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

# TILL GEOCHEMISTRY OF THE CHU CHUA - CLEARWATER AREA, B.C. (PARTS OF NTS 92P/8 AND 92P/9)

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# INTRODUCTION

This report provides the final results, discussion and interpretation of a drift exploration program conducted north of Kamloops by the British Columbia Geological Survey Branch (Figure 1). The till geochemistry project discussed here represents the end product of field investigations undertaken during the summer of 1998 as part of a larger, multidisciplinary, integrated resource assessment program aimed at defining the mineral potential of south-central British Columbia. The survey was undertaken as year three of the Eagle Bay Project (cf. Paulen *et al.*, 1999) which centred on the western part of the Eagle Bay Assemblage and Fennell Formation of the Kootenay Terrane. Interesting results from the 1997 till geochemistry survey directly south and east (Bobrowsky *et al.*, 1998) encouraged a further extension of the program into the Upper Triassic-Jurassic rocks of the Nicola Group. The "Eagle Bay" drift prospecting program is one of several provincial till geochemistry surveys (the most recent being Bobrowsky *et al.* 1998 in the Louis Creek-Chu Chua areas) which have been ongoing since 1990 to demonstrate the utility of integrating surficial geology mapping and exploration geochemical methods to locate buried mineral deposits in areas of drift-covered terrain (*see* Bobrowsky *et al.*, 1995 for a review).

Surficial studies and drift exploration work in 1998 was completed north of Kamloops in NTS map sheets 92P/8W (Chu Chua Creek) and 92P/9 (Clearwater). The work is a continuation of a till geochemical survey carried out in 1996 (see Bobrowsky *et al.*, 1997a) over the NTS map sheets 82M/4 (Adams Plateau) and 82M/5 (North Barriere Lake) and 1997 (see Paulen *et al.*, 1998a) in the eastern portions of NTS map sheets 92P/1E (Louis Creek) and 92P/8E (Chu Chua Creek) and in parts of the NTS map sheets 82M/3 (Albias), 82L/13 (Chase) and 82L/14 (Sorrento) (see Paulen *et al.*, 1999). The study area encompasses some 500 square kilometres of rugged drift-covered terrain (Figure 2) in the northeastern part of the Thompson Plateau, within the Interior Plateau. Volcanogenic massive sulphide (VMS) deposits hosted in the Fennell Formation, volcanogenic sulphide-barite deposits hosted in the Eagle Bay Formation, tombstone-style gold prospects hosted in the Baldy Batholith and the highly mineralized package of Nicola Group volcanic, sedimentary and associated intrusive rocks, all indicate that the region has considerable mineral potential. Polymetallic gold-bearing veins hosted in volcanic assemblages of the Fennell Formation and the anomalous gold values in altered quartz vein float near the margin of the Thuya River Batholith also suggest a high potential for gold in the area. Although the

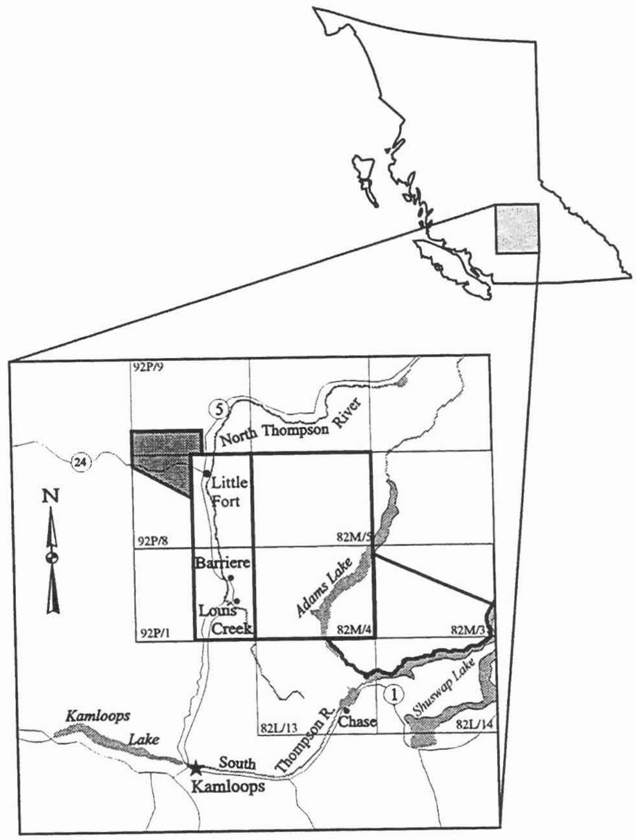


Figure 1. Location of the 1998 till geochemistry survey in south-central British Columbia. Bold outline indicates the 1996-1998 Eagle Bay Project.

exploration history in the region is poor with relatively few MINFILE occurrences (Figure 3, Table 1), the till geochemistry indicates that there is high potential in the region. Published bedrock maps of the area are lacking in detail, the area is limited to 1:250 000 maps by the Geological Survey of Canada (Campbell and Tipper, 1971). Exciting till geochemistry and the lack of detailed bedrock maps provided the impetus for continued drift prospecting in the region. Previously, the release of Open File 1997-03 and Open File 1998-06 stimulated renewed exploration by a number of mining companies. Exploration has been given further impetus by the published results of mineral deposit studies (Höy, 1997; 1999), geochemical orientation surveys (Lett, *et al.*, 1998; Lett *et al.*, 1999; Lett and Jackaman, 2000) and a stream water survey (Sibbick *et al.*, 1997; Lett *at al.*, 1998), as well as 1:50 000 scale surficial mapping and drift exploration sampling. The latter two components provide vital information for mineral exploration in regions where unconsolidated sediments of variable thickness mask the underlying bedrock.

Drift exploration integrates two allied components: surficial geology mapping and till geochemistry sampling. With this in mind, the objectives of the drift exploration project were to:

- define new anomalies which may be used in the discovery of mineralization targets;
- establish the dispersal of pathfinder elements down-ice from a known source;
- stimulate new exploration and economic activity, especially in the poorly explored Quesnel Trough;
- document ice flow indicators including both local and regional ice flow patterns to aid drift prospecting in the area; and,
- provide information where mineral exploration has been hampered by thick glacial drift cover, and where traditional prospecting and exploration techniques have proven unsuccessful despite indications of high mineral potential.

The purpose of the surficial mapping component was to document the variability in the types of sediments observed, including their distribution and general character for this particular area. These data, including origin and age of unconsolidated sediments in the area of glaciated terrain, provide critical constraints to a successful drift exploration program. Quaternary geologic history consisting of local and regional stratigraphy, sedimentology and glacial ice dynamics are the focus of much of the work, since the understanding of these parameters provides a framework for a complementary till geochemistry and pebble lithology sampling program. (Salonen, 1988). The till geochemistry consisted of a systematic sampling program (2-8 kilograms) collecting primary basal till, ablation till and colluviated till deposits which were first identified and then targeted during the surficial mapping.

