

**Ministry of Energy and Mines** Energy and Minerals Division Geological Survey Branch

# Stream Geochemical Exploration for Pluton-Related Quartz-Vein Gold Deposits in Southern British Columbia

NTS 82M/4, 5, 6; 92P/8; 82F7

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# STREAM GEOCHEMICAL EXPLORATION FOR PLUTON-RELATED QUARTZ-VEIN GOLD DEPOSITS IN SOUTHERN BRITISH COLUMBIA (NTS 82M/4, 5, 6; 92P/8 AND 82F/7)

**OPEN FILE 2000 - 23** 

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## ABSTRACT

Open File 2000-23 presents data from geochemical surveys carried out over two areas of southern British Columbia to compare the geochemical response of pluton-related quartz-vein gold mineralization in different reconnaissance scale stream sample media. Moss sediments, stream sediments and water samples were collected at 40 sites in NTS 82M/4, 5, 6 and 3 sites in 92P/8 and 26 sites in 82F/7 (including the area around the Cam Gloria gold property near Adams Lake). Bulk stream sediment samples for preparation of heavy mineral concentrates and rock samples for estimation of element background levels were also taken at selected sites. The results indicate that moss sediments and heavy mineral concentrates provide higher geochemical contrast and are a stronger indication of gold mineralization than routine regional survey scale stream sediments. The moss sediment and heavy mineral gold geochemistry has highlighted several drainage basins within the Baldy Batholith and Mount Skelley Pluton where the multielement associations suggest new areas of pluton-related mineralization. However, there may be other sources for typical pathfinder elements (e.g. Bi, Mo). The high variability of gold and bismuth in moss sediment suggests that these elements are present in relatively large mineral grains. Reconnaissance sampling for moss sediment or heavy minerals is recommended at a density of one sample per ten square kilometres. Follow-up basal till samples to trace the up-ice source of the stream anomaly should be collected at a density of one to two samples per square kilometre.

# INTRODUCTION

Open File 2000-23 presents new analytical data for up to 43 elements from the results of detailed surveys (Figure 1) carried out by the British Columbia Geological Survey Branch in 1999 to study the stream geochemical response of pluton-related quartz-vein gold mineralization. Interest in the potential for this type of gold mineralization in British Columbia has been stimulated by reports on the exploration and development of the Fort Knox bulk-tonnage gold mine and the high-grade Liese Zone on the Pogo property in Alaska (Smith *et al.*, 1999; Thompson *et al.*, 1999). The Pogo property was discovered by follow-up of a subdued (35 ppb) stream sediment geochemical gold anomaly (Robertson, 1998). Similarly, only 15 ppb gold was detected by a regional stream survey in a sediment sample collected from a creek draining the Cam-Gloria mineral occurrence (MINFILE 82M 221), a gold-bismuth-lead mineralized, granite-hosted quartz vein, in southern British Columbia (Matysek *et al.*, 1991). This occurrence was originally found by prospecting follow-up of a 215 ppb till gold geochemical anomaly identified during a 1996 regional till survey (Bobrowsky *et al.*, 1997).

There are presently only a few published reports specifically dealing with the geology or application of geochemistry for intrusion-related quartz-vein gold deposits in British Columbia. These deposits may be more difficult to find by traditional stream sediment surveys because the gold and associated pathfinder elements, such as bismuth and tungsten, are relatively immobile and tend to be erratically distributed in the sediment. Drainage sediments in British Columbia are also prone to dilution by barren glacial material (unlike the non-glaciated area in Alaska where the Fort Knox and Pogo Properties are located) and therefore gold anomaly contrast may be more subdued.

However, regional geochemical surveys (RGS) carried out in British Columbia by the Ministry of Energy and Mines and Geological Survey of Canada over the past 25 years have been very effective for detecting other types of gold and base metal mineralization (Jackaman *et al.*, 2000).

In addition to regional surveys, there have been several detailed stream geochemical orientation studies carried out by the B.C. Geological Survey Branch. One study on Vancouver Island compared the multi-element geochemistry of stream sediments, moss mat sediments and heavy mineral concentrates from different types of gold and copper mineralization (Matysek and Day, 1987). Gold anomaly contrast for moss sediment was found to be larger than for routine stream sediment and the moss sediment gold anomaly persisted for a greater distance downstream from copper-molybdenum-gold mineralization. The distribution of arsenic, copper, bismuth and tellurium in moss sediment was found to resemble gold. The relatively small variation of gold in moss sediment replicates suggested that the gold was fine grained rather than in nugget form. Matysek and Day (1987) also demonstrated on Vancouver Island that the ability of moss sediments to scavenge fine sediment overcame the problem of obtaining sufficient stream sediment in fines-poor streams typical of high rainfall, granitic terraines.

The difficulty of interpreting erratic gold patterns in drainage sediments from streams flowing over glacial deposits has been investigated in the Harris Creek, B.C. watershed by Day and Fletcher (1989, 1991), Fletcher and Wolcotte (1991) and Hou and Fletcher (1996). Here, gold concentrates in the <0.053 mm size fraction of sediment and heavy mineral fraction (SG>3.2) at sites corresponding to the breaks-in-slope along the stream gradient. Although the pattern of gold accumulation could be predicted by hydraulic modelling of heavy mineral transport, intermittent landslides into Harris Creek were also shown to be another potential source for the anomalous gold.

The study reported in this Open File was carried out in August 1999 to compare the geochemical response of plutonic-related quartz-vein gold mineralization in different reconnaissance scale sample media such as stream sediment, moss mat sediment and heavy mineral concentrates. Preliminary results for samples collected near Adams lake and Kootenay lake (Figure 1) have been published by Lett and Jackaman (2000).

Objectives of this study were to:

- develop a better understanding of the stream geochemical response of pluton-related quartz-vein gold mineralization;
- compare the merits (cost effectiveness) of different stream sampling, sample preparation and analytical methods to improve the ability of stream sediment geochemistry to detect pluton-related gold mineralization;
- add value to the current British Columbia Regional Geochemical Survey database and to stimulate future mineral exploration; and
- identify factors that most influence geochemical dispersion and are therefore important criteria for the interpretation of survey results.

# **OPEN FILE FORMAT**

Open File 2000-23 consists of the following sections:

- Introduction, survey methodology and quality control Summary of results and a brief discussion
- Exploration guidelines and potential target areas

- Sample location, geology and selected element distribution maps
- Listings of field variables, analytical and quality control data (Appendices A, B, C, D)
- Analytical and field data are included as an ASCII, comma delimited file on a 3.5-inch high density diskette located in the back pocket of the Open File.

# ADAMS LAKE SURVEY AREA DESCRIPTION (NTS 82M/4, 5, 6; 92P/8)

#### Location

Detailed stream geochemical studies in parts of NTS map sheet 82M/4, M/5 and M/6 focused on the area around the Cam-Gloria Gold occurrence (MINFILE 82M 221) located west of Honeymoon Bay on Adams Lake. Regional stream sampling covered a larger 350 square kilometre area to the west and north-west. Three sites were also sampled within the Newhykulston Creek watershed in NTS 92P/8(E).

#### Physiography and Climate

The survey area is within the Shuswap Highlands, a region of broad forested mountains of moderate to high relief (Holland, 1976). The region bounded by Gollen Creek, Adams Lake, Fennel Creek and the East Barriere River is a dissected plateau with an undulating surface averaging 1700 metres above sea level and with hill tops reaching 1800 metres. Principal drainage is by the west flowing Fennel Creek, East Barriere River and Bendelin Creek and to the east by Spapilem, Fisher, Stratton and Gollen Creeks. The creeks draining into Adams Lake typically have steep gradients (10-15 degrees), are fast flowing and follow steep-sided, deep valleys. The two tributaries of Newhykulston Creek, where samples were collected, join to flow west into the North Thompson River from a rolling plateau that has an average elevation of 1700 metres above sea level.

The climate of the area is moist and temperate. Winter temperatures typically range from -10 to -15°C, summer temperatures can reach 30°C. Annual precipitation averages 417 mm (measured at Vavenby) falling as snow in the winter months and as rain mainly between June and July. The spring freshet occurs between mid May and late June.



#### Figure 1. Location of survey areas.

#### Bedrock Geology

The survey area is partly underlain by Cambrian to Mississippian rocks of the Eagle Bay Assemblage, Fennell Formation and by the mid-Cretaceous Baldy Batholith. Regional geology has been described by (Schiarriza and Preto, 1987). The Eagle Bay Assemblage, part of the Kootenay terrane, was originally deposited along the ancestral margin of North America. Older Neoproterozic and Lower Paleozoic Eagle Bay rocks range from quartzites, quartz-rich schists and limestone representing ancestral North American miogeoclinal strata. These are overlain by grit, phyllite and quartz-mica schist and coarse grained clastic metasediments interbedded with felsic volcanic rocks. Above the metasedimentary rocks are limestone and calcareous phyllite, calcsilicate schist and skarn, pillowed greenstone and chlorite-sericite-quartz schist of felsic origin. The Late Paleozoic metavolcanic and metasedimentary rocks represent a volcanic arc sequence. At the top of the sequence are slates and siltstone. The Fennell Formation is a

Devonian to Permian sequence of oceanic bedded cherts, gabbro, diabase, pillow basalt, sandstone, quartz-porphyry rhyolite and conglomerate that forms part of the Slide Mountain Terrane and has a thrust contact with the Eagle Bay Assemblage.

The mid to Late Cretaceous Baldy Batholith is a west-trending, predominantly massive light-grey, coarse-grained quartz monzonite intrusive. Logan (2000) identified a potassium feldspar megacrystic hornblende-biotite granite to granodiorite phase and an equigranular biotite monzogranite comprising the western part of the batholith. The eastern part of the batholith consists of leucocratic biotite-muscovite granite. The eastern and northern margins of the Batholith are marked by medium-grey biotite and muscovite Devonian orthogneiss. In addition to the main batholith, there are several smaller apophyses or satellite intrusive granitic bodies. The Honeymoon stock, west of Honeymoon Bay on Adams lake, consists of quartz monzonite and is the host to the auriferous Cam Gloria quartz vein. Another small granitic body has been mapped close to the headwaters of Newhykulston Creek (Schiarriza and Preto, 1987).

