

Geochemical Surveys in the Lillooet Area (NTS Areas 092J, 092I, 092O, 092P), Southwestern British Columbia

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KEYWORDS: Lillooet, Spences Bridge Group, regional geochemical survey, geochemical samples

INTRODUCTION

Preliminary results of detailed drainage sediment, rock and soil sampling in a 500 km² area north of Lillooet, British Columbia (Fig. 1) are described in this paper. Volcanic and sedimentary rocks of the Spences Bridge Group underlie much of the area, and the group has been the recent focus of considerable exploration activity south of Lillooet. This activity started through the discovery of gold-mineralized quartz veins in 2002 by a company doing follow-up prospecting of government regional geochemical stream sediment survey data. The geochemical sampling described in this paper aimed to,

- find new mineral deposits,
- establish geochemical backgrounds for baseline determination,
- test other geochemical prospecting methods, and
- train First Nation and local community members in geochemical sampling methods.

SURVEY AREA

Physiography and Climate

Geochemical sampling focused on a 15 km wide corridor along the west side of the Fraser River between Lee and Ward Creeks (Fig. 2). Topography of the surveyed area is typical of the Camelsfoot Range that forms a transitional physiography between the Coast Mountains and the Fraser Plateau. The Camelsfoot Range is moderately rugged with steep and often precipitous slopes reflecting a change from elevations above 2000 m in the west to below 300 m along the Fraser River (Holland, 1964). There is a dissected plateau formed by Miocene volcanic rocks at about 1000 m elevation between McKay and Watson Bar creeks. Climate and vegetation are typical of transitional uplands between the Coast Mountains and the Fraser Plateau. Annual rainfall is less than 280 mm and temperatures range from -1°C in winter to above 40°C in summer. Vegetation along the Fraser River valley is typically steppe or bunchgrass prairie, with sagebrush or occasional ponderosa pine or Douglas-fir. Interior Douglas-fir, Montane Spruce and

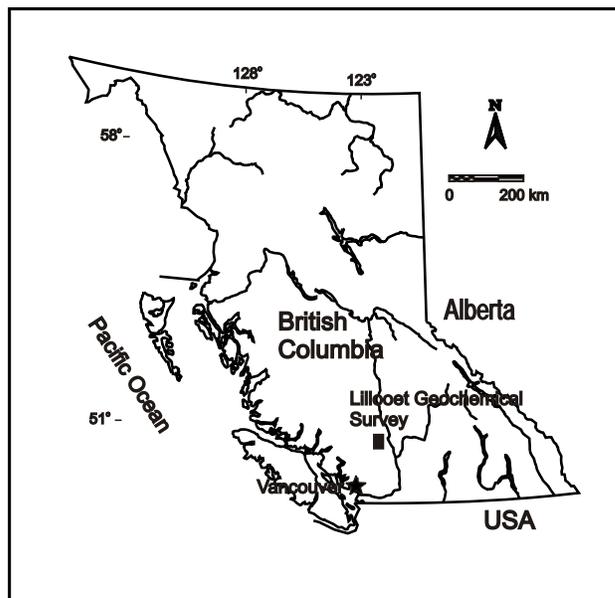


Figure 1. Location of the geochemical survey near Lillooet, British Columbia.

Engelmann Spruce are the dominant canopy species at higher elevations. Larger streams (e.g., Slok Creek, McKay Creek and Leon Creek) flow east from the uplands through deeply incised, narrow valleys into the Fraser River. In late summer, the larger creeks have a diminished water flow and many of the second and first-order drainages are completely dry.

Surficial Deposits

Trettin (1961) suggested that more than 300 m of unconsolidated sediment, ranging from boulder gravel to mud, filled the Fraser River valley by the late Pleistocene. Deltaic crossbedded sediments, silt deposits and mudflows are evidence for braided streams, glacial lakes and alluvial fans formed from tributaries of the proto-Fraser River. Recent rejuvenation caused the river channel to erode through the Pliocene sediments to bedrock. At higher elevations above the Fraser River talus and colluvium mantle the steeper slopes. The absence of glacial ice-flow features and rare, localized till deposits in the surveyed area can be explained by minimal movement of the Pliocene ice sheet close to a major ice divide.

Geology

Rocks in the surveyed area comprise the Middle to Late Cretaceous (Albion) Spences Bridge Group, the Mid-

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dle to Early Cretaceous Jackass Mountain Group, the Eocene Ward Creek assemblage and the Miocene to Pliocene Chilcotin Group. Spences Bridge and Jackass Mountain rocks are exposed as panels within the Fraser fault zone, a major northwest-trending dextral wrench fault system of Eocene age that comprises the Fraser fault, the Slok Creek fault, the Hungry Valley fault and the Watson Bar thrust (Trettin, 1961; Read, 1988). Offsets across the fault are most likely in the order of 130 km (Monger and Journeay, 1994). Cathro *et al.* (1998) described the Early Cretaceous Jackass Mountain Group as a southwest-dipping assemblage of volcanoclastic sedimentary rocks deposited as a submarine fan complex in a fore-arc environment represented by Tyaughton Basin. In the surveyed area, the Spences Bridge Group comprises an upper unit of grey to green dacite, andesite and minor basalt, and a lower unit of volcanic arenite, conglomerate, minor siltstone,

phyllitic argillite and rare carbonaceous shale. Eocene rocks are volcanic pebble conglomerate, shale, rhyodacite flows and tuffaceous wacke. Pliocene to Miocene Chilcotin rocks are mainly vesicular and amygdaloidal basalt with minor conglomerate and sandstone (Read, 1988).

