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BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY

NTS 92J - PEMBERTON

STREAM SEDIMENT AND WATER GEOCHEMICAL DATA

W. Jackaman and P.F. Matysek

BC RGS 41 / GSC OF 2667

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TABLE OF CONTENTS

BC RGS 41 / GSC OF 2667

NTS 92J - PEMBERTON

By W. Jackaman and P.F. Matysek

LIST OF APPENDICES

INTRODUCTION

Open File BC RGS 41 / GSC OF 2667 is one of three open files published in January, 1994 as part of the British Columbia Regional Geochemical Survey (RGS) Program. This Open File includes new analytical data for 26 elements in stream sediments. These results were obtained by analyzing archived sediment pulps collected during a 1981 joint Federal-Provincial stream sediment and water survey conducted in NTS map sheet 92J - Pemberton. Also included in this package are the original field and analytical results from Open File BC RGS 9 / GSC OF 867 published in 1982 for 14 elements in stream sediments plus uranium, fluoride and pH in stream waters. Open File BC RGS 41 / GSC OF 2667 supersedes all previous publications.

The 1981 survey was managed and funded by the British Columbia Ministry of Energy, Mines and Petroleum Resources (MEMPR) as part of the Regional Geochemical Survey Program. Data management was provided by the Geological Survey of Canada (GSC).

Initiated in 1990, as part of the Ministry's RGS Archive Program, the sediment samples collected from earlier surveys were retrieved from GSC storage facilities in Ottawa and analyzed by instrumental neutron activation analysis (INAA). This project was funded in part by the *Canada-British Columbia Mineral Development Agreement* (1985-1990). INAA determinations for Open File BC RGS 41 / GSC OF 2667 was funded by the *Geological Survey of Canada.*

Analytical results and field observations compiled by the RGS Program are used in the development of a high quality geochemical database suitable for resource assessment, mineral exploration, geological mapping and environmental studies. Sample collection, preparation and analysis are closely monitored to ensure consistency and conformance to national standards (Ballantyne, 1991).

ACKNOWLEDGMENTS

1981 STREAM SEDIMENT and WATER RGS PROGRAM

Contracts were let to the following companies for sample collection, preparation and analysis and were managed by staff of the MEMPR.

COLLECTION : Rooi Enterprises Ltd., Victoria, B.C.
PREPARATION : Kamloops Research Assay and Laboratory, Kamloops, B.C.
ANALYSIS : Chemex Laboratories Ltd., North Vancouver, B.C. (Sediments)
Novatrack Analysts Ltd., Vancouver, B.C. (U in Sediments)
Bondar Clegg Ltd., North Vancouver, B.C. (Waters)

1993 RGS ARCHIVE PROGRAM

The 1993 RGS Archive Program was managed by Geological Survey Branch staff of the MEMPR. *P.F. Matysek* and *W. Jackaman* coordinated the operational activities of contract and MEMPR staff. *W. Jackaman* coordinated the production of this open file. *S.J. Cook* assisted with the analysis and interpretation of the data. *K. J. Colbourne* provided production support.

PREPARATION : Rob Phillips, Ottawa, Ont.
ANALYSIS : Bondar-Clegg & Company Ltd., Ottawa, Ont.
Activation Laboratories, Ancaster, Ont.

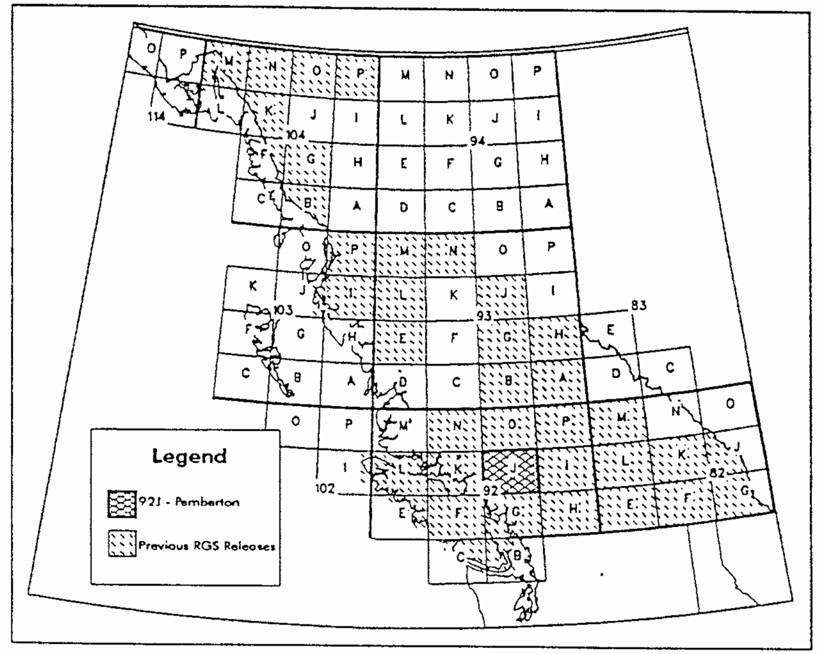

Figure 1. Location map.

OPEN FILE FORMAT

Open File BC RGS 40 / GSC OF 2666 includes a data booklet, a map booklet and a 3.5" floppy diskette.

The data booklet is divided into the following sections. ***Please refer to notes preceding each section for important information on data presentation format.***

- survey details and RGS data evaluation,
- listings of field and analytical data,
- listings of analytical duplicate data,

- threshold tables,
- summary statistics, and
- sample evaluation charts.

The map booklet contains the following maps :

- 4 - 1: 100 000 scale sample location maps,
- 1 - 1: 500 000 scale sample location clear overlay and map,
- 1 - 1: 500 000 scale bedrock geology clear overlay and map,
- 1 - 1: 500 000 scale surficial geology map,
- 43 - 1: 500 000 scale symbol and value maps for individual elements,
- 1 - 1: 500 000 base metal anomaly map, and
- 1 - 1: 500 000 precious metal anomaly map.

Analytical and field data is included as an ASCII file on a 3.5", high-density diskette. Document files detailing data format specifications and survey details are also included.

SURVEY DETAILS

PHYSIOGRAPHY and GEOLOGY

The Pemberton map sheet covers an area of approximately 15 500 square kilometres and is located within the Coast Mountain physiographic unit (Holland, 1976). The Coast Mountains are an extremely rugged and heavily glaciated mountain range. Summit elevations commonly exceed 2500 metres and extend above deeply cut U-shaped valleys. Mountain slopes tend to be steep and are comprised of exposed bedrock with a discontinuous layer of colluvium and till. Valley walls and lower slopes are generally covered by thick deposits of till. (Map 3, after Fulton *et al.*, 1982).

Underlain by the Coast Crystalline Complex, the survey area is comprised of Cretaceous granites and granodiorites. Within the Coast belt, roof pendants of gniess, amphibolite, metasediments and metavolcanics represent metamorphosed remnants of volcanic-arc rocks (Roddick and Tipper, 1985). The northeast corner of the region includes Permian to Middle Jurassic chert, argillite, basalt and alpine-type ultramafic rocks of the Bridge River Terrane and Upper Jurassic to Lower Cretaceous volcanic and sedimentary rocks of the Tyaughton-Methow trough (Wheeler *et al.*, 1988). The bedrock geology base map (MAP 2) used in this Open File is Roddick *et al.*, 1979.