The integration of surficial mapping and till geochemistry with mineral deposit studies and detailed bedrock mapping addresses the main objective of drift prospecting: to provide data that will lead to the discovery of economic mineralization in areas now covered by a blanket of unconsolidated sediments. We accomplish this by interpreting down-ice glacial dispersal patterns (mechanical dispersal trains) that will help us locate the sources of geochemical anomalies and clast lithologies (*cf.* Coker and DiLabio, 1989). Preliminary Quaternary geology results have been summarized in a series of papers (Bobrowsky *et al.*, 1997a; Dixon-Warren *et al.*, 1997a; Paulen *et al.*, 1998a; 1999a) and four 1:50 000 scale Open File terrain maps (Dixon-Warren *et al.*, 1997b; Leboe *et al.*, 1997; Paulen *et al.*, 1998b; Paulen *et al.*, 1998c).

Figure 2. General view of the Thompson Highland Plateau, northwest of Little Fort. Note the subdued topography and the thick moraine (basal till) covered terrain, which is typical of much of the study area.

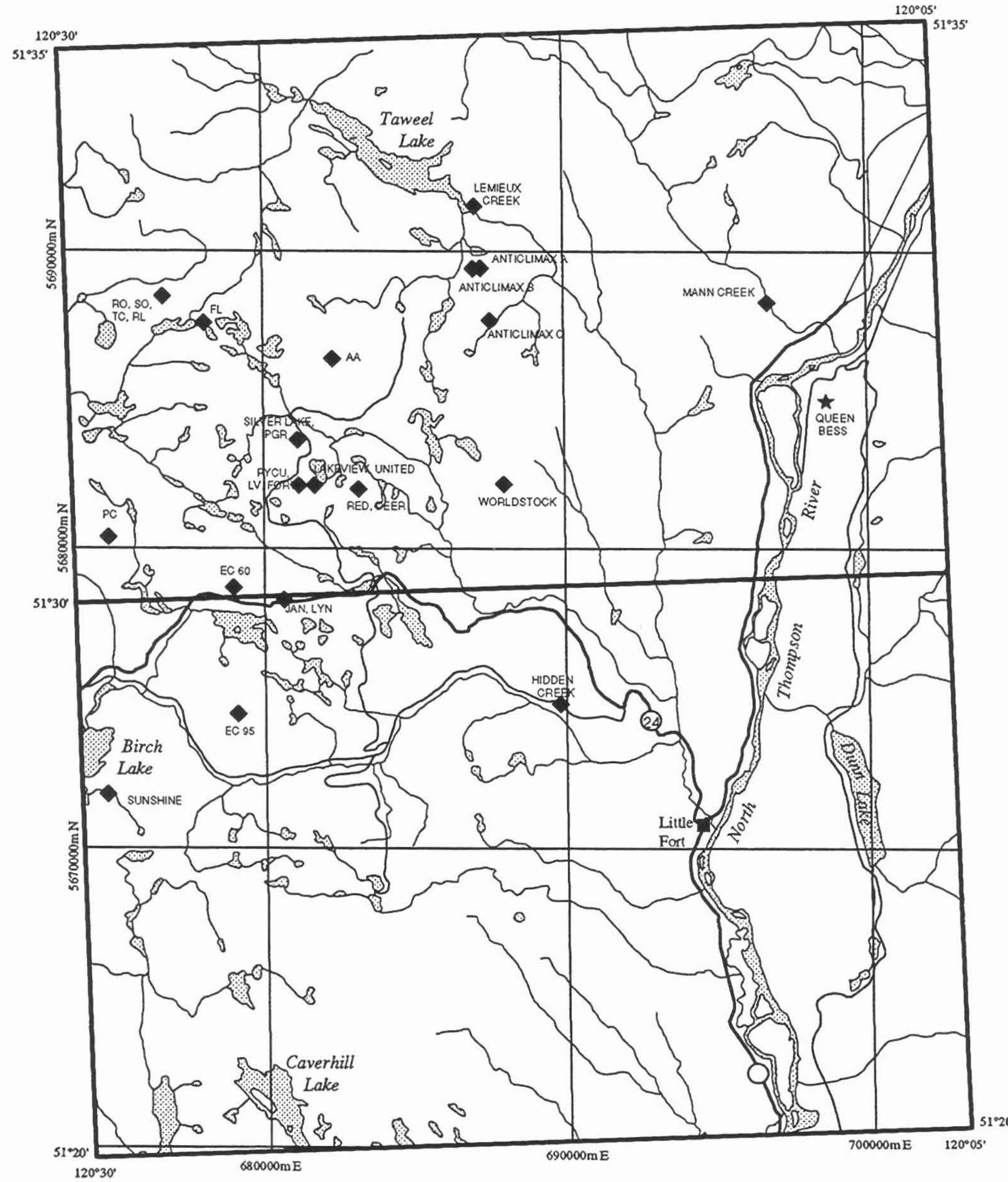


Figure 3. Mineral occurrence locations for NTS 92P/8W and 92P/9 from the MINFILE database, see Table 1 for respective commodity.

**TABLE 1**
**MINERAL OCCURRENCE LOCATIONS FOR NTS 92 P/8 AND 92 P/9 FROM THE MINFILE DATABASE**

| NTS | MINFILE | NAME | COMMODITY | STATUS | UTME | UTMN |
|---|---|---|---|---|---|---|
| 92P/8 | 092P 012 | EC 95 | Fe | Showing | 678950 | 5704500 |
| 92P/8 | 092P 013 | Hidden Creek | Au, Ag, Cu | Showing | 689650 | 5704850 |
| 92P/8 | 092P 017 | Jan, Lyn | Cu | Showing | 680500 | 5708300 |
| 92P/8 | 092P 106 | Sunshine | Cu | Showing | 674575 | 5701800 |
| 92P/9 | 092P 006 | RO, SO, TC, RL, LO | Cu, Mo, Ag, Pb | Showing | 676400 | 5718500 |
| 92P/9 | 092P 008 | Silver Lake, PGR | Cu | Showing | 680925 | 5713675 |
| 92P/9 | 092P 009 | PC | Cu | Showing | 674600 | 5710400 |
| 92P/9 | 092P 010 | Lakeview, United | Cu, Au | Showing | 681500 | 5712150 |
| 92P/9 | 092P 011 | EC 60 | Pb | Showing | 678790 | 5708700 |
| 92P/9 | 092P 014 | Anticlimax A | Mo | Showing | 687000 | 5719450 |
| 92P/9 | 092P 015 | Anticlimax B | Mo | Showing | 686750 | 5719420 |
| 92P/9 | 092P 016 | Anticlimax C | Mo | Showing | 687320 | 5717700 |
| 92P/9 | 092P 018 | Lemieux Creek | Ag, Pb, Au | Showing | 686800 | 5721500 |
| 92P/9 | 092P 027 | Red, Deer | Cu | Showing | 682975 | 5712025 |
| 92P/9 | 092P 029 | Mann Creek | Cu, Pb | Showing | 696500 | 5718300 |
| 92P/9 | 092P 042 | Queen Bess | Pb, Zn, Ag | Past Producer | 698410 | 5715000 |
| 92P/9 | 092P 134 | FL | Cu, Mo, Pb | Showing | 677800 | 5717600 |
| 92P/9 | 092P 136 | PYCU, LV, Fort | Cu, Au | Showing | 680975 | 5712150 |
| 92P/9 | 092P 137 | AA | Au, Ag, Pb, Zn, Cu, Mo | Showing | 682100 | 5716400 |
| 92P/9 | 092P 145 | Worldstock | Cu, Au | Showing | 687800 | 5712190 |

Open File 2000-17 provides the final summation of the till geochemical data collected in the two map sheets during 1998. All samples considered reliable and useful for further exploration research are included in this report. This consists of ICP, INAA and whole rock analytical results for some 181 basal till, ablation till and colluviated till samples. An important part of this report is the information provided regarding the regional Quaternary geologic history. Finally, the reader will benefit from the discussion regarding the distribution of anomalous values for several elements (Ag, Au, Cu, Cd, Zn, Pb, Ni and As) in this area, since it draws on the relevance of sample media, deposit genesis and probable mineral prospects.