Mineral Deposits

A cluster of mineral occurrences in the northern part of the surveyed area forms part of the Watson Bar Au belt. Cathro *et al.* (1998) described five distinct styles of gold mineralization hosted by Jackass Mountain rocks:

- iron carbonate–silica alteration zones enriched in Au, As, Sb and Hg
- thrust-hosted quartz-sulphide mineralization

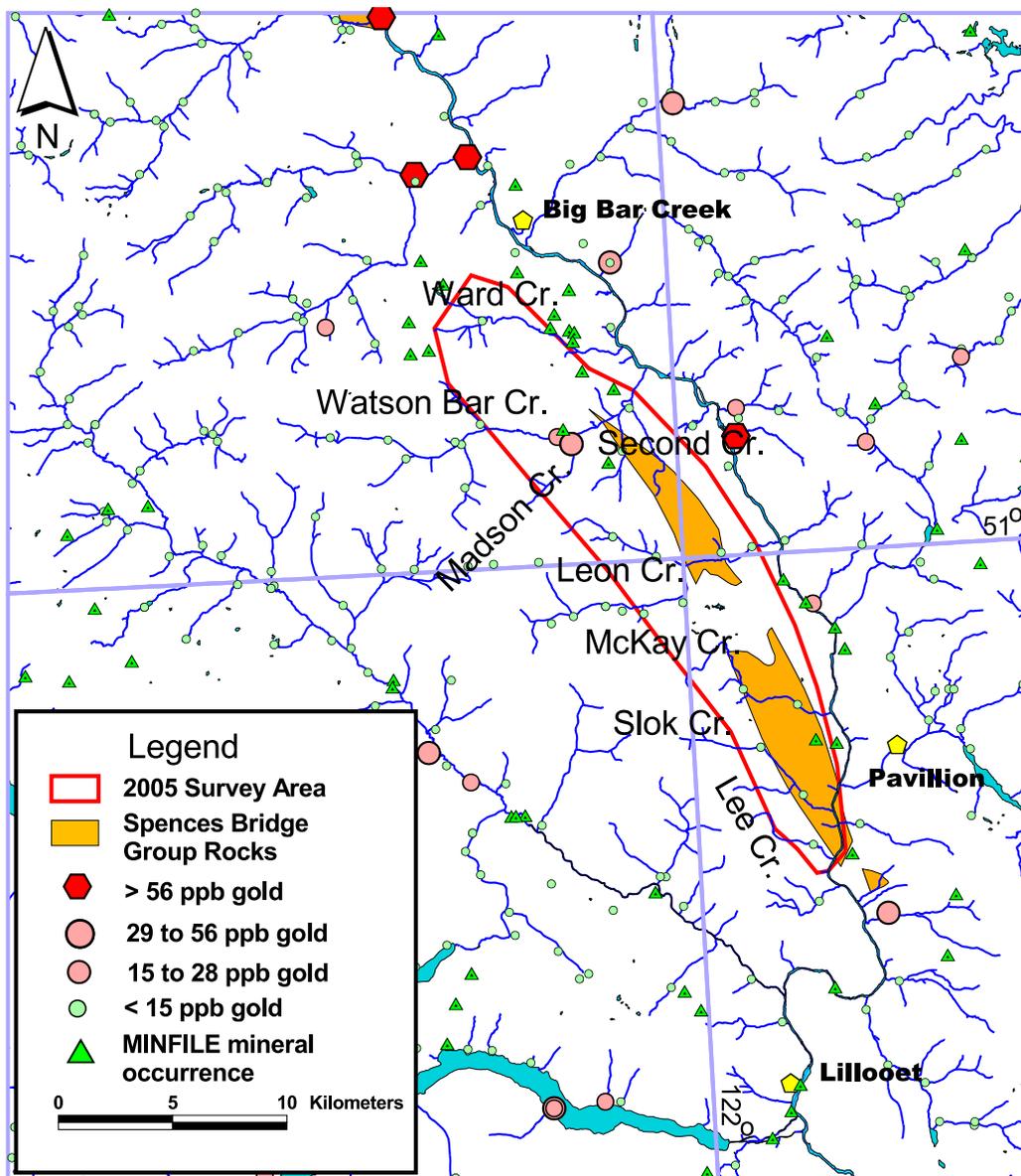


Figure 2. Gold by instrumental neutron activation analysis (INAA) in stream sediment samples taken during 1992 and 1994 regional geochemical surveys in the Lillooet area.

- quartz-sulphide veins related to quartz-feldspar porphyry sills intruding Jackass Mountain sedimentary rocks
- high-angle quartz-sulphide veins and stockworks
- Au-enriched horizons in the sedimentary rocks

The largest mineral occurrence in the surveyed area is the Watson Bar developed prospect (MINFILE 0920 051; MINFILE, 2005), where a shallow south-west-dipping thrust (zone V) contains an estimated 136 962 t grading 14.33 g/t Au (Cathro *et al.*, 1998). The Watson Bar prospect has been classified as an epithermal Au-Ag low-S deposit. Other smaller Au occurrences in the area are the MAD (MINFILE 0920 092), Buster (MINFILE 0920 055) and Astonisher (MINFILE 0920 054). Read (1988) documented a number of perlite, volcanic glass and bentonite industrial mineral occurrences in the surveyed area.

SURVEY METHODS

Sampling

In August 2005, 25 stream sediment, 25 stream water, 10 moss mat and 4 bulk sediment samples were collected from sites between Ward and Lee Creeks (NTS map sheets 092J, 092I, 092O and 092P). Sediment typical of that taken during reconnaissance-scale geochemical surveys was collected in high-wet-strength Kraft paper bags from mid and lateral bars in active stream channels at locations selected to avoid extremes of high or low energy. Water, taken from the active stream flow, was collected in a 12 mL Nalgene® bottle rinsed with stream water several times before collection. Living moss, where attached to boulders and logs, was collected in Kraft paper bags from just above the stream water surface. Field duplicate samples, generally 2–3 m apart, were collected from the same type of material and stream environment. Information about the sample, such as sediment texture, stream size and water flow, was recorded at each site.

