Geochemical Exploration Techniques for Plutonic-related Gold Deposits in Southern B.C. (NTS 82M/4, M/5, M/6 and 82F/7)

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INTRODUCTION

Discovery of the Liese Zone on the Pogo property in Alaska (containing an estimated 9.98 million tons of ore grading 0.52 oz gold/ton) where gold-arsenic-copper-bismuth mineralization occurs in gneiss-related quartz bodies close the margin of a Cretaceous batholith (Smith *et al.,* 1999) has stimulated exploration for similar plutonic-related gold deposits in British Columbia. 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 266), a gold-bismuth-lead mineralized, granite-hosted quartz vein, in southern B.C. (Matysek *et al.,* 1991). This occurrence was found in 1997 by prospecting after anomalous gold values were identified in a regional till sample close to the mineralized vein (Bobrowsky *et al.,* 1997).

There is presently limited published information about the geology or the application of geochemistry for plutonic-related gold deposits in British Columbia. These deposits may be difficult to find by traditional stream sediment surveys because the gold and associated pathfinder elements such as tin, 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 Pogo property is located) and therefore gold anomaly contrast may be more subdued. In general, gold anomaly contrast can be improved using more appropriate sample media such as moss mat sediment or a heavy mineral fraction (Matysek and Day, 1987).

A study was carried out in August 1999 by the authors to compare the geochemical response of intrusive-related gold mineralization in different reconnaissance scale sample media such as stream sediment, moss mat sediment and heavy mineral concentrates. The study is part of a Geological Survey Branch initiative to examine the potential for intrusive-related gold deposits in the Province. Results of the geological component are described by Logan, 2000, Geological Fieldwork 1999, Paper 2000-1, this volumes). Geochemical samples were collected in two areas of southern British Columbia, one near Adams Lake and the other east of Kootenay Lake.

Objectives of this study were to 1) develop a better understanding of the stream geochemical response of plutonic-related mineralization; 2) compare the merits (cost effectiveness) of different stream sampling, sample preparation and analytical methods to improve the ability of stream sediment geochemistry to detect plutonic-related gold mineralization; 3) add value to the current RGS database to stimulate future mineral exploration and; 4) evaluate other factors such as element backgrounds in different sample media and bedrock types for improving methods of geochemical data interpretation.

This paper describes the survey areas, sampling technique, the sample preparation and analytical methods used and discusses preliminary geochemical results.

ADAMS LAKE SURVEY AREA DESCRIPTION
(NTS 82M/4, M/5, M/6 and 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 266) 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 (Figure 1).

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

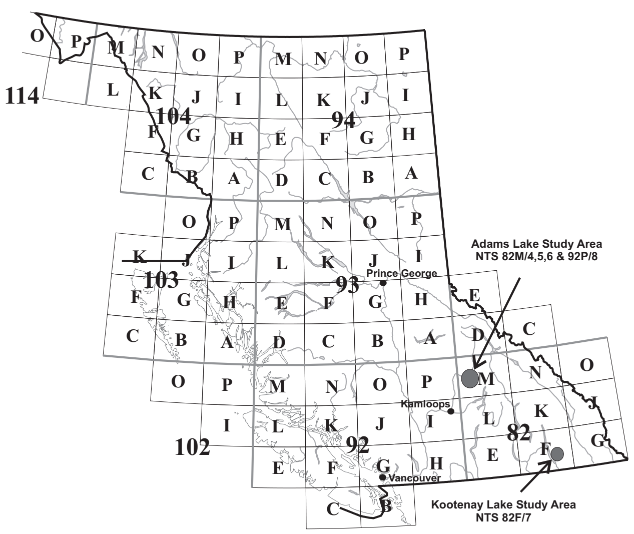

Figure 1. Location of survey areas.

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.

Bedrock Geology

The survey area is partly underlain by Cambrian to Mississippian rocks of the Eagle Bay Assemblage and Fennell Formation and by the mid-Cretaceous Baldy Batholith. The Eagle Bay Assemblage, part of the Kootenay Terrane, was originally deposited along the ancestral margin of North America. Older Eagle Bay rocks range from quartzites, quartz-rich schists and limestone. 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. 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 Eagle Bay Assemblage. The mid-Cretaceous Baldy Batholith is predominantly massive light-grey, coarse-grained quartz monzonite. Xenoliths of country rock are common close to the contact of the Batholith with the Eagle Bay Assemblage. The eastern and northern margins of the Batholith are marked by medium-grey biotite and muscovite Devonian orthogneiss. In addition to the Baldy Batholith there are several smaller satellite intrusive granitic bodies and one of these 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

The principal mineral occurrence in the survey area is the Cam-Gloria Gold property (MINFILE 82M 266) 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 centimeter wide quartz-pyrite-pyrrhotite vein.

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.

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 of those 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°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

Most of the survey area is underlain by rocks of the Cretaceous Bayonne Batholith. This Batholith comprises white to light-grey, medium to coarse-grained biotite granite and quartz monzonite. These rocks intruded siltstones and quartzites of the Creston Formation which forms the lower part of the Proterozoic Purcell Supergroup. The contact between the Creston Formation and Bayonne Batholith is located just south of Akokli Creek and trends northwest to southeast (Borovic, 1987).