## OPEN FILE FORMAT

Open File 2000-17 consists of the following sections:

- Introduction
- Description of the survey area
- Survey methodology
- Quality control
- Data interpretation and discussion
- Summary and Recommendations
- References
- Guide to field observations (Appendix A)
- Analytical data for ICP Analysis (Appendix B)
- Analytical data for INAA Analysis (Appendix C)
- Analytical data for Whole Rock Analysis (Appendix D)
- Summary statistics and element maps for ICP data (Appendix E)
- Summary statistics and element maps for INAA data (Appendix F)
- Summary statistics and major oxide maps for Whole Rock data (Appendix G)
- Analytical duplicate data for ICP, INAA and Whole Rock Analysis (Appendix H)
- Station Location Map (Appendix I)
- Analytical and field data as an ASCII file on a 3.5-inch high density diskette in the back pocket.

# DESCRIPTION OF THE SURVEY AREA

## PHYSIOGRAPHY AND GEOLOGIC SETTING

The Chu Chua and Clearwater area is located in south-central British Columbia, approximately 100 kilometres north of Kamloops (Figure 1). The study area is located on the Thompson Plateau, bounded to the east by the North Thompson River valley which divides the Shuswap Highland in the east from the Thompson Plateau (Holland, 1976). Topography is dominated by the high elevations of the Bonaparte Hills and the Nehalliston Plateau and is dotted with numerous small lakes and stream systems. Elevations range from 670 metres to 1680 metres above sea level. Topographic relief is a gently rolling, forested land surface, typical of Thompson Plateau. Ground moraine of various thickness dominates the landscape, followed in turn by colluvial, glaciofluvial, fluvial and organic sediments. As such, the region is extremely favorable for a till geochemistry survey.

### *Vegetation*

Vegetation is of the Southern Columbia and Interior Subalpine forest regions (Rowe, 1972). Valley bottoms are vegetated with black cottonwood and have been cleared and planted to suit agricultural purposes. Hillsides and plateaus between valley bottoms (at elevations of approximately 1220 m) support a dense vegetation cover of western hemlock, red cedar and Douglas fir. Upper valley slopes up to tree-line support a community of western white and Englemann spruce, and alpine fir. Alder and lodgepole pine are abundant in many disturbed areas.

### *Hydrologic system*

Several major creeks flow from the Thompson Plateau into the North Thompson River. The principal creeks draining the Thompson Plateau include Eakin, Thuya and Lemieux creeks. Several small lakes (1-3 $km^2$) dot the landscape and include Long Island Lake, Latremouille Lake, Rock Island Lake and the eastern part of Birch Lake.

### *Geologic setting*

North of Barriere, Permian to Devonian rocks of the Fennell Formation comprise imbricated oceanic rocks of the Slide Mountain Terrane. The rocks consist of bedded cherts, gabbro, diabase, pillowed basalt and volcanogenic metasediments. The rocks are in fault contact with Permo-Triassic andesites, tuffs, argillites, greywacke and limestone of the Nicola Group (Schiarrizza and Preto, 1987) and in contact with Early Jurassic porphyritic andesite breccia, tuff and flows of the Quesnel Terrane. Mid-Cretaceous granodiorite and quartz monzonite intrusions of the Baldy and Raft batholiths and the Late Triassic - Early Jurassic monzogranite and granodiorite of Thuya Batholith (Campbell and Tipper, 1971) underlie the area.

A major north-south fault paralleling the North Thompson River valley separates the Kootenay and Slide Mountain terranes from the younger Quesnel Terrane. This fault is a single break to Lemieux Creek, where it separates into several splays. This extensive block faulting signifies a major, unknown structural event (Campbell and Tipper, 1971) in a highly mineralized package of Nicola Group rocks within the northwest trending Quesnel Trough.

Polymetallic precious, sedimentary exhalative and Noranda/Kuroko type VMS base metal occurrences are hosted by Devono-Mississippian felsic to intermediate metavolcanic rocks of the Eagle Bay Assemblage. Massive sulphides are hosted in oceanic basalts of the Fennell Formation. Skarn mineralization and silver-lead-zinc mineralization occur as numerous vein deposits within the Fennell Formation near the Cretaceous granitic intrusions. Porphyry copper and copper-gold skarns are hosted in the Nicola Group and molybdenite mineralization occurs near the southern margin of the Raft Batholith. The MINFILE database lists a total of 20 occurrences in the study area (Figure 3), 2 occur in the Fennell Formation, including the past-producer Pb-Zn-Ag Queen Bess Mine. Twelve occur in the Nicola Group, 3 are associated with the Raft Batholith and related monzonite bodies and another 3 occur within the Thuya Batholith. In total, there are 6 occurrences of gold, of which one is placer.

## SURFICIAL GEOLOGY

Several types of surficial deposits were observed in the study area including: ground moraine (basal till and ablation till), colluvial, fluvial, glaciofluvial, glaciolacustrine, organic, and anthropogenic sediments. General observations suggest the plateaus and hills are mainly covered by combinations of till, colluvium and minor glaciofluvial deposits, whereas glaciolacustrine, glaciofluvial and fluvial sediments occur mainly in the valleys. Anthropogenic deposits are not widespread and can be found only near developed prospects and the town of Little Fort. Organic deposits occur locally in all types of terrain.

### Basal Till

Throughout much of the region, the bedrock topography is mantled by variable amounts of massive, very poorly-sorted matrix-supported diamicton (Figure 4). Deposits range in thickness from thin (<1 metre) veneers to thick (>8 metre) blankets. Characteristics of this diamicton suggest that it most likely formed in a lodgement depositional environment (Dreimanis, 1988). Basal till facies tend to be variable with respect to the underlying bedrock.