Ideally, bulk sediment for preparation of a heavy mineral concentrate (HMC) fraction was taken at the upstream point of midchannel bars. At each HMC site a 5 gallon plastic pail was lined with a heavy-duty polyethylene plastic bag (18 x 24 inches, 4 mil) and sediment was wet-sieved through a 12-mesh (1.68 mm) stainless steel sieve until a sample weight of 10–15 kg was obtained. The sample was weighed in the pail before the opening was taped shut with black electrical tape and placed in a second bag. Bulk samples were shipped directly to the Geological Survey of Canada for preparation and analysis. Twenty-four rock samples were taken from outcrops in the surveyed area and five C-soil horizon samples were collected from pits dug close to roads.

Sample Preparation

Fine-textured sediment and moss mat sediment samples were prepared in the BC Geological Survey Laboratory in Victoria. The samples were air dried and the <1 mm (<1 mesh) fraction recovered by gently disaggregating the sediment or by pounding the moss mat before dry sieving through a 1 mm stainless steel screen. A split of the

TABLE 1. DETECTION LIMITS, PRECISION (% RSD) AND ACCURACY FOR ELEMENTS ANALYZED BY INSTRUMENTAL NEUTRON ACTIVATION (_INA) AND AQUA REGIA – INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY (_ICP), LILLOOET AREA GEOCHEMICAL SURVEY. ABBREVIATIONS: DL, INSTRUMENTAL DETECTION LIMIT; GSBRM, ANALYSIS OF STSD 1 IDENTIFIED AS SAMPLE 92O20051008; STSD 1, RECOMMENDED ELEMENT VALUES BY LYNCH (1990) FOR CANMET REFERENCE MATERIAL; MEAN, MEAN OF TWO ANALYSES; % RSD, PERCENT RELATIVE STANDARD DEVIATION FOR TWO ANALYSES; % DIFF., PERCENT DIFFERENCE BETWEEN TWO ANALYSES; GRAV, LOSS-ON-IGNITION AT 550°C; ND, NOT DETERMINED BY CANMET

Element	Units	DL	Mean	% RSD	GSBRM	STSD 1	% Diff.
Ag_ICP	ppb	2	81	8	274	300	9.1
As_ICP	ppm	0.1	5.50	1.9	17.9	17	5.2
As_INA	ppm	0.5	4.8	23.6	23.8	23	3.4
Au_ICP	ppb	0.2	99.60	56.4	8.7	8	8.4
Au_INA	ppb	2	33	17.0	23	8	96.8
Ba_INA	ppm	50	410	6.9	780	630	21.3
Bi_ICP	ppm	0.02	0.51	1.4	0.44	N.D.	N.D.
Cd_ICP	ppm	0.01	0.23	6.2	0.9	0.8	11.8
Co_ICP	ppm	0.1	12.1	0.6	13.9	14	0.7
Co_INA	ppm	1	9.5	7.4	18	17	5.7
Cr_ICP	ppm	0.5	21.3	3.5	27.7	67	83.0
Cr_INA	ppm	5	37	0.0	58	67	14.4
Cu_ICP	ppm	0.01	178.50	0.6	34.22	36	5.1
Fe_INA	%	0.01	3.59	0.6	4.73	4.7	0.6
Hg_ICP	ppb	5	19	7	100	110	9.5
LOI_GRAV	%	0.01	4.15	2.6	29.5	31.6	6.9
Mn_ICP	ppm	1	459	0.1	3568	3740	4.7
Mo_ICP	ppm	0.01	14.25	2.9	1.06	2	61.4
Ni_ICP	ppm	0.1	13.35	0.8	19.5	18	8.0
Pb_ICP	ppm	0.01	6.90	0.46	33.11	34.00	2.70
Sb_ICP	ppm	0.02	0.19	9.6	2.3	2	14.0
Sb_INA	ppm	0.1	0.7	32.6	4.7	3.3	35.0
Se_ICP	ppm	0.1	3.50	1.0	1.9	N.D.	N.D.
V_ICP	ppm	2	101	0.4	46	47	2.2
Zn_ICP	ppm	0.1	54.40	1.2	154.2	165	6.8

1 mm fraction was then screened to –80 mesh ASTM (<0.177 mm) and a second split screened to –230 mesh (<0.063 mm). Control reference material and sieved analytical duplicate samples were inserted into each analytical block of 20 sediment samples. Any remaining –80 and –230 mesh sediment was archived for future analyses. Water samples were analyzed for pH and conductivity in the field using a calibrated Hanna model HI 98129 meter. A portion of the water sample was filtered through a 0.45 µm filter and acidified with Seastar Baseline 50% nitric acid.

Sample Analysis

Prepared stream sediment, moss sediment and rock samples, with quality-control replicate and standard reference materials, were analyzed at Acme Analytical Laboratories Ltd., Vancouver, BC for 37 trace and minor elements by a combination of inductively coupled plasma – mass spectrometry (ICP-MS) and inductively coupled plasma – emission spectrometry (ICP-ES) following aqua regia digestion. Selected –80 mesh fraction sediment samples were also analyzed for Au and 32 trace elements at Actlabs, Ancaster, Ontario by instrumental neutron activation analysis (INAA). Instrumental detection limits for selected elements are listed in Table 1. Filtered, acidified water samples, CANMET river water SLRS 3, unfiltered water

blanks and filtered blanks were analyzed for major and trace elements by ICP-MS at Acme Analytical Laboratories Ltd. Detection limits for trace elements in water range from 0.05 to 0.1 ppb. Preparation of a heavy mineral concentrate (HMC) from the bulk sediment samples and analysis of the HMC for Au and trace elements is still in progress.