The British Columbia mineral deposits database lists 234 mineral occurrences for map sheet 92J (MINFILE 092J). The major types of metallic deposits include porphyry copper and molybdenum deposits, volcanogenic massive sulphide mineralization, mesothermal base and precious metal vein deposits and a variety of precious and base metal epithermal deposits. The region is noted for its historical gold production and includes significant past producers such as Bralorne, Pioneer mine and Northair mine. There are currently no operating metal mines in the survey area.

SAMPLE COLLECTION - 1981

Helicopter and truck-supported sample collection was carried out during the summer of 1981. A total of 852 stream sediment and 848 stream water samples were systematically collected from 806 sites. Average sample site density was 1 site per 19 square kilometres over the 15 500 square kilometre survey area. Field duplicate samples were routinely collected in each analytical block of twenty samples.

Fine grained stream sediment material (< 1mm) weighing 1-2 kg was obtained from the active (subject to annual flooding) stream channel and placed in kraft bags. Unfiltered water samples were collected in 250 ml bottles, precautions were taken to exclude suspended solids when possible. Field observations regarding sample media, sample site and local terrain were also recorded.

SAMPLE PREPARATION - 1981

Field dried sediment samples were shipped to Kamloops Research Assay and Laboratory for final sample preparation. The samples were air-dried and the -80 mesh (<177 microns) fraction was obtained by dry sieving. Quality control reference standards and analytical duplicate samples were inserted into each analytical block of twenty sediment samples. Any -80 mesh sediment remaining after analyses was archived for future analyses.

SAMPLE ANALYSIS - 1981

Chemex Laboratories (North Vancouver) analyzed the sediment samples for: antimony, arsenic, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, tin, tungsten and zinc. Uranium in stream sediments was determined by Novatrack Analysts Ltd. (Vancouver). Water samples were analyzed for fluoride, uranium, and pH by Bondar Clegg Ltd. (North Vancouver). Concentrations reported below the detection limit are presented in the data listings as a value equivalent to one-half of the detection limit. Detection limits for each element are listed in Table 1.

For the determination of copper, cobalt, iron, lead, manganese, nickel, silver, and zinc, a 1 gram sample was reacted with 3 ml of concentrated HNO_3 for 30 minutes at 90°C. Concentrated HCl (1 ml) was added and the digestion was continued at 90°C for an additional 90 minutes. The sample solution was then diluted to 20 ml with metal free water and mixed. Concentrations were determined by atomic absorption spectroscopy (AAS) using an air-acetylene flame. Background corrections were made for Pb, Ni, Co and Ag.

Antimony was determined using a 2 gram sample digested with concentrated HCl in a hot water bath. The iron was reduced to Fe(II) and the antimony extracted with trioctyl phosphine oxide MIBK and measured by AAS with background correction.

Arsenic was determined by hydride generation/atomic absorption spectroscopy (AAS-H) on an aliquot of solution taken from the sample solution prepared for the base metal analyses.

Molybdenum was determined by AAS using nitrous oxide acetylene flame. A 0.5 gram sample was reacted with 1.5 ml concentrated HNO_3 at 90°C for 30 minutes. At this point 0.5 ml of concentrated HCl was added and the digestion continued for an additional 90 minutes. After cooling, 8 ml of 1250 ppm Al solution was added and the sample solution diluted to 10 ml before aspiration by AAS.

Mercury was determined using a 0.5 gram sample reacted with 20 ml concentrated HNO_3 and 1 ml concentrated HCl in a test tube for 10 minutes at room temperature and for 2 hours in a 90°C water bath. After digestion the sample was 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 of 10% weight per volume $SnSO_4$ in H_2SO_4. The Hg vapor was flushed by a stream of air into an absorption cell mounted in the light path of an atomic absorption spectrometer (AAS-F). Measurements were made at 253.7 nm. This method is described in detail by Jonasson, *et al.* (1973).

Element		Detection Limit	Method	Element		Detection Limit	Method
Antimony	Sb	0.2 ppm	AAS	Cerium	Ce	10 ppm	INAA
Arsenic	As	0.5 ppm	AAS-H	Cesium	Cs	0.5 ppm	INAA
Cobalt	Co	2 ppm	AAS	Chromium	Cr	5 ppm	INAA
Copper	Cu	2 ppm	AAS	Cobalt	Co	5 ppm	INAA
Iron	Fe	0.02 %	AAS	Hafnium	Hf	1 ppm	INAA
Lead	Pb	2 ppm	AAS	Iron	Fe	0.20 %	INAA
Manganese	Mn	5 ppm	AAS	Lanthanum	La	5 ppm	INAA
Mercury	Hg	10 ppb	AAS-F	Lutetium	Lu	0.2 ppm	INAA
Molybdenum	Mo	2 ppm	AAS	Molybdenum	Mo	1 ppm	INAA
Nickel	Ni	2 ppm	AAS	Nickel	Ni	10 ppm	INAA
Silver	Ag	0.2 ppm	AAS	Rubidium	Rb	5 ppm	INAA
Tungsten	W	2 ppm	COLOR	Samarium	Sm	0.5 ppm	INAA
Uranium	U	0.2 ppm	NADNC	Scandium	Sc	0.5 ppm	INAA
Zinc	Zn	2 ppm	AAS	Sodium	Na	0.10 %	INAA
Fluoride - water	FW	20 ppb	ION	Tantalum	Ta	0.5 ppm	INAA
Uranium - water	UW	0.05 ppb	LIF	Terbium	Tb	0.5 ppm	INAA
pH - water	pH	0.1	GCE	Thorium	Th	0.5 ppm	INAA
Gold	Au	2 ppb	INAA	Tungsten	W	2 ppm	INAA
Antimony	Sb	0.1 ppm	INAA	Uranium	U	0.2 ppm	INAA
Arsenic	As	0.5 ppm	INAA	Ytterbium	Yb	2 ppm	INAA
Barium	Ba	100 ppm	INAA	Zirconium	Zr	200 ppm	INAA
Bromine	Br	0.5 ppm	INAA				

TABLE 1 ANALYTICAL SUITE OF ELEMENTS: NTS 92J

Uranium in sediments was determined using a neutron activation method with delayed neutron counting (NADNC). A 1 gram sample was weighed in a seven dram polyethylene vial, capped and sealed. Irradiation was provided by the Triumf Cyclotron with an operating flux of 10^{12} neutrons/cm^2/second. Each sample was irradiated for 60 seconds. Following a 20 second delay, the sample was counted for 60 seconds with six BF3 detector tubes embedded in paraffin.

Tungsten was determined colourimetrically after a pyrosulfate fusion and a dithiolcarbonate complexing for the generation of the colour (COLOR).

Uranium in waters was determined by a fluorometric method (LIF). The U was initially preconcentrated by evaporation. The residue was fused with a mixture of Na_2CO_3, K_2CO_3 and NaF in a platinum dish. After cooling the fluorescence of the fused pellet was measured using a Turner Fluorometer.

The determination of fluoride in waters involved an aliquot of sample being mixed with an equal volume of total ionic strength adjustment buffer (TISAB II solution). The fluoride was measured using a Corning 101 Electrometer with an Orion Fluoride Electrode (ION).

pH in waters was measured using an aliquot of sample in a clean dry beaker by a Fisher Accumet pH Meter (GCE).

SAMPLE PREPARATION - 1993 RGS Archive Program

Of the 852 sediment samples collected during the original survey, 805 samples contained sufficient material to be analyzed by instrumental neutron activation analysis (INAA). New quality control reference standards were inserted into each analytical block of twenty samples and existing analytical and field site duplicate samples were checked and verified.

