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British Columbia
Ministry of Energy and Mines
Resource Development Division
Geological Survey Branch

REGIONAL STREAM SEDIMENT and WATER DATA

FORT FRASER, BRITISH COLUMBIA (NTS 93K)

GSC Open File 1766 / BC RGS 57

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National Geochemical Reconnaissance (NGR)

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INTRODUCTION

GSC Open File 1766/BC RGS 57 includes analytical and statistical data compiled from a reconnaissance-scale geochemical survey conducted in the Fort Fraser (NTS 93K) map sheet during 2002. Stream sediment and water samples were collected from 795 sites located in the 10,500 square kilometer survey area (Figure 1). Survey results include 49 variables in stream sediments, fluorine and loss-on-ignition in sediments, and pH, uranium, fluoride and conductivity in stream waters. In addition, 186 stream water samples were analyzed for trace and major elements.

Regional geochemical surveys have been carried out in BC since 1976. A total of 44 1:250 000 scale open files have been published to date, covering approximately 500 000 square kilometres. Sample collection, preparation 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. Survey information compiled by the National Geochemical Reconnaissance (NGR) and BC Regional Geochemical Survey (RGS) programs are used in the development of a high-quality geochemical database suitable for mineral exploration, resource assessment, geological mapping and environmental studies.

In collaboration with the Geological Survey of Canada, the Fort Fraser survey was designed and managed by the BC Geological Survey Branch. The BC Ministry of Energy and Mines and Targeted Geoscience Initiative (TGI) provided funding.

ACKNOWLEDGMENTS

P.W.B. Friske and R.E.W. Lett directed the survey and coordinated the activities of the various contractors, BC Geological Survey Branch (BCGS) staff and Geological Survey of Canada (GSC) staff. Contracts were awarded to the following companies for sample collection, preparation, and analysis, and were managed by the listed BCGS and GSC staff:

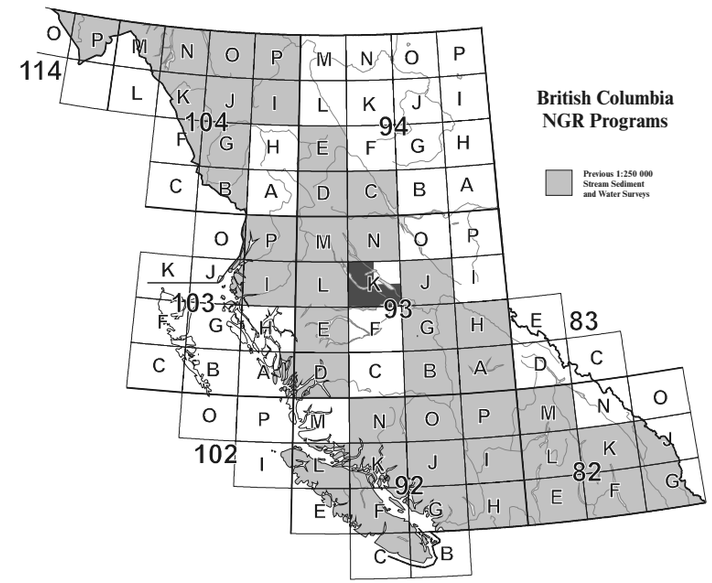

Figure 1. Location Map

Collection: McElhanney Consulting Services Ltd., Vancouver, BC
R.E.W. Lett (BCGS)

Preparation: ACME Analytical Laboratories, Ltd., Vancouver, BC
R.E.W. Lett (BCGS) and P.W.B. Friske (GSC)

Analysis: ACME Analytical Laboratories, Ltd., Vancouver, BC
R.E.W. Lett (BCGS) and P.W.B. Friske (GSC)

Becquerel Laboratories, Ltd., Mississauga, Ontario
P.W.B. Friske (GSC)

CanTech Laboratories, Inc., Calgary, Alberta
P.W.B. Friske (GSC) and R.E.W. Lett (BCGS)

GSC Analytical Method Development, Ottawa, Ontario
G.E.M. Hall (GSC) and J.E. Vaive (GSC)

Sample Collection

Helicopter and truck-supported sample collection was carried out during the period July 25 to September 5, 2002. A total of 843 stream sediment and 789 stream water samples were systematically collected from 795 sites. Average sample site density was 1 site per 13.2 square kilometres over the 10,500 square kilometre survey area. Field duplicate sediment and water samples were routinely collected in each analytical block of twenty samples.