Quality Control

Reliable data interpretation depends on discriminating between real geochemical trends and those variations introduced by sampling and analysis. Control reference standards and analytical duplicates are therefore routinely inserted into the batches of stream sediment, stream water and moss sediment samples submitted for commercial analysis to measure accuracy and precision. National Geo-

chemical Reconnaissance (NGR) quality-control procedures used in this project are based on analysis of seventeen routine sediment or water samples, a field duplicate sample, an analytical duplicate sample or water blank, and A control reference sample in a block of 20 samples. Results from this project show that, for most elements, the combined analytical and sampling variation expressed as a percentage difference between duplicate sample values is less than 20%. Table 1 lists mean concentration and percent relative standard deviation (% RSD) for a duplicate pair of the BC Geological Survey sediment reference material for each element. Also shown in Table 1 is the percentage difference between analyses of stream sediment reference material STSD1 and the CANMET recommended value for this material (Lynch, 1990).

Precision (% RSD) for most elements other than Au, As (INAA) and Sb (INAA) is less than 10%. Lower preci-

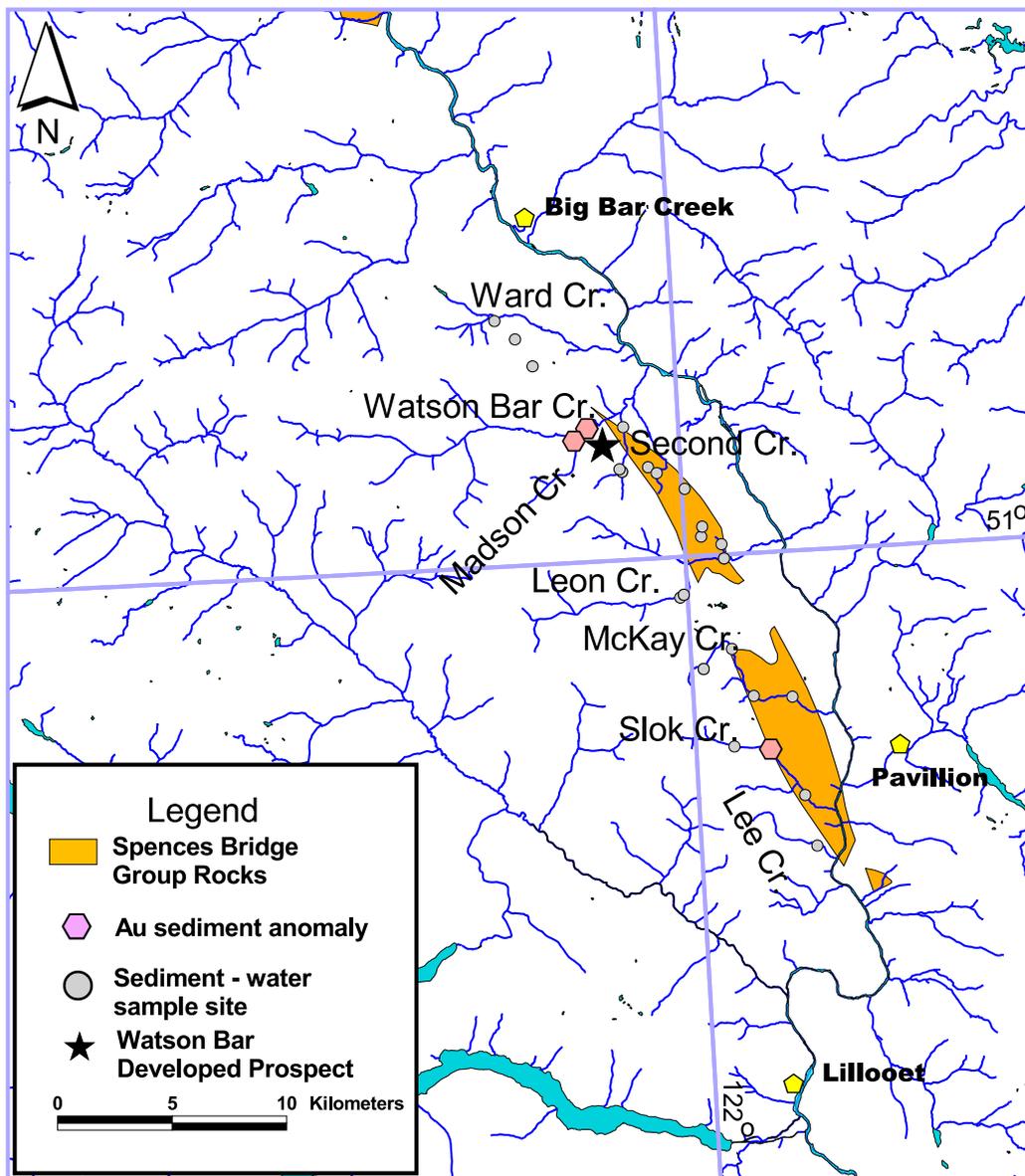


Figure 3. Stream sediment and water sample locations, 2005 detailed geochemical survey, Lillooet area. Symbols indicate sites with anomalous Au in stream sediment.

TABLE 2. MOSS SEDIMENT (MOSS) AND STREAM SEDIMENT (SED.) STATISTICS, LILLOOET AREA DETAILED GEOCHEMICAL SURVEY. MEAN, MEDIAN, 3RD QUARTILE, 95TH PERCENTILE, MAXIMUM AND MINIMUM VALUES HAVE BEEN CALCULATED FROM DATA FOR 25 SEDIMENT AND 10 MOSS MAT SAMPLES

