# Multimedia Geochemical Surveys in the Lillooet and McLeod Lake Map Sheets (NTS 092O, 093J), Central British Columbia

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*KEYWORDS:* geochemistry, Lillooet, McLeod Lake, stream sediments, moss sediments, till

## INTRODUCTION

Glacial sediment and plateau basalt covering much of the British Columbia interior have limited exploration for new mineral deposits. However, a follow-up of BC Regional Geochemical Survey (RGS) drainage sediment anomalies in areas of higher relief, where bedrock is better exposed, has resulted in the recent discovery of new mineral prospects, such as Au-mineralized quartz veins hosted by Spences Bridge Group rocks between Lillooet and Lytton (Schroeter *et al.,* 2006). Geochemical sampling in 2006 by the BC Geological Survey (BCGS) north of Lillooet between Lee Creek and Ward Creek found Au and base-metal anomalies in sediment from streams that were draining intensely faulted volcanic and sedimentary rocks (Lett, 2006). Sources of Au anomalies in sediment were interpreted as previously known bedrock Au occurrences along Watson Bar Creek and unidentified mineralization in Jackass Mountain Group rocks to the west of the area surveyed. Spences Bridge and Jackass Mountain Group rocks are known to outcrop beyond the northern limit of the 2006 geochemical project in an area where a past BCGS regional survey reported significant Au values in stream sediment (Jackaman *et al.,* 1992). The reported Au values from this survey were determined by reanalyzing the archived RGS stream sediment samples for new elements by instrumental neutron activation (INAA).

Mineral exploration has been previously stimulated in different parts of BC when the results of archived RGS sample reanalysis by INAA or by aqua regia digestion and inductively coupled plasma mass spectrometry (ICP-MS) were released. The aqua regia – ICP-MS reanalysis of archived RGS samples from the McLeod Lake map sheet in 2006 revealed several Au anomalies in an area covered by thick glacial sediments, but underlain by prospective Takla Group rocks (Lett and Bluemel, 2006).

Multimedia geochemical surveys were carried out by the authors in 2006 in an area north of Lillooet between Ward Creek and French Bar Creek and in the McLeod Lake map sheet around Great Beaver Lake (Fig 1) to identify

- the main types of glacial sediment and their distribution,
- the surface environment variations likely to influence geochemical dispersion,
- the sample media most effective for improving geochemical anomaly contrast, and
- the source of previous regional stream sediment – water geochemical anomalies.

Preliminary results of the geochemical surveys are reported in this paper.

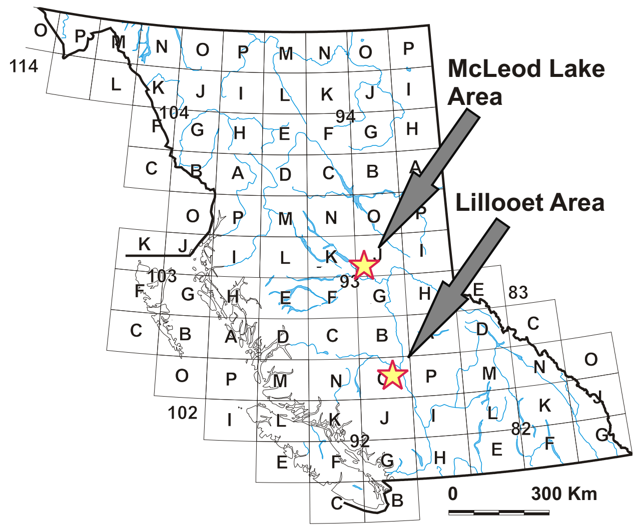


Figure 1. Location of the Ward Creek – French Bar Creek and McLeod Lake survey areas.

## SAMPLING AND ANALYTICAL METHODS

Sampling and analytical techniques used in both areas have been previously described by Lett (2006) and are summarized as follows:

- analysis of the –80 mesh (<0.177 mm) fraction of drainage sediment and moss sediment for Ag, Al, As, Au, B, Ba, Bi, Ca, Cu, Fe, Ga, Hg, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Se, Sr, Te, Th, Ti, Tl, U, V, W and Zn by aqua regia digestion – inductively coupled plasma mass spectrometry (ICP-MS) and for Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Sm, Sn, Sr, Ta, Tb, Th, U, W, Yb and Zn by instrumental neutron activation (INAA) and for loss on ignition (LOI) at 500°C
- analysis of the –230 mesh (<0.063 mm) fraction of till, colluvium and B-horizon soil collected from

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roadcuts for elements by aqua regia digestion – ICP-MS and INAA

- analysis of the –200 mesh (<0.070 mm) fraction of rock samples collected from outcrop for elements by aqua regia digestion – ICP-MS and INAA
- analysis of filtered (0.45 micron) acidified water samples for Al, B, Ag, As, Ba, Be, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, In, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Pr, Rb, Re, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Ti, Tl, Tm, U, V, Y, W, Zn and Zr, by ICP-MS and for Ca, K and Na by inductively coupled plasma emission spectroscopy (ICP-ES). The water samples will be analyzed later for sulphate and fluoride
- collection of bulk drainage sediment samples for preparation of a heavy mineral concentrate. The heavy mineral concentrate will be used for mineralogical examination and for geochemical analysis

Water sample preservation was carried out in the field; sediment and rock samples were prepared in the BC Geological Survey Laboratory, Victoria. Pre-preparation (*i.e.,* in the field) and post-preparation duplicate samples and standard reference materials were included with samples sent for analysis to commercial laboratories. The drainage sediment, moss sediment, glacial sediment and soil and rock samples were analyzed by aqua regia digestion – ICP-MS at Acme Analytical Laboratories Ltd., Vancouver, and by INAA at Activation Laboratories, Ancaster, Ontario. Water samples were analyzed by the Environmental Geochemistry Laboratory, Geological Survey of Canada, Ottawa, Ontario.

Field and analytical duplicate samples and standard reference materials were analyzed with routine samples to generate the data for assessing accuracy and precision. The percent difference for analytical duplicates was less than 5% for most elements and below 10% for field replicates. Precision at the 95% confidence limit calculated from replicate analyses of a BCGS standard was less than ±15% for most elements. Larger variations between replicate samples and precision more than ±15% were measured for Au and Sb.