Stream sediment samples weighing 1 to 2 kilograms were obtained from the active (subject to annual flooding) stream channel and placed in kraft paper bags. Samples were composed of fine-grained sediment mixed with varying amounts of coarse sand, gravel and organic material. Contaminated or poor-quality sample sites were avoided by choosing an alternate stream or by sampling a minimum of 60 metres upstream from the source of contamination. Surface water samples were collected in 250-millilitre bottles and, at every fifth site an additional 60-millilitre water sample was collected. Precautions were taken to exclude suspended solids. Standard field observations regarding sample media, sample site and local terrain were recorded on standard forms provided by the BCGS. To assist follow-up, aluminum tags inscribed with the sample site identification number were fixed to permanent objects at each sample site.

Site positions were marked on 1:50 000 scale NTS maps in the field and later digitized to obtain Universal Transverse Mercator (UTM) coordinates. The rock type underlying each sample site was determined by simple GIS routines using a digital geological base map modified from Struik (1998b).

Sample Preparation

Sediment samples were air dried at 30°C to less than 50°C in a sample drying facility set up in the community of Fraser Lake. Material finer than 1 millimetre was recovered by sieving each sample through a -18 mesh ASTM screen. At ACME Analytical Laboratories, the -80 mesh (<177 μm) fraction was obtained by dry sieving and was used for all subsequent analytical determinations. Any remaining -80 mesh sediment combined with the +80 to -18 mesh fraction was archived for future analyses.

Multi-element ICP analysis of trace and major element constituents was completed on water samples collected at every fifth sample site. Clear water samples were collected in rinsed 125-millilitre high-density polyethylene (HDPE) Nalgene bottles and stored in a cooler. At the end of each day (within 10 hours), all collected samples were filtered to 0.45 microns using a single-use Millipore filter unit attached to a 50-millilitre Luer-Lok sterile syringe. Each water sample was filtered into a 60-millilitre high-density polyethylene (HDPE) Nalgene bottle and acidified with 0.5 millilitres of Ultrex high purity nitric acid. The nitric acid was dispensed using an Eppendorf Repeater pipette and a 12.5 millilitre repeater syringe.

To minimize any possible contamination, filtering equipment was carefully rinsed with distilled deionised water (DDI) before and after every sample was processed. Further cleaning was done by filtering approximately 25 millilitres of sample through the equipment and discarding the processed water. The second portion of sample was then filtered and saved. Filters were replaced after every sample and syringes were discarded at the end of each filtering session.

Analytical Quality Control

Control reference standards and analytical blind duplicate samples were inserted into each block of twenty sediment samples to monitor analytical variation. For unfiltered water samples, only quality control reference standards and analytical blanks were inserted into each block of twenty samples. No analytical duplicate samples were used for water sample quality control.

Analytical controls for filtered and acidified water samples included one field duplicate sample for every ten samples collected and at least one blank per day and/or for every ten samples processed. Blanks used alternated between filtered and acidified DDI, and acidified un-filtered DDI. One in every 20 samples included an acidified pre-filled DDI sample (travel blank) provided by the GSC. The processed samples were stored in a cool, dark location until analysed.