#### Surficial Geology

The uplands are mainly covered by till, colluvium and glaciofluvial deposits, whereas fluvial, glaciofluvial and glaciolacustrine sediments have accumulated in the valleys. These sediments were deposited initially by a predominately northwest to southeast ice advance followed by deglaciation processes during the late Wisconsin. There are two types of basal till deposited in the area, each reflecting a different bedrock source. South of the survey area where geology is dominated by metavolcanic and metasedimentary rocks basal till is massive to poorly stratified with a sandy silt to silty clay texture. In most of the stream survey area, however, the basal till is sandier and light to medium grey in colour reflecting a granitic bedrock source. Boulder fields and massive clast-supported ablation till covers bedrock and basal till on the plateau. The ablation till is generally less compact, dense and cohesive and the sandy matrix is poorly consolidated. Clast content is higher than basal till (up to 45 per cent) and clast size ranges from granule to boulder. Clast lithologies are almost entirely of Baldy Batholith rocks (Dixon-Warren *et al.*, 1997).

#### **Mineral Occurrences**

Location of mineral occurrences around and within the Baldy Batholith is shown in Appendix A-Map 1. The principal mineral occurrence in the survey area is the Cam-Gloria Gold property (MINFILE 82M 221) discovered in 1997 by follow-up of a regional till geochemical anomaly (Bobrowsky *et al.*, 1997). The "discovery" occurrence is a large, rusty auriferous quartz vein located on the north fork of the Grizzly Creek Forest Service road, approximately 3 kilometres west of the Honeymoon Bay campsite on Adams Lake. The vein strikes at 50 degrees, dips steeply northwest and is up to 10 metres wide and roughly 200 metres in length. Pyrite, galena and minor chalcopyrite occur in the quartz and samples of the sulphide-rich vein material contain 1.38 ppm gold, 7.8 ppm silver, 55 ppm bismuth, 430 ppm lead, 118 ppm copper and 21 ppm molybdenum (Lett *et al.*, 1998). Within one kilometre of the auriferous quartz vein there are several narrow monzonite-hosted quartz-fluorite veins and a 30 centimetre wide quartz-pyrite-pyrrhotite vein. The geology of this occurrence and details of more recent exploration are described by Cathro and Lefebure (2000).

Two other documented mineral occurrences within, or close to, the Baldy Batholith are the NSP (MINFILE 82M 127) near the headwaters of Spapilem Creek where chalcopyrite occurs as disseminations and in thin quartz stringers in quartz-biotite gneiss and the SAN (MINFILE 82M 135) between North Barriere and Saskum Lakes where pyrite, galena, sphalerite and chalcopyrite occur in a granite hosted, sheared quartz vein. Cathro and Lefebure (2000) also describe two new showings related to the batholith. On the Lucky Bear property, northwest of the Cam Gloria occurrence, scheelite, chalcopyrite and pyrrhotite occur in a quartz vein hosted by Devonian orthogneiss. Mineralization on the E-D1 property, in the headwaters of Birk Creek, consists of chalcopyrite, sphalerite and pyrrhotite in altered limestone within 500 metres of the batholith contact. The CM (L.K.) chalcopyrite occurrence (MINFILE 92P 101) is located near the headwaters of Newhykulston Creek.

# KOOTENAY LAKE SURVEY AREA DESCRIPTION (82F/07)

#### Location

The geochemical survey covered roughly 150 square kilometre southeast of Boswell on Kootenay Lake within the watersheds of Akokli, Sanca and Skelly Creeks (Figure 1). Stream sampling included creeks draining known mineral occurrences on Mount Sherman and Mount Dickson.

#### Physiography and Climate

The survey area is located in the southern Purcell Mountains. Elevations range from 550 metres on the shore of Kootenay Lake to 2700 metres on the peak of Haystack Mountain. Principal watersheds are those of Akokli and Sanca Creeks and east flowing Skelly Creek. The height of land between Akokli and Sanca Creeks is very rugged and the highest elevation (2700 metres) on this ridge is Mount Sherman. South of Sanca Creek the topographic relief is more subdued and above 1700 metres the land surface is a rolling, forested plateau. Climate of the area is moist and temperate. Winter temperatures average  $-6^{\circ}$ C and in summer reach 30°C. Annual precipitation averages 580 mm (measured at Bonners Ferry) falling mainly as snow at higher elevations in the winter months. The spring freshet occurs between mid-May and late June.

#### **Bedrock Geology**

The survey area is underlain by rocks of the Cretaceous Mount Skelly Pluton and the Creston Formation. The Mount Skelly Pluton belongs to the Bayonne Plutonic suite and intrudes siltstones and quartzites of the Creston Formation which forms the lower part of the Proterozoic Purcell Supergroup (Reesor, 1996). Within the pluton, Logan (2000) identified a potassium feldspar magacrystic hornblende-biotite granodiorite, a coarse or fine grained biotite granodiorite and a biotite plagioclase porphyritic leucrogranite phase. These phases were intruded by quartz-feldspar-garnet aplite and hornblende-biotite-plagioclase phyric dikes, quartz veins and pegmatite dikes. The Sanca Creek stock, a satellite body of coarse grained, biotite monzogranite is located on the northern margin of the Mount Skelly Pluton. The contact between the Creston Formation and Mount Skelly Pluton is located just south of Akokli Creek and trends northwest to southeast.

#### Surficial Geology

Glacial and recent surficial deposits range from talus and colluvium above timber line and on steep slopes to basal till at lower elevations. Thick glaciofluvial, glaciolacustrine and fluvial deposits fill the major valleys and the Kootenay Lake basin. The till, deposited by a predominately north to south ice advance parallel to Kootenay Lake during the Fraser Glaciation is sandy textured reflecting a predominantly granite source rock (Fulton and Smith, 1978). Glacial and inter-glacial deposits from earlier Wisconsinian glaciations including Okanagan Centre till, paleosol and Bessette sediments have been recognised at the north end of Kootenay Lake (Alley *et al.*, 1986).

#### **Mineral Occurrences**

Mineral occurrences in the survey area are typically polymetallic gold-silverlead-zinc-tungsten veins and mineralized quartz vein stockworks within the Mount Skelly pluton (Appendix A-Map 22). The Valparaiso-Government past producing gold mine (MINFILE 82FSE 038), located south of Akokli Creek, is an 800 metre long quartz-filled fissure in biotite granodiorite of the Sanca Creek stock. Mineralization consists of pyrite, arsenopyrite, wolframite, galena, sphalerite and rare chalcopyrite. Gold and silver are disseminated in the quartz. Other mineralized quartz veins close to the Valparaiso-Government mine are the Imperial-Sara property (MINFILE 82FSE 055) and the Lost Mine property (MINFILE 82FSE 131).

The German (Gold) Basin showing (MINFILE 82FSE 039) is also a gold mineralized quartz vein in granodiorite at an elevation of 2133 metres located on the western slope of Mount Sherman. The vein contains scattered irregular bands and patches or pyrite, galena, chalcopyrite and scheelite hosting gold. Typical metal concentrations of the vein material are 39.7 percent lead, 366 grams per tonne silver and 3.4 grams per tonne gold. The Elmo showing (MINFILE 82FSE 137), located in a cirque west of Mount Dickson, is a stockwork of quartz-muscovite veinlets in medium grained, equigranular and coarse- grained to porphyritic quartz monzonite phases of the Bayonne Batholith. Within the stockwork are scattered molybdenite, scheelite, fluorite, magnetite, pyrite and chalcopyrite grains.

# SAMPLING TECHNIQUES

An objective of this study is a comparison of the geochemical response from pluton-related gold mineralization in different sample media at an average density of 1 sample per 12 kilometres typical of a routine regional stream geochemical survey. Consequently, samples were taken from larger, first and second order creeks draining catchments covering 10 - 15 square kilometres and especially creeks where previous regional stream sediment and till surveys had detected anomalous gold levels. More detailed stream sampling at a higher density was attempted around known gold occurrences. Samples were collected in August, 1999 following the spring freshet. The number and type of samples collected in each are summarized in Table 1.

Table 1. Summary of samples collected.

Sample type	82M/4,5,6	92P/8	82F/7	Total
Stream sediment	43	4	30	77
Moss sediment	42	4	30	76
Bulk sediment	17	2	6	25
Water	40	3	25	68
Rock	16	0	1	17

A total of 69 stream water, 77 stream sediment and 76 moss mat samples (including field duplicates) were collected from 40 sites in 82M/4, 82M/5 and 82M/6 (Adams Lake area), 3 sites in 92P/8 (Newhykulston Creek) and 26 sites in 82F/7 (Kootenay Lake area). Location of stations where the samples were collected are shown in Appendix A-Maps 2 and 22. In addition 25 bulk screened sediment samples were taken from selected sites for analysis of gold and other elements in a -150 (<0.100 mm) mesh heavy mineral fraction. The bulk samples

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were collected from the higher energy environment corresponding to a coarse gravel deposit in the stream channel by wet-sieving sufficient material through an 18 mesh (<1 mm) nylon screen to recover 10 kilograms of <1 millimetre sized sediment. Wet sieving typically required one hour to obtain 10 kilograms of the <1 millimetre fraction and the material was then stored in a heavy-duty plastic bag. The location of stations where bulk samples were taken are shown in Appendix A-Maps 2 and 23.

Fine textured sediment, typical of material routinely collected during a regional survey was also taken, generally from the sandy part of a bar in the stream channel, and stored in a high wet strength Kraft paper bag. Live moss containing trapped sediment, collected from the surface of boulders or logs in the active stream above the water level, was also stored in Kraft bags. Abundant moss occurred at almost all of the stream sites and was only sparse in areas disturbed by logging. Water samples were collected by filling a 125 millilitre high-density polyethylene bottle after previously rinsing the bottle with the stream water.

Considerable effort was made to choose sample sites upstream of known anthropogenic disturbances such as bridges or culverts or logged areas. This was often difficult in practice because of extensive logging in both survey areas. In fact, detailed stream sediment sampling around the Cam-Gloria occurrence was limited because of poorly developed primary drainages and considerable surface disturbance of stream channels by logging. During regional sampling where a stream flowed through an obviously disturbed area every effort was made to locate the sample site in an undisturbed riparian zone or where secondary timber growth had stabilized the terrain. Field observations about sample media, sample site, local terrain and float geology were recorded and an aluminum tag inscribed with the sample identification number was fixed to a permanent object at each sample site.

Seventeen rock samples were also taken from selected outcrops.

# SAMPLE PREPARATION

Sediment and moss mat samples were prepared by Eco-Tech Laboratories Ltd. (Kamloops, B.C). The samples were air dried and the -80 ASTM mesh (<0.177 mm) fraction recovered by disagregating the sediment or pounding the moss and then dry sieving through a stainless steel screen. Control reference material and analytical duplicate samples were inserted into each analytical block of twenty sediment samples at the Geological Survey Branch Laboratory in Victoria. Any remaining -80 mesh sediment was archived for future analyses. Selected moss sediment and stream sediment samples (-80 mesh) were re-sieved to the -230 (<0.063mm) size fraction. Rock samples were jaw crushed, split and pulverized in a chromium-steel mill to -150 mesh.