Element	Units	Mean		Median		3 rd Quartile		Maximum		95 th Percentile	
		Sed.	Moss	Sed.	Moss	Sed.	Moss	Sed.	Moss	Sed.	Moss
Ag_ICP	ppb	53	71	46	76	73	82	110	103	88	94
As_ICP	ppm	31.4	69.3	4.5	5.8	17.8	66.3	289.2	353.9	184.1	290.4
As_INA	ppm	24.7	43.3	2.4	3.2	92.2	10.9	188.0	226.0	127.2	190.4
Au_ICP	ppb	2.6	6.7	0.7	0.7	1.5	7.9	29.6	28.8	9.6	27.0
Au_INA	ppb	17	92	2	5	3	6	331	494	23	426
Ba_INA	ppm	426	380	410	350	690	430	780	580	644	580
Bi_ICP	ppm	0.07	0.08	0.05	0.06	0.07	0.07	0.26	0.18	0.16	0.18
Cd_ICP	ppm	0.01	0.10	0.10	0.11	0.12	0.14	0.22	0.17	0.16	0.16
Co_ICP	ppm	13.7	14.6	13.7	12.1	15.4	14.8	29.5	24.7	21.5	24.1
Co_INA	ppm	11	10	11	8	19	13	22	17	19	17
Cr_ICP	ppm	40.2	45.1	41.6	46.8	46.9	51.6	54.2	54.1	52.7	54.0
Cr_INA	ppm	80	96	77	86	125	115	126	141	123	133
Cu_ICP	ppm	39.84	46.81	28.88	28.52	38.38	52.16	182.63	120.85	89.44	110.78
Fe_INA	%	2.76	2.66	2.60	2.43	4.74	3.27	5.46	3.50	4.38	3.49
Hg_ICP	ppb	204	214	32	59	60	242	3282	1035	461	739
LOI_GRAV	%	9.30	11.99	8.40	9.50	10.35	14.90	17.90	18.30	17.80	18.10
Mn_ICP	ppm	597	633	582	619	643	657	1080	821	897	796
Mo_ICP	ppm	0.64	0.73	0.40	0.54	0.48	1.01	2.58	1.41	2.04	1.37
Ni_ICP	ppm	32.4	34.6	33.1	34.4	36.7	38.0	43.4	41.0	41.7	40.4
Pb_ICP	ppm	4.70	5.55	4.58	4.81	5.12	5.38	8.49	12.61	7.72	9.43
Sb_ICP	ppm	0.8	1.6	0.2	0.4	0.4	2.2	7.8	6.9	3.4	5.5
Se_ICP	ppm	0.8	1.0	0.6	0.9	0.9	1.1	3.8	2.4	1.9	2.0
V_ICP	ppm	78	89	80	92	90	95	115	132	112	117
Zn_ICP	ppm	60.7	66.2	59.1	65.3	68.3	67.9	93.6	83.5	80.1	78.2

TABLE 3. STATISTICS FOR THE -80 AND -230 MESH FRACTIONS OF STREAM SEDIMENT, LILLOOET AREA DETAILED GEOCHEMICAL SURVEY. MEDIAN, 3RD QUARTILE AND MAXIMUM VALUES HAVE BEEN CALCULATED FROM DATA FOR TWENTY-FIVE -80 MESH AND THIRTEEN -230 MESH SEDIMENT SAMPLES. CONTRAST IS THE RATIO OF THE MAXIMUM VALUE TO THE 3RD QUARTILE

Element	Units	Mean		Median		3 rd Quartile		Maximum		Contrast	
		-80	-230	-80	-230	-80	-230	-80	-230	-80	-230
Ag_ICP	ppb	54	124	46	68	73	80	110	826	1.5	10.3
As_ICP	ppm	31.3	46.2	4.5	20.9	17.8	48.0	289.2	260.1	16.2	5.4
Au_ICP	ppb	2.6	6.5	0.7	0.9	1.5	2.2	29.6	59.5	19.7	27.0
Bi_ICP	ppm	0.07	2.39	0.05	0.08	0.10	0.09	0.26	0.17	2.6	1.9
Cd_ICP	ppm	0.11	0.14	0.10	0.14	0.10	0.14	0.22	0.22	2.2	1.6
Co_ICP	ppm	13.7	14.2	13.7	13.2	15.4	16.5	29.5	25.9	1.9	1.6
Cr_ICP	ppm	40.2	40.8	41.6	40.5	46.9	41.9	54.2	52.8	1.2	1.3
Cu_ICP	ppm	39.8	46.6	28.9	41.3	38.4	63.1	182.6	106.3	4.8	1.7
Fe_ICP	%	3.05	3.07	2.98	3.13	3.40	3.38	5.61	4.66	1.7	1.4
Hg_ICP	ppb	204	371	32	262	60	588	3282	999	54.7	1.7
Mn_ICP	ppm	597	664	582	638	643	674	1080	1286	1.7	1.9
Mo_ICP	ppm	0.6	0.6	0.4	0.6	0.5	1.5	2.6	2.1	5.2	1.4
Ni_ICP	ppm	32.4	32.0	33.1	32.3	36.7	33.1	43.4	39.7	1.2	1.2
Pb_ICP	ppm	4.80	5.60	4.60	5.20	5.10	6.20	8.50	9.20	1.7	1.5
Sb_ICP	ppm	0.82	1.17	0.22	0.41	0.40	1.53	7.79	3.95	19.5	2.6
Se_ICP	ppm	0.8	1.1	0.6	0.6	0.9	1.6	3.8	4.4	4.2	2.8
V_ICP	ppm	78	74	80	71	90	91	115	109	1.3	1.2
Zn_ICP	ppm	60.7	65.7	59.1	64.3	68.3	76.3	93.6	82.7	1.4	1.1

sion for Au by ICP-MS (56%) reflects the small sample (1 g) used for the analysis. Accuracy (difference between reported and recommended) for Au, Ba, Cd, Cr, Mo and Sb is greater than 10%. Low accuracy (>10%) for some of the elements (e.g., Cr) can be explained by a difference between the methods used to produce the reported and recommended value. The reason for a large difference (93%) between the reported and recommended Au value for STSD 1 is presently unknown. Percent relative standard deviation values for As, Ba, Cu, Ni, Pb and Zn calculated from duplicate analyses of the river water standard SLRS 3 are less than 10%. Mean values for these elements are less than 10% different than their CANMET recommended value in the water standard. Filtered water blanks analyzed with the stream water samples have less than 1.5 ppb Cu, less than 1.5 ppb Zn and detectable Pb and As.