SEDIMENT SAMPLE ANALYSES

Aqua regia digestion-inductively coupled plasma mass spectroscopy (ICPMS) and epithermal instrumental neutron activation analysis (INAA) were the analytical methods used to determine elements in stream sediments. A complete list of elements and stated detection limits are given in Table 1 and 2. INAA is non-destructive to the sample and estimates the 'total' element concentration, but this technique is inadequate for measuring ore-indicator elements such as lead and copper. Ore-indicator elements are determined on a separate sample by aqua regia-ICPMS. Aqua regia digestion is very effective for dissolving gold, carbonates and sulphides, but cannot completely break down alumino-silicate, oxide and other refractory minerals such as barite. Therefore, the element concentrations determined by aqua regia-ICPMS are considered to be 'partial'. As a result, elements by ICPMS may be determined at lower concentrations relative to INAA.

Inductively Coupled Plasma Mass Spectroscopy

A split of the -80 mesh material was analyzed for 37 elements (aluminum, antimony, arsenic, barium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, scandium, selenium, silver, sodium, strontium, sulphur, tellurium, thallium, thorium, titanium, tungsten, uranium, vanadium and zinc) by Acme Analytical Laboratories. The digestion involved leaching a 1-gram sample with 6 millilitres of hydrochloric acid, nitric acid and distilled, deionized water (2:2:2 v/v) at 95°C for one hour. The solution was diluted to 20 millilitres and analysed by inductively coupled plasma emission spectroscopy on a Jarrell Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin Elmer Elan 6000 instrument. Data for boron and gold are not published due to inadequate detection limits and precision.

Table 1. Detection Limits: ICPMS (Sediments).

Element		Detection Limit	Units	Method
Aluminum	Al	0.01	%	ICPMS
Antimony	Sb	0.02	ppm	ICPMS
Arsenic	As	0.1	ppm	ICPMS
Barium	Ba	0.5	ppm	ICPMS
Bismuth	Bi	0.02	ppm	ICPMS
Cadmium	Cd	0.01	ppm	ICPMS
Calcium	Ca	0.01	%	ICPMS
Chromium	Cr	0.5	ppm	ICPMS
Cobalt	Co	0.1	ppm	ICPMS
Copper	Cu	0.01	ppm	ICPMS
Gallium	Ga	0.2	ppm	ICPMS
Iron	Fe	0.01	%	ICPMS
Lanthanum	La	0.5	ppm	ICPMS
Lead	Pb	0.01	ppm	ICPMS
Magnesium	Mg	0.01	%	ICPMS
Manganese	Mn	1	ppm	ICPMS
Mercury	Hg	5	ppb	ICPMS
Molybdenum	Mo	0.01	ppm	ICPMS
Nickel	Ni	0.1	ppm	ICPMS
Phosphorus	P	0.001	%	ICPMS
Potassium	K	0.01	%	ICPMS
Scandium	Sc	0.1	ppm	ICPMS
Selenium	Se	0.1	ppm	ICPMS
Silver	Ag	2	ppb	ICPMS
Sodium	Na	0.001	%	ICPMS
Strontium	Sr	0.5	ppm	ICPMS
Sulphur	S	0.02	%	ICPMS
Tellurium	Te	0.02	ppm	ICPMS
Thallium	Tl	0.02	ppm	ICPMS
Thorium	Th	0.1	ppm	ICPMS
Titanium	Ti	0.001	%	ICPMS
Tungsten	W	0.1	ppm	ICPMS
Uranium	U	0.1	ppm	ICPMS
Vanadium	V	2	ppm	ICPMS
Zinc	Zn	0.1	ppm	ICPMS

Instrumental Neutron Activation Analysis

Becquerel Laboratories weighed and encapsulated samples for irradiation along with internal standards and international reference materials. Samples and standards were irradiated together with neutron flux monitors in a 2-megawatt pool-type reactor. After a 7-day decay period, samples were measured on a high-resolution germanium detector. Computer control was achieved with a Microvax II computer. Typical counting times are 500 seconds. Elements determined by INAA include: antimony, arsenic, barium, bromine, cadmium, cerium, cesium, chromium, cobalt, europium, gold, hafnium, iridium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, selenium, silver, sodium, tantalum, tellurium, terbium, thorium, tin, titanium, tungsten, uranium, ytterbium, zinc and zirconium. Data for cadmium, iridium, molybdenum, nickel, selenium, silver, tin, tellurium, titanium, zinc and zirconium are not published because of inadequate detection limits and precision.