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 occurrence in the survey area are typically polymetallic gold-silver-lead-zinc-tungsten veins and mineralized quartz vein stockworks hosted by the granite and quartz monzonite. The Valparaiso occurrence (MINFILE 82FSE 038), located north of Ginol Creek and south of Akokli Creeks is a quartz-filled fissure containing pyrite, arsenopyrite, wolframite, galena, sphalerite and chalcopyrite in granite and granodiorite locally altered to chlorite and sericite. Gold and silver are disseminated in the quartz. 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. 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 the study was to compare the geochemical response from plutonic-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. 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.

A total of 68 stream water, 74 stream sediment and 74 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 25 sites in 82F/7 (Kootenay Lake area). In addition 25 bulk screened sediment samples were taken from selected sites for analysis of gold and other elements in a -150 (<100 micron) mesh heavy mineral fraction. The bulk samples 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 millimetre) nylon screen to recover 10 kilograms of <1 millimetre sized sediment. Wet

TABLE 1
SUMMARY OF SAMPLES COLLECTED

Element	82M/4,5,6	92P/8	82F/7	Total
Stream Sediment	42	4	28	74
Moss Mat Sediment	42	4	28	74
Bulk Sediment	17	2	6	25
Water	40	3	25	68
Water Filter	17	2	6	25
Rock	16	0	1	17

sieving typically needed one hour to obtain 10 kilograms of the <1 millimetre fraction and the material was then stored in a heavy-duty plastic bag.

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. A two litre bulk water sample was collected at selected sites (generally where a bulk sediment was taken) and later filtered through a 0.45 micron filter to recover the suspended sediment.

Considerable effort was made to chose 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 a 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.

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 (<177 micron) 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.

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 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 Matysek *et al.,* 1991. Fluorine content of samples was determined by the sodium carbonate-nitric acid fusion-fluoride 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. Aluminium 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 iobutyl ketone extraction and flame atomic absorption spectrometry (NAIAA) 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^{o}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, gold, hafnium, iron, lanthanum, lutetium, nickel, rubidium, samarium, scandium, sodium, tantalum, terbium,

TABLE 2
REPORTED DETECTION LIMITS

Element	N	Mthd	D.L.	Unit
Antimony	Sb	INA	0.1	ppm
Arsenic	As	INA	0.5	ppm
Barium	Ba	INA	50	ppm
Bromine	Br	INA	0.5	ppm
Calcium	Ca	INA	1	%
Cerium	Ce	INA	3	ppm
Cesium	Cs	INA	1	ppm
Chromium	Cr	INA	5	ppm
Cobalt	Co	INA	1	ppm
Europium	Eu	INA	2	ppm
Gold	Au	INA	2	ppb
Hafnium	Hf	INA	1	ppm
Iron	Fe	INA	0.01	%
Lanthanum	La	INA	0.5	ppm
Lutetium	Lu	INA	0.05	ppm
Neodymium	Nd	INA	5	ppm
Rubidium	Rb	INA	15	ppm
Samarium	Sm	INA	0.5	ppm
Scandium	Sc	INA	0.1	ppm
Sodium	Na	INA	0.01	%
Tantalum	Ta	INA	0.5	ppm
Terbium	Tb	INA	0.5	ppm
Thorium	Th	INA	0.2	ppm
Tungsten	W	INA	1	ppm
Uranium	U	INA	0.5	ppm
Ytterbium	Yb	INA	0.2	ppm
Bismuth	Bi	AAS-H	0.2	ppm
Cadmium	Cd	AAS	0.2	ppm
Cobalt	Co	AAS	2	ppm
Copper	Cu	AAS	2	ppm
Iron	Fe	AAS	0.02	%
Lead	Pb	AAS	2	ppm
Loss on Ignition	LOI	GRAV	0.1	%
Mercury	Hg	AAS-F	10	ppb
Manganese	Mn	AAS	5	ppm
Molybdenum	Mo	AAS	1	ppm
Nickel	Ni	AAS	2	ppm
Silver	Ag	AAS	0.2	ppm
Tin	Sn	NAIAA	1	ppm
Vanadium	V	AAS	5	ppm
Zinc	Zn	AAS	2	ppm
Fluoride (waters)	FW	ION	20	ppb
pH (waters)	pH	GCE		
Sulphate(waters)	S0$_4$	TURB	1	ppm
Uranium (waters)	UW	AAS	0.05	ppb

thorium, tungsten, uranium, ytterbium and zinc using thermal, instrumental neutron activation analysis (INAA) by Activation Laboratories (Ancaster, Ontario). Instrumental neutron activation analysis involves irradiating the sediment samples, which range from 1 to 46 grams for 30 minutes with neutrons (flux density of 7×10^{11} neutrons/cm^2/second). After approximately 1 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 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 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.

PRELIMINARY RESULTS

Neutron activation data for stream sediment and moss mat sediment samples are discussed in this paper. Because of the small number of drainage samples collected only six field duplicate moss mat sediment and eight analytical duplicate samples were analysed. The R^2 correlation coefficients are greater than +0.9 for most elements in the field duplicate sample pairs and in the analytical duplicate sample pairs. This demonstrates good sampling and analytical reliability. An exception is the poor correlation (R^2 coefficient + 0.227) between gold values for moss sediment field duplicate samples (Table 3). This large variation between duplicate samples has been observed by Matysek, Gravel and Jackaman, (1988) and is believed to reflect local differences affecting the entrapment and sorting of sediment by the moss.

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 are listed in Tables 4 and 5. Data from both survey areas was combined to calculate the statistics. The majority of elements demonstrate higher mean, median and maximum concentrations in moss mat sediments compared to stream sediments. Most notable is gold that exceeds 1000 ppb in moss mat sediment from two sites, but only reaches 59 ppb in stream sediments.