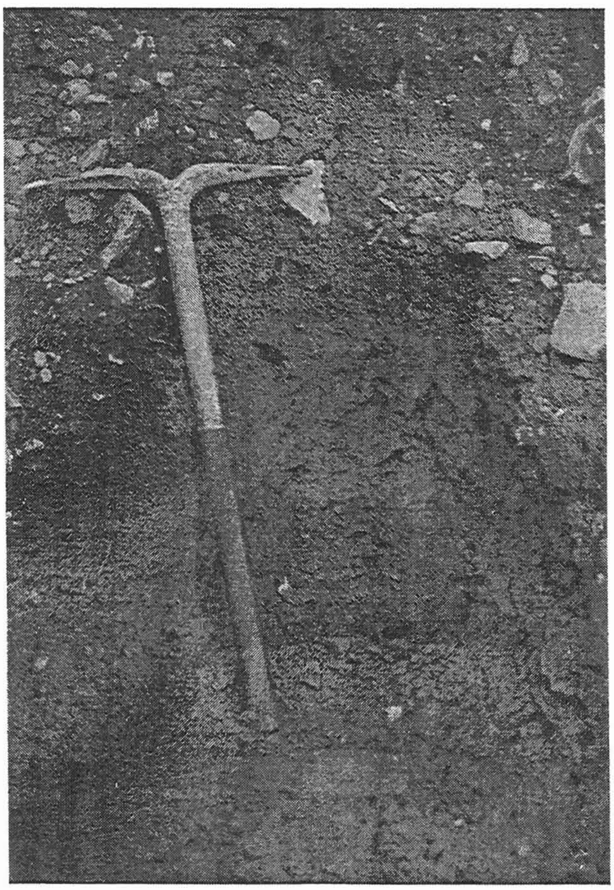

Figure 4. Basal lodgement till exposed in a recent roadcut.

In this area, basal till (lodgement) deposits are primarily massive to poorly-stratified, light to dark olive grey, moderately to highly consolidated sediments derived from greenstone metavolcanics and metasediments of the Fennell Formation or Nicola Group. The matrix is fissile and has a clayey silt to a silty-sand texture. Deposits are dense, compact, cohesive with irregular jointing patterns. Clast content ranges from 15-35%, averaging about 25%, and clasts range in size from granules to boulders (over 2 metres) but average 1-2 centimetres. The clasts are mainly subrounded to subangular in shape and consist of various lithologies of local and exotic source. A number of clasts have striated and faceted surfaces.

### Ablation Till

Massive to crudely stratified clast-supported diamicton occurs throughout the study area. Most commonly, deposits of ablation till occur as a thin mantle overlying basal till and/or bedrock on the higher plateaus. Deposits also occur in areas of hummocky terrain where evidence of recessional ice and mass wasting occurred during deglaciation. In contrast to the basal tills, the diamictons are light to medium grey, moderately compact and cohesive. The sandy matrix is poorly consolidated and usually contains less than 5% silt and clay. Clast content ranges from 30-60% and average clast size is 2-5 centimetres. Clast lithology is variable but often deposits are monolithologic, primarily granodiorites and monzonite derived from the Thuya River and Raft batholiths. Such diamictons are interpreted as supraglacial or ablation till deposits, resulting from deposition by stagnating glacier ice (Dreimanis, 1988).

### Ice Flow Indicators

The striation record in the map area is poor due to the lack of preserved outcrop exposure. Striations were recorded at a few locations where recent logging has exposed fresh bedrock. There is an abundance of sculpted landforms on the plateau tops that provide regional ice flow information which occurred during the peak of glacial activity (Figure 5). Local paleo-ice flows are documented to be coincident with regional south to southeast flows (Fulton *et al.*, 1986). Regional ice flow directions are to the southeast, with deviations to the south in the North Thompson River valley.

## GLACIAL HISTORY AND STRATIGRAPHY

According to Fulton and others (Clague, 1989; Fulton, 1975; Fulton and Smith, 1978; Ryder *et al.*, 1991), the present day landscape of south-central British Columbia is the result of two glacial cycles, one interglacial and vigorous early-Holocene erosion and sedimentation. Evidence for only the latter glacial event

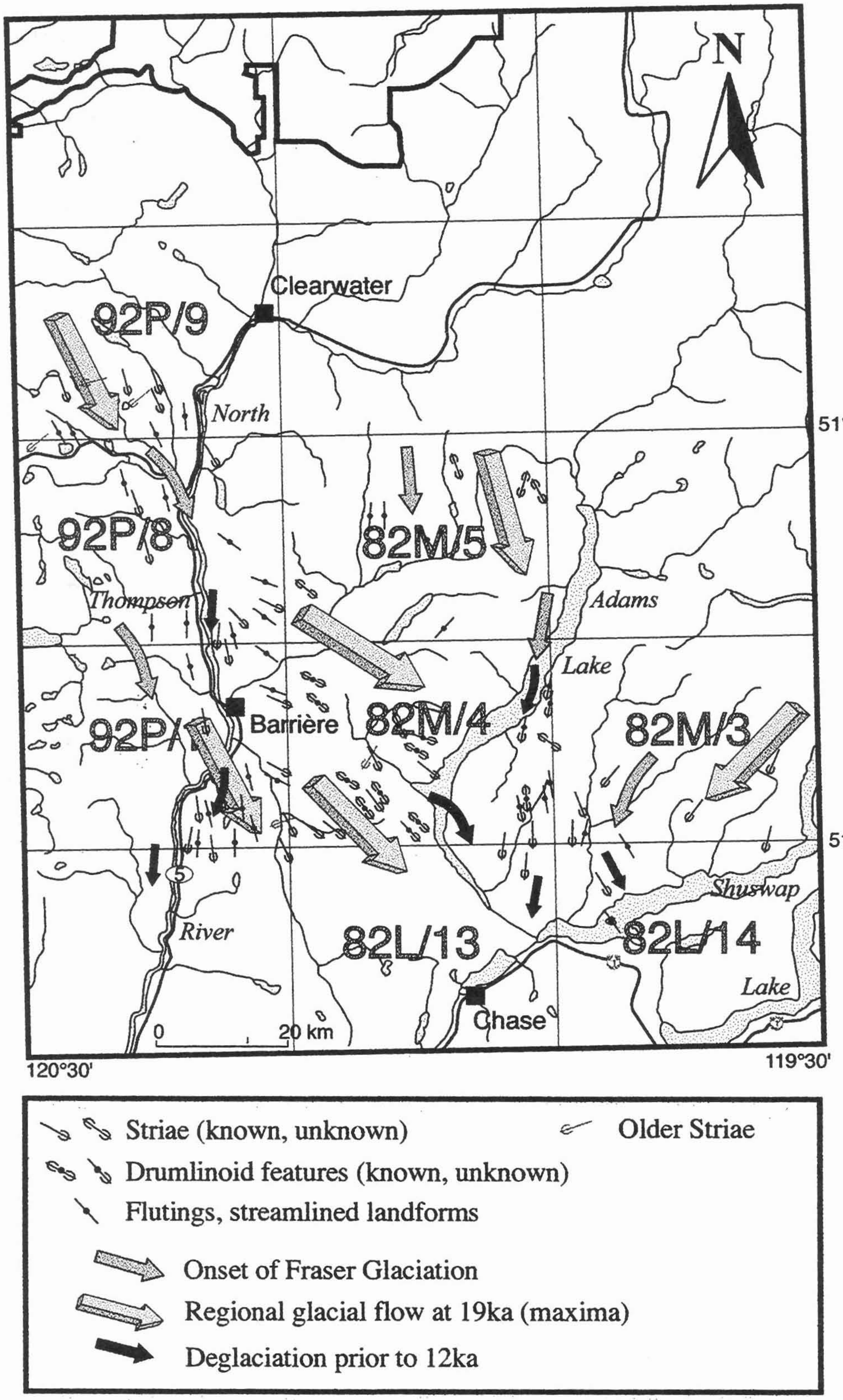


Figure 5. Summary of ice flow indicators for the Eagle Bay Project (1996-1998). Data compiled from the Eagle Bay project terrain geology maps (Dixon-Warren *et al.*, 1997b; Leboe *et al.*, 1997; Paulen *et al.*, 1998b; Paulen *et al.*, 1998c) and 1998 field observations.