Other Sediment Analyses

Loss-on-ignition was determined by Acme Analytical Laboratories using a 1-gram sample splits weighed into Luco crucibles. These were placed in a 100°C muffle furnace and taken up to 500°C for one hour. The oven was cooled to 100°C and the crucibles were transferred to a desiccator for cooling to room temperature. The crucibles were re-weighed and the difference is reported as loss-on-ignition (GRAV).

Acme Analytical Laboratories determined fluorine using 0.25-gram sample splits weighed into Ni crucibles. One gram of sodium hydroxide was added and the mixture was fused at 600°C in a muffle furnace. The fusion product was dissolved in 7-millilitres of de-ionized water and 5-millilitres of 30% sulfuric acid. The solutions were transferred to plastic beakers and 5-millilitres of 30% ammonium acetate is added. The volume is made to 90 mL with de-ionized water. The pH was tested and adjusted to 7.8 with either of sodium hydroxide or sulfuric acid. Fluorine content was determined using a F selective ion electrode (ION).

Table 2. Detection Limits: INAA, F and LOI in Sediments, and Natural Waters.

Element		Detection Limit	Units	Method
Antimony	Sb	0.1	ppm	INAA
Arsenic	As	0.5	ppm	INAA
Barium	Ba	50	ppm	INAA
Bromine	Br	0.5	ppm	INAA
Cerium	Ce	5	ppm	INAA
Cesium	Cs	0.5	ppm	INAA
Chromium	Cr	20	ppm	INAA
Cobalt	Co	5	ppm	INAA
Europium	Eu	1	ppm	INAA
Gold	Au	2	ppb	INAA
Hafnium	Hf	1	ppm	INAA
Iron	Fe	0.2	%	INAA
Lanthanum	La	2	ppm	INAA
Lutetium	Lu	0.2	ppm	INAA
Rubidium	Rb	5	ppm	INAA
Samarium	Sm	0.1	ppm	INAA
Scandium	Sc	0.2	ppm	INAA
Sodium	Na	0.02	%	INAA
Tantalum	Ta	0.5	ppm	INAA
Terbium	Tb	0.5	ppm	INAA
Thorium	Th	0.2	ppm	INAA
Tungsten	W	1	ppm	INAA
Uranium	U	0.2	ppm	INAA
Ytterbium	Yb	2	ppm	INAA
Sample Weight	Wt	0.01	gm	GRAV
Fluorine	F	10	ppm	ION
Loss on Ignition	LOI	0.1	%	GRAV
pH	pH			GCE
Uranium	UW	0.01	ppb	ICPMS
Fluoride	FW	10	ppb	ION
Conductivity	CND	0.01	uS	SNSR

WATER SAMPLE ANALYSES

Natural Water Samples

Natural stream water samples were analyzed for fluoride, uranium, pH and conductivity. A list of elements and stated detection limits are given in Table 2.

Hydrogen ion activity (pH) was measured with a Corning Checkmate Model 90 meter and a combined glass-reference electrode (GCE). Conductivity was measured with a Corning Checkmate Model 90 meter and a conductivity sensor (SNSR).

CanTech Laboratories analyzed for uranium using a Perkin Elmer ELAN 6000 or 6100 Inductively Coupled Plasma Mass Spectrometer (ICPMS). Fluoride in waters was measured using the DIONEX DX-120 Ion Chromatography System (ION).

Trace and Major Elements

Acidified and filtered stream water samples were analyzed for trace metal and major elements at GSC's Analytical Method Development facility in Ottawa. A complete list of elements and stated detection limits are given in Table 3.