## LILLOOET AREA

### Description

Geochemical samples were collected in a 400 $km^2$ area west of Ward Creek and French Bar Creek. Topography of this area ranges from deep valleys occupied by creeks that flow through the rugged Camelsfoot Range into the Fraser River to a more subdued upland relief characteristic of the dissected Fraser Plateau. This plateau was formed by the erosion of flat-lying Miocene volcanic and associated sedimentary rocks (Holland, 1964). The Fraser River valley forms the eastern boundary of the area surveyed. Climate and vegetation of the area reflect a transitional environment from that of the Coast Ranges to 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 in the Camelsfoot Range is mainly Interior Douglas fir, Montane spruce and Engelmann spruce. Much of the mature timber has been harvested and the remaining stands are heavily damaged by mountain pine beetle. Closer to the Fraser River and on the Fraser Plateau vegetation is typically steppe or bunchgrass prairie with sagebrush and scattered Ponderosa pine or Douglas fir. Ward Creek and French Bar Creek flow east from the uplands into the Fraser River through deeply incised valleys. Commonly, there is a dense alder and willow growth in the valleys. Moore Lake, the source of Ward Creek, is supplied by water flowing through an aqueduct that crosses the watershed and intersects an upper reach of French Bar Creek 20 km to the west.

Alpine glaciers increased in size at higher elevations during the early stages of the Fraser Glaciation. Ice flowed northeast and southwest from a dispersal centre in the Camelsfoot Range forming glaciers that filled the major northeast and east-trending valleys (*e.g.,* French Bar Creek). Eventually the valley glaciers coalesced to block the Fraser River resulting in the formation of a large, proglacial lake. Sand and gravel deposits are common along the Fraser River and up to 300 m of lacustrine, glaciofluvial and fluvial sediment may have been deposited in the Fraser River valley during the Pleistocene. Debris flows, crossbedding and climbing ripples reflect the deposition of sediment into the river valley from braided streams, glacial lakes and alluvial fans. Huntley and Broster (1993) infer the presence of an ice divide separating north and south-flowing ice near Ward Creek and French Bar Creek from the orientation of cirques in the Camelsfoot Range. Broster and Huntley (1992) have identified massive matrix-supported, massive clast-supported and stratified diamict units in the area. Locally, surficial sediments range from a sandy till deposited on the uplands to talus and colluvium covering steeper hill slopes. Ice melt-out features and glaciofluvial deposits in the area include eskers and gravel terraces along valleys. An example of an esker in the French Bar Creek area is shown in Figure 2.

Rocks of the Lower Cretaceous Jackass Mountain Group, an Eocene volcanic assemblage and the Chilcotin Group outcrop in the surveyed area. The northwest-trending Slok Creek fault, a splay of the Fraser fault system, separates Eocene volcanic rocks in the northeast from the predominantly sedimentary Jackass Mountain Group in the southwest. Cathro *et al.* (1998) describe the Jackass Mountain Group as a southwest-dipping assemblage of volcaniclastic sedimentary rocks deposited during the Cretaceous as a submarine fan complex in the Tyaughton Ba-

Figure 2. Winding east-trending esker near French Bar Creek. The esker is approximately 2 km in length.

sin. South and west of Moore Lake, outcropping Jackass Mountain rocks range from massive sandstone to polymictic conglomerate (Hickson *et al.,* 1994). Eocene rocks are typically green to maroon andesite and dacite with minor banded rhyolite that most likely are representative of unit Evd mapped by Read (1988). The Eocene volcanic rocks in the area have been described in detail by Hickson *et al.* (1994). Chilcotin Group rocks are mainly vesicular and amygdaloidal basalt flows.

No precious or base-metal mineralization has been found in the surveyed area, but there are several Au-vein occurrences south of Moore Lake in the Watson Bar Au belt. These occurrences are spatially associated with a cluster of porphyry bodies that have intruded the Jackass Mountain Group. At the largest mineral occurrence, the Watson Bar deposit (MINFILE 092O 051), a shallow southwest-dipping thrust (Zone 5) contains an estimated 136 962 tonnes grading 14.33 g/t Au. Other styles of Au mineralization found in the Watson Bar Au belt are Fe carbonate silica alteration zones enriched in Au, As, Sb and Hg; quartz-sulphide veins related to quartz-feldspar porphyry sills, high-angle quartz-sulphide vein stockworks and conformable Au-rich zones in the sediments (Cathro *et al.,* 1998). Northwest of the Watson Bar deposit are several smaller Au prospects such as the MAD (MINFILE 092O 092), Buster (MINFILE 092O 055), Astonisher (MINFILE 092O 054) and GB (MINFILE 092O 060). The GB, an epithermal low-sulphur Au-mineralized vein with elevated Hg, Sb, Pb and Zn, is close to the headwaters of Roderick Creek immediately south of the surveyed area. Between the Watson Bar deposit and the Fraser River is the Big Bar (MINFILE 092O 091) epithermal Au prospect. Quartz-carbonate veins in a Late Cretaceous andesite contain chalcopyrite, sphalerite and arsenopyrite with up to 2.17 ppm Au. Read (1988) mapped several perlite, volcanic glass and bentonite mineral occurrences in the surveyed area, such as the French Bar Creek (MINFILE 092O 106) and Moore Lake (MINFILE 092O 103).