Stratigraphically oldest and identified only at two locations to the south of the study area, are the interglacial Westwold Sediments. The deposits consist of cross-stratified gravely sand capped by marl, sand, silt, and clay, all of which are equivalent to the Highbury non-glacial interval in the Fraser Lowland (Sangamonian). Next in age are Okanagan Centre Drift deposits, consisting of coarse, poorly-stratified gravel, till and laminated silt. The sediments were deposited during the Okanagan Centre Glaciation, equivalent to the Semiahmoo Glaciation in the Fraser Lowland (early Wisconsinan). Middle Wisconsinan, Olympic Non-Glacial Bessette Sediments overlie the Okanagan Centre Drift. They consist of nonglacial silt, sand and gravel with some organic material and up to two tephras. The Kamloops Lake Drift (20.2 ka; Dyck *et al.*, 1965) overlies the Bessette sediments, and underlies the present-day surface cover of postglacial deposits. This unit consists of silt, sand, gravel and till deposited during the Fraser Glaciation (Late Wisconsinan).

Rare older striae preserved on bedrock surfaces suggest an early glacial advance from the northeast to the southwest, but there is no evidence of this in the sediment record. The surface and near-surface sediments sampled in both the southern and northern regions directly result from the last cycle of glaciation and deglaciation (Fraser Glaciation), as well as ensuing post-glacial activity.

## Fraser Glaciation

The onset of Fraser glaciation began in the Coast, Cariboo and Monashee mountains. Valley glaciers descended to lower elevations to form piedmont lobes in the Interior Plateau, and eventually coalesced to form a mountain ice sheet (Ryder *et al.*, 1991). Ice sheet margins reached a maximum elevation between 2200 and 2400 metres along rimming mountains; the entire Shuswap Highland was completely buried beneath an ice cap by approximately 19 ka. At Fraser Glaciation maximum, regional ice flow was to the south-southeast on the Bonaparte and Adams plateaus (Tipper, 1971) with deviations up to 45° (Fulton *et al.*, 1986). This deviation was particularly noted in the eastern part of the study area, where ice from the north and west coalesced with ice flowing from the Monashee Mountains and was subsequently directed into the Shuswap Basin. Basal till deposits, which range widely in texture with the underlying bedrock, blanketed the land surface.

Deglaciation of the Interior Plateau was rapid; the equilibrium line likely rose considerably, reducing the area of accumulation for the Cordilleran ice sheet, as the ice mass decayed by downwasting. Ablation till was deposited by stagnating ice in several high-elevation portions of the region. As uplands were deglaciated prior to low benches and valleys, meltwater was channeled to valley sides, resulting in kame terraces and ice-contact sediments. Valleys clear of ice above the stagnating glaciers in their lower reaches became the confinement for meltwater blocked from drainage, thereby resulting in local mantling of glaciolacustrine sediments. Radiocarbon dates of 11.3 ka at McGillivary Creek (Clague, 1980), 10.5 ka at Chase (Lowdon and Blake, 1973) and 10.1 and 9.84 ka on Mount Fadear Plateau (Blake, 1986) indicate that deglaciation began about 12 ka and that the modern drainage pattern was established prior to 8.9 ka (Dyke *et al.*, 1965; Fulton, 1969).

## Holocene Post-Glacial

Once ice-dammed lakes drained, meltwater carrying heavy sediment loads deposited thick units of stratified sand and gravel in valleys. As sediment loads decreased, deposition was replaced by erosion, and water courses cut down through valley fills, leaving glaciofluvial terraces abandoned on valley sides. Following the complete deglaciation of the region, unstable and unvegetated slopes were highly susceptible to erosion and sedimentation. Intense mass wasting of surface deposits on oversteepened valley slopes resulted in the deposition of colluvial fans and aprons along valley bottoms. Most post-glacial deposition occurred within the first few hundred years of deglaciation, and certainly before the eruption of Mt. Mazama, circa 7000 radiocarbon-years ago, which deposited tephra near the present-day ground surface. Fluvial fan deposits and active talus slopes typify the modern sedimentation in the area.

# SURVEY METHODOLOGY

## SAMPLE COLLECTION

Fieldwork was based out of one base camp at Tod Mountain. Access to the area is excellent. An extensive network of logging roads intersects most moderate slopes and all plateaus. The majority of fieldwork was conducted using a 4-wheel drive vehicle along secondary roads and trails of varying condition. Where road or 4-wheel drive track access was blocked or non-existent, traverses were completed on foot.

Initial work consisted of compiling and evaluating all existing terrain information available for the area. Regional Quaternary mapping completed by the Geological Survey of Canada (Tipper, 1971; Fulton, 1975) provided information on the types and distribution of the surficial sediments. Detailed local ice-flow directions were obtained by measuring and determining the directions of striations, grooves and local roche moutonnées. The MINFILE database was examined to gain insight on the local mineral showings with respect to the deposit types and host rock relationships.

At each ground-truthing field station some or all of the following observations were made: GPS-verified UTM location, identifying geographic features (*i.e.* creek, cliff, ridge, plateau, etc.), type of bedrock exposure if present, unconsolidated surface material and expression (terrain polygon unit), general slope, orientation of striations/grooves on bedrock or bullet-shaped boulders, large scale features of streamlined landforms, elevations of post-glacial deposits (glaciofluvial and glaciolacustrine) and active geological processes.

Bulk sediment samples (1-5 kilograms) were collected for geochemical analysis over much of the study area. Emphasis was placed on collecting basal till deposits (first derivative products according to Shilts, 1993), although ablation till, colluviated till and colluvium were also collected under certain circumstances. Natural exposures and hand excavation were used to obtain samples from undisturbed, unweathered C-horizon (parent material) deposits. At each sample site (Figure 6), the following information was recorded: type of exposure (gully, roadcut, etc.), depth to sample from top of soil, thickness of A and B soil horizons, total exposed thickness of the surficial unit, stratigraphy of the exposure, clast percentage, matrix or clast-supported diamicton, consolidation, matrix texture, presence or absence of structures, bedding, clast angularity (average and range), clast size (average and range), clast lithologies, and colour. The samples were evaluated as being derived from one of the three categories; basal till, ablation till, or colluviated/reworked basal till.