TABLE 3
ARITHMETIC CORRELATION COEFFICIENTS FOR ANALYTICAL AND FIELD DUPLICATE SAMPLES

Element	Analytical Duplicates	Field Duplicates
Gold	$R^2 = 0.998$	$R^2 = 0.227$
Arsenic	$R^2 = 0.983$	$R^2 = 0.987$
Chromium	$R^2 = 0.984$	$R^2 = 0.968$
Tungsten	$R^2 = 0.955$	$R^2 = 0.973$

TABLE 4
STATISTICS FOR MOSS MAT

Element	Unit	Mthd	N	Mean	Med	Std Dev	Min	Max	> D.L.
Antimony	ppm	INA	68	0.4	0.3	0.3	0.1	1.6	45
Arsenic	ppm	INA	68	3.9	2.6	3.9	0.5	18.2	60
Barium	ppm	INA	68	665	650	213.05	50	1300	67
Bromine	ppm	INA	68	9.3	6.8	11.11	0.5	67.2	62
Calcium	%	INA	68	2.63	2	1.72	1	7	44
Cerium	ppm	INA	68	201	165	125.2	50	575	68
Cesium	ppm	INA	68	4	4	1.99	2	11	68
Chromium	ppm	INA	68	48	34	45.62	5	208	67
Cobalt	ppm	INA	68	9	8	5.61	2	27	68
Europium	ppm	INA	68	2.2	1.9	1.12	0.9	6	26
Gold	ppb	INA	68	41	2	188.16	2	1140	28
Hafnium	ppm	INA	68	35	20	39.49	3	177	68
Iron	%	INA	68	4.26	3.83	2.24	1.4	11	68
Lanthanum	ppm	INA	68	132.5	104	87.45	24.8	463	68
Lutetium	ppm	INA	68	1.06	0.78	0.67	0.36	2.96	68
Neodymium	ppm	INA	68	65	53	36.37	24	160	68
Rubidium	ppm	INA	68	89	87	46.93	15	204	61
Samarium	ppm	INA	68	13.1	11	6.44	5.5	28	68
Scandium	ppm	INA	68	12.3	10.7	7.05	3.6	34.6	68
Sodium	%	INA	68	2.25	2.36	0.47	0.77	3.21	68
Tantalum	ppm	INA	68	7.6	5.9	6	0.5	28.2	62
Terbium	ppm	INA	68	1.6	1.5	0.9	0.5	3.8	57
Thorium	ppm	INA	68	67.8	35.9	65.21	6.1	278	68
Tungsten	ppm	INA	68	19	4	51.5	1	402	42
Uranium	ppm	INA	68	37.3	21.9	37.4	1.5	150	68
Ytterbium	ppm	INA	68	6.8	5.2	4.18	2.3	17.9	68
Bismuth	ppm	AAS-H	69	1.9	0.4	3.65	0.2	22	49
Cadmium	ppm	AAS	69	1.3	0.3	3.6	0.2	24.3	44
Cobalt	ppm	AAS	69	6	5	2.76	2	14	67
Copper	ppm	AAS	69	19	12	29.27	6	244	69
Iron	%	AAS	69	1.3	1.3	0.37	0.6	2.2	69
Lead	ppm	AAS	69	11	7	14.4	2	117	67
LOI	%	GRAV	69	7.8	6.6	6.42	1.1	45.6	69
Mercury	ppb	AAS-F	69	32	30	20.86	10	170	65
Manganese	ppm	AAS	69	433	295	345.85	126	2020	69
Molybdenum	ppm	AAS	69	3	2	4.47	1	33	38
Nickel	ppm	AAS	69	8	5	6.29	2	27	61
Silver	ppm	AAS	69	0.3	0.2	0.25	0.2	1.9	12
Tin	ppm	NAIAA	69	1	1	0.28	1	2	6
Vanadium	ppm	AAS	69	28	27	11.68	11	60	69
Zinc	ppm	AAS	69	45	39	25.17	17	155	69