Trace metal analysis was performed using a VG PQII ICPMS with a Meinhard concentric glass nebulizer, Type K (solution uptake rate 1 ml min^{-1}), a quartz Scott-type Double-pass chilled spray chamber (2°C) and a 27 MHz standard quartz torch. The argon flow-rates are: Cool 12.5 l min^{-1}, Auxiliary 0.85 l min^{-1}, and Nebulizer 0.9 l min^{-1}. The RF power is 1350 Watts. Isotopes measured and corrections for spectral interferences are detailed in Hall *et al*., (1995) and Hall *et al*., (1996). Hafnium and zirconium are not sufficiently stabolized in waters by the additon of nitric acid. Data for cadmium, europium, gallium, germanium, hafnium, holmium, indium, lutetium, niobium, rhenium, selenium, silver, tantalum, tellurium, terbium, thallium, thulium, tin, tungsten and zirconium are not published because of inadequate detection limits and precision.

Major element analysis was performed using a Perkin-Elmer 3000DV Inductively Coupled Plasma Emission Spectrometer (ICPES) with a cross-flow nebulizer, (solution uptake rate 1 ml min^{-1}), a Ryton Scott-type double-pass spray chamber and a custom de-mountable quartz ICPES torch. The argon flow-rates are: Plasma 15.0 l min^{-1}, Auxiliary 0.5 l min^{-1}, and Nebulizer 0.7 l min^{-1}. The RF power is 1350 Watts. All elements were analysed in axial mode except for sodium and potassium. These elements were were run in radial mode. Inter Element Correction factors were applied as required to correct for various spectral interferences. Data for phosphorus and scandium are not published because of inadequate detection limits and precision.

Table 3. Detection Limits: Trace and Major Elements in Processed Waters.

Element		Detection Limit	Units	Method
Aluminium	Al	2	ppb	ICPMS
Antimony	Sb	0.01	ppb	ICPMS
Arsenic	As	0.1	ppb	ICPMS
Barium	Ba	0.2	ppb	ICPMS
Beryllium	Be	0.005	ppb	ICPMS
Boron	B	0.5	ppb	ICPMS
Cerium	Ce	0.01	ppb	ICPMS
Cesium	Cs	0.01	ppb	ICPMS
Chromium	Cr	0.1	ppb	ICPMS
Cobalt	Co	0.05	ppb	ICPMS
Copper	Cu	0.1	ppb	ICPMS
Dysprosium	Dy	0.005	ppb	ICPMS
Erbium	Er	0.005	ppb	ICPMS
Gadolinium	Gd	0.005	ppb	ICPMS
Lanthanum	La	0.01	ppb	ICPMS
Lead	Pb	0.01	ppb	ICPMS
Lithium	Li	0.02	ppb	ICPMS
Manganese	Mn	0.1	ppb	ICPMS
Molybdenum	Mo	0.05	ppb	ICPMS
Neodymium	Nd	0.005	ppb	ICPMS
Nickel	Ni	0.2	ppb	ICPMS
Praseodymium	Pr	0.005	ppb	ICPMS
Rubidium	Rb	0.05	ppb	ICPMS
Samarium	Sm	0.005	ppb	ICPMS
Strontium	Sr	0.5	ppb	ICPMS
Titanium	Ti	0.5	ppb	ICPMS
Uranium	U	0.005	ppb	ICPMS
Vanadium	V	0.1	ppb	ICPMS
Ytterbium	Yb	0.005	ppb	ICPMS
Yttrium	Y	0.01	ppb	ICPMS
Zinc	Zn	0.5	ppb	ICPMS
Calcium	Ca	0.02	ppm	ICPES
Iron	Fe	0.005	ppm	ICPES
Magnesium	Mg	0.005	ppm	ICPES
Potassium	K	0.05	ppm	ICPES
Silicon	Si	0.02	ppm	ICPES
Sodium	Na	0.05	ppm	ICPES
Sulphur	S	0.05	ppm	ICPES

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