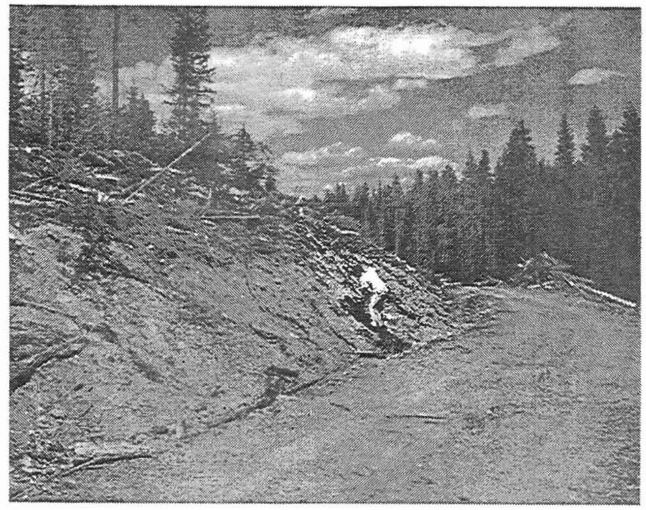

Figure 6. Roadcut exposing basal ground moraine at a sample site.

## SAMPLE PREPARATION AND ANALYSIS

Sediment samples were sent to Eco Tech Laboratories in Kamloops for processing. This involved air drying, splitting and sieving to <63 µm. The pulps, <63 µm sample and unsieved split were subsequently returned to the BCGS sample preparation laboratory in Victoria. The -63 µm fraction of each sample was further divided into 10 and 30 gram portions. The smaller portion was sent to Acme Analytical Laboratory, Vancouver, where samples were analysed for 35 elements by aqua regia digestion - Ultratrace-ICP (ultrasonic nebulizer-inductively coupled plasma emission spectroscopy) and for 11 oxides, loss on ignition, carbon, sulphur and 7 minor elements by $LiBO_2$ (lithium borate) fusion - ICP. The larger portion was sent to Activation Laboratories, Ancaster, Ontario, for INAA (instrumental thermal neutron activation analysis) analysis for gold and 34 elements. Instrumental detection limits for the methods are given in Table 2.

Analytical results are provided as Appendix B (ICP), Appendix C (INAA) and Appendix D (Whole Rock). Data for 30 of the 35 INAA elements and 31 of the 35 ICP elements are presented. Elements excluded from the database are those that contained an excessive number of values at or below the detection limit. For the INAA analysis the excluded elements are Ag, Hg, Ir and Sn.

Elements excluded from the ICP results are Au, B, Ni, W and U. Nb was excluded from the Whole Rock results. Detection limits for the included elements for all methods of analysis are shown in Table 2. Summary statistics are included with the element maps.

**TABLE 2**
**DETECTION LIMITS FOR INAA, ICP AND WHOLE ROCK ANALYSIS FOR TILL SAMPLES**

| | INAA | ICP | | | INAA | ICP | | Whole-rock | |
|---|---|---|---|---|---|---|---|---|---|
| Al | | 0.01% | | Mn | | 1 ppm | | SiO2 | 0.01% |
| Ag | | 1 ppb | | Na | 0.01% | 0.01 % | | Al2O3 | 0.01% |
| As | 0.5 ppm | 0.1 ppm | | Nd | 5 ppm | | | Fe2O3 | 0.01% |
| Au | 2 ppb | | | Ni | | 1 ppm | | MgO | 0.01% |
| Ba | 50 ppm | 1 ppm | | P | | 0.001 % | | CaO | 0.01% |
| Bi | | 0.1 ppm | | Pb | | 0.1 ppm | | Na2O | 0.01% |
| B | | | | K | | 0.01 % | | K2O | 0.01% |
| Br | 0.5 ppm | | | Rb | 15 ppm | | | TiO2 | 0.01% |
| Cd | | 0.2 ppm | | Se | 3 ppm | 0.3 ppm | | P2O5 | 0.01% |
| Ca | 1 % | 0.01 % | | Sm | 0.1 ppm | | | MnO | 0.01% |
| Ce | 3 ppm | | | Sc | 0.1 ppm | | | Cr2O3 | 0.01% |
| Cr | 5 ppm | 1 ppm | | Sr | 0.05 ppm | 1 ppm | | LOI | 0.01% |
| Co | 1 ppm | 1 ppm | | Sb | 0.1 ppm | 0.1 ppm | | Ba | 5 ppm |
| Cu | | 0.1 ppm | | Ta | 0.5 ppm | | | C | 0.01% |
| Cs | 1 ppm | | | Te | | 0.2 ppm | | Ni | 20 ppm |
| Eu | 0.2 ppm | | | Tb | 0.5 ppm | | | S | 0.01% |
| Fe | 0.01 % | 0.01 % | | Th | 0.2 ppm | 1 ppm | | Sc | 5 ppm |
| Ga | | 0.5 ppm | | Ti | | 0.01 % | | Sr | 10 ppm |
| Hg | | 10 ppb | | Tl | | 0.2 ppm | | Y | 10 ppm |
| Hf | 1 ppm | | | U | 0.5 ppm | | | Zr | 10 ppm |
| La | 0.5 ppm | 1 ppm | | V | | 1 ppm | | | |
| Lu | 0.05 ppm | | | W | 1 ppm | | | | |
| Mg | | 0.01 % | | Yb | 0.2 ppm | | | | |
| Mo | 1 ppm | 0.1 ppm | | Zn | 50 ppm | 0.1 ppm | | | |

# QUALITY CONTROL

## METHODOLOGY

Distinguishing geochemical trends caused by geological changes from those variations due to anthropogenic influences, spurious sampling or analytical errors is important for reliably interpreting regional till geochemical data. The routine regional stream and lake sediment geochemical survey quality control methodology developed by the BCGS for monitoring sampling and analytical variability was adopted for this project. Control reference standards and analytical duplicates are routinely inserted into sample suites to monitor and assess accuracy and precision of analytical results. Control reference standards are used to assess analytical accuracy. Sampling and analytical variation can be quantified using estimates of precision within and between sample sites determined by utilizing field and analytical duplicate data. Each block of 20 till samples contains:

- Seventeen routine samples,

- One field duplicate sample collected adjacent to one of the routine samples,

- One blind duplicate sample split from one of the 17 routine samples prior to analysis,

- One control reference standard containing sediment of known element concentrations.

The locations of blind duplicate and control reference samples are selected prior to sampling, whereas field duplicate sites are chosen randomly during fieldwork. The control reference standards consist of CANMET certified and different 'prepared' bulk till of known element concentration. In total, the quality control consisted of 11 pairs of field duplicates and 12 pairs of analytical duplicates (Appendix H). It is common to observe greater variability in the field duplicate pairs as compared to the analytical duplicates. The reason for this difference is that the former represents two different but 'adjacent' samples ( = field sampling + preparation + analytical variability), whereas the latter represents two parts of the same sample ( = analytical variability).

Scatter plots of the analytical and duplicate pairs were generated to facilitate quality control evaluation (Figures 7 and 8). The field duplicate data contained very few outliers, but as expected some were present for the gold analyses.

In general, the results shows good correlation for most field duplicate pairs with correlation coefficients (r) ranging from 0.805 to 1.000, excluding gold which had a correlation coefficient of 0.164. All values of r are significant at the 0.0.1 level. The presence of individual, anomalous samples would have significantly reduced the overall correlation coefficients for each analysis. Analytical duplicate pairs show a slightly higher degree of correlation with r values ranging between 0.766 and 0.999, and a gold r value of 0.530. Analytical duplicates of zinc and arsenic were slightly lower than the field duplicates, with differing r values up to 0.04.