## Results

Results of the 1992 RGS, shown in Figure 3, reveal that sediment from French Bar Creek below the confluence with Boiler Creek has more than 95 ppb Au. The analysis of 100 samples collected at 50 sites in the same area during 2006 identifies several additional stream sediment, moss sediment and till multi-element anomalies. Site locations, sample types and the numbered anomalies with their multi-

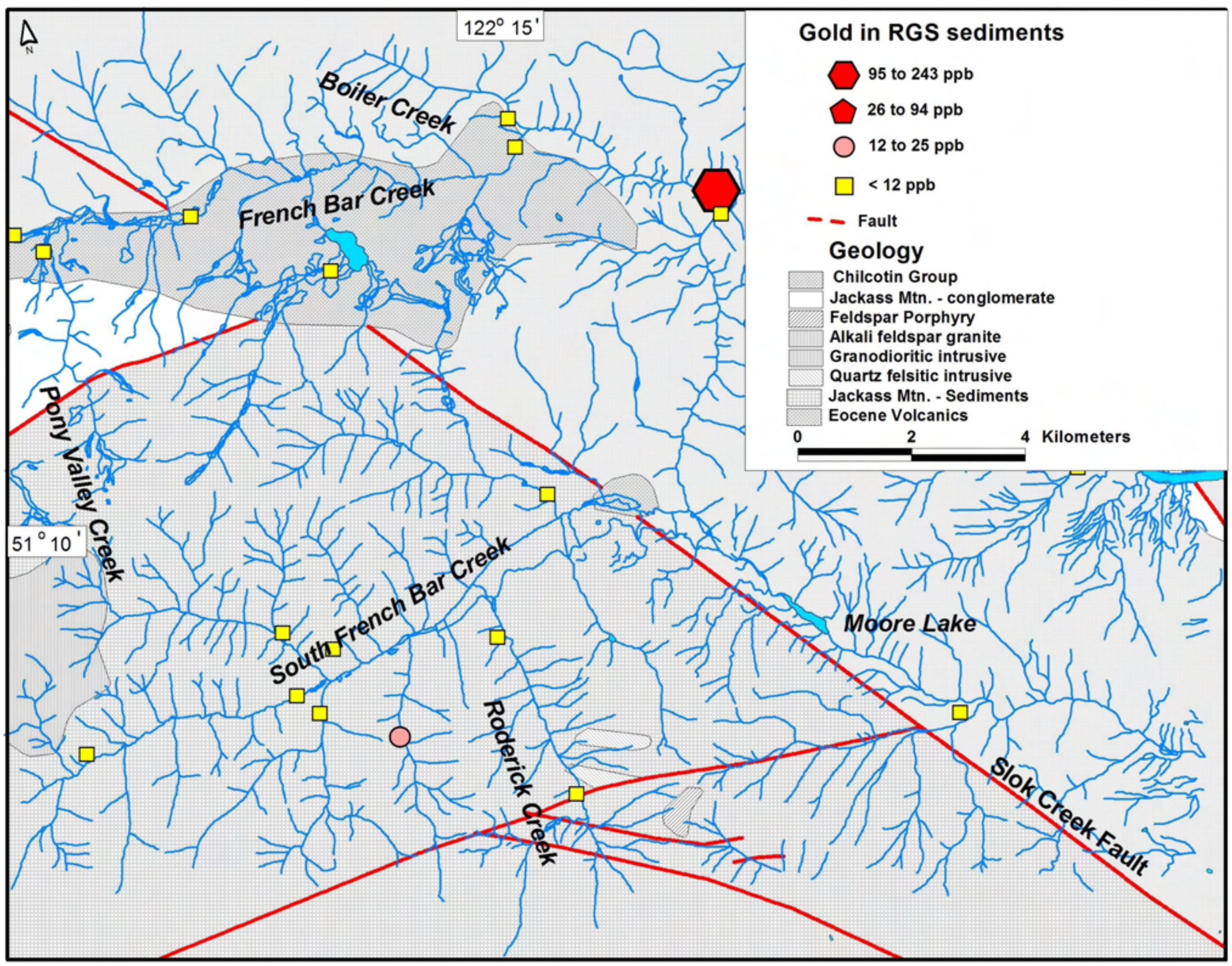


Figure 3. Distribution of regional geochemical survey (RGS) Au values in the French Bar Creek – Ward Creek survey area. Symbols represent intervals at the 90$^{th}$, 95$^{th}$ and 98$^{th}$ percentiles from data previously published by Jackaman *et al*. (1992).

element signature are shown on Figure 4. Median, third quartile and maximum values for ore indicator and pathfinder elements representing each sample type and listed in Table 1. Third quartile values have been used an anomaly threshold.

Anomaly 1 in moss sediment from a stream flowing into Pony Valley Creek, a tributary of French Bar Creek, has up to 10.4 ppb Au (by ICP-MS) with anomalous Zn, Ag and Se. This stream flows through a marshy area and the anomalous levels could reflect the effect of higher organic matter (17% LOI) in the sediment. However, there is a similar Au content (9.7 ppb) in sediment from Pony Valley Creek downstream from the confluence with the anomalous tributary. Colluvium overlying a steeply dipping fracture zone filled with Fe-carbonate and hematite in a conglomerate exposure on a road 500 m east of Pony Valley Creek has anomalous Zn, Cu, Fe, As, Sb, Hg and V.

Sediment from a tributary of Boiler Creek contains 420 ppb Au by aqua regia – ICP-MS, a value confirmed by an INAA analysis of 367 ppb (Anomaly 2). In addition to the anomalous Au value, only high Mn (>2800 ppm) was detected in the sample. Slightly alkaline (pH 7.8) streamwater contains elevated Al, Zn, Si and rare earth elements; this signature could be explained by the weathering of clay minerals in rhyolite bedrock. A sample from Boiler Creek about 3 km to the west also has elevated levels of the rare earth elements La, Ce, Nd, Sm, Eu, Tb, Yb and Lu in the stream sediment and the water, although Au is not anomalous (Anomaly 3). The weathering of clay minerals may also be the reason for the elevated rare earth elements in the sediment.

Up to 85 ppm As with anomalous Mo, Mn, Hg and V and a trace (3.9 ppb) of Au were found in organic (*i.e.,* 70% LOI) sediment from a small creek flowing east through a swampy valley into the Fraser River (Anomaly 4). High organic matter content and observed colloidal iron-hydroxide precipitate in the sediment could partially explain the elevation of metal values caused by adsorption to the organic matter and iron hydroxide.