TABLE 5
STATISTICS FOR STREAM SEDIMENT SAMPLES

Element	Unit	Mthd	N	Mean	Med	Std Dev	Min	Max	> D.L.
Antimony	ppm	INA	68	0.3	0.2	0.3	0.1	1.6	39
Arsenic	ppm	INA	68	3.9	2.4	3.81	0.5	19.3	63
Barium	ppm	INA	68	636	600	153.9	300	990	68
Bromine	ppm	INA	68	8.4	5	10.64	0.5	65	59
Calcium	%	INA	68	2	2	3.04	1	25	38
Cerium	ppm	INA	68	135	99	91.13	29	401	68
Cesium	ppm	INA	68	5	4	2.1	1	12	67
Chromium	ppm	INA	68	38	23	38.22	5	178	64
Cobalt	ppm	INA	68	9	8	5.5	2	25	68
Europium	ppm	INA	68	1.7	1.4	1.05	0.2	5.5	14
Gold	ppb	INA	68	4	2	7.46	2	59	17
Hafnium	ppm	INA	68	15	8	18.92	1	84	67
Iron	%	INA	68	3.25	2.83	1.85	1.03	11.9	68
Lanthanum	ppm	INA	68	85.5	69.8	52.04	18.8	211	68
Lutetium	ppm	INA	68	0.69	0.48	0.5	0.24	2.24	68
Neodymium	ppm	INA	68	45.5	36	31.68	14	165	68
Rubidium	ppm	INA	68	96	90	45.72	15	234	66
Samarium	ppm	INA	68	9.2	7.2	5.66	3.4	29.7	68
Scandium	ppm	INA	68	10.7	9.6	6.44	2.5	31.1	68
Sodium	%	INA	68	2.29	2.39	0.54	0.65	3.19	68
Tantalum	ppm	INA	68	4.8	3	4.31	0.5	15.5	56
Terbium	ppm	INA	68	1.1	1	0.69	0.5	3.5	51
Thorium	ppm	INA	68	37.2	24.4	35.5	2.3	158	68
Tungsten	ppm	INA	68	9	1	17.42	1	77	32
Uranium	ppm	INA	68	27.6	11.4	35.35	1.4	155	68
Ytterbium	ppm	INA	68	4.5	3.4	3.21	1.5	14.2	68
Bismuth	ppm	AAS-H	69	1.1	0.3	1.59	0.2	7.5	43
Cadmium	ppm	AAS	69	1.2	0.3	4.2	0.2	25.6	37
Cobalt	ppm	AAS	69	6	5	2.76	2	14	68
Copper	ppm	AAS	69	19	12	29.36	6	233	69
Iron	%	AAS	69	1.24	1.2	0.43	0.5	2.4	69
Lead	ppm	AAS	69	10	7	7.83	2	38	68
LOI	%	GRAV	69	6.6	4.4	6.85	0.6	38.2	69
Mercury	ppb	AAS-F	69	29	30	19.86	10	150	63
Manganese	ppm	AAS	69	394	289	311.6	89	1800	69
Molybdenum	ppm	AAS	69	3	2	4.79	1	34	43
Nickel	ppm	AAS	69	9	6	7.19	2	32	62
Silver	ppm	AAS	69	0.3	0.2	0.16	0.2	1.2	10
Tin	ppm	NAIAA	69	1	1	0.12	1	2	1
Vanadium	ppm	AAS	69	29	25	12.66	11	65	69
Zinc	ppm	AAS	69	46	38	26.18	17	167	69

Tungsten, iron and tantalum are also enhanced in moss mat samples relative to the stream sediments suggesting that the moss preferentially captures heavier minerals (Matysek, Gravel and Jackaman, 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 these 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 2 where element concentration in moss sediment is plotted as a function of element concentration in stream sediment for samples collected at the same site.

The distribution of gold in moss mat sediment samples from the Adams Lake and Newhykulston Creek survey areas is shown in Figure 3. The highest gold (1140 ppb) detected in the survey area is in moss mat sediment from a small stream flowing from the north into the headwaters of Spapilem Creek. Duplicate moss mat samples from this site have 1140 ppb and 159 ppb gold, respectively, illustrating the potential for high variability of gold in moss sediment. Sediment from the Spapilem Creek headwaters stream only has 7 ppb gold by comparison to 1140 ppb in the moss mat sediment (Figure 4). A gold concentration of 1080 ppb was found in a moss sediment sample near the mouth of the creek over 6 kilometres downstream from the headwaters. Stream sediment gold levels only reach 18 ppb at this site. By contrast to the high values in Spapilem Creek, 35 ppb gold occurs in the moss sediment from a small stream draining the area around the Cam-Gloria occurrence. No gold was detected in stream sediment. Moss mat sediment from Grizzly Creek draining a larger watershed just north of Cam-Gloria has 25 ppb gold, but the sediment only contains 5 ppb gold (Figure 4). A previous regional stream sediment surveys (RGS) reported by Matysek *et al.,* (1991) found a similar, low level of gold (15 ppb) in the stream sediment from Grizzly Creek.