Table 2.	Detection	limits	for Stream	Sediment	Analysis.
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Element		Method	Detection Limit	Unit
Antimony	Sb	INA/AAS-H	0.1/0.2	ppm
Arsenic	As	INA/AAS-H	0.5/0.2	ppm
Barium	Ba	INA	50	ppm
Bismuth	Bi	AAS-H	0.2	ppm
Bromine	Br	INA	0.5	ppm
Cadmium	Cd	AAS	0.2	ppm
Calcium	Ca	INA	1	- %
Cerium	Ce	INA	3	ppm
Cesium	Cs	INA	1	ppm
Chromium	Cr	INA	5	ppm
Cobalt	Co	INA/AAS	1/2	ppm
Copper	Cu	AAS	2	ppm
Europium	Eu	INA	0.2	ppm
Fluorine	F	ION	40	ppm
Gold	Au	INA	2	daa
Hafnium	Hf	INA	1	ppm
Iron	Fe	INA/AAS	0.01/0.02	<b>`</b> %
Lanthanum	La	INA	0.5	ppm
Lead	Pb	AAS	2.0	ppm
Loss on ignition	LOI	GRAV	0.1	<b>`</b> %
Lutetium	Lu	INA	0.05	ppm
Manganese	Mn	AAS	5	ppm
Mercury	Hg	AAS-F	10	ppb
Molybdenum	Mo	AAS	2	ppm
Neodymium	Nd	INA	5	ppm
Nickel	Ni	AAS	1	ppm
Rubidium	Rb	INA	15	ppm
Samarium	Sm	INA	0.5	ppm
Scandium	Sc	INA	0.1	ppm
Selenium	Se	INA	5	ppm
Silver	Ag	AAS	0.2	ppm
Sodium	Na	INA	0.01	%
Tantalum	Та	INA	0.5	ppm
Terbium	Тb	INA	0.5	ppm
Tin	Sn	AAS	1	ppm
Thorium	Th	INA	0.2	ppm
Tungsten	W	INA	1.0	ppm
Uranium	U	INA	0.5	ppm
Vanadium	V	AAS	5	ppm
Ytterbium	Yb	INA	0.2	ppm
Zinc	Zn	INA/AAS	50/2	ppm
pH (waters)	pН	GCE	0.1	
Fluoride (waters)	F	ION	20	ppb
Sulphate (waters)	SO₄	TURB	1	ppm
Uranium (waters)	U	FLU	0.05	ppb

The <1 millimetre fraction of bulk stream sediments were processed by C.F. Minerals Research Ltd. (Kelowna, B.C.) to recover heavy minerals. Samples were wet sieved into the following size fractions: -20+35, -35+60 and -60 mesh and after drying, the -60 mesh fraction was slowly fed into the middle of a column of tetrabromomethane (TBE), with a specific gravity of 2.96. The resultant heavy

minerals that settled to the bottom of the TBE column were then further separated by methylene iodide (MI), with an effective specific gravity of 3.27. The minerals with a specific gravity above 3.27 are called the heavy (H) fraction. The -60 mesh heavy fraction was then further sieved into -60 +150 and -150 (<100 micron) mesh fractions. A Frantz electromagnetic separator was use to generate distinct -150 mesh, heavy fractions based on variations in magnetic susceptibility as follows: magnetic (M), paramagnetic (P) and nonmagnetic (N). The -150 mesh, heavy, nonmagnetic fractions (-150HN) were placed in vials for neutron activation analysis.

### SAMPLE ANALYSIS

The prepared stream sediment, moss mat sediment and quality control samples were analysed for bismuth, arsenic and antimony by aqua regia digestion - hydride generation atomic absorption spectroscopy (AAS-H) and for cadmium, cobalt, copper, iron, lead, manganese, nickel, silver and zinc by aqua regia digestion - flame atomic absorption spectroscopy (AAS). Background corrections were made for lead, nickel, cobalt and silver. The analytical methods are described in more detail by Aslin (1976) and by Matysek *et al.* (1991). Fluorine content of samples was determined by the sodium carbonate-nitric acid fusionfluoride ion electrode method (FION) described by Ficklin (1970). The samples were also analysed for molybdenum and vanadium by an aqua regia digestion and atomic absorption spectroscopy using a nitrous oxide acetylene flame. Aluminum chloride solution was added to the digested sample solution as a releasing agent before the determination of molybdenum and vanadium by atomic absorption.

Mercury was determined by aqua regia digestion - flameless atomic absorption (AAS-F) using the method described by Jonasson *et al.* (1973). Samples were analysed for tin by ammonium iodide fusion, trioctylphosphine oxide - methyl isobutyl ketone extraction and flame atomic absorption spectrometry as described by Moldan *et al.* (1970). Loss on ignition of sediment and moss mat samples (GRAV) was determined by ashing the material at 500°C for three hours and then weighing the residue. All of the atomic absorption, fluorine and tin analyses were carried out by CanTech Laboratories (Calgary, Alberta). Reported detection limits for the elements determined by atomic absorption, fluoride and loss on ignition are given in Table 2.

A representative split of each sediment, rock and heavy mineral sample was analysed for antimony, arsenic, barium, bromine, cerium, cesium, chromium, cobalt, europium, gold, hafnium, iron, lanthanum, lutetium, molybdenum, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium, thorium, tungsten, uranium, ytterbium and zinc using thermal, instrumental neutron activation analysis (INA) by Activation Laboratories (Ancaster, Ontario). Instrumental neutron activation analysis involves irradiating the sediment samples, which range 
 Table 3. Detection limits for Stream Sediment and Rock Analysis by aqua regia - ICPMS.

Element		Detection Limit	Unit
Antimony	Sb	0.02	ppm
Arsenic	As	0.1	ppm
Aluminium	Al	0.01	%
Barium	Ba	0.5	ppm
Bismuth	Bi	0.02	ppm
Boron	B	1	ppm
Cadmium	Cd	0.01	ppm
Calcium	Ca	1	%
Chromium	Cr	0.5	ppm
Cobalt	Co	0.1	ppm
Copper	Cu	0.01	ppm
Galium	Ga	0.02	ppm
Gold	Au	0.2	ppb
Iron	Fe	0.01	%
Lanthanum	La	0.5	ppm
Lead	Pb	0.01	ppm
Manganese	Mn	5	ppm
Magnesium	Mg	0.01	%
Mercury	Hg	10	ppb
Molybdenum	Mo	2	ppm
Nickel	Ni	0.1	ppm
Phosphorus	Р	0.001	%
Potassium	K	0.01	%
Selenium	Se	0.1	ppm
Silver	Ag	2	ppb
Sodium	Na	0.001	%
Strontium	Sr	0.5	ppm
Sulphur	S	0.02	%
Tellurium	Te	0.02	ppm
Titanium	Ti	0.001	%
Thorium	Th	0.2	ppm
Thallium	TI	0.02	ppm
Tungsten	W	0.2	ppm
Uranium	U	0.1	ppm
Vanadium	v	2	ppm
Zinc	Zn	0.1	ppm

from 1 to 46 grams for 30 minutes with neutrons (flux density of  $7x10^{11}$  neutrons/cm<sup>2</sup>/second). After approximately one week, the gamma ray emissions for the elements are measured using a gamma-ray spectrometer with a high resolution, coaxial germanium detector. Counting time was approximately 15 minutes per sample. Table 2 also lists the detection limits reported for elements determined by this method.

Water samples were analysed for pH, sulphate, fluoride and uranium by CanTech Laboratories (Calgary, Alberta). Detection limits for each element are

Table 4. Data for two analyses of CANMET standard LKSD 1.

Element	Method	Mean	%RSD	Recomm.	Unit
Antimony	AAS-H	1.2	6.1	1.2	ppm
Arsenic	INA	39.1	2.4	40	ppm
Arsenic	AAS-H	30	2.2	30	ppm
Barium	INA	475	7.4	430	ppm
Bismuth	AAS-H	1.1	0.0	-	ppm
Bromine	INA	13.1	6	11	ppm
Cadmium	AAS	1.3	5.7	1.2	ppm
Calcium	INA	7.5	9.4	7.7	%
Cerium	INA	29	0.0	27	ppm
Cesium	INA	0.5	400	1.5	ppm
Chromium	INA	29	7.4	31	ppm
Cobalt	INA	11	12.9	11	ppm
Cobalt	AAS	8	0.0	9	ppm
Copper	AAS	47	1.5	44	ppm
Fluorine	ION	240	5.9	300	ppm
Gold	INA	2	330	5	ppb
Hafnium	INA	3.5	20.2	3.6	ppm
Iron	INA	3.04	3.7	2.8	%
Iron	AAS	1.8	3.8	1.8	%
Lanthanum	INA	15.9	2.2	16	ppm
Lead	AAS	83	1.7	84	ppm
LOI	GRAV	28.9	2.0	23.5	%
Lutetium	INA	0.4	6.1	0.4	ppm
Manganese	AAS	413	0.9	460	ppm
Mercury	AAS-F	105	6.7	110	ppb
Molybdenum	AAS	9.5	22.3	12	ppm
Neodymium	INA	11.5	6.1	16	ppm
Nickel	AAS	13	5.7	11	ppm
Rubidium	INA	15	0	24	ppm
Samarium	INA	3.5	4	4	ppm
Scandium	INA	8.4	3.4	9	ppm
Selenium	INA	-3	0	-	ppm
Silver	AAS	0.6	11	0.6	ppm
Sodium	INA	1.55	2	1.48	%
Tantalum	INA	-0.5	0	0.3	ppm
Terbium	INA	-0.5	0	0.6	ppm
Tin	AAS	13.5	5.2	16	ppm
Thorium	INA	2.0	7.1	2.2	ppm
Tungsten	INA	-1	0	-4	ppm
Uranium	INA	9.3	3	9.7	ppm
Vanadium	AAS	27	5.2	27	ppm
Ytterbium	INA	2.3	6.1	2.0	ppm
Zinc	INA	372	7.2	331	ppm
Zinc	AAS	346	0.4	337	ppm

listed in Table 2. The pH of water samples was measured using a combination glass-reference electrode (GCE). Sulphate was determined by a barium sulphate suspension turbidimetric method (TURB). Water samples were analysed for fluoride by mixing an aliquot of the sample with an equal volume of total ionic strength adjustment buffer (TISAB II solution) and measuring fluoride ion content using a Corning 101 meter with an Orion fluoride electrode (ION). Uranium in waters was determined by laser-induced fluorescence analysis (LIF) with a Scintrex UA-3 uranium analyzer.