SAMPLE ANALYSIS - 1993 RGS Archive Program

The determination of antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zirconium by INAA was conducted by Bondar-Clegg (Ottawa). Instrumental neutron activation analysis involves irradiating the sediment samples, which range from 0.5 to 54 grams (average 25 grams), for 20 minutes in a neutron flux of 10^{11} neutrons/cm^2/second. After a decay period of approximately 1 week, gamma-ray emissions for the elements were measured using a gamma-ray spectrometer with a high resolution, coaxial germanium detector. Counting time was approximately 15 minutes per sample. Table 1 lists the associated detection limits reported by this analytical technique.

Repeat analysis by INAA have been performed by Activation Laboratories on the original split for samples returning gold values exceeding 20 ppb and are reported as Au2 in Appendix A. This level represents the 95th percentile for gold based on the total RGS data set for map sheets 92H, 92I and 92J.

RGS Data Evaluation

The ability to discriminate real trends, related to geological and geochemical conditions, from those that result from spurious factors such as sampling and analytical errors is of considerable importance in the success of geochemical data interpretation. An estimate of precision allows sampling and analytical variation to be quantified, and is an integral part of the evaluation of geochemical data. Estimates of analytical precision and element variability within and between sample sites can be determined by utilizing control reference, analytical duplicate and field duplicate data.

Control reference standards, analytical duplicates and field duplicates are routinely inserted to monitor and assess accuracy and precision of analytical results. Each analytical block of twenty sediment samples consists of :

- 17 routine samples,
- 1 field duplicate sample collected adjacent to one of the 17 routine samples (Listed in Appendix A),
- 1 analytical duplicate sample; a subsample taken from one of the 17 routine samples prior to analysis (Listed in Appendix B), and
- 1 control reference standard sample containing sediment of known element concentrations.

Analytical blocks of corresponding water samples differ slightly in that they contain two control reference standard samples but no analytical duplicate samples.

ANALYTICAL REPRODUCIBILITY

Scatterplots of analytical results of field duplicate pairs and analytical duplicate pairs are presented for Cu, Pb, Ni, Zn (AAS sediment data) and Au, As (INAA sediment data). A total of 125 field and analytical duplicate pairs from the 1994 data set (NTS map sheets 92H, 92I and 92J) were included in this analysis. Field duplicate data and analytical duplicate data (Figures 2a and 2b) show very good reproducibility, particularly for those trace elements with concentration levels well above detection limits. This gives a high degree of confidence in the quality of both the field sampling and the analytical methods. Poor reproducibility for gold is primarily due to the influence of the particle sparsity effect (see section : Interpretation of Gold Data).

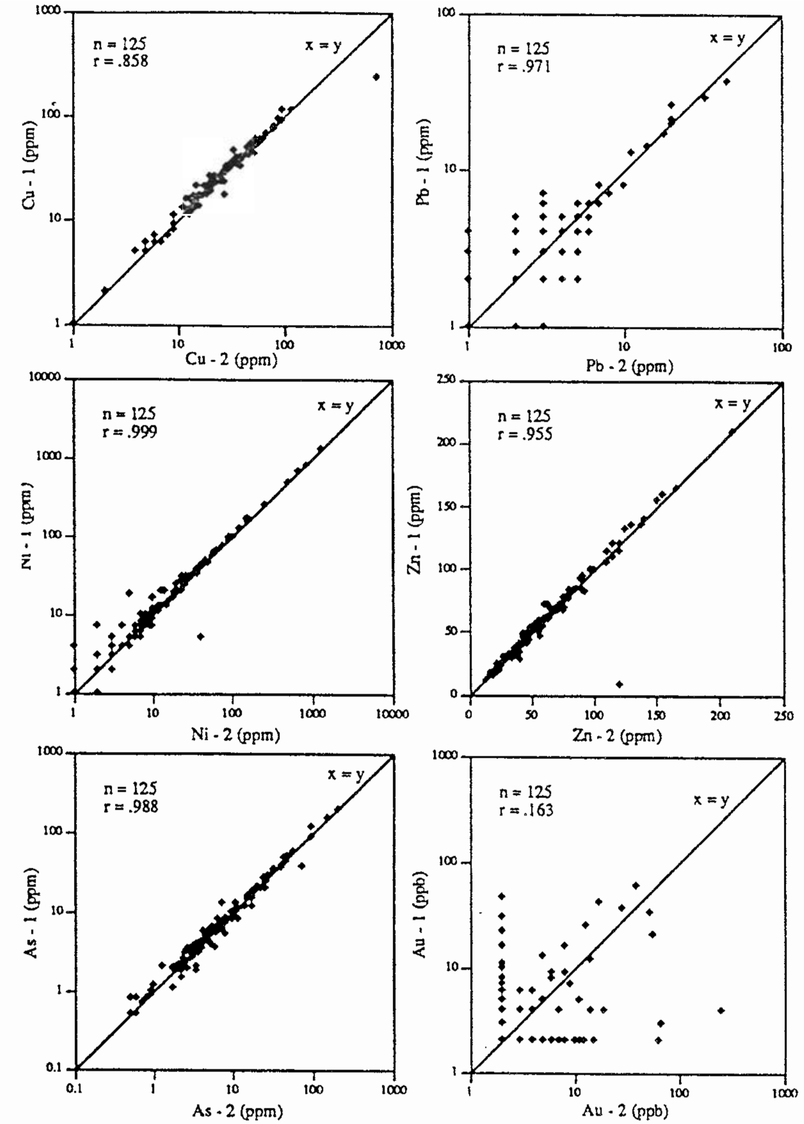

Figure 2a. Scatterplots showing field duplicate pairs for Cu. Pb, Ni, Zn (1981 data) and As, Au (1993 data).