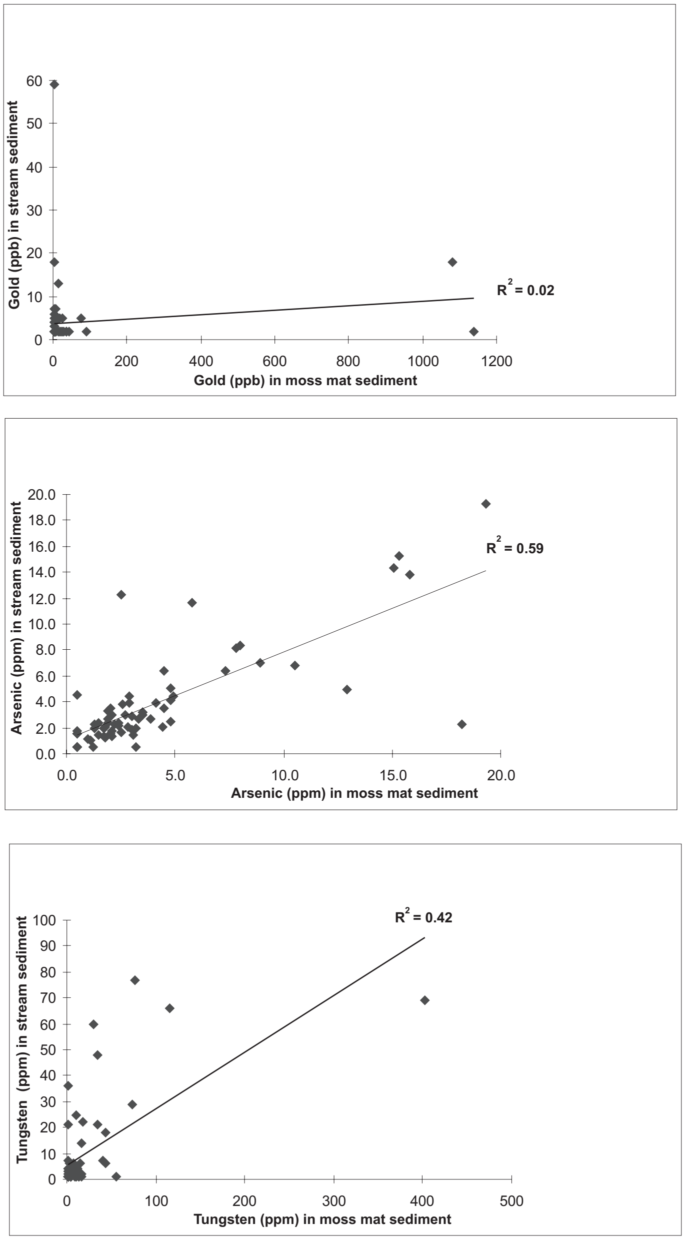

Figure 2. Scatter plots for elements in stream and moss mat sediment.

A moss mat sediment sample from a branch of Newhykulston Creek has 223 ppb gold, and values to 45 ppb could be detected 5 kilometres downstream. Only 5 ppb gold occurs in the stream sediment. However, moss sediment and stream sediment have almost identical arsenic levels reaching 15.3 ppm. The headwaters of Newhykulston Creek are underlain by a small granite intrusive and up to 51 ppb gold has been found in till down-ice of the granite (Bobrowsky *et al.*, 1998).

A moss mat sediment sample from a stream flowing north into Gollen Creek (82M/5) has 92 ppb gold in the moss sediment. Fisher and Stratton Creeks located to the south have over 20 ppb gold in the moss sediment, but only just detectable gold in the stream sediment (Figure 4). Stratton Creek water also contains 41 ppm sulphate and 550 ppb fluoride. The combination of enhanced gold in the moss sediment and anomalous water chemistry suggest a sulphide-fluorite mineralized source in the watershed of Stratton Creek. The distribution of tungsten in moss sediment is shown in Figure 7 and the highest value (40 ppm) found in the area occurs in a north branch of Bendelin Creek. There is only a weak spatial correlation between moss sediment gold and moss sediment tungsten anomalies.

Gold content in moss sediment samples from the Kootenay Survey area is lower than in the Adams lake

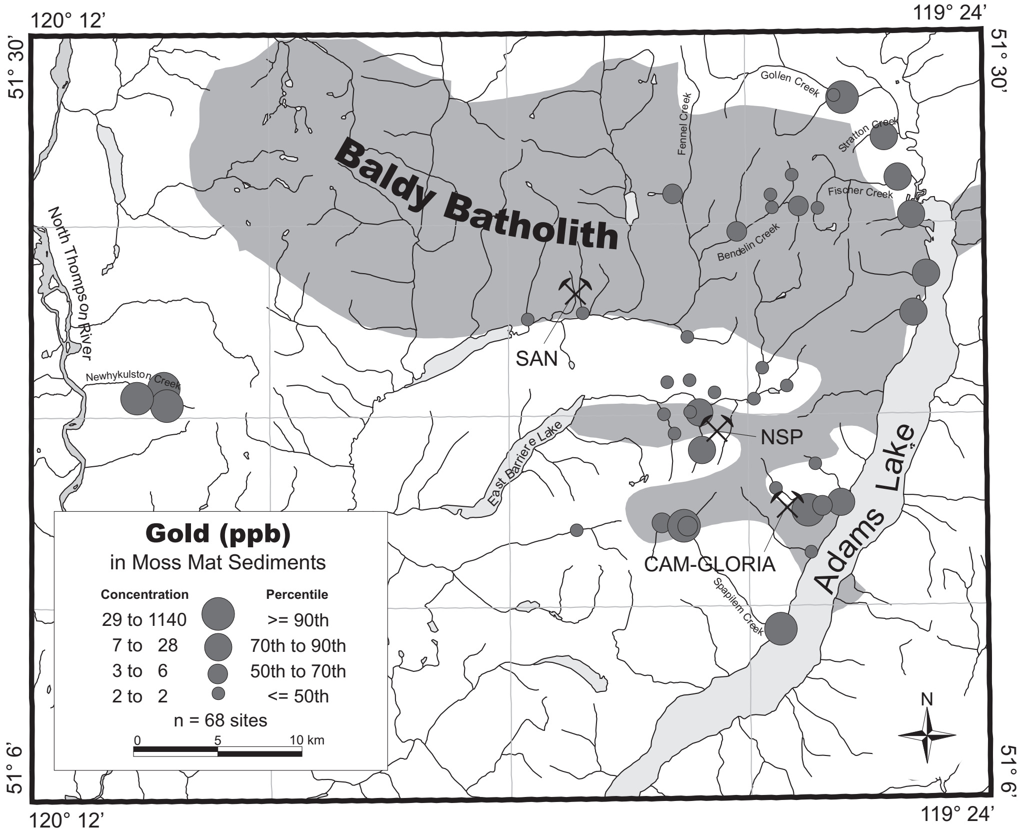

Figure 3. Gold in moss mat sediments, Adams Lake area.