Rock samples were analysed for 32 elements by an aqua regia digestion and inductively coupled plasma emission spectroscopy. The suite of 29 selected moss sediment and stream sediment samples, sieved to both -80 (<0.177 mm) and -230 (<0.063 mm) size fractions, were analysed for 40 elements by aqua regia digestion and a combination of inductively coupled plasma emission spectroscopy and inductively coupled plasma mass spectroscopy. 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 for elements by inductively coupled plasma emission spectroscopy on a Jarell Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin Elmer Elan 6000 instrument. Detection limits for elements determined by this method are listed in Table 3. A split of the heavy mineral concentrate was analysed for elements at Activation Laboratories by aqua regia digestion- inductively coupled plasma emission spectroscopy (Perkin Elmer Optima 3000 instrument).

# **QUALITY CONTROL**

#### Methodology

Reliable data interpretation depends on discriminating between real geochemical trends and those variations introduced by sampling and analysis. Control reference standards and analytical duplicates were therefore routinely inserted into the batches of stream sediment, moss sediment and water samples submitted for commercial analysis to measure the accuracy and precision. The standard National Geochemical Reconnaissance (NGR) and Regional Geochemical Survey (RGS) quality control procedures were used in this project and are based on the analysis of a block of 20 samples. Each block comprises:

- seventeen routine sediment or water samples,
- one field duplicate sample collected adjacent to one of the routine samples, and
- one control reference standard containing known element concentrations or water blank.



Figure 2. Analytical and field duplicate precision scatter plots for arsenic, gold and bismuth.

Figure 3. Analytical and field duplicate precision scatter plots for chromium, cobalt and copper.



Figure 4. Analytical and field duplicate precision scatter plots for fluoride, iron and tungsten.



Tungsten in moss mat sediments (ppm)

The location of control reference samples within each batch of samples were selected before sampling, whereas field duplicate sites were chosen randomly during fieldwork. Field duplicate samples were generally collected 2-3 metres apart from the same type of material and stream environment.

#### Precision and accuracy of stream and moss sediment data

Element variations in stream and moss sediment can reflect changes in regional geology (bedrock geochemistry, surficial geochemistry, presence of mineralization), within-site variations (combined sampling, analytical and sample preparation variation) or analytical precision alone. Good analytical precision is of little value if the combined sample preparation and collection error is larger than the regional geochemical variation (Fletcher, 1981). The accuracy and precision of neutron activation and aqua regia digestion-atomic absorption analysis used in this project has been determined from duplicate data for CANMET certified standard LKSD 1 (Lynch 1990). The mean concentration of two analyses, percent relative standard deviation (%RSD) and the CANMET recommended values for LKSD 1 are listed in Table 4. No recommended values are available for bismuth and selenium and no %RSD values could be calculated for tantalum, terbium and tungsten because concentrations of these elements in LKSD 1 are below detection limits.

Combined sampling-analytical and analytical precision can be estimated visually by scatterplots showing the correlation between the moss sediment field duplicate and analytical duplicate samples pairs and, more objectively, from correlation coefficients calculated from the scatterplots. Because of the small number of drainage samples collected overall, only seven field duplicate moss mat sediment and nine analytical duplicate samples were analysed. Scatterplots for arsenic (INA), gold (INA), bismuth, chromium, cobalt, copper, fluorine, iron (INA) and tungsten in field and analytical duplicate samples are shown in Figure 2, 3, 4. The correlation coefficients  $(R^2)$  for arsenic, copper, cobalt, chromium, iron, lead, tungsten in both field duplicate sample pairs are greater than 0.9, demonstrating good overall sampling and analytical precision. Arsenic gold, chromium, iron and manganese have higher correlation coefficients for analytical duplicates than for the field duplicates because of the cumulative effect of sampling and analytical variation on the data. However, there are weak (and unexplained) correlations for lead and fluorine in the analytical duplicates compared to the correlation for these elements in the field duplicates. There is no significant correlation ( $R^2 + 0.249$ ) between gold in moss sediment field duplicate samples and this is believed to reflect local differences affecting the entrapment and sorting of sediment by the moss samples, especially when the gold is coarse grained (Matysek et al., 1988).

Table 5. Initial and repeat determinations for bismuth in stream and moss sediments by
aqua regia digestion-hydride atomic absorption.

Sample	Bismuth 1 (ppm)	Bismuth 2 (ppm)	Bismuth 3 (ppm)
008001	1.6	0.8	
998016	1.5	1.2	21
998017	0.7	0.5	0.5
998018	1.0	0.8	0.6
998053	3.6	2.9	7.8
998054	1.6	0.8	0.5
998055	0.6	0.4	0.3
998056	10.0	1.9	0.7
998061	1.0	13.0	1.8
998062	0.2	0.2	0.2
998063	1.2	0.5	0.2
998064	2.9	0.2	0.2
998077	11.0	2.4	0.7
998078	5.5	0.4	0.4
998079	2.0	0.4	0.3
998080	1.8	0.3	0.3
998084	2.3	1.8	1.2
998087	4.4	1.4	0.4
998088	3.8	1.3	10.0
998090	4.2	1.4	0.6
998106	6.1	0.2	13
998117	3.4	2.5	2.0
998118	3.2	8.0	4.7
998119	48.0	42.0	45.0
998120	3.9	3.0	3.8
998121	17.0	0.6	0.4
998122	10.0	2.9	2.8
998123	1.2	1.9	0.4
998124	5.9	0.5	0.5
998125	2.6	1.7	1.4
998126	22.0	34.0	2.8
998128	7.5	3.0	3.4
998129	7.0	1.8	2.3
998130	4.9	11.0	0.4
998131	1.3	1.9	0.5
998136	1.5	0.9	0.2
998141	2.2	0.4	0.2
998143	8.4	1.4	1.9
998150	5.9	0.4	0.3
998155	1.5	0.2	0.2
998159	2.1	1.5	0.7
998160	3.3	0.3	0.0
998101	5.7	0.8	5.2
998163	1.5	1.5	15.0

Analytical precision at the 95 percent confidence limit can be estimated at different concentrations using the method developed by Thompson and Howarth (1978). From data for the nine analytical sample pairs analysed in this study a precision estimate of 16 percent at 100 ppm copper, 11 percent at 10 ppm arsenic, 88 percent at 100 ppb gold and 100% at 10 ppm bismuth can be obtained.

Samples with an initial bismuth concentration above one ppm were re-analysed in duplicate. The original and repeated determinations are listed in Table 5. The large variation between original and repeat analyses for many samples is attributed to the erratic distribution of the bismuth mineralization in the samples. In Appendix B the median bismuth value of the three determinations has been substituted for the original value and has been flagged in bold type.

#### Precision of stream water geochemical data

Analytical precision for uranium, fluoride, pH and sulphate in stream waters is given in Table 6. Precision is expressed as percentage relative standard deviation (%RSD) calculated from values of repeated analyses of a blank water and two internal GSB standards. The precision is typically less than 5 percent except for uranium in GSB standard 2 where percent relative standard deviation is 13.

Table 6. Precision of stream water geochemical data.

	U (ppb)	F (ppb)	pН	SO₄ (ppm)
Blank Mean of 7 analyses	0.07	27	6.3	1
Percent RSD of blank	14	43	2	<1
Mean of GSB Standard 1 (4 analyses)	25	63	6.2	31
Percent RSD of GSB Standard 1	4	2	3	2
Mean of GSB Standard 2 (2 analyses)	0.69	99	1.4	83
Percent RSD of GSB Standard 2	13	2	5	<1

#### Precision and accuracy of aqua regia-ICPMS geochemical data

Mean element concentration and analytical precision (%RSD) calculated from data for aqua regia-ICPMS analyses of three splits of one sample (998001, 998024, 998041) are listed in Table 7. Results for the - 80 and - 230 mesh size fractions of these samples are shown. Precision and mean values for trace elements commonly concentrated in the clay sized fraction (e.g. arsenic, lead, copper, zinc) are higher in the - 230 mesh fraction, whereas elements (e.g. chromium, barium, gold, aluminum and calcium) and elements typically more abundant in coarser material show higher precision in the - 80 mesh fraction.

This comparison of size fraction chemistry demonstrates that while a smaller size fraction can enhances anomaly contrast, the precision may not necessarily be improved for all elements. In Table 8, element analyses by aqua regia-ICPMS for the CANMET standard, Till 4, are compared to the recommended values ("total concentrations") for the standard. Except for arsenic, bismuth and copper where the reported analyses are higher than the recommended values, element

**Table 7.** Precision of aqua regia-ICPMS analysis.

Element	Detection	Mean -80	%RSD -80	Mean -230	%RSD -230
	Limit				
Antimony	0.02	0.62	7.6	0.68	3.9
Arsenic	0.1	11.2	6.3	12.8	3.9
Aluminium	0.01%	1.21	4.6	1.32	5.9
Barium	0.5	66.3	6.1	88.0	5.4
Bismuth	0.02	0.86	33.4	0.86	18.5
Boron	1	1	43	1	43
Cadmium	0.01	0.17	17.3	0.15	10.4
Calcium	1%	0.65	4.1	0.74	6.4
Chromium	0.5	57.5	0.9	44.6	6.5
Cobalt	0.1	13.1	2.2	12.9	5.9
Copper	0.01	31.3	4.0	34.7	2.3
Gallium	0.02	3.7	4.7	3.7	4.1
Gold	0.2 ppb	10	114.6	6	39.7
Iron	0.01%	2.54	1.6	2.23	5.9
Lanthanum	0.5	8.7	7.2	11.8	4.5
Lead	0.01	12.82	20.8	13.83	2.5
Manganese	5	384	4.3	429	4.0
Magnesium	0.01	0.64	3.1	0.60	7.0
Mercury	10 ppb	35	31.2	45	11.0
Molybdenum	2	1.08	46.2	1.25	6.7
Nickel	0.1	25.1	3.2	25.0	5.9
Phosphorus	0.001%	0.072	1,4	0.081	2.8
Potassium	0.01%	0.05	0.1	0.06	9.1
Selenium	0.1	0.5	12.4	0.3	62.4
Silver	2 ppb	146	73.1	126	5.2
Sodium	0.001%	0.017	3.5	0.019	0.1
Strontium	0.5	20	5.1	24	5.7
Sulphur	0.02%	0.03	21.7	0.02	24.7
Tellurium	0.02	0.03	34.6	0.09	72.9
Titanium	0.001%	0.246	1.5	0.224	9.2
Thorium	0.2	2.1	10.1	3.0	9.5
Thallium	0.02	0.02	24.7	0.05	40
Tungsten	0.2	0.03	21.7	0.2	40
Uranium	0.1	0.6	8.7	1.0	14.8
Vanadium	2	76	2.0	69	6.1
Zinc	0.1	39.2	7.1	42.2	5.3

concentrations are in good agreement with those in the standard, allowing for the differences in analytical methods.