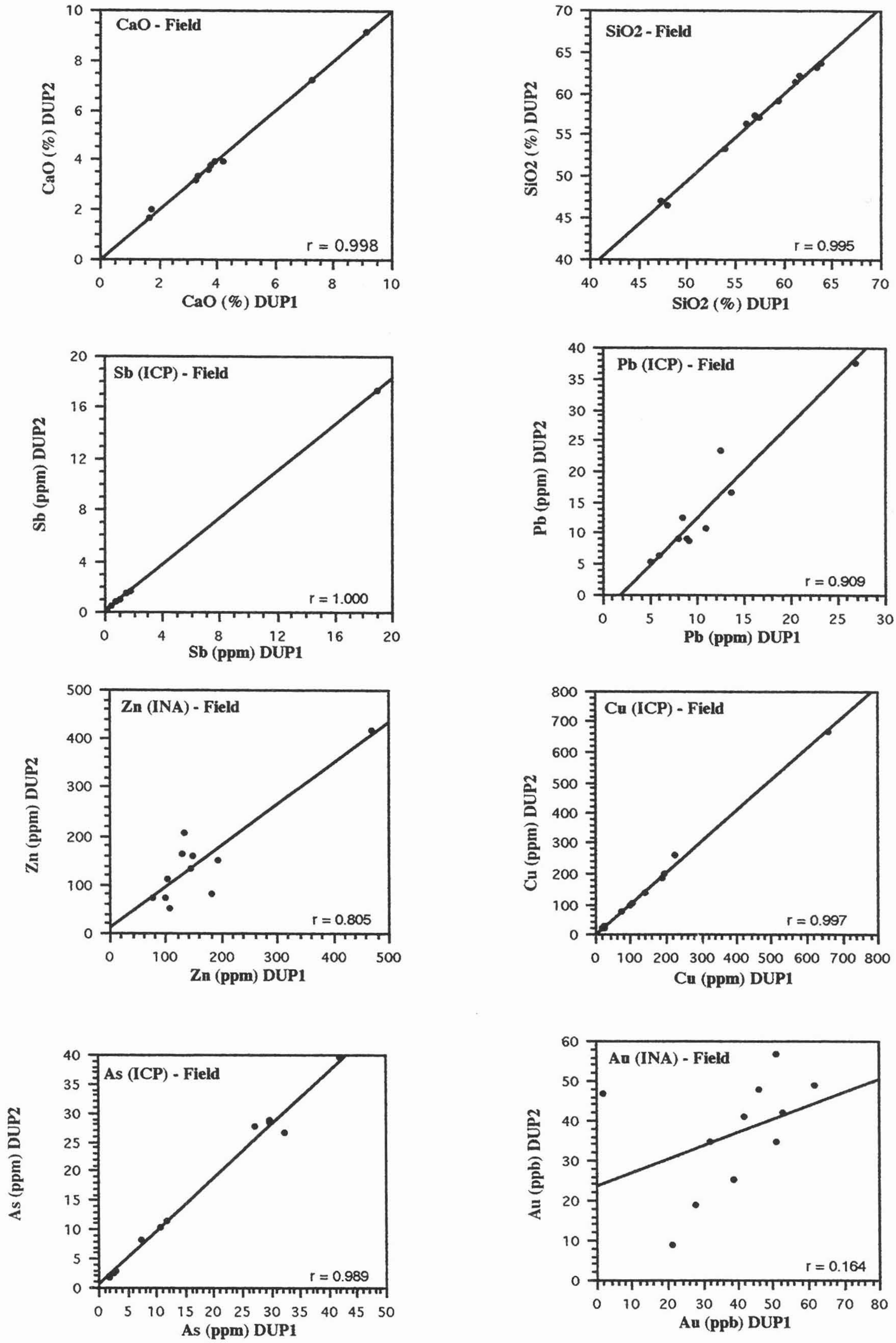


Figure 7. Bivariate scatter plots of field duplicate pairs for the Chu Chua - Clearwater till geochemistry study

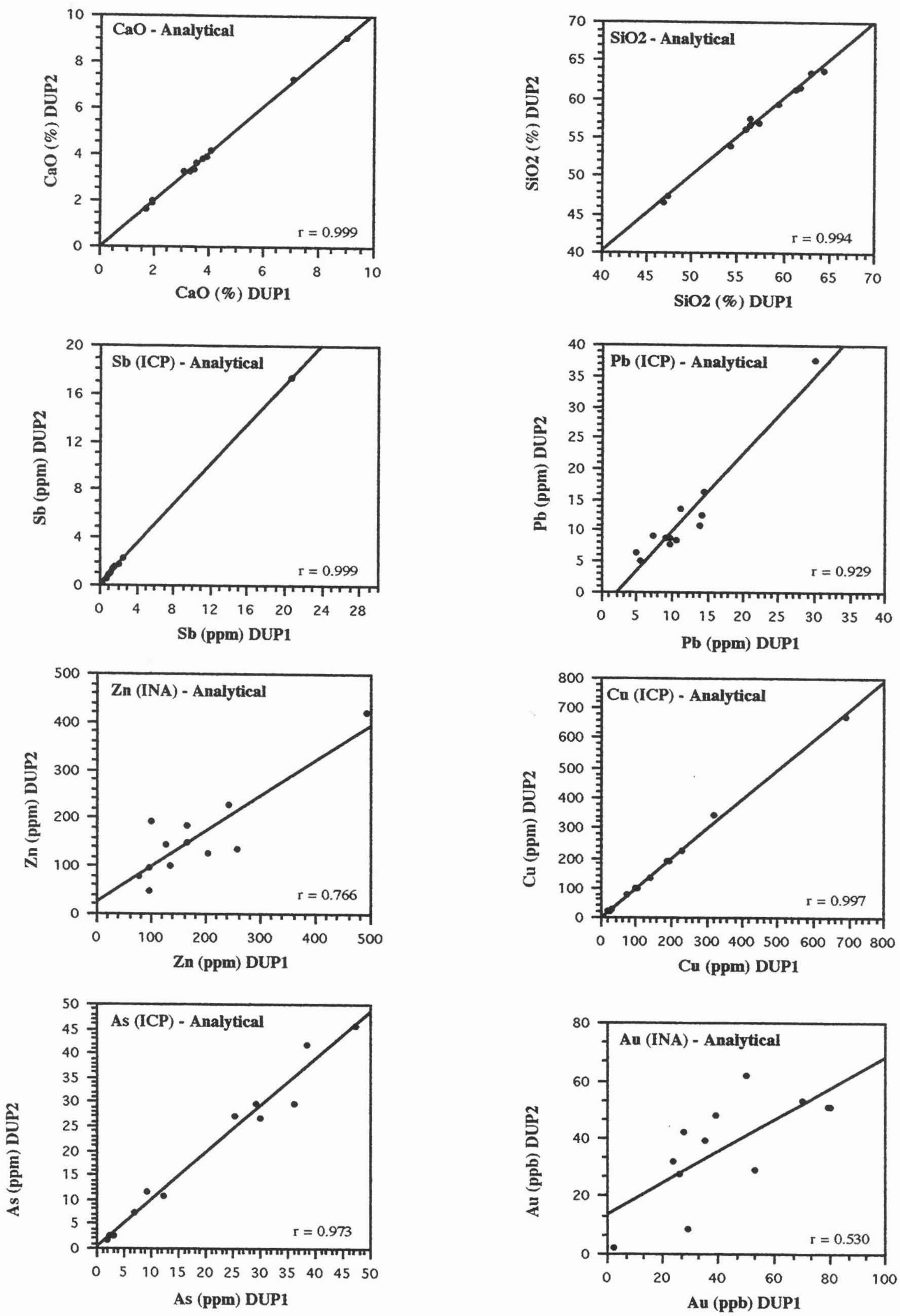


Figure 8. Bivariate scatter plots of analytical duplicate pairs for the Chu Chua - Clearwater till geochemistry study.