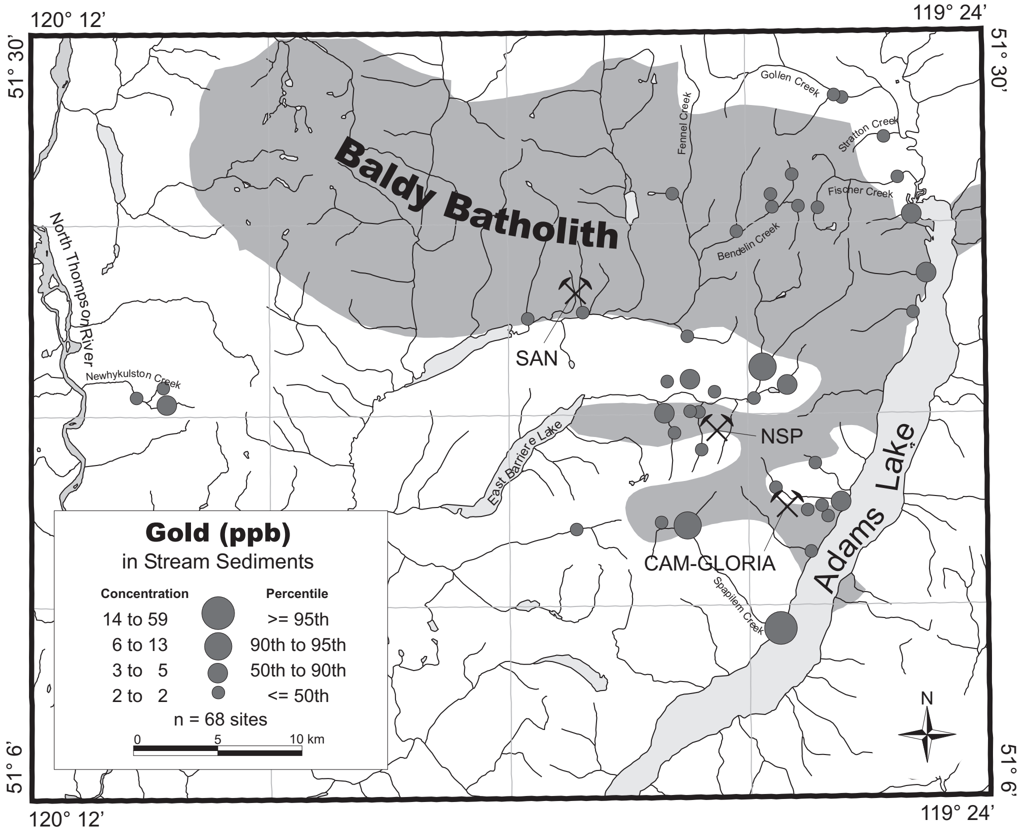

Figure 4. Gold in stream sediments. Adams Lake area.

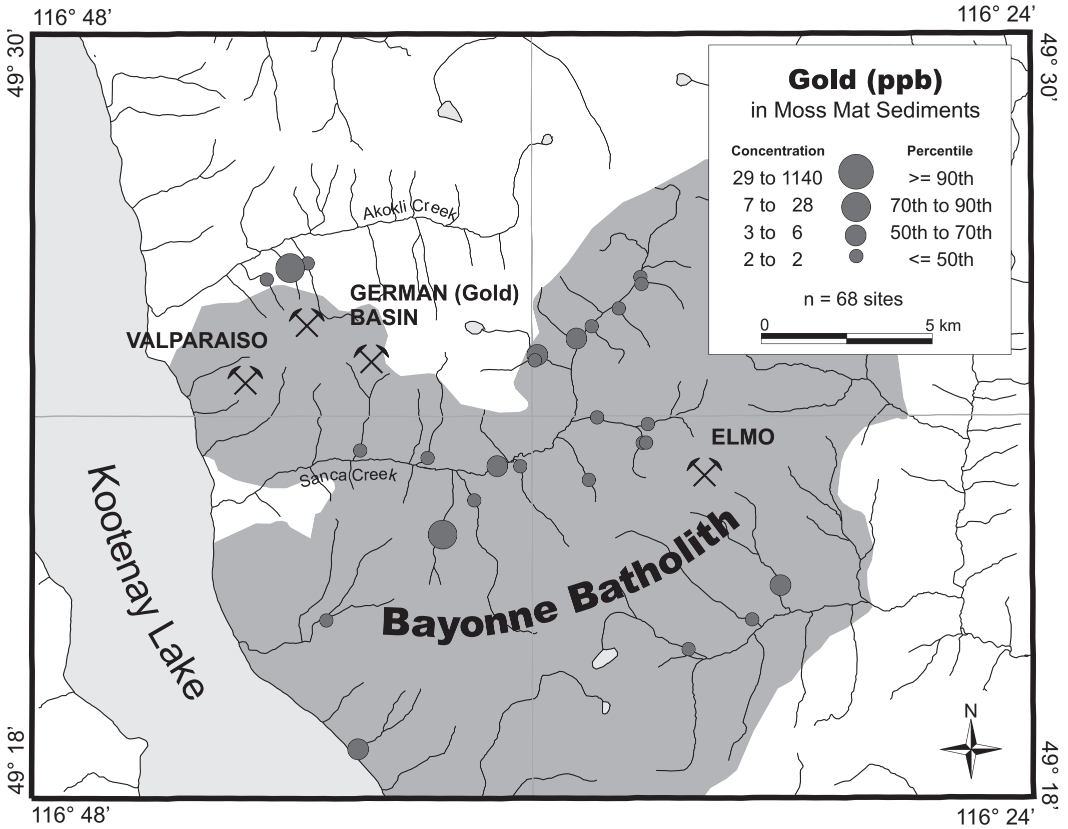

Figure 5. Gold in moss mat sediments, Kootenay Lake area.