Table 9. S	Stream sediment and	l water statistics	for 82M/4, 5,	, 6 and 92P/8	(43 samples)
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Element	Detection	Till 4	Till 4 CANMET		
	Limit	Reported	Recommended		
Antimony	0.02	0.8	1.0		
Arsenic	0.1	118.8	111		
Aluminium	0.01%	1.94	7.6		
Barium	0.5	81.3	395		
Bismuth	0.02	50.52	40		
Boron	1	2	nr		
Cadmium	0.01	0.13	< 0.33		
Calcium	1%	0.13	0.89		
Chromium	0.5	22.3	53		
Cobalt	0.1	7.2	8		
Copper	0.01	249.7	237		
Gallium	0.02	6.8	nr		
Gold	0.2 ppb	6.0	5.0		
Iron	0.01%	3.3	3.3		
Lanthanum	0.5	32.8	41		
Lead	0.01	39.1	50		
Manganese	5	327	490		
Magnesium	0.01	0.54	0.76		
Mercury	10 ppb	9	39		
Molybdenum	2	15	16		
Nickel	0.1	17.3	17		
Phosphorus	0.001%	0.073	0.09		
Potassium	0.01%	0.032	2.70		
Selenium	0.1	0.7	nr		
Silver	2 ppb	152	<200		
Sodium	0.001%	0.026	1.83		
Strontium	0.5	11.2	109		
Sulphur	0.02%	0.06	0.08		
Tellurium	0.02	0.017	nr		
Titanium	0.001%	0.14	0.048		
Thorium	0.2	13	17.4		
Thallium	0.02	0.36	nr		
Tungsten	0.2	154.9	204		
Uranium	0.1	2.8	5.0		
Vanadium	2	45	67		
Zinc	0.1	63.2	70		

### SUMMARY OF RESULTS

#### Summary Statistics

Statistics (mean, median, standard deviation, maximum value, minimum value) for gold, loss on ignition and 39 other elements in stream sediment and moss mat sediment samples for the two survey areas are listed in Tables 9, 10, 11 and 12.

Element	Method	Mean	Median	Max	70%ile	90%ile	95%ile
Antimony	INA	0.3	0.10	1.6	0.2	0.4	1.5
Antimony	AAS	0.2	0.20	0.7	0.2	0.4	0.5
Arsenic	INA	3.5	2.1	15.3	3.0	7.9	13.3
Arsenic	AAS	2.8	1.5	12.0	1.5	6.8	10.7
Barium	INA	650	630	990	720	848	939
Bismuth	AAS	0.5	0.3	3.6	0.3	0.9	1.5
Bromine	INA	7.1	5	30.8	7.9	17.1	22.7
Cadmium	AAS	1.7	0.2	25.6	0.4	1.0	6.1
Calcium (%)	INA	2.7	2.0	25.0	3.0	4.0	4.9
Cerium	INA	101	82	235	116	182	202
Cesium	INA	4	4	11	5	7	8
Chromium	INA	41	26	178	39	93	149
Cobalt	INA	10	9	25	10	19	24
Cobalt	AAS	7	6	14	7	12	12
Copper	AAS	17	16	37	20	27	30
Europium	INA	1.3	1.3	3.5	1.5	1.7	2
Fluorine	ION	237	220	450	274	338	359
Gold (ppb)	INA	3	2	18	2	5	7
Hafnium	INA	8	7	20	8	16	19
Iron (%)	INA	3.06	2.89	6.04	3.7	4.8	5.7
Iron (%)	AAS	1.36	1.2	2.40	1.5	2.0	2.1
Lanthanum	INA	68.9	55.4	176	88.3	121.8	134
Lead	AAS	8	6	38	8	12	17
LOI (%)	GRAV	5.5	4	28.4	5.8	9.4	12.7
Lutetium	INA	0.44	0.39	0.77	0.5	0.6	0.7
Manganese	AAS	454	343	1800	460	771	1113
Mercury (ppb)	AAS	26	30	60	30	30	39
Molybdenum	AAS	2	2	8	2	4	6
Neodymium	INA	33	29	60	38	55	57
Nickel	AAS	11	9	32	8	12	17
Rubidium	INA	92	77	234	121	160	184
Samarium	INA	6.9	6.4	13.3	7.9	9.9	12.1
Scandium	INA	11.1	9.7	31.1	12.2	17.4	28.5
Selenium	INA	3	3	3	3	3	3
Silver	AAS	0.2	0.2	0.8	0.2	0.3	0.4
Sodium (%)	INA	2.33	2.45	2.99	2.5	2.7	2.7
Tantalum	INA	2.7	2	8.7	3.3	5.7	6.3
Terbium	INA	0.8	0.8	1.7	1.0	1.4	1.4
Tin	AAS	1	1	2	1	1	1
Thorium	INA	23.4	13.8	73.2	28.1	50.3	65.2
Tungsten	INA	2	1	7	1	4	6
Uranium	INA	9.6	5.2	46.0	10.7	22.8	27.6
Vanadium	AAS	30	26	65	33	46	54
Ytterbium	INA	2.9	2.6	5.1	3.4	4.2	4.6
Zinc	AAS	46	42	102	54	71	74
Zinc	INA	83	77	160	103	132	140
pH (W)	GCE	7.4	7.4	8.4	7.6	7.8	8.1
Fluoride (W) ppb	ION	74	46	550	55	130	203
Sulphate (W)	TURB	6	3	57	4	12	13
Uranium (W) ppb	FLU	0.66	0.28	6.8	0.63	1.52	1.98

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Table 11. Stream sediment and water statistics for 82F/	1 (26 samples).
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Table 10. Moss	Sediment Da	ta for 82M	I/4, 5, 6 and	92P/8 (42	2 samples).	,		Element	Method	Mean	Median	Max	70%ile	90%ile	95%ile
Floment	Mathad	Meen	Modian	Mor	700/10	000, 110	0507.10	Antimony	INA	0.4	0.3	0.8	0.4	0.6	0.8
Artimony	INIA		Niedian 0.2	1.4	70%ne	90%ne	<u>95%11e</u>	Antimony	AAS	0.2	0.2	0.3	0.2	0.2	0.3
Antimony		0.5	0.2	1.0	0.3	0.4	1.4	Arsenic		4.4	3.1	19.5	3.9	9.1	12.2
Anumony	AAS	0.2	0.2	0.8	0.2	0.2	0.4	Borium	AAS INIA	609	1.0	000	2.0	700	9.0
Arsenic		3.8	2.2	15.8	3.3	0.0	14.9	Biemuth		1 4	07	14	03	07	12
Arsenic	AAS	2.1	1.0	10	2.3	0.9	9.5	Bromine	INIA	107	5.5	65	0.5	21	1.2
Barium	INA	6/6	6/5	1300	750	840	910	Cadmium	244	0.4	0.3	14	0.3	07	12
Bismuth	AAS	1.2	0.3	11.0	0.6	2.3	4.2	Calcium (%)		21	2.0	5.0	3.0	4.0	5.0
Bromine	INA	8.5	6.9	56.3	8.4	15.8	21.9	Cerium	INA	105	175	401	234	361	302
Cadmium	AAS	1.6	.3	24.3	.7	2.0	6.4	Cesium	INA	54	50	12.0	60	7.0	80
Calcium (%)	INA	2.6	2.5	7	3	4	6	Chromium	INA	33	22	110	70	79	100
Cerium	INA	187	128	575	197	367	473	Cobalt	INA	7	6	16	9	12	14
Cesium	INA	4	4	11	4	6	7	Cobalt	244	5	4	12	5	8	11
Chromium	INA	51	36	208	50	104	200	Copper	244	22	9	233	11	21	85
Cobalt	INA	10	9	27	11	23	25	Europium	INA	24	21	55	28	46	4.8
Cobalt	AAS	7	6	14	8	11	13	Eluorine	ION	336	265	800	358	590	620
Copper	AAS	18	16	38	22	27	32	Gold (nnh)	INA	6	205	59	2	10	17
Europium	INA	1.9	1.8	4.2	2.0	2.6	3.0	Hafnium	INA	30	16	84	43	76	77
Fluorine	ION	267	245	570	320	397	410	Iron (%)	INA	3 63	2 64	11.9	4 16	6.81	777
Gold (pph)	INA	65	3	1140	17	44	91	Iron(%)	AAS	1.05	1.00	1.80	12	1.55	1 70
Hafnium	INA	22	15	101	26	48	51	Lanthanum	INA	115	98	211	146	204	209
Iron (%)	ΓΝΔ	4.07	3.86	7 70	4.51	6 59	7 25	Lead		13	8	32	15	26	28
Iron(%)	445	1.43	1.4	22	1.6	1.9	2	LOL(%)	GRAV	84	57	38.2	74	12.8	31.4
Lonthonum	INIA	1.45	04	162	120	244	212	Lutetium	INA	1 13	1.07	2.24	1.51	1.98	215
Lanulanum		120	54	403	139	12	515	Manganese	AAS	296	225	1050	292	453	594
	CDAV	10	6.2	11/	9	13	10	Mercury (nnh)	AAS	34	30	150	30	35	93
LUI (%)	GKAV	0.7	0.3	15.0	1.5	12.4	14.0	Molybdenum	AAS	5	2	34	4	8	18
Lutenum	INA	0.81	0.71	2.90	0.79	1.32	1.61	Neodymium	INA	68	57	165	75	122	142
Manganese	AAS	522	359	2020	610	9/2	1288	Nickel	AAS	4	4	12	4	7	9
Mercury (ppb)	AAS	29	30	80	30	40	50	Rubidium	INA	102	95	196	113	152	163
Molybdenum	AAS	2	2	5	2	3	4	Samarium	INA	13.5	11.6	29.7	16.3	24.7	25.1
Neodymium	INA	56	45	145	68	103	109	Scandium	INA	10.3	7.4	22.5	11.3	20.8	22.1
Nickel	AAS	10	10	27	11	23	24	Selenium	INA	3	3	9	3	3	4
Rubidium	INA	84	76	204	119	130	159	Silver	AAS	0.3	0.2	1.2	0.2	0.3	0.7
Samarium	INA	1.9	1.8	4.2	2.0	2.6	3.0	Sodium (%)	INA	2.24	2.39	3.19	2.69	2.99	3.12
Scandium	INA	13.2	11.6	34.6	15.9	19.9	32.8	Tantalum	INA	8.7	8.3	15.5	11.8	14.5	15.1
Selenium	INA	3	3	3	3	3	3	Terbium	INA	1.7	1.5	3.5	1.9	2.9	3.1
Silver	AAS	0.3	0.2	1.9	0.2	0.3	0.4	Tin	AAS	1	1	1	1	1	1
Sodium (%)	INA	2.3	2.37	2.78	2.47	2.63	2.75	Thorium	INA	63.0	58.8	158.0	86.0	119.5	126.8
Tantalum	INA	5.5	3.6	28.2	6.1	11.3	14.3	Tungsten	INA	22	15	77	24	63	68
Terbium	INA	1.3	1.1	3.8	1.7	2.3	2.9	Uranium	INA	57.8	43.3	155	69.2	119.0	138.5
Tin	AAS	1	1	2	1	1	1	Vanadium	AAS	26	21	56	30	47	53
Thorium	INA	51.1	29.4	208	53.9	128 5	152.2	Ytterbium	INA	7.3	6.7	14.2	9.8	12.9	13.9
Tungsten	INA	6	1	40	6	14	17	Zinc	AAS	46	33	167	40	91	115
Uranium	INA	20.0	9.1	107	20.7	44 4	71.1	Zinc	INA	91	72	221	110	157	188
Vanadium	AAS	30	29	60	33	43	53	pH (W)	GCE	7.2	7.2	7.9	7.3	7.5	7.6
Ytterhium	INA	52	47	16.4	54	82	92	Fluoride (W) ppb	ION	69	60	180	67	110	140
Zinc	200	47	42	116	45	65	103	Sulphate (W)	TURB	2.0	2.0	3.0	2.0	3.0	3.0
Zinc	TNA	87	84	156	101	134	144	Uranium (W) ppb	FLU	1.54	1.05	11.0	1.45	2.55	2.68
£.411154		07	OT	100	101	1.77	1								