RESULTS

Previous Regional Survey Results

Figure 2 shows the concentration of Au in stream sediment samples collected during previous regional geochemical surveys that covered the surveyed area (Jackaman *et al.*, 1992a, b; Jackaman and Matysek, 1994). The highest Au value (43 ppb) detected in the area covered by detailed sampling is in sediment from Madson Creek, a north-flowing tributary of Watson Bar Creek. This sediment also contains 343 ppm As and 14.2 ppm Sb in the sediment. The source of the Au and other anomalous metals in Madson creek is the Au mineralization at the Watson Bar developed prospect.

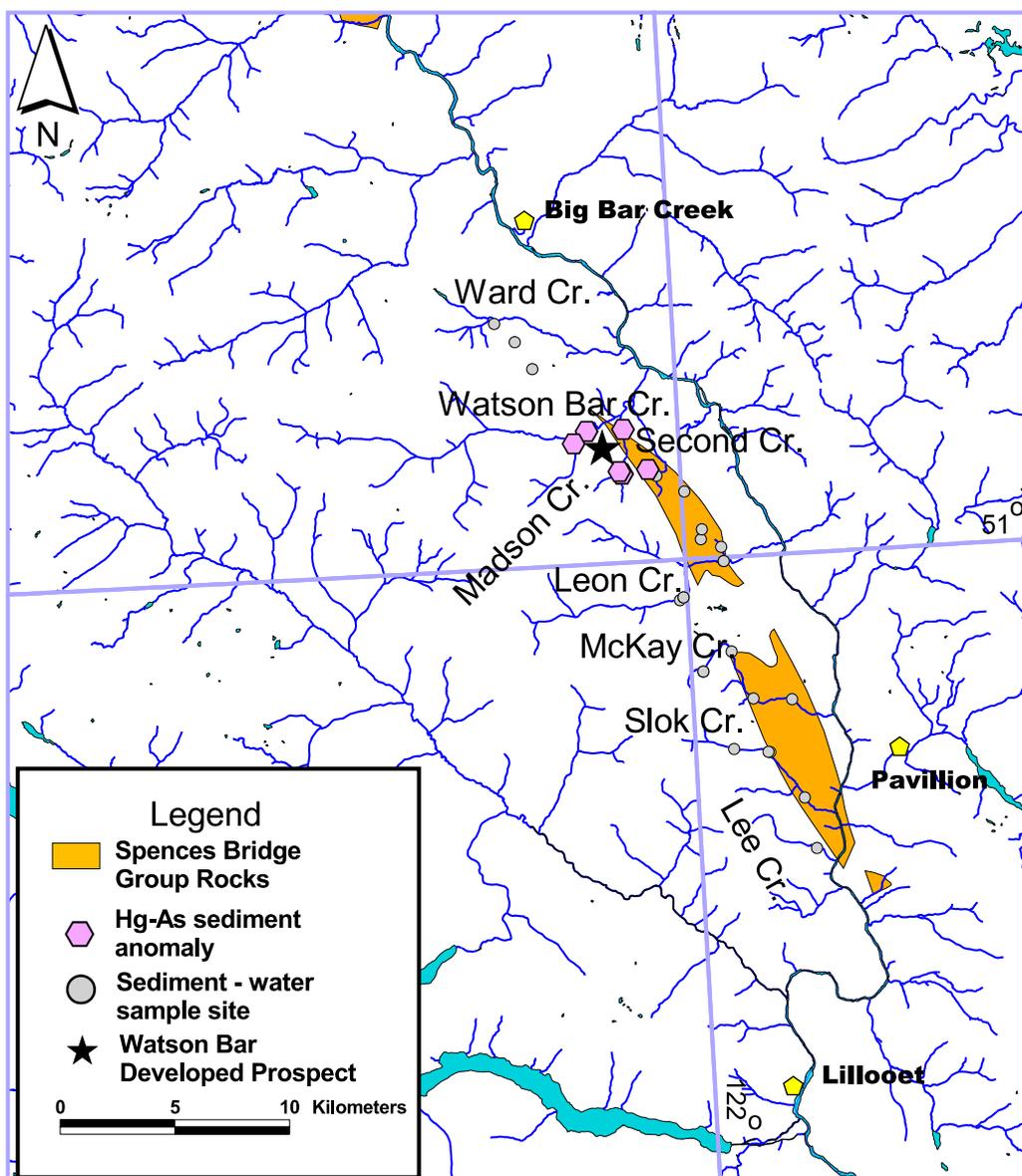


Figure 4. Stream sediment and water sample locations, 2005 detailed geochemical survey, Lillooet area. Symbols indicate sites with anomalous As-Hg in stream sediment.

Detailed Survey Results: Drainage Sample Type and Size Fraction Comparison

Figure 3 shows the location of the stream sediment and water samples collected during the detailed survey. Listed in Table 2 are selected element statistics for stream sediment and moss mat samples, including both 3rd quartile and 95th percentile values. The 3rd quartile can be a more realistic threshold for a small dataset than the more traditional 95th percentile. Both 3rd quartile and 95th percentile show that most elements (*e.g.*, Au, Ag, Cu, As, Hg, Mo, Pb) are higher in the moss sediment than in the stream sediment. Matysek and Day (1988) reported a similar pattern of element enhancement in the moss sediment from streams draining Cu and Au mineralization on Vancouver Island. Higher element values most likely reflect capture of metal-rich suspended sediment, including Au grains, by moss

during periods of higher stream flow. Although moss sediment analysis can improve geochemical anomaly contrast (Matysek and Day, 1988), the moss is not present in every stream due to the relatively dry climate. It therefore has limited exploration application in the Lillooet area.

