. One ml of concentrated HCl is added and heating continues for another 90 minutes. 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 gram 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 two 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 a 30 ml beaker, is placed in a cold muffle furnace and brought up to 500° C over a period of two to three hours. The sample is held at this temperature for four hours, then allowed to cool to room temperature for weighing.

Fluorine is determined as described by Ficklin (1970). A 250 mg sample is sintered with 1 gram 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 solution should range from 5.5 to 6.5. The fluoride content of the

test solution is measured using a fluoride ion electrode. Standard solutions contain sodium carbonate and citric acid in the same quantities as the sample solution.

Tin in stream sediments is determined by heating a 200 mg sample with NH<sub>4</sub>I: the sublimed SnI<sub>4</sub> is dissolved in acid and the tin determined by atomic absorption spectrometry after solvent extraction of the tin into methyl isobutyl ketone containing trioctylphosphine oxide (TOPO). The method is described by E.P. Welsch and T.T. Chao (1976).

### Water Analyses

Fluoride in 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. Detection limit = 20 ppb.

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 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 aliquot of either 55 or 550 ppb U are used). All readings are taken against a sample blank.

A summary of analytical methods and detection limits is provided in Table 1.

### COMPARISON OF DATA PRODUCED BY TWO METHODS

The data listed in **Section A** 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.

TABLE 1. Summary of Analytical Data and Methods

ELEMENT		DETECTION LEVEL		METHOD
SEDIMENTS:				
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
Sn	Tin	1	ppm	FUS
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
WATERS:				
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

FUS
- atomic absorption spectrometry

- cold vapour (flameless) atomic absorption spectrometry

- glass Calomel electrode and pH meter

- gravimetry

- Instrumental Neutron Activation Analysis

- ion selective electrode

- laser-induced fluorescence

- NH<sub>4</sub>I fusion

## PRESENTATION AND INTERPRETATION OF GOLD DATA

The following 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.

The correct interpretation of geochemical gold 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. 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 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, 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 determination 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.

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

- 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.
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**Welsch, E.P. and Chao, T.T.** (1976) Determination of trace amounts of tin in geological materials by atomic absorption spectrometry; Anal. Chim. Acta., Vol. 82, pp. 337-342.

**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
MAPSHEET	National Topographic System (NTS); lettered quadrangle (1:250 000 or 1:50 000 scale)	095D or 105A
SAMPLE ID	Remainder of sample number: Year of collection ..... Field crew ..... Sample sequence number .....	95 1 001-999
REP STAT	Replicate status; relationship of the sample to others within the survey: Routine sample site ..... First of a site duplicate pair ..... Second of a site duplicate pair .....	00 10 20
UTM	Universal Transverse Mercator UTM co-ordinate system; digitized sample location co-ordinates	
ZN	Zone (7 to 22)	9
EASTING	UTM Easting in metres	
NORTHING	UTM Northing in metres	
ROCK UNIT	Major rock type of stream catchment area: <b>CENOZOIC</b> Felsic to intermediate volcanic rocks; minor tillite and limestone ..... Nonmarine clastic sediments; minor felsic volcanics..... <b>PALAEOZOIC</b> Mafic to ultramafic rocks and associated marine carbonates and clastics ..... Intermediate to felsic volcanics and associated marine carbonates and clastics ..... Mainly marine carbonates and shales; minor siliceous sediments (chert) ..... Marine and nonmarine clastic sediments; minor limestone and coal ..... <b>PROTEROZOIC</b> Mainly clastic marine sediments; minor limestone and basalt..... Mainly siliceous and carboniferous sediments; minor evaporite, mafic volcanics, and iron formation..... <b>PLUTONIC ROCKS</b> <i>mid-Cretaceous</i> Granite, leucogranite, alaskite, quartz monzonite, granophyre ..... <i>Devonian-Carboniferous</i> Granodiorite, leucogranodiorite, quartz monzonite, quartz diorite, tonalite ..... <i>Palaeozoic-Mesozoic</i> Ultramafic rocks .....	11 10  9 8 7 6  5 4  3 2 1
ROCK AGE	Stratigraphic age of dominant rock type in catchment basin: Cenozoic ..... mid-Cretaceous..... Palaeozoic-Mesozoic..... Devonian-Carboniferous..... Palaeozoic..... Proterozoic .....	95 54 40 29 9 4
SAMPLE TYPE	Sample material collected: Stream bed sediment only ..... Spring or sediment seep..... Heavy mineral concentrate..... Stream water only ..... Natural groundwater, spring seep ..... Simultaneous stream sediment and water..... Simultaneous spring or seep water and sediment.....	SedOnly SpgSedOnly HvMnCn Strm GrWat  Sed/Water SpgSep/Sed
STREAM WIDTH	Stream width in meters	