#### British Columbia

Element	Method	Mean	Median	Max	70%ile	90%ile	95%ile
Antimony	INA	0.4	0.4	0.7	0.5	0.6	0.7
Antimony	AAS	0.2	0.2	0.4	0.2	0.2	.0.2
Arsenic	INA	4.0	3.1	18.2	4.0	5.3	11.1
Arsenic	AAS	2.6	1.7	14.0	2.0	3.9	10.0
Barium	INA	649	640	1100	750	990	1075
Bismuth	AAS	3.2	0.7	22.0	2.7	8.9	9.8
Bromine	INA	10.7	6.6	67.2	9.2	23.7	29.4
Cadmium	AAS	0.4	0.3	1.3	0.3	0.7	0.7
Calcium (%)	INA	3.0	2.0	7.0	3	6	6
Cerium	INA	225	207	430	299	373	389
Cesium	INA	5	5	9	6	8	8
Chromium	INA	43	25	116	62	101	108
Cobalt	INA	7	6	13	9	12	12
Cobalt	AAS	5	5	8	6	7	8
Copper	AAS	21	8	244	11	25	54
Europium	INA	2.9	2.7	6.0	3.2	4.9	5.3
Fluorine	ION	336	270	790	370	650	675
Gold (ppb)	INA	3	2	14	2	6	8
Hafnium	INA	55	24	177	87	131	156
Iron (%)	INA	4.56	3.66	11.00	5.98	8.60	10.53
Iron (%)	AAS	1.13	1.05	2.10	1.05	1.55	1.60
Lanthanum	INA	141.0	140.0	268.0	197.5	217.5	225.8
Lead	AAS	12	8	31	13	27	28
LOU(%)	GRAV	8.8	6.8	45.6	78	13.5	17.8
Lutetium	INA	1.46	1 41	2.84	1.93	2 43	2 54
Manganese	AAS	294	254	1040	275	438	561
Mercury (nnh)	445	36	30	170	30	45	73
Molyhdenum	AAS	4	2	33	2	9	16
Neodymium	INA	80	76	160	04	137	145
Nickel	112	4	3	100	4	6	2
Pubidium	INIA	4	94	190	102	161	190
Samarium	INA	15.0	16.1	28	10.2	26.2	27 1
Sanatum		10.9	7.6	24	14.3	20.3	27.1
Selenium	INA	10.0	2	12	2	21.5	0
Silver	446	0.3	0.2	12	0.2	02	0.2
Sodium (%)	IN A	2.17	2.21	2.21	2.6	0.2	2.90
Tontolum	INA INA	2.17	12.51	17.9	2.0	2.0	2.09
Tantalum	INA	2.1	2.1	2.4	2.7	10.9	2.2
Terofulli		2.1	2.1	3.4	2.1	3.2	3.5
The adverse	RAS DIA	019	1	270	116 5	200	214.0
Thorium		94.8	84.0	2/8	110.5	200	214.0
lungsten	INA	40	14	402	39	00	105
Uranium	INA	05.4	54.6	150	15.9	117.5	135.3
vanadium	AAS	27	23	52	35	47	49
Ytterbium	INA	9.3	9.2	17.9	13	16	17.1
Zinc	AAS	41	32	155	41	75	84
Zinc	INA	76	59	201	73	125	186

Table 12. Moss sediment statistics for 82F/7 (26 samples).

#### Comparison of stream and moss sediment chemistry

Barium, bismuth, bromine, cerium, chromium, fluorine, hafnium, iron, lanthanum, loss on ignition, lutetium, neodymium, scandium, tantalum, thorium, tungsten and uranium clearly demonstrate higher mean, median and maximum concentrations in moss sediments compared to stream sediments for both survey areas. The partitioning of other elements (e.g. arsenic, manganese, gold) into the different sample media appears to be more dependant on other factors such as catchment basin size, stream characteristics and source material mineralogy. Gold exceeded 1000 ppb in moss mat sediment at two sites in NTS 82M/4, but only reached 18 ppb in stream sediment. However, in 82F/7 the highest gold value was 59 ppb in stream sediment compared to a maximum 34 ppb in moss sediment. The enhanced tungsten, iron and tantalum levels in moss mat samples relative to the stream sediments suggests that the moss preferentially captures heavier minerals (Matysek et al., 1988). Other elements such as antimony, arsenic and cobalt have almost identical mean, median and maximum concentrations in both sample types, or in the case of rubidium and sodium, are lower in the moss mat sediments. This difference could be explained by the different hydraulic behaviour of individual minerals (e.g. gold, scheelite), as opposed to rock grains (containing varying sodium and rubidium), when they are transported by stream water. The relationship between gold, arsenic and tungsten in moss sediment and stream sediment is also demonstrated by the scatter plots shown in Figure 5, where element concentration in moss sediment is plotted as a function of element concentration in stream sediment for samples collected at the same site.

# Regional Moss Sediment, Stream Sediment and Water Geochemistry for 82M/4, 5, 6; 92P/8

The distribution of gold in moss mat sediment samples from the Adams Lake and Newhykulston Creek survey areas is shown in Appendix A-Map 4. The highest gold (1140 ppb) detected in the survey area is in moss sediment at Station 12 from a small stream flowing from the north into the headwaters of Spapilem Creek. Duplicate moss mat samples from this site had 1140 ppb and 159 ppb gold, respectively, illustrating the potential for high variability of gold in moss sediment. Stream sediment from the Spapilem Creek headwaters stream has only 7 ppb gold by comparison to 1140 ppb in the moss sediment (Appendix A-Map 5). This moss sediment sample is also anomalous in cadmium. Moss sediment sample at Station 14 near the mouth of Spapilem creek over 6 kilometres downstream from the headwaters has 1080 ppb gold whereas stream sediment gold levels only reach 18 ppb. This sample also had anomalous (>90<sup>th</sup> percentile) copper, cobalt and lead levels. By contrast to the high values in Spapilem Creek, only 35 ppb gold was detected in the moss sediment from a small stream draining the area around the Cam-Gloria occurrence (Station 5) and no gold was detected in stream sediment (Appendix A-Maps 4, 5). However, this sample contained elevated (>70<sup>th</sup> percentile) barium, bromine, copper, fluorine, lead and zinc concentrations (Appendix A-Maps 11, 13). Moss sediment from Station 1 on Grizzly Creek, draining a large watershed north of Cam-Gloria, had 25 ppb gold, but the steam sediment only contained 5 ppb gold (Appendix A-Map 4). A previous regional stream sediment survey (RGS) reported by Matysek *et al.*, (1991) found a similar, low level of gold (15 ppb) in the stream sediment from Grizzly Creek.

A moss sediment sample from a branch of Newhykulston Creek (Station 8) had 223 ppb gold, and values to 45 ppb could be detected 5 kilometres downstream at Station 10. Only 5 ppb gold occurred in the stream sediment. Moss sediment and stream sediment had similar arsenic levels (Appendix A-Maps 4, 5) and all of the moss sediment samples from Newhykulston Creek (Stations 8,9,10) had strongly anomalous (>95<sup>th</sup> percentile) arsenic, cobalt, nickel and antimony levels. The headwaters of Newhykulston Creek are underlain by a small granite intrusive and up to 51 ppb gold have been found in a basal till sample collected down-ice of the granite (Bobrowsky *et al.*, 1998). A follow-up stream sediment collected close to Station 9 in late 1999 contained 3130 ppb gold (Mike Cathro, pers. comm.)

Moss sediments contained up 11 ppm bismuth compared to 5.5 ppm in stream sediments. The highest bismuth occurred in moss sediment from a north flowing tributary of Bendelin Creek (Station 33) and in a creek south of Stratton Creek (Station 23). None of these samples were anomalous in gold. Anomalous (>90<sup>th</sup> percentile) bismuth, arsenic, lead, silver, tantalum, zinc and fluorine levels also occurred in a moss sediment sample at Station 36 from a creek draining the Baldy Batholith close to the SAN occurrence (Appendix A-Maps 6, 8, 12). Up to 10 ppm bismuth with anomalous (>90<sup>th</sup> percentile) chromium, fluorine and tungsten was present in moss sediment samples from Stations 38 and 39 in a creek east of the Lucky Bear occurrence.

A moss mat sediment sample from a stream flowing north into Gollen Creek (82M/5) had 92 ppb gold in the moss sediment (Appendix A-Map 4). Fisher and Stratton Creeks to the south of Gollen Creek have between 20 and 30 ppb gold in the moss sediment, but only detectable gold in the stream sediment (Appendix A-Maps 4,5). The moss sediment samples from Fisher and Stratton Creeks had anomalous (>90<sup>th</sup> percentile) levels of bismuth, bromine, barium, cobalt, copper, fluorine and molybdenum (Appendix A-Maps 8, 10, 12). In addition, the water in Stratton Creek contained 550 ppb fluoride (Appendix A-Map 16) and 41 ppm sulphate (Appendix A-Map 17). This combination of enhanced gold, fluorine and bismuth in the moss sediment and anomalous water chemistry suggest weathering

of a mineral sulphide source and the presence of fluorite in the Stratton Creek watershed.