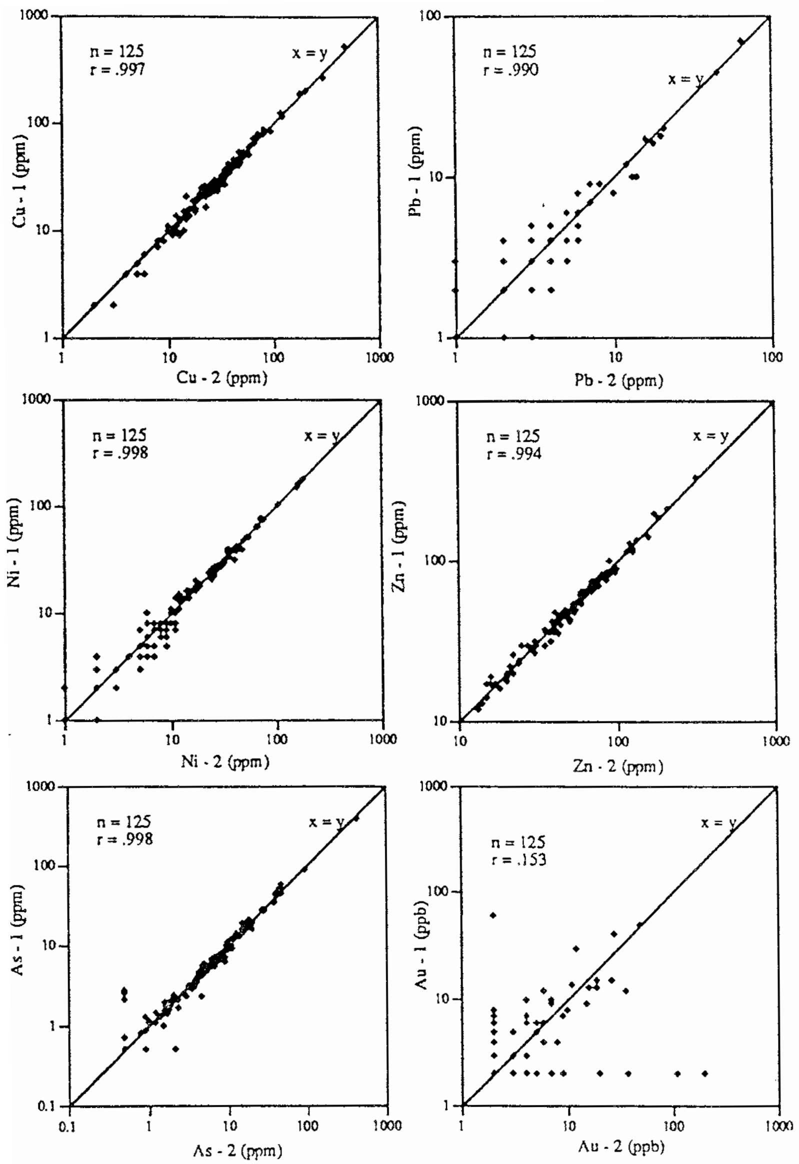

Figure 2b. Scatterplots showing analytical duplicate pairs for Cu. Pb, Ni, Zn (1981 data) and As, Au (1993 data).

PRECISION ESTIMATES

Precision estimates for selected elements were calculated using 125 analytical duplicate pairs from the total 1994 analytical data set using the Thompson and Howarth (1973, 1976, 1978) method.

Their method involves dividing 50 or more analytical duplicate pairs (x_1, x_2) into groups with narrow concentration ranges. For each group, the median value of absolute differences between duplicate pairs ($|x_1-x_2|$) is used as an estimation of the standard deviation (s), whereas the mean value of all the duplicate pair means $(x_1+x_2)/2$ is used as an estimation of the average concentration. Repetition of this procedure for successive groups of concentration ranges produces a set of corresponding mean concentration and standard deviation estimates for the entire range of data. Linear regression of the estimates provides slope and intercept values from which precision of the date set can be calculated using the equation:

$$Pc = 200(K/c + S_O)$$

where S_O (coefficient of slope) is the standard deviation at zero concentration and K (intercept) is a constant. This linear function has been determined in practical cases (Matysek and Sinclair, 1984) to be a satisfactory model for the expression of analytical variation.

Precision estimates were calculated as follows:

Step 1. A list of duplicate means and corresponding absolute differences was calculated for each sample pair.

Step 2. The list was sorted in increasing order of concentration means.

Step 3. The mean concentration and the median difference between pairs for the first group of 11 analytical pairs were determined.

Step 4. Step 3 was repeated for each successive group of 11 pairs ignoring any remainder less than 11.

Step 5. The linear regression of the median differences on the means was calculated. The resultant intercept and coefficient of the calculated line are multiplied by 1.048 and were used to estimate precision.

Precision estimates were determined for Cu, Fe and Zn (AAS), and As (INAA). This particular suite of elements was selected on the following basis:

- Their distributions approximated a Gaussian (normal) curve, and
- The majority of their concentrations were well above their detection limits.

This methodology may not be applicable for elements characterized by non-normal distributions. These distributions are recognized when the following conditions arise:

- Element abundance is dependent on rare grains,
- Concentration levels are at or near the detection limit, and/or
- Data contains outliers.

RESULTS

Precision estimates calculated at different concentration levels using the Thompson and Howarth method are presented in Table 2 and Figure 2. Precision estimates for As averaged 16.1% at the 50th percentile (5.3 ppm As), 13.9% at the 80th percentile (14.0 ppm As) and 13.0% at the 95th percentile (44.0 ppm As). Precision estimates for Cu, Fe and Zn were lower, averaging 10.5% at the 50th percentile, 9.7% at the 80th percentile, and 9.0% at the 95th percentile. These estimates are of similar magnitude to those obtained from studies on error evaluation in stream sediment surveys (Plant, 1971; Chork, 1977; Fletcher, 1981). These studies generally concluded that precision ranges of 10 to 15% at the 95% confidence level are often encountered and considered acceptable for laboratory variability in most exploration programs.

Element	r	Intercept	Slope	50th (ppm)	Precision	80th (ppm)	Precision	95th (ppm)	Precision
Copper	0.8116	0.382	0.0426	26	12%	46	11%	80	10%
Iron	0.8194	0.015	0.0397	1.85	10%	2.70	9%	3.95	9%
Zinc	0.7752	0.716	0.0334	55	10%	80	9%	140	8%
Arsenic	0.9043	0.090	0.0600	5.3	16%	14.0	14%	44.0	13%

TABLE 2 THOMPSON AND HOWARTH PRECISION ESTIMATES

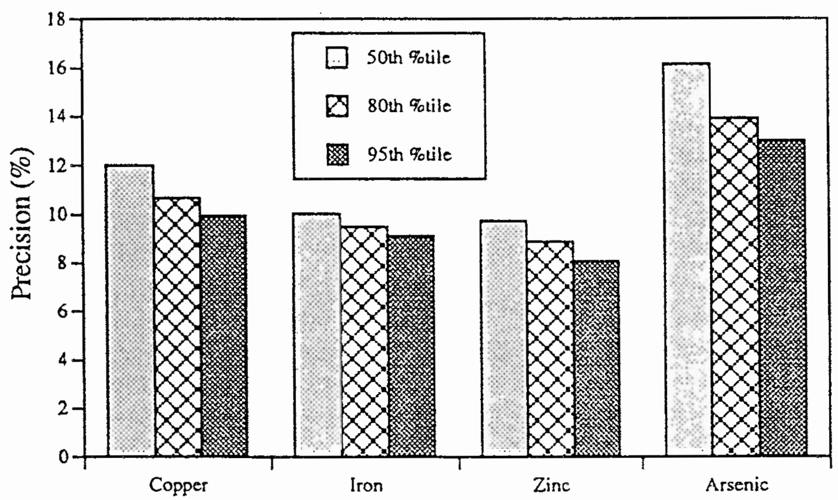

Figure 3. Bar graph showing precision estimates.

COMPARISON of INAA and AAS TECHNIQUES

Several elements (Sb, As, Co, Fe, Mo and Ni) were determined by both atomic absorption spectroscopy (AAS) and by instrumental neutron activation analysis (INAA). Variations observed between original (AAS) and subsequent (INAA) results are due largely to differences in the analytical methods. AAS requires dissolution of the sample with acids prior to analysis. Aqua regia, a combination of hydrochloric and nitric acids, was used to dissolve RGS sediment samples. Gold and sulphide minerals are dissolved, whereas silicates and some oxides (*i.e.* magnetite) are only partially digested. Conversely, INAA does not require sample digestion prior to analysis. Concentrations determined by INAA generally represent the *total* content of that element in the sample. Due to this difference between methods, INAA generally reports slightly higher concentrations than aqua regia AAS.

Using the 92H data set, Figure 4 represents a comparison of the two techniques for iron and nickel. In both cases, INAA gives higher results. A strong correlation is noted for nickel (r = .907). The slightly higher INAA results are probably due to the presence of minute quantities of nickel within the lattices of silicates (i.e. feldspars). Iron demonstrates substantial concentration differences between analytical methods and a weaker correlation (r = .569). These results are probably due to the presence of variable amounts of magnetite and hematite commonly found in stream sediment samples.