Table 3 compares the -80 mesh stream sediment geochemistry with that of the -230 mesh fraction. Third quartile values show that elements are higher in the -230 mesh fraction of the sediment, with the exception of Cr and Ni. Except for Ag and Au, however, the geochemical anomaly contrast (ratio of the maximum to 3rd quartile) is larger in the -80 mesh fraction. Although the ability of stream sediment geochemistry to detect Au mineralization is improved by using the -230 mesh fraction, there are limitations to using this fraction, such as 1) the need to collect a larger sample for preparation of enough material for analysis, 2) the problem of levelling data produced from the two

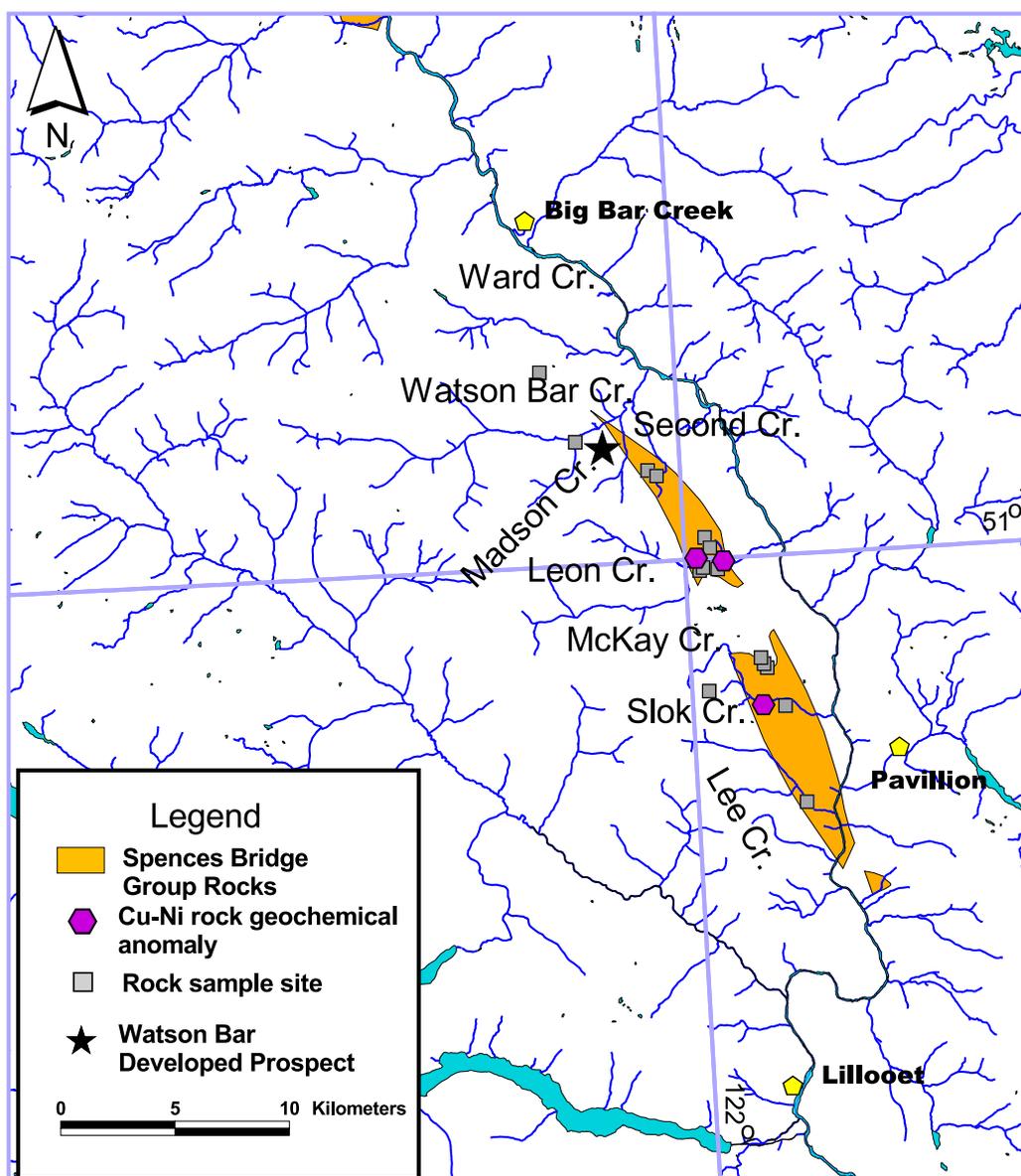


Figure 5. Location of rock samples collected during the 2005 detailed geochemical survey, Lillooet area. Symbols indicate sites with anomalous Cu-Ni in bedrock.

TABLE 4. STATISTICS CALCULATED FROM ANALYTICAL DATA FOR 21 SAMPLES OF VOLCANIC ROCK FROM THE SPENCES BRIDGE GROUP, LILLOOET AREA DETAILED GEOCHEMICAL SURVEY

Element	Mean	Median	3 rd Quartile	Maximum	95 th Percentile
Ag_ICP	47	35	46	259	72
As_ICP	4.8	4.9	7.0	12.2	10.7
Au_ICP	0.7	0.5	0.9	2.7	1.80
Bi_ICP	0.1	0.0	0.1	0.2	0.15
Cd_ICP	0.10	0.07	0.10	0.35	0.31
Co_ICP	18.4	17.9	20.9	39.9	33.3
Cr_ICP	49.4	37.0	67.0	128.5	115.7
Cu_ICP	52.0	46.1	65.9	129.61	88.78
Fe_ICP	3.5	3.6	4.4	6.27	5.05
Hg_ICP	10	7.0	14.0	45	35
Mn_ICP	665	664.0	820.0	1164	1064
Mo_ICP	0.38	0.35	0.49	0.59	0.58
Ni_ICP	41.2	28.0	48.2	180.7	125.8
Pb_ICP	3.53	3.24	3.39	12.63	5.42
Sb_ICP	0.15	0.14	0.18	0.43	0.36
V_ICP	121	110	163	252	228
Zn_ICP	59.7	54.6	71.6	125.3	77.20

size fractions, and 3) the lower anomaly contrast for other elements.