Tungsten distribution in moss sediments and stream sediments is shown in Appendix A-Maps 14 and 15. The highest tungsten value (40 ppm) occurred in moss sediment from a south-flowing branch of Bendelin Creek (Station 29). Anomalous tungsten and fluorine levels were detected in moss sediment from Fisher Creek (Station 24) and Gordon Creek (Station 23). Elevated tungsten was also present in the moss mat sediment from a stream near the NSP occurrence (Station 19).

# Regional Moss Sediment, Stream Sediment and Water Geochemistry for NTS 82F/7

The distribution of gold in moss and stream sediment in the Kootenay Lake survey area (NTS 82F/7) is shown in Appendix A-Maps 24 and 25. Gold content in moss sediment samples is lower than in the Adams lake area and the highest value (34 ppb) occurred in a stream flowing into Akokli Creek from the area containing the German Basin and Vancouver showings on the north west side of Mount Sherman. Although no gold was detected in the corresponding sediment, 59 ppb gold was found in the stream sediment at Station 66 where a creek flows into Sanca Creek from the south side of Mount Sherman (Appendix A-Map25). This sediment also had 10 ppm arsenic and 32 ppm lead (Appendix A-Map 27). The highest arsenic in stream sediment (15 ppm) and in moss sediment (14 ppm) occurred at Station 58 from a stream draining the Elmo occurrence (Appendix A-Maps 26, 27). Moss sediment at station 58 also had elevated bismuth (2.9 ppm), silver (1.3 ppm), cadmium (1.3 ppm), copper (244 ppm), fluorine (490 ppm), mercury (170 ppb), lead (28 ppm), tungsten (115 ppm) and zinc (155 ppm). The stream water at this station had 180 ppb fluoride (Appendix A-Map 34). Bismuth increased downstream from this site to a peak concentration of 22 ppm at station 60 (Appendix A-Map 28). The distribution of bismuth in stream sediment, shown in Appendix A-Map 29, is generally similar to that in moss sediment, although the levels are lower. The strongest copper anomaly in moss sediment (244 ppm) and stream sediment (233 ppm) was detected at station 58 (Appendix A-Maps 30 and 31).

Fluorine and tungsten in stream and moss sediment samples for the Kootenay lake survey area were typically higher than for the Adams lake area. The highest fluorine (790 ppm) values occurred in moss sediment at Station 72 from Twin Creeks, a stream that flows west into Kootenay lake (Appendix A-Map 32). Other streams draining the southern part of the Mount Skelley Pluton also have anomalous fluorine in moss sediments (Appendix A-Maps 32 and 33). The highest tungsten (402 ppm) values occurred in moss sediment at Station 60 and lower levels were present in other creeks to the west (Appendix A-Maps 35 and

Sample	Type	<b>A</b> 11	An	A 11	As	Ae	Åe
Number	турс	-80	-230	INA	-80	-230	AAS
998001	Moss	3	9	39	11.7	12.8	8.2
998002	Sediment	-1	1	5	2.6	3.8	2.7
998003	Moss	3	7	25	4	2.5	3.1
<b>998010</b>	Sediment	1	4	-2	1.3	1.7	2.3
998011	Moss	8	29	35	1.5	1.9	1.4
998018	Moss	27	20	223	9.8	10.9	9.3
998023	Sediment	3	5	-2	15	14.6	11
998024	Moss	4	4	45	10.4	13.4	10
998028	Moss	36	2	1140	1.3	1.7	1
998031	Sediment	-1	2	18	1.9	2.9	2.2
998032	Moss	3068	2	1080	4.3	3.2	4.5
998037	Sediment	2	-1	-2	1.2	1.6	1.2
998038	Moss	5	2	18	1.5	1.6	1.5
998042	Sediment	2	1	-2	0.9	1.3	1.0
998043	Moss	46	14	28	3.8	1.7	1.9
998059	Sediment	2	2	-2	2.9	4.2	2.7
998060	Moss	12	242	92	2.6	3.3	2.6
998067	Sediment	-1	1	-2	1.8	2.6	2.5
998068	Moss	1	-1	4	1.6	2.1	1.8
998087	Sediment	1	2	7	9.6	8.3	5.8
998088	Moss	-1	1	2	7.8	7.4	6.7
998125	Sediment	-1	-1	2	1.2	1.7	0.9
998126	Moss	-1	5	-2	1.5	2.4	1.8
998140	Moss	2	3	-2	11.4	13.6	12.0

 Table 13. Size fraction analysis of gold (ppb) and arsenic (ppm).

36). Less than 10 ppm tungsten is present in the moss sediments and stream sediments from creeks draining the German (Gold) Basin Showing on south side of Akokli Creek (including Tungsten Creek).

#### Size Fraction Geochemistry

Analysis of the -230 (<0.063 mm) and -80 (<0.177 mm) size fractions of selected stream sediment and moss sediment samples by aqua regia-ICPMS allows comparison of the different analytical methods available for gold and pathfinder elements. All of the results are listed in Appendix D. In Tables 13 and 14 results of gold, arsenic, bismuth and copper in both -80 and -230 mesh fractions are listed. Also shown are corresponding values for gold by neutron activation and arsenic, copper and bismuth by aqua regia digestion-atomic absorption spectrometry.

For most samples arsenic and copper levels in the -230 mesh fraction are higher than in the -80 mesh. Other geochemically mobile metals (e.g. zinc, cobalt, manganese) also show similar enhancement in the -230 mesh fraction, reflecting

Sample	Туре	Bi	Bi	Bi	Cu	Cu	Cu
Number		-80	-230	AAS	-80	-230	AAS
998001	Moss	0.34	.68	1.6	31.62	34.2	28
998002	Sediment	0.18	0.3	-0.2	23.1	26.16	26
998003	Moss	0.21	0.27	0.2	24.6	23.86	27
998010	Sediment	0.34	0.52	0.4	20.63	29.68	23
998011	Moss	0.37	0.54	0.4	25.36	31.49	27
998018	Moss	1.07	1.09	1.0	26.11	26.78	28
998023	Sediment	0.56	0.7	0.4	36.58	36.9	30
998024	Moss	0.56	0.97	0.6	29.95	35.65	32
998028	Moss	0.15	0.24	1.0	10.6	18.25	14
998031	Sediment	0.18	0.25	0.3	24.32	34.43	25
998032	Moss	0.69	0.39	0.3	36.41	37.24	36
998037	Sediment	0.45	1.06	0.3	15.31	18.94	16
998038	Moss	0.6	0.74	0.5	17.72	18.73	20
998042	Sediment	0.2	0.67	2.4	13.07	16.52	18
998043	Moss	10.29	1.22	1.0	18.33	21.09	20
998059	Sediment	0.3	0.64	0.2	26.9	39.23	26
998060	Moss	0.38	0.36	0.3	23.01	29.58	25
998067	Sediment	2.6	0.43	0.3	7.91	12.57	12
998068	Moss	0.58	1.1	0.5	7.21	7.93	10
998087	Sediment	0.67	1.01	4.4	18.02	23.35	22
998088	Moss	1.31	1.48	3.8	16.62	22.07	22
998125	Sediment	5.75	5.28	2.6	18.94	23.94	20
998126	Moss	6.94	8.61	22.0	22.75	36.48	27

Table 14. Size fraction analysis for bismuth (ppm) and copper (ppm).

concentration of these metals in the fine silt and clay sized material of the sample. However, gold and bismuth show less consistent distribution trends in the -230 mesh fraction. In some samples (e.g. 998060) gold levels are higher in the -230 mesh whereas in others (e.g. 998032 and 998043) gold and bismuth are more abundant in the -80 mesh. Although large gold variations can be expected in the small sample (typically 1 gram) used for the aqua regia-ICPMS analysis, the results suggest that gold and bismuth in moss sediment from some streams are present as coarser grains. Results of aqua regia-ICPMS analysis are similar to those obtained by aqua regia-atomic absorption spectrometry allowing for differences in the conditions of the aqua regia digestion and the analytical method.

#### Heavy Mineral Concentrate Geochemistry

Neutron activation and aqua regia-ICPES results of the heavy mineral (-150, non-magnetic, >3.27 SG) fraction of the bulk stream sediment samples are listed in Appendix E. Also listed in Appendix E are weights of the initial -18 (<1 mm) fraction, weights of the magnetic (HM), paramagnetic (HP) and nonmagnetic (HN) -150 mesh, heavy (>3.27 SG) fractions and the standardized weight of gold

Table 15. Gold (ppb) and trace elements in heavy mineral concentrates.

Sample	Station	Au-H	Au-M	As	Bi	Cu	W	S
-		(ppb)	(ppb)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
999002	1	4530	25	-2	-10	91	212	10800
999003	2	9480	-2	-2	-10	74	154	22180
999004	3	50	-2	14	11	35	167	3842
999005	5	12200	35	13	-10	35	148	7741
999006	6	57	-2	-2	-10	39	405	8682
999007	7	-5	-2	-2	17	41	934	3674
999008	9	59600	75	38	-10	36	294	4384
999009	10	16600	45	258	22	223	418	12300
999010	11	18600	5	-2	-10	27	299	902
999011	13	-5	6	-2	-10	27	-4	1011
999012	14	7610	1080	25	-10	168	46	19951
999013	15	27	-2	-2	-10	29	476	299
999014	16	579	18	17	-10	33	52	1085
999015	18	2230	28	20	51	38	312	2717
999016	24	5210	26	-2	60	60	287	7756
999017	27	103	7	-2	35	18	145	3238
999018	29	4530	4	42	37	23	663	612
999019	34	20	4	-2	141	25	207	2459
999020	38	52	2	175	60	133	283	87115
999022	50	96	-2	-2	-10	96	716	6040
999023	53	7240	-2	-2	-10	21	891	216
999024	57	37	-2	-2	-10	23	30200	286
999025	59	46	-2	-2	548	96	2070	575
999026	65	-5	3	-2	164	21	1080	119
999027	69	27	34	-2	38	14	681	212

in micrograms for a 10 kilogram (< 1 mm) sample. The standardized weight shown in Appendix D was calculated from measured concentrations of gold in the -150, non-magnetic, >3.27 SG fraction. In Table 15 the gold concentrations in the heavy mineral fraction are compared to gold values in the moss sediment. A comparison of streams where there were enhanced (above 70 percentile) heavy mineral gold levels (> 5074 ppb) to streams with elevated moss sediment (> 17 ppb) reveals that there were 8 stations with anomalous heavy mineral gold values and 9 with anomalous moss sediment gold values.