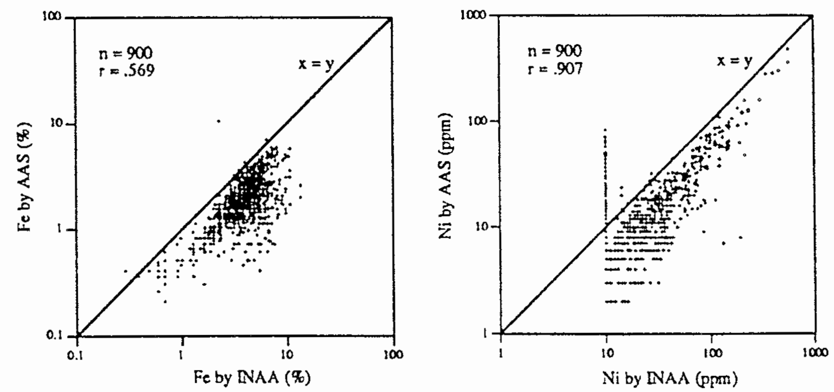

Figure 4. Scatterplots comparing INAA and AAS results for Fe and Ni.

INTERPRETATION OF GOLD DATA

Understanding gold geochemical data from regional stream sediment surveys requires an understanding of the chemical and physical characteristics of gold in the surficial environment.

Gold is a soft, malleable element of high density (19.3 g/cm³). Gold is chemically inert and commonly occurs in native form (pure Au) or as electrum (alloyed with silver). Sub-micron sized gold is often bound to clays, adsorbed onto Fe-Mn oxides or contained within organic colloids. At normal surface temperatures, gold will dissolve under rare conditions of high oxidation potential and high acidity where ions such as chloride (Cl^-), thiosulphate ($S_2O_3^{-2}$) or cyanide (CN^-) are present. Normal background concentrations for gold in bedrock vary, but are generally less than 5 ppb. Background levels encountered for stream sediments seldom exceed 10 ppb and commonly are near the detection limit of 2 ppb.

Gold generally occurs as rare, discrete particles. In many instances a geochemical subsample may or may not contain a gold grain. This is known as the '*nugget effect*'. Generally, larger geochemical sample sizes are required to minimize the nugget effect and more accurately represent gold concentrations. (Clifton *et al.*, 1969; Harris, 1982). Neutron activation analyses for the RGS Archive program utilized samples weighing on average 20 grams.

Follow-up investigations of gold anomalies should be based on careful consideration of related geological and geochemical information and an understanding of the variability of gold geochemical data. 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. Analysis of field and analytical duplicate samples enables assessment of the reliability of gold results and permits better data interpretation.

ANOMALY RATING PROCEDURE

Stream sediments collected downstream from mineralized sources commonly exhibit enhanced concentrations for ore and pathfinder elements. An interpretive technique has been developed by Matysek *et al.* (1991) to highlight sample sites characterized by anomalous, multi-element signatures (Figure 5). As an example of this methodology, sample evaluation charts (Appendix D) and 1:500 000 scale anomaly maps (Map Booklet) have been produced which outline areas considered to have relatively higher base metal and precious metal potential.

METHODOLOGY

Step 1 - Subset analytical data by lithology.
Element concentrations for stream sediment samples typically reflect the underlying geology found within the sampled drainage basin. Considerable variability in element concentrations are associated with different lithologies and must be considered in order to distinguish samples which most likely reflect mineralized sources from lithological units characterized by high background values. Consequently, analytical data is initially subset on the basis of the underlying lithology found at each sample site.

Step 2 - Calculate 90th, 95th and 98th percentiles (threshold values) for each lithology.
The 90th, 95th and 98th percentiles are calculated for lithologies having 10 or more sample sites. Lithologies having less than 10 sample sites list threshold values determined from the current provincial RGS data set. The results are listed in a threshold table (Appendix D). To better estimate element variability within lithologies, data from adjoining survey areas (NTS map sheets 92H, 92I, 92J, 92N, 92O, and 92P) have been included.

Step 3 - Assign anomaly ratings to each sample.
Element concentrations for each sample are then compared to the calculated threshold values and assigned the following anomaly ratings :

- an anomaly rating of 1 for concentrations >= 90th but < 95th percentile,
- an anomaly rating of 2 for concentrations >= 95th but < 98th percentile, and
- an anomaly rating of 3 for concentrations >= 98th percentile.

Sample evaluation charts graphically display the anomaly rating for individual elements. In addition, the summed element ratings provide a measure of the anomalous multi-element nature of each sample. Anomaly maps produced from the sample evaluation charts highlight the spatial relationships between anomalous samples.

Utilizing the above technique, sample evaluation charts (Appendix D) and anomaly maps (Map Booklet) have been generated to aid the user in identifying potential base metal and precious metal targets. The element suite used for the identification of base and precious metal multi-element anomalies include Cu - Pb - Zn - Ag and Au - Sb - As - Hg - Ag, respectively.

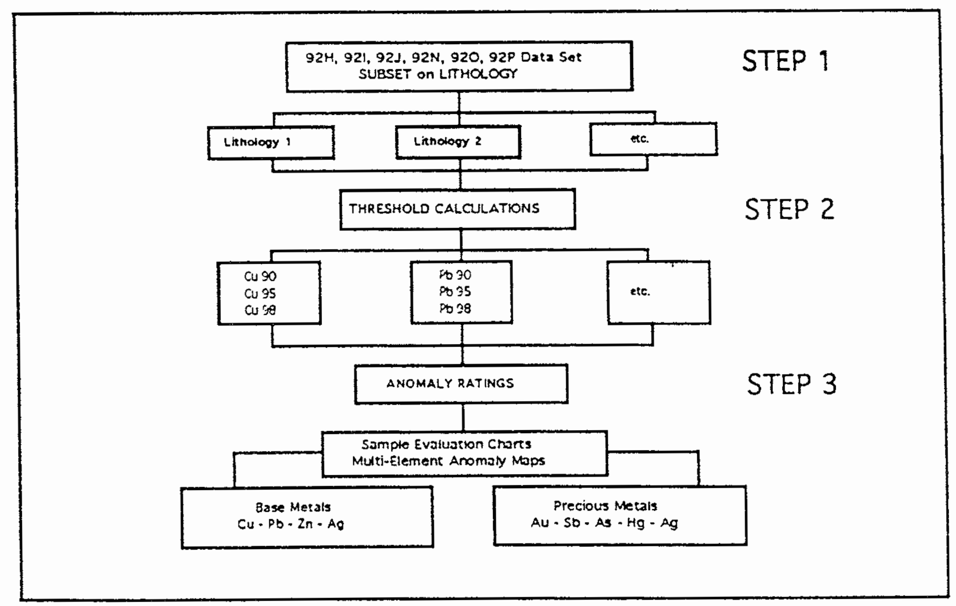

Figure 5. Anomaly Rating Flowchart.

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BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY

NTS 92J PEMBERTON

BC RGS 41 / GSC OF 2667

APPENDIX A

FIELD OBSERVATIONS AND ANALYTICAL DATA

Notes:

- AAS results less then the detection limit are reported as one half the detection limit.
- Repeat analysis of Au by INAA have been performed on the original split for samples reporting Au values exceeding 20 ppb and are reported as Au2. This level represents the 95th percentile for Au based on the total RGS data set for map sheets 92H, 92I and 92J.
- Analytical duplicate results for Au are also reported as Au2.
- Missing data is reported as blanks.