Moss sediment from south French Bar Creek has 110 ppb Au (INAA), but only anomalous Pb (6 ppm) in the corresponding steam sediment (Anomaly 5). Till from a road exposure on the south side of the valley near the stream site contains anomalous Cu and Ag levels. The most likely cause for the Au anomaly is the capture of Au grains by moss from the suspended sediment load, but the source of

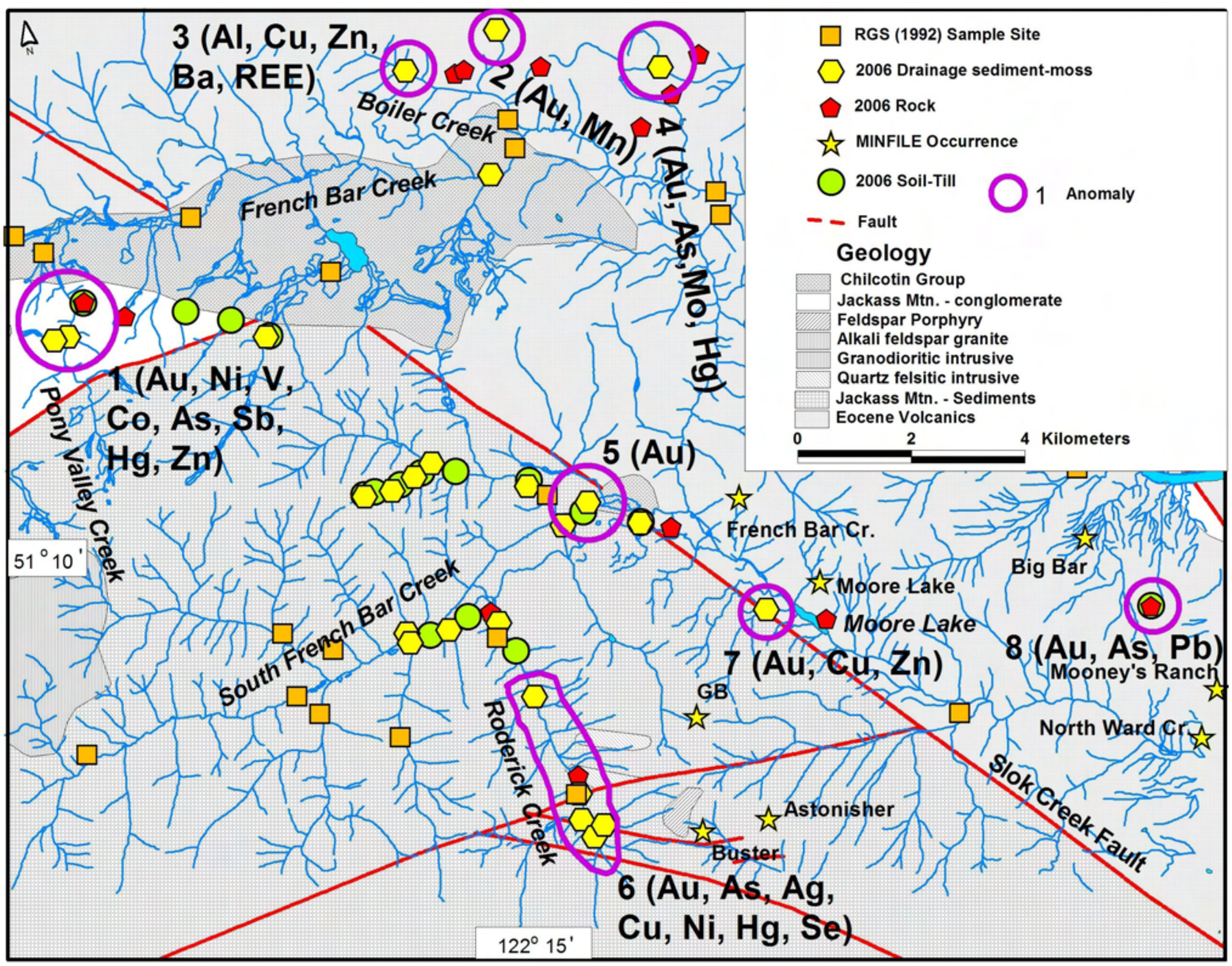


Figure 4. Location of samples in the French Bar Creek – Ward Creek survey area. Bedrock geology, mineral occurrences and major faults are shown on the map. Sample types are distinguished by symbols and numbered anomalies with their geochemical signature are described in the text. Geology is based on digital data published by Massey *et al.* (2006a).

the Au in the sediment cannot be determined precisely because of a large catchment basin upstream from the sample site.

Up to 220 ppb Au (ICP-MS) in moss sediment occurs along a 2 km reach of Roderick Creek (Anomaly 6). Anomalous Ag, Ni and As values occur with Au, but no other elements are above the threshold in stream sediment. A stream draining from the east into the upper basin of Roderick Creek has anomalous Ag, As, Ni, Hg, Se and Zn in sediment with 4.3 ppb As in streamwater, but no detectable Au. This creek meanders across an inclined, swampy valley floor that has been disturbed by logging and the high (*i.e.,* 27% LOI) sediment organic content could explain the elevated metals. However, the creek drains an area where there are several known epithermal Au-Ag-As-Sb-Hg mineral occurrences (*e.g.*, Buster) and this type of mineralization could be a likely source for the sediment-water multi-element anomaly.

Sediment from a stream draining a ridge underlain by the Jackass Mountain Group south of Moore Lake has an Au content of 101 ppb by INAA and 28.5 ppb by aqua regia – ICP-MS with anomalous Cu and Zn (Anomaly 7). This sample site is almost directly over the surface projection of the Slok Creek fault and Au mineralization associated with this structure or in Jackass Mountain Group rocks upstream could explain the elevated Au, Cu and Zn.

Colluvial till from an exposure on the West Pavilion Road roughly 4 km south of the Big Bar ferry contains 28 ppb Au by INAA and 26.5 ppb Au by aqua regia – ICP-MS with anomalous As and Pb values (Anomaly 8). No Au or other anomalous metal could be detected in a dark brown, clay-rich sedimentary or volcaniclastic rock outcropping beneath the colluvium. The source of this anomaly may be epithermal Au mineralization similar to that reported at the Big Bar occurrence (MINFILE 092O 091).