There are other geochemical indicators of mineralization in addition to gold. For example, while the gold content of moss sediment at Station 24 is below 44 ppb, the sample was anomalous in bismuth, fluorine, molybdenum and tungsten, elements that are pathfinders for pluton-related quartz-vein gold deposits. High arsenic, bismuth, copper, tungsten and sulphur in heavy mineral concentrates also suggests a greater abundance of mineral sulphides in the samples from stations 10, 24 and 38. The heavy mineral concentrate gold values shown in Appendix A-Map Table 16. Rock Geochemistry for 82M/4, 5, 6 and 82P/8 (9 samples).

Element	Method	Mean	Median	Max	95%ile
Antimony	INA	0.1	0.1	0.2	0.1
Arsenic	INA	0.8	0.6	1.5	1.4
Barium	INA	97	68	290	234
Cerium	INA	73	71	141	121
Cesium	INA	3	3	6	5.5
Cobalt	INA	2	2	3	1
Copper	ICP	3	2	8	8
Europium	INA	0.7	0.7	1.3	1.2
Gold (ppb)	INA	3	2	8	6
Hafnium	INA	4	4	5	2
Iron (%)	INA	1.29	1.37	2.06	1.87
Lanthanum	INA	30	29	64	55
Lead	AAS	5	4	8	8
Lutetium	INA	0.20	0.18	0.34	0.05
Manganese	ICP	280	301	387	363
Molybdenum	ICP	1.0	1.0	2	2
Neodymium	INA	19	21	31	28
Nickel	ICP	2	2	5	4
Rubidium	INA	160	160	289	287
Samarium	INA	3.7	3.5	5.0	4.8
Scandium	INA	3.8	3.6	5.4	5.3
Sodium (%)	INA	2.72	2.50	3.85	3.71
Tantalum	INA	1.8	1.7	4.0	3.4
Terbium	INA	0.5	0.5	0.6	0.5
Thorium	INA	22	23	36	35
Uranium	INA	5.1	3.8	10.3	10.0
Vanadium	ICP	14	11	40	34
Ytterbium	INA	1.3	1.2	2.2	2.0
Zinc	AAS	34	34	50	14

18 identifies strong gold anomalies in the stream draining the Cam Gloria occurrence, and in Spapilem and Newhykulston Creeks.

There was only one sample site from Station 53 with anomalous heavy mineral gold (7240 ppb) in the Kootenay Lake area (Appendix A-Map 37). Although there were no moss sediment or stream sediment gold anomalies at this station, the stream drains the headwaters of Sanca Creek covering an estimated area of 30-40 square kilometres. The highest tungsten values (30,200 ppm) in the heavy mineral samples were from the stream flowing from the area of the Elmo occurrence.

#### Rock Sample Geochemistry

Neutron activation and aqua regia-ICPES results of rock sample analysis are listed in Appendix F. Sample locations are shown in Appendix A-Maps 3 and 23. Although most of the rock types sampled in the Adams Lake area were granite, the suite collected includes orthogneiss and volcanic rocks. Background levels for elements in granite have been calculated at mean, median and at the 95<sup>th</sup> percentile concentration from data for nine selected granite samples (Table 16). No detectable levels of bismuth, bromine, cadmium, mercury, selenium and tin were found in the nine granite samples used to calculate the statistics. Chromium values are not reported because of contamination from the chromium-steel milled used to prepare the samples. However, samples of molybdenite bearing quartz vein hosted by granite near Station 32 contain up to 2720 ppm molybdenum and 54 ppm bismuth. No gold was detected in the sample.

### DISCUSSION

Stream geochemistry of the Adams Lake area revealed that the gold content of moss sediment is much higher than stream sediment collected at the same sample site. However, gold is highly variable in duplicate moss sediment samples. This pattern of gold enhancement and high variability is consistent with the results of previous geochemical studies where both sample media were compared (Matysek and Day, 1987). Results of different size fraction analyses suggest that in some creeks the gold captured by moss is relatively coarse grained. Other elements such as tungsten and chromium are also enriched in the moss sediment relative to stream sediment, but they exhibit less variability in field duplicates than gold. In the Kootenay Lake area the highest gold value occurred in stream sediment rather than moss mat sediment. In addition, the anomalous gold stream sediment and moss sediment samples are from different streams. The reason for this disparity is presently unknown.

Pluton-related gold deposits range from intrusion-hosted, low grade, large tonnage sheeted and stockwork low sulphide vein systems (e.g. Fort Knox, Alaska) to high grade auriferous quartz veins and bodies peripheral to granitoid intrusions (e.g. Pogo Claims, Alaska). A key exploration guideline proposed for this type of deposit is the association of the gold with bismuth, tungsten and arsenic (Logan, 2000). Anomalous molybdenum, tellurium and fluorine may also be related to the pluton-related gold mineralization. The stream sediment anomalies associated with known pluton-related quartz-vein gold deposits have typically low gold contrast.

The Cam Gloria occurrence has several geological and geochemical characteristics of this type of pluton-related deposit. Gold occurs in one of several

Area	Station	Moss sed. Au (ppb)	Stream Sed. Au (ppb)	Heavy Mineral Au (ppb)	Associated Elements
Α	12	1140	<2	No sample	Cd, Br
Α	14	1080	18	7610	As, Co, Cu, Pb
Α	5	35	<2	12200	Br, Cu, Ni, Zn
В	8	223	<2	No sample	As, Co, Cr, Cu, Mo, Ni, Sb
В	9	75	5	59600	As, Co, Cr, Cu, Ni, Sb
В	10	45	<2	16600	As, Co, Cr, Cu, Ni, Sb
С	23	18	<2	No sample	Ba, Bi, F, Mo, Ta, W
С	24	26	<2	5210	Ba, Bi, F, Mo, Ta, W
С	25	21	<2	No sample	Br, Co, Cu, Mo, Ni
С	26	92	<2	No sample	As, Br, Cu, Mo
D	18	28	<2	2230	Bi, W

 Table 17. Stream geochemical anomalies for 82M/4, 5 and 92P/8.

quartz veins (possibly sheeted) that are hosted by altered quartz monzonite of the Honeymoon Bay stock. Up to 3746 ppb gold, 61.4 ppm silver, 87 ppm arsenic, 123 ppm bismuth, 794 ppm copper, 420 ppm lead, 33 ppm molybdenum, 4.1 ppm tellurium and 86 ppm tungsten have been reported in various grab samples taken from the Main vein (Cathro and Lefebure, 2000).

Integration of stream and till geochemistry for the area surrounding the Cam Gloria main vein provides a guide to the size and contrast of gold geochemical dispersal and of the pathfinder element signature. In Appendix A-Map 20 the gold content of stream sediment, moss sediment, heavy mineral concentrate and basal till samples is displayed. Till geochemistry reveals that gold content declines from 215 ppb to 43 ppb roughly 1.5 km down-ice from the vein. Only the till sample nearest to the Main vein had enhanced arsenic, bismuth, lead and tungsten values with gold (Bobrowsky et al., 1997). Similarly, moss sediment and heavy mineral samples from the stream draining the area of the Main vein had anomalous gold with a multi-element anomaly that includes some (but not all) of the elements abundant in the auriferous quartz vein (Appendix A-Map 21). Background gold levels occur in the heavy mineral concentrate at Station 3 downstream from this anomaly. There was insufficient moss sediment at this site for a gold analysis. Overall, the stream geochemical expression of the Main vein gold mineralization is subdued and the stream and moss sediment anomaly may reflect mineralized bank material washed into the stream from the till.

One limitation of using pathfinder element geochemistry to identify a specific type of mineralization is that other mineral associations can also produce a similar

signature, especially where secondary dispersion of elements is involved. One example where the bismuth may be a misleading indication for pluton-related quartz-vein gold mineralization may be moss sediment bismuth anomalies near the headwaters of Bendelin Creek where the source is most likely quartz veins containing bismuth minerals and molydenite.

There are several moss sediment and heavy mineral anomalies in the Adams Lake area where gold levels and multi-element signatures suggests a possible pluton-related mineralized source for the anomaly (Appendix A-Map 19). Elements (levels above the 70<sup>th</sup> percentile level) associated with gold for these areas are summarised in Table 17. Area A represents Cam Gloria and Spapilem Creek. The reason for high bromine in moss sediment in this area is presently unknown. Newhykulston Creek (Area B) has a strong arsenic, antimony, cobalt, chromium, nickel association with the gold and presently there is no known source for this anomaly. Area C is of interest because of the several pluton-related gold pathfinders (e.g. tungsten, molybdenum) and a water sulphate-fluoride anomaly. There is presently no identified mineral source for the high values. Area D is close to the Lucky Bear occurrence and has a weak bismuth-tungsten association. Of the three areas outlined in 82F/7 (Appendix A Map 38, Table 18) area C has the most significant gold in the heavy mineral concentrate, but no corresponding multi-element association.

Table 18. Stream geochemical anomalies for 82F/07.

Area	Station	Moss sed. Au (ppb)	Stream Sed. Au (ppb)	Heavy Mineral Au (ppb)	Associated Elements
A	66	<2	59	No sample	As, Pb
В	69	34	<2	No sample	Ag, Cd, Cu, Pb, Zn
С	53	<2	<2	7240	-

# CONCLUSIONS AND EXPLORATION GUIDELINES

Stream geochemistry in the Adams and Kootenay Lake areas has shown that:

- 1. Moss mat sediments and heavy mineral concentrates provide higher geochemical contrast and a generally stronger indication of gold mineralization than routine RGS stream sediments.
- 2. Moss sediment and heavy mineral gold geochemistry has highlighted several drainage basins within the Baldy Batholith and Mount Skelley Pluton where the multi-element associations suggest new areas of plutonrelated mineralization. However, there may be other sources for typical

pathfinder elements (e.g. Bi, Mo) such as bismuth enriched molybdenitebearing quartz veins in granite.

- 3. The high variability of gold and bismuth in moss sediments suggests that these elements are present in relatively coarse grains. Heavy minerals recovered from large bulk samples (10 kilogram) can reduce this variability, although the sampling is slower than collecting moss sediments.
- 4. Results for most elements (except gold and bismuth) obtained by aqua regia-ICPMS are similar to those determined by aqua regia-AAS.
- 5. Analysis of the -230 (<0.063 mm size) fraction rather than the -80 (<0.177 mm) fraction has only a slight improvement on anomaly contrast for most metals.
- 6. The recommended sampling density for moss sediment or heavy minerals is 1 sample per 10 square kilometres. Follow-up basal-till samples should be collected at a density of 1 to 2 samples/1 square kilometre to trace the up-source of the stream anomaly

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