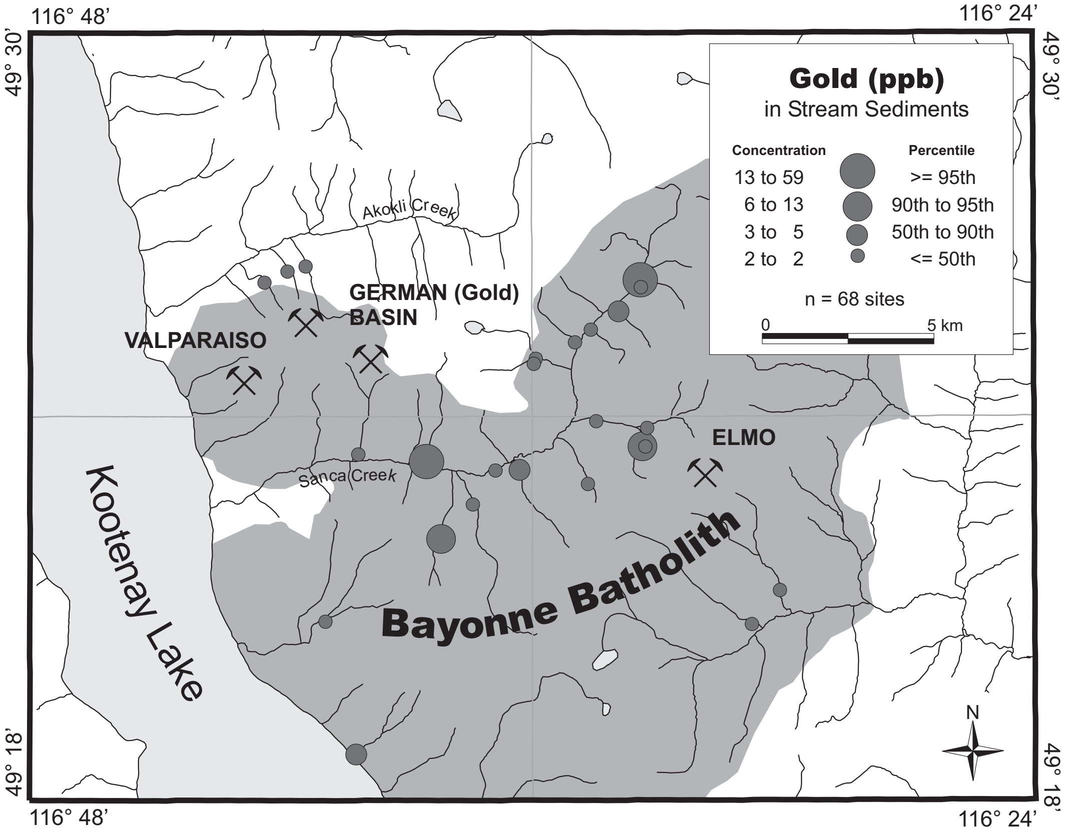

Figure 6. Gold in stream sediments, Kootenay lake area.

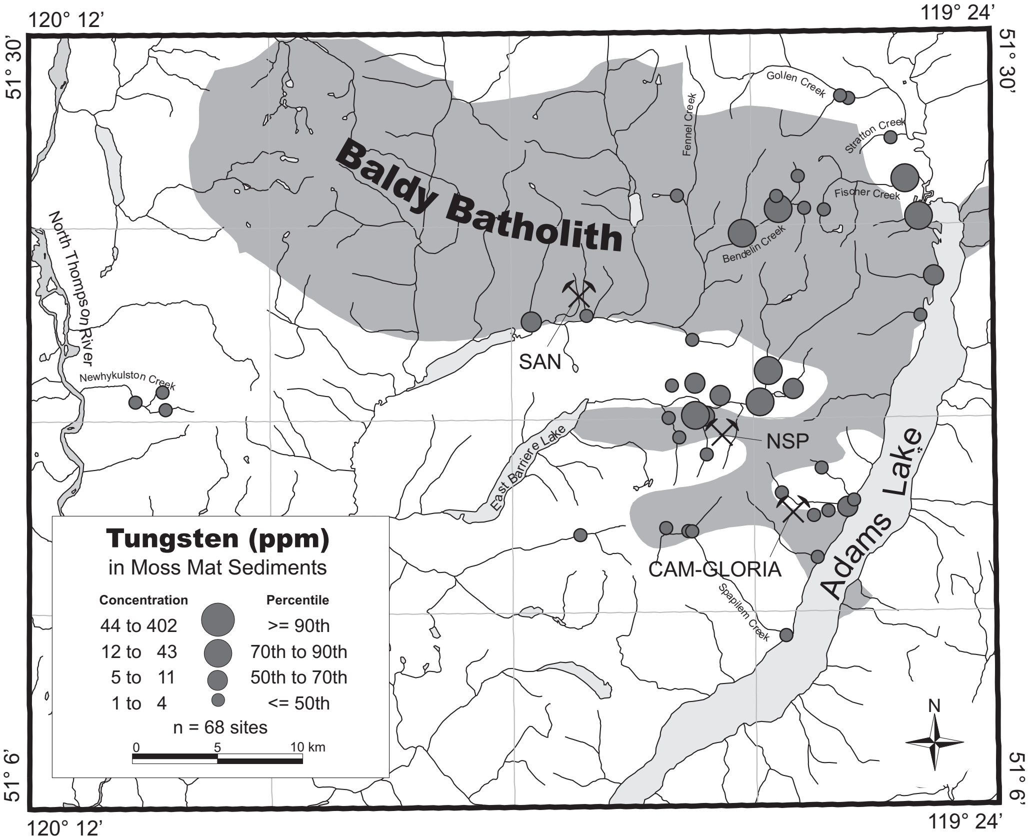

Figure 7. Tungsten in moss mat sediments, Adams Lake area.