**TABLE 1. MEDIAN, THIRD QUARTILE AND MAXIMUM VALUES FOR ELEMENTS IN STREAM SEDIMENT (SED; 25 SAMPLES), MOSS SEDIMENT (MOSS; 10 SAMPLES) AND TILL (TILL; 17 SAMPLES); ABBREVIATIONS: ICP, AQUA REGIA – ICP-MS; INA, NEUTRON ACTIVATION; N.D., NOT DETERMINED.**

| Analytical parameter | Moss | | | Stream sediments | | | Till | | |
|---|---|---|---|---|---|---|---|---|---|
| | Median | Third quartile | Maximum | Median | Third quartile | Maximum | Median | Third quartile | Maximum |
| **Ag** (ppb; ICP) | 63 | 73.8 | 199 | 54 | 71 | 169 | 130 | 91 | 359 |
| **Al** (%; ICP) | 1.82 | 1.96 | 2.27 | 1.81 | 1.97 | 2.61 | 3.28 | 2.83 | 5.03 |
| **As** (ppm; ICP) | 6.0 | 9.4 | 45.1 | 6.0 | 8.2 | 72.8 | 15.75 | 7.50 | 93.2 |
| **As** (ppm; INA) | 9 | 13.75 | 57.3 | 9.3 | 11.5 | 85.4 | 21.28 | 10.75 | 111 |
| **Au** (ppb; ICP) | 1.2 | 2.9 | 220.0 | 0.7 | 1.2 | 420.4 | 4.03 | 1.90 | 26.6 |
| **Au** (ppb; INA) | 2 | 8.5 | 198 | 2 | 2 | 367 | 8.00 | 5.00 | 37 |
| **Ba** (ppm; INA) | 505 | 535 | 640 | 580 | 613 | 760 | 680 | 615 | 770 |
| **Bi** (ppm; ICP) | 0.07 | 0.08 | 0.09 | 0.06 | 0.07 | 0.12 | 0.12 | 0.11 | 0.2 |
| **Br** (ppm; INA) | 15 | 24.8 | 72.1 | 11.9 | 19.8 | 92.3 | 2.80 | 1.50 | 6 |
| **Ca** (%; ICP) | 1.11 | 1.22 | 1.82 | 1.16 | 1.61 | 6.23 | 1.42 | 0.97 | 11.42 |
| **Cd** (ppm; ICP) | 0.1 | 0.2 | 0.3 | 0.13 | 0.17 | 0.6 | 0.15 | 0.10 | 0.3 |
| **Co** (ppm; ICP) | 12.3 | 13.9 | 17.4 | 11.8 | 13.5 | 24.8 | 21.08 | 15.75 | 31.1 |
| **Co** (ppm; INA) | 16 | 17 | 19 | 15 | 16 | 25 | 21.50 | 17.00 | 28 |
| **Cr** (ppm; ICP) | 43.3 | 48.3 | 56.9 | 33.0 | 44.2 | 76 | 57.98 | 47.10 | 64.6 |
| **Cr** (ppm; INA) | 166 | 210 | 276 | 106 | 151 | 220 | 120 | 106 | 146 |
| **Cu** (ppm; ICP) | 24.3 | 29.2 | 53.3 | 21.86 | 25.38 | 59.41 | 56.45 | 50.12 | 124.37 |
| **Fe** (%; INA) | 4.03 | 4.40 | 4.69 | 3.84 | 4.02 | 5.34 | 5.00 | 4.77 | 9.47 |
| **Hg** (ppb; ICP) | 43 | 50 | 208 | 37 | 49 | 234 | 74.75 | 52.50 | 191 |
| **La** (ppm; INA) | 16.6 | 18.2 | 21.8 | 14.6 | 15.2 | 27.5 | 20.55 | 17.95 | 31.5 |
| **LOI** (%) | 12.35 | 19 | 33.8 | 14.1 | 23.2 | 71.8 | n.d. | n.d. | n.d. |
| **Mn** (ppm; ICP) | 569 | 626 | 3099 | 631 | 1401 | 4102 | 759.25 | 531.50 | 1301 |
| **Mo** (ppm; ICP) | 0.62 | 0.74 | 1.87 | 0.57 | 0.81 | 3.02 | 0.63 | 0.54 | 2.02 |
| **Ni** (ppm; ICP) | 33.9 | 37.6 | 46.5 | 31.7 | 36.3 | 65.6 | 48.03 | 45.80 | 57.9 |
| **P** (%; ICP) | 0.084 | 0.098 | 0.114 | 0.074 | 0.083 | 0.46 | 0.09 | 0.08 | 0.099 |
| **Pb** (ppm; ICP) | 5.74 | 5.88 | 7.62 | 5.02 | 5.97 | 8.84 | 7.70 | 6.72 | 13.15 |
| **Sb** (ppm; INA) | 1 | 1.6 | 3.1 | 0.8 | 1.2 | 3.4 | 1.93 | 1.25 | 5.1 |
| **Se** (ppm; ICP) | 1.0 | 1.425 | 2.8 | 0.9 | 1.3 | 3.5 | 0.20 | 0.10 | 0.5 |
| **V** (ppm; ICP) | 83 | 91 | 95 | 76 | 84 | 238 | 102.25 | 88.00 | 233 |
| **Zn** (ppm; ICP) | 63.3 | 65.8 | 81.5 | 60.0 | 66.5 | 87.3 | 69.73 | 64.90 | 136.4 |

Abbreviation: n.d., not determined

## MCLEOD LAKE

### *Description*

Geochemical samples were collected in an area around Great Beaver Lake in the western part of the McLeod Lake map sheet (NTS 093J/05, 06, 11, 12). A predominantly rolling to hilly land surface reflects the effects of extensive glaciation across the Fraser Basin, a physiographic subdivision of the Interior Plateau. The highest feature of the undulating landscape is Mount Prince southwest of Great Beaver Lake, which is drained by the Salmon River into the Fraser River. Smaller streams, while clearly marked on 1:20 000 scale maps, are commonly dry or have minimal water flow. Vegetation, dominated by White spruce, reflects a cold, dry climate and basic soils. Locally, there are stands of Black spruce and Lodgepole pine favouring better-drained, acid soils. Tamarack is common on organic soils in valleys formed by meltwater and Trembling aspen favours soils with a higher base saturation or where the area has been disturbed by logging (Dawson, 1989).