Table A-1. Reference Guide for Geological Formations (Roddick *et al.*, 1979)

STRATIFIED ROCKS

QUATERNARY

Pleistocene and Recent

QG	Garibaldi Group : basalt, andesite

TERTIARY

Eocene and Oligocene

EOK	Kamloops Group : dacite, basalt

Lower Tertiary

lTps	shale, sandstone, arkose
lTvr	rhyolite, dacite
lTv	andesite, basalt

CRETACEOUS AND/OR TERTIARY

Upper Cretaceous

uKKW	Kingsvale Group : arkose, conglomerate, greywacke

Lower Cretaceous

lKB	Brew Group : argillite, quartzite, conglomerate
lKJM	Jackass Mountain Group : greywacke, conglomerate
lKTP	Taylor Creek Group : shale
lKC	Cheakamus : greywacke, arkose
lKFL	Fire Lake Group : greenstone, slate, schist
lKG	Gambier Group : tuff, breccia, argillite
lKTV	Taylor Creek Group : andesite, basalt

JURASSIC AND CRETACEOUS

JKRM	Relay Mountain Group : shale, greywacke, conglomerate

TRIASSIC

Upper Triassic

uTC	Cadwallader Group : argillite, phyllite, limestone
uTP	Pioneer : andesite breccia, tuff, flows, greenstone
uTv	basalt, andesite, sediments

PALEOZOIC AND TRIASSIC

PTBR	Bridge River Group : chert, argillite, phyllite

PENNSYLVANIAN AND PERMIAN

PPTI	Twin Island Group : granulite, amphibolite, gneiss, schist

PALEOZOIC

Pqs	quartzite, schist

INTRUSIVE ROCKS

TERTIARY

Late Tertiary

LTqm	quartz monzonite

Early Tertiary

ETqm	quartz monzonite
ETgd	granodiorite
ETfp	dacitic feldspar porphyry

CRETACEOUS

Kg	granite
Kqm	Remmell: quartz monzonite, granodiorite, quartz diorite

Late Cretaceous

LKgd	granodiorite

PERMIAN AND TRIASSIC

PTub	serpentinite, peridodite, Shulaps : ultramafic rocks

AGE UNKNOWN

Coast Plutonic Complex

gd	granodiorite
qd	quartz diorite
di	diorite
b	gabbro
ng	migmatitic complexes of amphibolite grade

Table A-2. Reference Guide for Field Observations

MAP	1:50 000 NTS map sheet number
SAMPLE ID	Sample Number
UTM ZONE	UTM Zone
UTM EAST	UTM East Coordinate
UTM NORTH	UTM North Coordinate
STA	Replicate Sample Status: Routine Sample 10 1st Field Duplicate 20 2nd Field Duplicate
MED	Sample Media Collected: 1 Stream Sediment 6 Steam Sediment and Water
FORM	Geological Formations (see Table A-1)
WAT COL	Water Color: 0 Colorless; 2 White Cloudy 1 Brown Clear; 3 Brown Cloudy
FLW	Water Flow Rate: 0 Stagnant; 3 Fast 1 Slow; 4 Torrent 2 Moderate
SED COL	Sediment Color: R Red; O Olive-Green W White-Buff; G Grey-Blue B Black; P Pink Y Yellow; T Tan-Brown
SED PPT	Sediment Precipitate : N = None (otherwise, same as SED COL)
CON	Site Contamination: N None; A Agricultural P Possible; D Domestic M Mining; F Forestry
SED COMP	Sediment Composition : Estimate of Sand-Fines-Organic Content 0 Absent 1 Minor (<1/3 of total) 2 Moderate (>1/3 but <2/3 of total) 3 Major (<2/3 of total)
STRM WDTH	Stream Width (metres)
STRM DPTH	Stream Depth (centimetres)
BNK	Bank Composition: U Unknown; G Glacial Outwash A Alluvium; R Rock C Colluvium; S Scree, talus T Till; O Organic
BNK PPT	Bank Precipitate : N = None (otherwise, same as SED COL)
PHY	Physiography: L Lowland; H Hilly S Swamp; M Mature Mts P Plateau; Y Youthful Mts
DRN	Drainage Pattern: D Dendritic; I Interrupted H Herringbone; G Glacially deranged R Rectangular
TYP	Stream Type: P Permanent; R Re-emergent S Seasonal
ODR	Stream Order: 1 Primary; 3 Tertiary 2 Secondary; 4 Quaternary
SRC	Stream Source: U Unknown; S Spring Runoff G Groundwater; M Meltwater
DATE	Sample Collection Date (day-month)
WT	Weight of Sample Analyzed by INAA