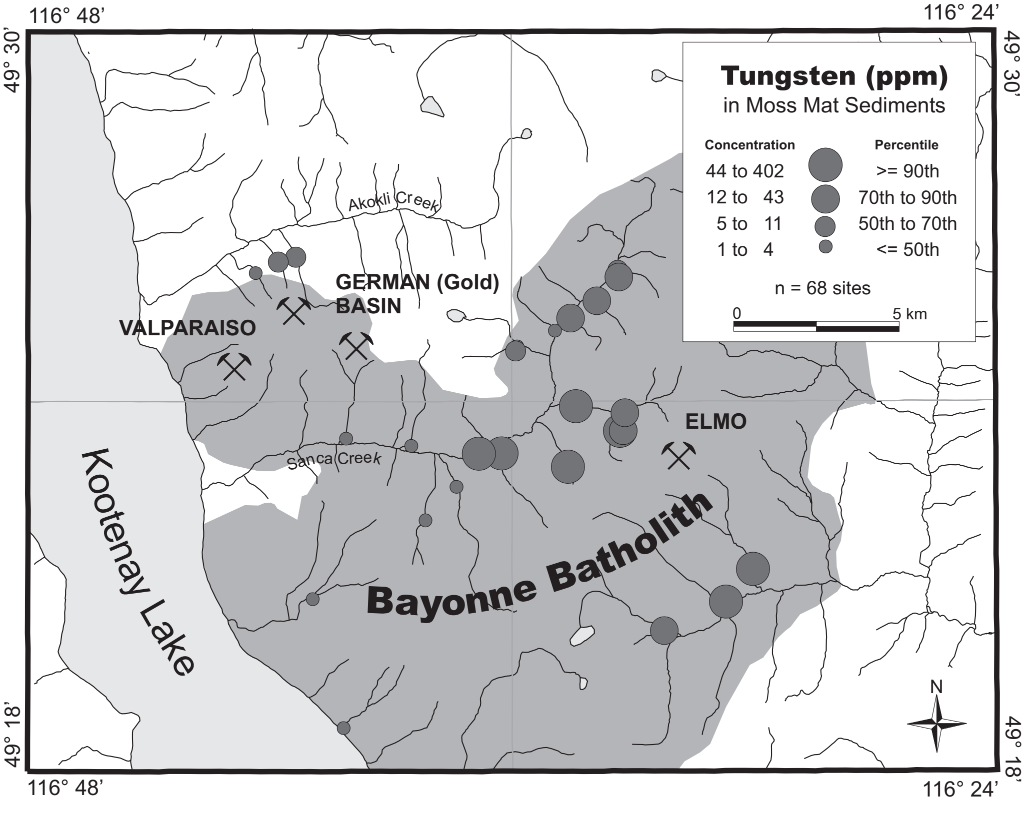

Figure 8. Tungstein in moss mat sediments, Kootenay Lake area.

area and the highest value (34 ppb) occurs in stream flowing into Akokli Creek from the German (Au) Basin showing on the north west side of Mount Sherman (Figure 5). No gold was detected in sediment from this stream although 59 ppb occurs the sediment from a creek draining the south side of Mount Sherman into Sanca Creek (Figure 6). Tungsten levels (Figures 7 and 8) are typically higher in the Kootenay area moss mat sediment samples and the highest value (402 ppm) occurs in moss sediment from a creek flowing from the watershed containing the Elmo occurrence. Almost no (less than 10 ppm) tungsten is present in moss sediment and stream sediment from creeks draining the German (Gold) Basin Showing on south side of Akokli Creek (including "Tungsten" Creek).

CONCLUSIONS

Preliminary results for the Adams Lake area reveal that the gold content of moss mat 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). Other elements such as tungsten and chromium are also enriched in the moss sediment relative to stream sediment, but element variability between field duplicate samples is smaller. In the Kootenay Lake area the highest gold value occurs in stream sediment rather than moss mat sediment. However, the gold anomalous stream sediment and moss mat sediment samples are from different streams. Tungsten values are much higher in moss mat sediment from the Kootenay area and levels, to some extent, reflect known tungsten mineral occurrences.

Further work to complete this study will involve: 1) comparison of gold and other element values in heavy mineral concentrates, stream sediments, suspended sediments and moss mat sediments. The heavy mineral samples are intended to assess the ability of streams to concentrate gold and other high density minerals in stream-bed sediment; 2) evaluation of stream and moss sediment data for other pathfinders (e.g. tin, bismuth, fluorine) for intrusive related gold mineralization; 3) comparison of aqua regia digestion - atomic absorption spectrometry and aqua regia digestion - inductively coupled plasma mass spectrometry analysis of selected samples for gold and pathfinder elements and; 4) field follow-up to establish if the gold anomalies do indeed reflect intrusive related or other styles of gold mineralization.

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