A till blanket deposited by an ice sheet advancing from the Coast Mountains onto the Interior Plateau during the later stages of the Fraser Glaciation (15 Ka) covers much of the area. Southwest to northeast ice advances deposited the till and formed surface features such as glacial grooves and numerous cigar and egg-shaped drumlins that are up to 30 m high (Clague *et al.*, 1987). A dark grey-brown, dense, calcareous till is the most common glacial deposit forming the drumlins. West and south of Great Beaver Lake there are extensive lacustrine varved clay, silt and sand deposited into a large glacial lake that extended into the Nechako Plateau. Locally, the lacustrine sediments are fluted and mounded by minor ice re-advances into drumlins. Glaciofluvial sand, silt, clay and gravel, locally up to 70 m thick, were deposited around Great Beaver Lake and along the Salmon River valley indicating a significant meltwater channel. Luvisolic soil has developed on well-drained glacial sediments, whereas gleysolic and organic have formed in poorly drained areas (Dawson, 1989).

Struik (1989) mapped several distinct, fault-bounded assemblages within the McLeod Lake map sheet. Mainly Precambrian to early Paleozoic carbonate and clastic sedimentary rocks were deposited in the eastern half of the map sheet. The western half of the map sheet is composed of late Paleozoic to Triassic basalt, diorite, gabbro, limestone, greywacke and chert of the Slide Mountain, Cache Creek and Takla Groups. The Wolverine complex, which consists mainly of quartz-feldspathic paragneiss and granitic plutonic rocks with smaller postdeformational granite, tonalite, syenite and granodiorite intrusions, forms the another assemblage in the north-central part of the map sheet.

Pennsylvanian to Triassic Cache Creek rocks are predominantly massive blue-grey recrystallized limestone with minor bedded limestone, marble chert, argillite and greenstone. The Cache Creek Group is in fault contact with volcanic and sedimentary rocks of the Upper Triassic Takla Group. Locally, Cache Creek rocks have been subdivided into the Pope and Sowchea successions. Great Beaver Lake is partly underlain by a northwest-trending belt of Takla Group mudstone, siltstone and fine sedimentary rocks in fault contact to the southwest with calcalkaline volcanic flows, agglomerate and breccia. To the northwest, the Takla Group has been intruded by small granodiorite and ultramafic bodies and is partly covered by flat-lying vesicular, columnar-jointed olivine basalt flows of the Chilcotin Group. The basalt erupted from centres such as Teapot Mountain and Coffeepot Mountain to the east of the surveyed area.

Northwest, north and northeast-trending strike-slip and extensional faults cross the McLeod Lake map sheet and are believed to reflect two distinct plate-motion configurations between the North American and the Kula-Pacific plates. The Pinchi Fault crossing the southwest corner of the area is one example of a major northwest-trending structure that forms the Cache Creek – Takla contact.

Only two mineral occurrences, the Mount Prince Southeast (MINFILE 093J 010) and the Mount Prince Northwest (MINFILE 093J 011), have been reported in the area surveyed. The few known occurrences most likely re-