Field Observations and Analytical Data

MAP	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	STA	MED	FORM	WAT COL	FLW	SED COL	SED PPT	CON	SED COMP	STRM WDTH	STRM DPTH	BNK	BNK PPT	PHY	DRN	TYP	ODR	SRC	DATE	FW	UW	pH	Sb	As	Co	Cu	Fe	Pb	Mn	Hg	Mo	Ni	Ag	W	U	Zn
																								Water			Stream Sediment													
:DL																								20	0.05	0.1	0.2	0.5	2	2	0.02	2	5	10	2	2	0.2	2	0.2	2
:Unit																								ppb	ppb		ppm	ppm	ppm	ppm	pct	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm
:Mthd																								ION	LIF	GCE	AAS	AAS-H	AAS	AAS	AAS	AAS	AAS	AAS-F	AAS	AAS	AAS	AAS	NADNC	AAS
92J16	811002	10	561885	5646574		6	uKKW	0	3	R	N	N	220	2.2	10	A	N	Y	D	P	2	G	0708	54	0.02	8.3														
92J16	811004	10	563094	5647153		6	lKJM	0	3	R	N	N	210	1.5	10	A	N	Y	D	P	3	G	0708	38	0.02	8.0														
92J16	811005	10	565338	5647671	10	6	lKJM	0	3	R	N	N	220	0.8	10	A	N	Y	D	P	3	G	0708	48	0.12	8.1														
92J16	811006	10	565338	5647671	20	6	lKJM	0	3	R	N	N	220	0.8	10	A	N	Y	D	P	3	G	0708	54	0.10	8.2														
92J16	811007	10	566009	5646919		6	lKJM	0	3	R	N	N	120	0.8	10	A	N	Y	D	P	3	G	0708	40	0.02	8.1														
92J16	811008	10	567640	5646716		6	EOK	0	3	R	N	N	220	1.0	10	A	N	Y	D	P	3	G	0708	36	0.05	8.1														
92J16	811009	10	570045	5647696		6	EOK	0	3	R	N	N	210	3.0	10	A	N	Y	D	P	2	G	0708	40	0.02	7.6														
92J10	811010	10	501133	5615104		6	qd	0	3	W	N	N	220	3.0	10	A	N	Y	D	P	4	M	0808	10	0.02	7.9														
92J10	811011	10	502147	5618090		6	qd	0	3	W	N	N	120	8.5	20	A	N	Y	D	P	4	M	0808	10	0.02	7.7														
92J10	811012	10	503958	5619866		6	ETgd	0	3	R	N	N	120	0.3	10	A	N	Y	D	P	4	G	0808	10	0.05	7.6														
92J10	811013	10	505037	5621366		6	ETgd	0	3	W	N	N	120	4.5	10	A	N	Y	D	P	4	M	0808	10	0.05	7.7														
92J15	811014	10	505902	5623540		6	ETgd	0	3	R	N	N	220	0.4	10	A	N	Y	D	P	4	G	0808	22	0.05	7.4														
92J15	811015	10	506494	5624001		6	ETgd	0	3	R	N	N	210	0.2	10	A	N	Y	D	P	4	G	0808	30	0.05	7.4														
92J15	811016	10	527882	5643722		6	PTub	0	3	R	N	N	210	1.2	10	A	N	Y	D	P	4	G	0908	10	0.10	7.6														
92J15	811017	10	529303	5641469		6	uKKW	0	3	R	N	N	120	1.5	10	A	N	Y	D	P	4	G	0908	10	0.02	7.9														
92J15	811018	10	529651	5641074		6	PTBR	0	3	G	N	N	220	1.0	10	A	N	Y	D	P	4	G	0908	10	0.02	8.0														
92J15	811019	10	532190	5639057		6	PTBR	0	3	G	N	N	120	0.5	10	A	N	Y	D	P	4	G	0908	10	0.05	8.1														
92J15	811020	10	533708	5639058		6	ETfp	0	3	G	N	N	130	2.5	10	A	N	Y	D	P	4	G	0908	10	0.02	8.1														
92J15	811022	10	535207	5637236	10	6	PTBR	0	3	R	N	N	220	2.0	10	A	N	Y	D	P	4	G	0908	26	0.02	8.2	1.0	21.5	23	48	2.60	1	495	10	1	260	0.1	1	1.0	68
92J15	811023	10	535207	5637236	20	6	PTBR	0	3	R	N	N	220	2.0	10	A	N	Y	D	P	4	G	0908	20	0.05	8.3	1.0	19.0	24	49	2.60	1	490	10	2	260	0.2	1	1.0	68
92J16	811024	10	536129	5634102		6	PTBR	0	3	R	N	N	130	4.0	10	A	N	Y	D	P	4	G	0908	26	0.10	8.0	1.2	20.5	29	48	3.60	2	720	90	1	300	0.3	1	1.0	95
92J15	811025	10	521282	5627795		6	PTBR	0	3	R	N	N	030	3.0	10	A	N	Y	D	P	4	G	1008	10	0.05	8.0	4.0	80.0	9	35	1.30	2	200	40	1	40	0.1	1	2.0	48
92J15	811026	10	521395	5629331		6	PTBR	0	3	R	N	N	030	1.0	10	A	N	Y	D	P	4	G	1008	10	0.02	7.7	2.2	425.0	22	140	2.15	1	280	110	1	140	0.1	1	1.5	59
92J15	811027	10	522152	5629525		6	PTBR	0	3	R	N	N	030	1.0	10	A	N	Y	D	P	4	G	1008	28	0.18	7.5	14.0	325.0	36	98	4.30	7	790	50	3	240	0.4	1	3.0	175
92J15	811028	10	522421	5631923		6	PTBR	0	3	B	N	N	210	2.0	10	A	N	Y	D	P	4	G	1008	20	0.02	7.8	2.0	27.0	33	75	4.35	7	840	70	2	290	0.4	1	2.0	140
92J15	811029	10	521611	5632745		6	PTBR	0	3	W	N	N	220	3.0	10	A	N	Y	D	P	4	G	1008	10	0.02	7.7	0.6	56.5	16	53	1.85	1	255	30	1	90	0.1	1	1.0	58
92J15	811030	10	521904	5634769		6	PTBR	0	3	R	N	N	220	0.8	10	A	N	Y	D	P	4	G	1008	64	0.05	8.2	5.0	45.0	24	73	3.80	4	945	90	2	110	0.1	1	1.5	100
92J15	811031	10	520857	5636843		6	PTBR	0	3	R	N	N	220	0.6	10	A	N	Y	D	P	4	G	1008	130	0.24	8.2	4.2	55.0	32	52	3.50	14	650	80	2	300	0.4	1	1.0	105
92J15	811032	10	517435	5637149		6	PTBR	0	3	B	N	N	220	1.5	10	A	N	Y	D	P	4	G	1008	50	0.05	8.3	13.8	132.5	35	110	4.90	12	1260	110	6	240	1.1	1	2.5	200
92J15	811033	10	514890	5636011		6	PTBR	0	3	R	N	N	130	3.0	10	A	N	Y	D	P	4	G	1008	38	0.10	8.2	4.4	53.5	29	62	3.45	4	600	180	2	235	0.2	1	1.5	100
92J15	811034	10	514224	5632737		6	PTBR	0	3	W	N	N	030	1.0	10	A	N	Y	D	P	4	G	1008	28	0.24	8.1	1.8	18.0	29	63	3.20	2	610	70	1	260	0.1	1	2.0	92
92J15	811035	10	512387	5634091		6	PTBR	0	3	R	N	P	220	3.0	10	A	N	Y	D	P	4	G	1008	30	0.10	7.8	5.8	95.0	16	45	2.25	3	610	170	1	90	0.1	1	3.5	74
92J09	811037	10	558020	5595287		6	PTBR	0	3	W	N	N	220	3.0	10	A	N	Y	D	P	4	G	1108	42	0.10	8.0	0.2	6.0	5	20	1.30	1	130	20	1	15	0.1	1	1.5	68
92J09	811038	10	559255	5597593		6	PTBR	0	3	G	N	N	120	3.0	10	A	N	Y	D	P	4	G	1108	90	0.16	7.8	0.1	3.5	12	50	2.55	1	225	10	1	40	0.1	1	3.0	75
92J09	811039	10	559847	5598099		6	PTBR	0	3	B	N	N	120	2.8	10	A	N	Y	D	P	4	G	1108	62	0.12	7.8	0.2	8.5	15	80	3.10	2	580	20	1	40	0.1	1	1.5	90
92J09	811040	10	561351	5597813		6	PTBR	0	3	W	N	N	120	4.5	10	A	N	Y	D	P	4	G	1108	150	0.02	7.6	0.2	35.5	15	46	2.25	2	420	20	1	32	0.2	1	1.5	80
92J09	811042	10	561182	5595046		6	PTBR	0	3	W	N	N	120	4.5	10	A	N	Y	D	P	4	G	1108	160	0.02	8.0	0.8	45.0	13	47	2.40	2	490	10	1	31	0.1	9	2.0	70
92J09	811043	10	562483	5597999		6	gd	0	3	G	N	N	120	2.0	10	A	N	Y	D	P	4	G	1108	34	0.12	8.1	0.8	16.5	14	50	2.70	3	560	10	1	39	0.1	1	1.5	68
92J09	811044	10	563477	5598897		6	gd	0	3	R	N	N	130	4.0	20	A	N	Y	D	P	4	G	1108	36	0.10	7.0	0.6	12.0	16	44	2.80	3	535	10	1	70	0.1	2	2.0	75
92J09	811045	10	564889	5601284		6	PTBR	0	3	R	N	N	030	0.5	10	A	N	Y	D	P	4	G	1108	100	0.18	7.4	1.8	53.5	22	85	4.20	5	900	10	1	61	0.1	1	2.5	175