Detailed Survey Results: Sediment and Water Geochemistry

Sediment samples (–80 mesh fraction) with more than 10 ppb aqua regia – ICP-MS Au or 23 ppb INAA Au are identified on Figure 3. The multielement signature of stream anomalies can help characterize the source mineralization. The highest Au value (311 ppb by INAA) is accompanied by 188 ppm As and 511 ppb Hg in sediment from Matson Creek, which flows from the Watson Bar epithermal Au-Ag deposit. Watson Bar creek sediment has only to 25 ppb Au but up to 210 ppm As in the sediment. This compares to sediment with 21 ppb Au, 38 ppm As and 230 ppb Hg taken from a similar site in the creek during the original regional survey. Samples of the –80 mesh sediment with more than 18 ppb As and 60 ppb Hg (3rd quartile) shown on Figure 4 cluster around the Watson Bar deposit. The sediment also has elevated As, Bi, Cu and Mo values, but only background Au levels. Anomalous As and Hg can be detected 2 km from the Au mineralization in Second Creek, a stream flowing north into Watson Bar Creek.

Although no other samples in the survey area have anomalous As and Hg, one sample from Slok Creek, close to the contact between the Spences Bridge and Jackass Mountain groups, has 29 ppb Au determined by aqua regia – ICP-MS but no detectable Au by INAA. This difference can be explained by the characteristic high variability or ‘nugget effect’ of Au in stream sediment. Stream waters are alkaline (median pH 8.3) and typically have a high (50–100 ppm) dissolved Ca-Mg concentration. Concentrations of most trace heavy metals (e.g., Cr, Ag) are either below or just above instrument detection limit. Low concentrations of pathfinder metals (e.g., As, Cd, Pb, Cu, Zn) are detectable in the stream water. For example, the highest amounts are 1.4 ppb Pb, 2.3 ppb Zn, 38 ppb Cu and 17.5 ppb As in water from the upper reach of a branch of Second Creek.

TABLE 5. STATISTICS CALCULATED FROM ANALYTICAL DATA FOR FIVE C-HORIZON SOIL SAMPLES, LILLOOET AREA DETAILED GEOCHEMICAL SURVEY

Element	Mean	Median	3 rd Quartile	Maximum	95 th Percentile
Ag_ICP	76	60	101	135	128
As_ICP	6.7	6.1	8.3	9.4	9.2
Au_ICP	2.6	2.2	3.1	3.6	3.5
Bi_ICP	0.08	0.08	0.08	0.10	0.10
Cd_ICP	0.17	0.18	0.18	0.21	0.20
Co_ICP	18.00	19.20	19.40	22.40	21.80
Cr_ICP	64.7	64.8	67.4	73.0	71.9
Cu_ICP	49.76	48.70	55.34	56.72	56.44
Fe_ICP	4.24	4.19	4.20	4.70	4.60
Hg_ICP	46	39	55	93	85
Mn_ICP	576	611	619	806	769
Mo_ICP	0.63	0.60	0.61	0.82	0.78
Ni_ICP	65.60	62.80	67.00	78.70	76.40
Pb_ICP	4.85	4.47	4.97	6.40	6.11
Sb_ICP	0.36	0.35	0.37	0.51	0.48
Se_ICP	0.2	0.2	0.2	0.3	0.3
V_ICP	86	88	88	98	96
Zn_ICP	70.4	73.4	76.8	81.2	80.3

Two kilometres downstream, the As level is 3.3 ppb and other metals are below detection limit.

Detailed Survey Results: Rock and Overburden Geochemistry

Table 4 lists statistics calculated from data for 21 samples of volcanic rock from the Spence’s Bridge Group collected as part of the survey (Fig. 5). The maximum Au value detected in the sample suite is 2.7 ppb and there are no high concentrations of those pathfinder elements characteristically associated with Au mineralization in the area (e.g., As, Hg). However, Table 4 reveals that the Spences Bridge Group has relatively high background levels for Cu, Ni and V. The actual background levels for these and other elements (e.g., Cr and Ba) may be even higher because the aqua regia digestion will not dissolve all of the aluminosilicate and oxide minerals and therefore will not liberate all of the silicate-bound metal. Figure 5 shows the locations of samples with more than 65 ppm Cu and 48 ppm Ni. These samples also have elevated V and appear to cluster near the fault-bounded contact of the Spences Bridge Group. The anomalous Cu and Ni could be explained by fault-controlled serpentinization of mafic or ultramafic rocks in the volcanic stratigraphy. Further analysis of the rock samples by INAA is in progress. Table 5 lists statistics calculated from aqua regia – ICP-MS data for five C-horizon soil samples collected on plateau area underlain basalt. The C-horizon soil samples have a relatively uniform distribution of elements, and no anomalous Au values were detected.

CONCLUSIONS

Detailed stream geochemical studies in an area north of Lillooet reveal that,

- sediment and moss sediment in streams draining the Watson Bar Au-Ag deposit have anomalous As and Hg values, with varying amounts of Au. Arsenic and Hg are geochemical pathfinders for the epithermal Au-Ag min-

eralization. Dissolved metal in alkaline stream water flowing from the Au-mineralized area fall to levels approaching instrument detection limit within 2 km downstream.

- the -230 mesh fraction of stream sediment and -80 mesh fraction of moss sediment typically have higher metal contents than the -80 mesh fraction of stream sediment. However, except for Au and Ag, geochemical anomaly contrast for elements in the -80 mesh stream sediment is larger than the -230 mesh stream sediment fraction.
- Au and As levels in the sediment are similar to those found in a previous regional geochemical survey.
- one sediment sample from Slok Creek has detectable Au measured by aqua regia ICP-MS but no other anomalous metal. Rock and C-horizon soil samples have no anomalous Au, As or Hg, but elevated Cu and Ni values could reflect the presence of mafic rocks associated with faulting.

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