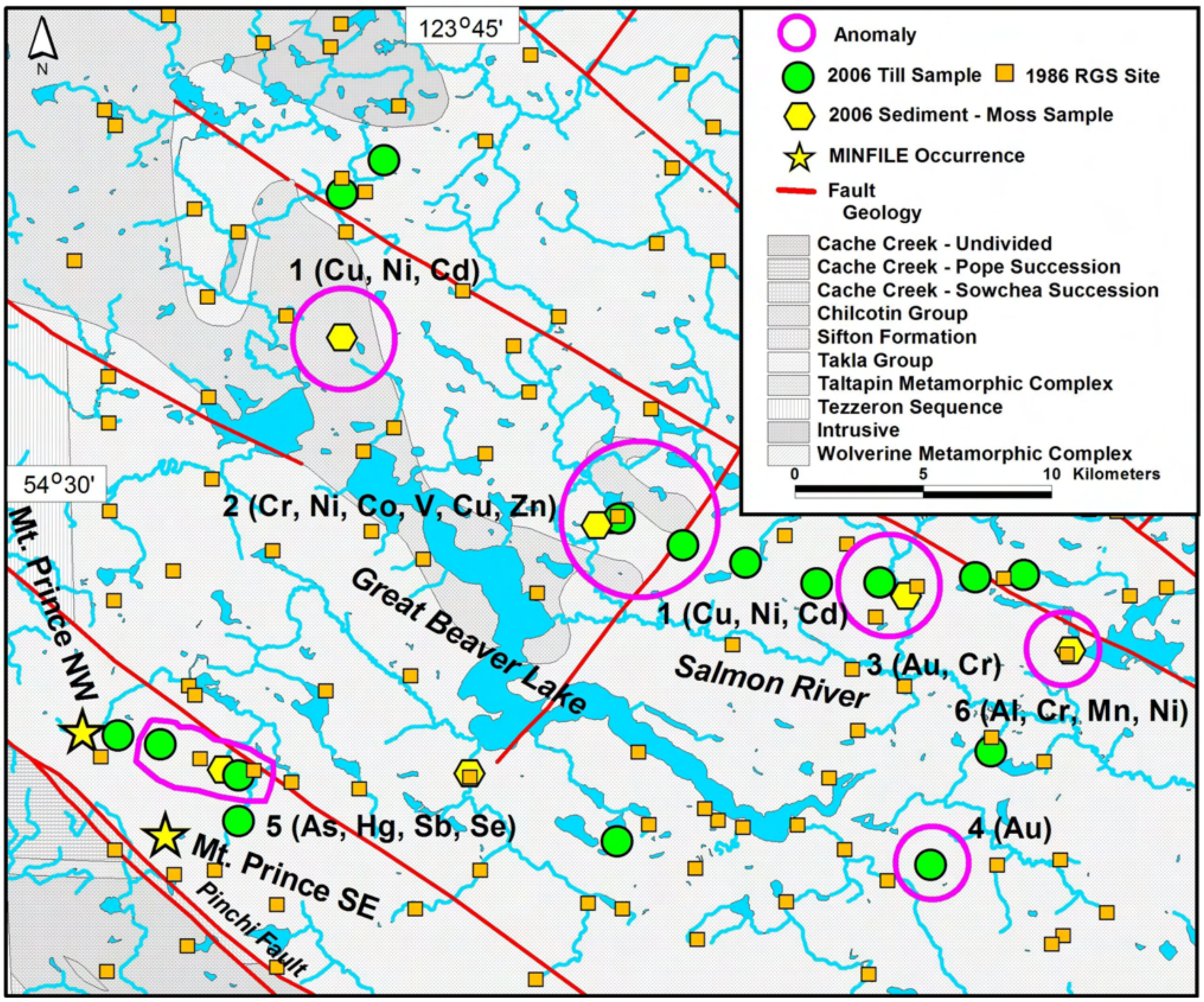


Figure 5. Location of samples in the McLeod Lake survey area. Bedrock geology, mineral occurrences and major faults are shown on the map. Sample types are distinguished by symbols and numbered anomalies with their geochemical signature are described in the text. Geology is based on digital data published by Massey *et al.* (2006b).

flect the problem of prospecting in an area covered by thick, almost continuous overburden. Mount Prince Southeast and Northwest are Hg prospects where minor cinnabar occurs in carbonatized, sheared Takla Group mafic volcanic rocks close to the Pinchi Fault. North of the area surveyed is the Windy (MINFILE 093J 024), described as an example of alkalic porphyry Cu-Au mineralization. This showing is underlain by poorly exposed Takla Group augite porphyry flows and minor tuffaceous rocks to the north and an extensively chloritized and sheared diorite intrusion to the south. Chalcopyrite with minor pyrite with up to 0.57 ppm Au and 1.25 ppm Pd occurs disseminated and in veinlets in the diorite.

### *Results*

The location of stream sediment, moss sediment and till geochemical anomalies revealed by the analysis of 40 samples collected at 22 sites around Great Beaver Lake are shown on Figure 5. Median, third quartile (threshold) and maximum values for Au and selected elements in till and stream sediment are listed in Table 2. Till statistics were calculated from data for the 17 samples collected during the present survey, whereas the stream sediment statistics were calculated using the results of the reanalysis of regional survey samples previously reported by Lett and Bluemel (2006).

Anomaly 1 reflects increased Mo (2.06 ppm), Cu (61 ppm), Ni (117 ppm) and Cd (1.76 ppm) values in sediment from a small, dry creek northwest of Great Beaver Lake. The anomalous metals could reflect adsorption of metal to organic matter because the sediment from this creek has high organic matter content (*i.e.,* LOI = 30%). Faulkner (1987) commented on the frequency of highly organic RGS sediment samples in the McLeod Lake map sheet. Previously published regional geochemical survey data from the region northwest of Great Beaver Lake revealed high Cr and Ni values in stream sediment (BC Ministry of Energy, Mines and Petroleum Resources, 1986). Anomaly 2 outlines part of the same area where several samples of a dense, calcareous till from sites over an 8 km distance have anomalous Cr, Ni, V, Co, Cu and Zn. While Cu values in the till are less than 100 ppm, Cr and Ni exceed 200 ppm. Similar Cu and V levels (up to 700 ppm) have been reported by Lett and Jackaman (2000) in till down-ice from the Samatosum Cu-Pb-Zn-Au-Ag massive sulphide deposit where mafic rocks in the mineralized zone contain the Cr-rich mica, fuchsite. The source for the Cr-Ni-V–rich till cannot be confirmed, but the southwest to northeast ice flow suggested that the metal-rich till may have originated from the basin presently occupied by Great Beaver Lake. Moss sediment from a dry creek within 30 m of one anomalous till site also has elevated Cr and over 900 ppb Hg. The corresponding stream sediment also has anomalous Cr, but background Hg values and the high Hg concentration in the moss could reflect sample contamination.

Sediment from a creek draining into the Salmon River from a large catchment basin to the north had up to 289 ppb Au (INAA), 441 ppm Cr and 2213 ppm Mn (Anomaly 3). The presence of Au is confirmed by an 82.8 ppb value by aqua regia – ICP-MS in a split of the prepared sediment sample. A regional geochemical survey sample from the Salmon River about 4 km to the south of the anomalous site recorded 63 ppb Au in the sediment (Lett and Bluemel, 2006). The source of the anomalous Au cannot be determined for certain except that the higher Cr associated with the Au may reflect stream sediment that has been largely derived from Cr-rich till.

**TABLE 2. MEDIAN, THIRD QUARTILE AND MAXIMUM VALUES FOR ELEMENTS IN STREAM SEDIMENT (1152 SAMPLES) AND TILL (17 SAMPLES). ABBREVIATIONS: ICP, AQUA REGIA – ICP-MS; INA, NEUTRON ACTIVATION; N.D., NOT DETERMINED.**