Field Observations and Analytical Data

Stream Sediment

MAP	SAMPLE ID	UTM ZONE	UTM EAST	UTM NORTH	STA	MED	FORM	Au1	Au2	Sb	As	Ba	Br	Ce	Cs	Cr	Co	Hf	Fe	La	Lu	Mo	Ni	Rb	Sm	Sc	Na	Ta	Tb	Th	W	U	Yb	Zr	Wt
							:DL	2	2	0.1	0.5	100	0.5	10	0.5	5	5	1	0.2	5	0.2	1	20	5	0.5	0.5	0.1	0.5	0.5	0.5	2	0.2	2	200	0.01
							:Unit	ppb	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	g
							:Mthd	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	INAA	
92J16	811002	10	561885	5646574		6	uKKW																												
92J16	811004	10	563094	5647153		6	lKJM																												
92J16	811005	10	565338	5647671	10	6	lKJM																												
92J16	811006	10	565338	5647671	20	6	lKJM																												
92J16	811007	10	566009	5646919		6	lKJM																												
92J16	811008	10	567640	5646716		6	EOK																												
92J16	811009	10	570045	5647696		6	EOK																												
92J10	811010	10	501133	5615104		6	qd																												
92J10	811011	10	502147	5618090		6	qd																												
92J10	811012	10	503958	5619866		6	ETgd																												
92J10	811013	10	505037	5621366		6	ETgd																												
92J15	811014	10	505902	5623540		6	ETgd																												
92J15	811015	10	506494	5624001		6	ETgd																												
92J15	811016	10	527882	5643722		6	PTub																												
92J15	811017	10	529303	5641469		6	uKKW																												
92J15	811018	10	529651	5641074		6	PTBR																												
92J15	811019	10	532190	5639057		6	PTBR																												
92J15	811020	10	533708	5639058		6	ETfp																												
92J15	811022	10	535207	5637236	10	6	PTBR	3		1.8	26.0	770	2.1	31	1.9	670	43	3	5.5	16	0.2	3	350	25	4.7	20.8	2.4	0.9	0.6	2.3	2	1.3	2	200	34.10
92J15	811023	10	535207	5637236	20	6	PTBR	4		1.6	24.0	800	1.5	35	1.7	660	43	2	5.2	16	0.2	4	340	22	4.5	20.3	2.4	0.7	0.7	2.4	2	1.1	2	200	33.70
92J16	811024	10	536129	5634102		6	PTBR	8		2.6	26.0	600	1.7	44	2.4	720	52	4	7.7	23	0.3	3	330	34	6.0	26.9	1.7	1.4	1.0	3.2	2	1.5	3	340	33.90
92J15	811025	10	521282	5627795		6	PTBR	4	6	6.7	90.2	570	0.9	37	2.7	150	18	3	4.4	18	0.3	4	48	18	5.3	19.0	3.1	0.5	0.7	2.6	2	2.1	3	200	41.00
92J15	811026	10	521395	5629331		6	PTBR	31	35	4.1	448.0	450	4.2	20	7.2	380	46	1	7.1	13	0.3	5	180	19	4.1	25.3	2.2	0.5	0.7	1.2	3	1.3	2	200	33.80
92J15	811027	10	522152	5629525		6	PTBR	79	77	18.6	392.0	750	41.0	54	7.5	370	43	3	6.9	31	0.4	8	210	43	6.7	24.1	0.9	1.3	1.0	4.9	3	3.1	4	200	16.30
92J15	811028	10	522421	5631923		6	PTBR	11		2.8	31.0	1100	13.0	45	5.3	800	50	4	7.0	26	0.3	5	290	49	6.3	25.7	1.2	1.2	0.9	5.0	2	2.3	3	200	30.00
92J15	811029	10	521611	5632745		6	PTBR	7		1.7	57.3	370	2.2	32	3.5	410	39	4	7.1	19	0.3	3	110	10	6.1	29.5	2.7	1.1	0.9	1.8	2	0.9	2	200	37.80
92J15	811030	10	521904	5634769		6	PTBR	32	32	6.9	50.9	790	5.7	43	5.4	360	37	5	8.0	22	0.3	4	98	43	5.4	26.9	1.7	1.1	0.9	4.2	3	1.6	3	200	30.50
92J15	811031	10	520857	5636843		6	PTBR	16		6.5	63.3	650	12.0	34	4.5	990	47	3	6.5	18	0.2	3	330	22	4.6	22.2	1.5	0.7	0.7	2.9	2	1.2	2	200	31.50
92J15	811032	10	517435	5637149		6	PTBR	33	32	16.8	132.0	1400	4.6	58	6.6	480	44	4	7.1	27	0.3	10	220	59	6.8	24.6	1.0	0.9	1.2	6.0	2	2.9	3	200	24.90
92J15	811033	10	514890	5636011		6	PTBR	25	23	6.7	66.0	1100	3.4	36	4.1	510	43	2	5.9	21	0.2	5	240	43	5.9	25.7	1.3	1.3	1.0	4.1	2	1.9	3	200	33.40
92J15	811034	10	514224	5632737		6	PTBR	8		2.8	21.0	1100	3.6	50	3.2	430	43	3	5.9	26	0.2	5	220	42	6.0	25.0	1.7	1.2	0.9	4.3	3	1.9	3	200	30.80
92J15	811035	10	512387	5634091		6	PTBR	10		8.8	108.0	550	3.0	35	5.4	210	24	4	4.7	17	0.2	5	71	23	4.4	18.0	2.4	0.7	0.7	4.1	3	4.3	3	350	11.90
92J09	811037	10	558020	5595287		6	PTBR	2		0.8	7.2	740	0.6	37	3.0	33	5	3	2.3	17	0.2	2	20	41	4.1	9.5	3.6	0.6	0.5	3.0	3	1.9	2	340	31.90
92J09	811038	10	559255	5597593		6	PTBR	2		0.4	3.9	500	1.7	42	2.5	140	21	3	5.5	19	0.2	3	45	19	5.6	24.6	2.5	0.6	0.8	3.1	2	3.6	3	200	35.30
92J09	811039	10	559847	5598099		6	PTBR	3		0.9	10.0	760	0.5	48	2.1	93	24	4	5.7	23	0.4	3	43	37	6.9	24.5	2.2	0.7	1.0	4.0	2	1.9	3	200	40.20
92J09	811040	10	561351	5597813		6	PTBR	5		0.5	41.0	610	1.4	70	2.5	85	19	5	4.7	32	0.2	3	23	29	8.2	19.0	2.1	1.5	1.3	4.6	2	1.9	3	280	35.50
92J09	811042	10	561182	5595046		6	PTBR	2		0.5	57.5	470	3.4	69	3.1	99	17	8	4.7	34	0.2	2	42	26	8.4	18.0	2.0	1.6	1.3	5.0	12	2.3	2	200	19.40
92J09	811043	10	562483	5597999		6	gd	5	5	0.9	19.0	590	0.5	57	1.5	110	19	5	4.0	28	0.3	1	50	24	8.1	18.0	1.6	1.5	1.2	4.7	3	1.7	2	270	17.50
92J09	811044	10	563477	5598897		6	gd	2		0.7	91.8	500	4.8	58	2.6	150	20	4	4.6	28	0.2	3	49	28	7.3	19.0	2.0	1.5	0.9	4.1	3	2.1	2	250	26.40
92J09	811045	10	564889	5601284		6	PTBR	9		2.3	61.6	890	15.0	59	4.5	120	26	4	6.3	29	0.3	5	52	52	7.6	24.2	1.5	1.4	1.2	5.1	5	2.5	3	300	13.30