FIELD RECORD	DEFINITION	TEXT CODE
STREAM DEPTH	Stream depth in meters	
SAMPLE CONT.	Contamination, human or natural: None ..... Possible ..... Probable ..... Definite ..... Mining activity ..... Industrial sources ..... Agricultural ..... Domestic or household ..... Forestry activities ..... Burned areas.....	- Possible Probable Definite Mining Industry Agricuilt Domestic Forestry Burn
BANK TYPE	Bank type; the general nature of the bank material adjacent to the sample site: Alluvial ..... Colluvial (bare rock, residual or mountain soils) ..... Glacial till ..... Glacial outwash sediments ..... Bare rock ..... Talus scree ..... Organic predominant (debris, peat, muskeg, swamp).....	Alluv Colluv Till Outwash Bare Rk Tal/Scr Organic
WATER COLOUR	Water colour; the general colour and suspended load of the sampled water: Clear ..... Brown transparent..... White cloudy..... Brown cloudy.....	Clear BnTrans WhCl'dy BnCl'dy
STREAM FLOW	Water flow rate: Stagnant ..... Slow ..... Moderate ..... Fast..... Torrential .....	Stagnt Slow Modert Fast Torrrnt
SAMPLE COLOUR	Predominant sediment colour: Red-brown..... White-buff..... Black..... Yellow ..... Green ..... Grey, blue grey..... Pink..... Buff to brown ..... Brown .....	Rd-Bn Wh-Bf Black Yellow Green Gy-Blu Pink Bf-Bn Brown
SAMPLE COMP.	Sediment composition; description of the bulk mechanical composition of the collected sample on a scale of 1 to 3, the total of the column must add up to 3 or 4 or 5: Size fractions are divided as follows:  Column 1 >0.125 mm (sand) Column 2 <0.125 mm (fines – organic silt, clay) Column 3 organic material  Amount of size fraction: sum of amounts =      3          4          5  Absent                    0          0          0 ..... Minor                    <33%   25%   20% ..... Medium                   33-67% 50%   40% ..... Major                    >67%   75%   60% .....	0 1 2 3

FIELD RECORD	DEFINITION	TEXT CODE
BOTTOM PCPT	Precipitate or stain; the presence of any coatings on pebbles, boulders or stream bottoms: None ..... Red-brown..... White or buff..... Black..... Yellow..... Green ..... Grey..... Pink..... Buff to brown .....	- Rd-Bn Wh-Bf Black Yellow Green Grey Pink Bf-Bn
BANK PCPT	Distinctive precipitate, stains or weathering on rocks in immediate area of catchment basin or stream bank: None ..... Red, brown (eg. Fe)..... White, buff (eg. CO <sub>3</sub> , Zn) ..... Black (e.g. Fe, Mn, sulphides)..... Yellow (e.g. Pb, U, Fe, Mo, REE)..... Green (Cu, Ni, U, Mo, As, Fe) ..... Bluish (Zn, P) ..... Pink (Co, As).....	- Rd-Bn Wh-Bf Black Yellow Green Blue Pink
STREAM PHYSIOG	General physiography of the drainage basin: Plain..... Muskeg, swampland..... Peneplain, plateau ..... Hilly, undulating..... Mountainous, mature ..... Mountainous, youthful (precipitous) .....	Plain Swamp Penpln Hill Moun/M Moun/Y
STREAM DRAINAGE	Drainage pattern: Poorly defined, haphazard..... Dendritic ..... Herringbone ..... Rectangular..... Trellis..... Discontinuous shield type (chains of lakes)..... Basinal..... Others.....	Poor Dendrc Herrbn Rectln Trellis Discnt Closed Other
STREAM TYPE	Stream type: Undefined ..... Permanent, continuous..... Intermittent, seasonal..... Re-emergent, discontinuous .....	Undfnd Permnt Intermitt Re-emerg
STREAM CLASS	Classification based on proximity to source: Undefined ..... Primary ..... Secondary ..... Tertiary ..... Quaternary .....	Undfnd Pri'ary Sec'ary Ter'ary Qua'ary
STREAM SOURCE	Source of water: Unknown ..... Groundwater ..... Snow melt or spring run-off ..... Recent precipitation ..... Ice-cap or glacier meltwater .....	Unknown Ground Sp'gMelt RecRain Glacier
Miscellaneous	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 gm