| Analytical parameter | Till | | | Stream sediments | | |
|---|---|---|---|---|---|---|
| | Median | Third quartile | Max-imum | Median | Third quartile | Max-imum |
| **Ag** (ppb; ICP) | 106 | 114 | 245 | 111 | 194 | 2571 |
| **Al** (%; ICP) | 1.67 | 1.86 | 2.06 | 1.15 | 1.50 | 4.23 |
| **As** (ppm; ICP) | 9.50 | 12 | 14.0 | 3.7 | 5.5 | 91.8 |
| **As** (ppm; INA) | 13.60 | 14.90 | 20.5 | n.d. | n.d. | n.d. |
| **Au** (ppb; ICP) | 2.10 | 3.70 | 121 | 1.1 | 1.7 | 147.5 |
| **Au** (ppb; INA) | 2 | 6 | 101 | n.d. | n.d. | n.d. |
| **Ba** (ppm; INA) | 1020 | 1100 | 1310 | n.d. | n.d. | n.d. |
| **Bi** (ppm; ICP) | 0.13 | 0.15 | 0.18 | 0.09 | 0.13 | 0.73 |
| **Br** (ppm; INA) | 0.5 | 0.5 | 1.3 | n.d. | n.d. | n.d. |
| **Ca** (%; ICP) | 2.23 | 2.78 | 3.54 | 0.57 | 0.83 | 6.8 |
| **Cd** (ppm; ICP) | 0.67 | 0.77 | 1.37 | 0.32 | 0.53 | 8.97 |
| **Co** (ppm; ICP) | 21.1 | 15.8 | 31.1 | 10.4 | 13.5 | 24.8 |
| **Co** (ppm; INA) | 19 | 23 | 28 | n.d. | n.d. | n.d. |
| **Cr** (ppm; ICP) | 83.80 | 101.80 | 131.9 | 37.1 | 55.6 | 175.3 |
| **Cr** (ppm; INA) | 190 | 211 | 256 | n.d. | n.d. | n.d. |
| **Cu**; (ppm; ICP) | 55.8 | 66.2 | 72.8 | 21.3 | 30.5 | 107.0 |
| **Fe** (%; INA) | 3.50 | 3.68 | 4.04 | 2.20 | 2.73 | 12.98 |
| **Hg** (ppb; ICP) | 136 | 195 | 229 | 92 | 151 | 4437 |
| **La** (ppm; INA) | 12.40 | 13.40 | 18.2 | 12.6 | 16.9 | 96.2 |
| **LOI** (%) | n.d. | n.d. | n.d. | 8.2 | 18.4 | 92.4 |
| **Mn** (ppm; ICP) | 770 | 871 | 1051 | 544 | 838 | 7832 |
| **Mo** (ppm; ICP) | 1.14 | 1.34 | 2.71 | 0.71 | 1.13 | 21.39 |
| **Ni** (ppm; ICP) | 122.4 | 160.1 | 210.8 | 31.0 | 47.0 | 293.4 |
| **P** (%; ICP) | 0.088 | 0.096 | 0.120 | 0.085 | 0.104 | 0.353 |
| **Pb** (ppm; ICP) | 8.08 | 9.06 | 16.9 | 6.44 | 9.02 | 32.8 |
| **Sb** (ppm; INA) | 0.61 | 0.72 | 1.65 | 0.28 | 0.40 | 4.35 |
| **Se** (ppm; ICP) | 0.3 | 0.3 | 0.5 | 0.4 | 0.8 | 19.6 |
| **V** (ppm; ICP) | 69 | 75 | 85 | 40 | 56 | 156 |
| **Zn** (ppm; ICP) | 91.30 | 114.90 | 191.5 | 66.6 | 87.6 | 922.8 |

Abbreviation: n.d., not determined

Anomaly 4 is represented by an Au value of 1010 ppb (INAA) in a till sample from a site east of Great Beaver Lake. Analysis of a second split of the sample determined a value of 121 ppb Au by aqua regia and ICP-MS. No other elements are anomalous in the sample and a possible source for the Au is most likely concealed in bedrock to the southwest. East of Mount Prince, several till sites have samples containing anomalous Ba, As, Hg, Sb and Se. Anomaly 5, for example, has 229 ppb Hg and the most likely source for the metal is Hg mineralization along the Pinchi Fault similar to that reported at the Mount Prince occurrences.

Most of the water samples collected are weakly alkaline and have no detectable or very low metal contents. One water sample, however (Anomaly 6), has several ppb of Al, Mn, Co, Ni and Y. The stream flows through a swampy area and the elevated metals could be explained by natural complexes formed with dissolved organic matter. There are no anomalous metals in stream sediment at the site.

## CONCLUSIONS

- Detailed geochemical surveys north of Lillooet and in the McLeod Lake map sheet have identified new Au and base-metal anomalies.
- In the French Bar Creek – Ward Creek area, a possible source for the high Au values with anomalous Hg and As in stream and moss sediment from

Roderick Creek is epithermal Au-Ag-As-Hg mineralization.

- There is no obvious source for high Au values in sediment from Boiler Creek draining Eocene volcanic rocks north of French Bar Creek. Elevated rare earth element and Al in water may be caused by the weathering of the Eocene volcanic rocks. Similarly, there is no known mineralization to explain Au and trace-element anomalies in the Pony Creek valley area. More detailed stream sediment sampling and prospecting should be carried out in both areas.

- While there is no clear source for the Au anomalies in stream sediment and till around Great Beaver Lake in the McLeod Lake map sheet, the high Cr, Ni and V in till indicates the presence of mafic and/or ultramafic rocks. Ice flow indicators suggest that these rocks are concealed beneath the lake or south of the lake.

- An absence of active first-order drainages in both areas limits more detailed follow-up stream sediment sampling. Moss sediment is often more effective than drainage sediment for detecting Au where there are streams. However, moss is not always present in low-relief areas and therefore cannot be used for routine geochemical sampling. Moss sampling is most effective in mountainous, high-rainfall areas where drainage samples are commonly depleted in fine-textured sediment. An abundance of lakes in the McLeod Lake map sheet suggests that a lake sediment survey would be a good follow-up strategy for the RGS stream-sediment anomalies.

- Basal till (*i.e.,* a first derivative of bedrock), is very effective for stream sediment anomaly follow-up. Well-developed basal or lodgment till in Great Beaver Lake area should be sampled as part of a regional till survey to identify the source of the Au and base-metal anomalies. Ideally, in combination with collecting basal till samples, the ice flow history of the area would have to be established by surficial mapping so that the transport direction of the till, and ultimately the trace-element chemistry, could be more accurately interpreted. A mineralogical examination of till heavy mineral concentrates in addition to geochemical analysis should be a routine component of a till survey.

- A sandy till in the French Bar Creek – Ward Creek area suggests a predominantly ice melt-out sediment derived from a relatively large source area. Till or soil geochemistry would less effective for stream sediment anomaly follow-up because melt-out till, unlike basal till, is a less well-defined source of anomalous metal. However, systematic prospecting and colluvium sampling would be better follow-up techniques because of the greater bedrock exposure.

- Highly organic sediment and soil can lead to spuriously elevated trace element values (*e.g.,* Cu, Pb, Zn and Hg) in steam sediment and soil. Field recording of sample site characteristics and loss on ignition (LOI) analysis of samples are simple ways for interpreting spurious anomalies caused by the presence of organic matter.

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