# DATA INTERPRETATION

This report provides the results of the till geochemical survey which was part of the South Kootenay drift exploration program. The results of the till geochemical survey program provide a reconnaissance level guide to geochemical patterns established in the area. From an exploration perspective the relation between "anomalous" values of certain elements such as copper, gold, silver, lead, zinc, arsenic, molybdenum, nickel and cadmium and the surficial geologic history warrants further discussion to ensure that follow-up studies are executed with a good knowledge of probable source areas and higher likelihood of discovering those source areas.

As noted previously, analytical results for 31 ICP elements (Appendix B) and 30 of the 35 INAA elements (Appendix C) are presented in this report. The whole rock analysis data provides results of analysis for 11 major oxides, 6 minor elements as well as Loss-On-Ignition (LOI) values (Appendix D). The field data in Appendix A consists of a map identification column (MAP), station identification label (ID), UTM zone (GRID), easting and northing (UTME and UTMN, respectively), field duplicate identification (STA), and sample media. The ICP data in Appendix B consists of an identification label (ID) and field duplicate identification. The individual elements are listed along the top of the x- axis under which a unit of measurement (*e.g.* ppm or %) is provided, followed in each case by the level of detection. In Appendix C, the INAA analytical data consists of the same first seven columns as the ICP data. Under each of the elements detailed for the INAA data, units of measurement include ppb, ppm and %, which in turn are underlain by levels of detection. Finally, the whole rock analysis data provided in Appendix D consist of the same first six columns as in the ICP data, as well as data for major oxides and LOI concentrations presented as a percentage of total. The final column gives the analytical summed value for each sample.

Appendix E provides graphical plots of the 31 elements analyzed by ICP. Each illustration provided consists of an element specific map covering the full sample area (parts of NTS 92P/8 and 9), geographical reference points (*e.g.* towns, villages, and river names), geographical coordinates (UTM as well as latitude and longitude), and a symbol legend. The symbol legend describes the distribution of values for eight percentile categories, minimum and maximum values within each percentile category and a graphic representation of the symbol size used to denote the particular percentile category. The facing page of each element map provides a frequency histogram of the specific distribution, as well as a normal cumulative probability curve. Analytical summary data presented includes the fraction analyzed, the analytical method and the detection limit. Summary statistics for each element consist of the number of samples, minimum and maximum values, mean, mode, median, lower and upper quartiles, standard deviation and a coefficient of variation.

The graphical representation, analytical summary and statistical summary is duplicated for the 30 elements analyzed by INAA and for the 11 major oxides, LOI, carbon, sulphur and minor elements. These results are provided as Appendix F and G, respectively. To assist in station identification, a mylar overlay map with all station locations and identification labels is included as Appendix I. Lastly, a digital version of the geochemical data is provided in ASCII format on the 3.5" diskette included in the back cover insert.

The elements presented here are those for which analytical results appear to be both minimally biased and well above detection limits. Moreover, the data presented include results for comparable media (tills and colluviated till). Hence, the integrity of the data is interpreted to be exceptionally high in comparison to any discussion centred on mixed media samples (*e.g.* till, colluvium, soils, outwash, etc.). Given the nature of the surficial sediments in the Eagle Bay area, the media sampled and presented here reflect 'parent' materials or proximal sources which are 'local' in origin; that is, where transport distances are on the order of tens of metres to a few kilometres from source area, rather than tens or hundreds of kilometres as is the case in other regions.

In the following discussion, several of the more important elements associated with volcanogenic massive sulphide (VMS) deposits, volcanogenic sulphide-barite deposits and tombstone-style gold prospects (gold, copper, lead, silver, zinc, cadmium, molybdenum, nickel, and arsenic) are reviewed. Elevated element concentrations are highlighted and evaluated with reference to known mineral occurrences (see MINFILE 92P). Interpretations regarding likely associations between the till geochemistry anomalies and known mineral occurrences are provided. Similarly, as yet unexplained associations are emphasized with suggestions for probable source areas. Glacial ice flow directions, deposit types and drift thickness are discussed and integrated into the element interpretation to assist explorationists in follow up efforts.

## SILVER

The 170 till samples collected and analyzed by ICP provided silver concentrations ranging from less than 30 ppb to 8419 ppb. The samples generated a mean concentration of 367 ppb; mode and median values were <30 and 222 ppb, respectively. Most of the sample results occurred in the lower 90th percentile (163 samples) with 6 samples having concentrations of >1000 ppb.

A basal till sample at station 989186 located approximately 1 km east of Lost Horse Lake provides the highest concentration of silver recorded (8419 ppb). The nearest known mineral occurrence is the AA showing directly east, >1 km in distance. Silver, molybdenum and zinc have been reported as "scattered highs" at the AA showing (Aird, 1974). Documented ice-flow in the region trends south-southeast. Therefore, it is unlikely that this particular geochemical anomaly in till is derived from the AA showing, but may possibly be a product of the same mineralized augite andesite breccias that host the mineralization at the showing. The bedrock source for this anomaly is presently unknown, and is most likely located within one or two kilometres of the sample site, directly to the north-northwest along the eastern edge of Lost Horse Lake. This station also boasts a multi-element signature with appreciably high zinc, lead, cadmium, bismuth, tellurium, mercury, arsenic, antimony, molybdenum and gold concentrations.

The second highest concentration of silver was obtained from station 989569 approximately one kilometre east of Deer Lake. The 4033 ppb silver value is associated with high copper values. As well, abundant mineralized float was noted at the station. There are several showings in the vicinity including the Red (Deer) showing to the south, Lakeview (United) to the southwest and the PGR-Silver Lake property two kilometres to the north-northwest. The source of this anomaly is likely from a mineralized zone proximal to the Deer Lake diorite trend where grab samples from quartz-carbonate veins have been reported up to 1456 g/t Ag (Wells, 1998).

Two high values of silver were obtained from stations 989163 and 989162; 1531 and 1393 ppb, respectively. The two stations occur within several hundred metres from each other on a small hill approximately three kilometres northwest of Long Island Lake. Located near the southwestern corner of NTS 92P/9, the sample occurs in an area where there are no known silver occurrences. There is a small copper showing (PC) about one kilometre to the west but this is unlikely to be the source. Appreciable values of cadmium and mercury occur at one of the stations (989162). The most probable source for these two samples lies one to two kilometres to the northwest, along the strike of the valley occupied by a few small unnamed lakes.

A value of 1513 ppb was obtained from a basal till sample at station 989316. Located about two kilometres south of Rock Island Lake, east of Nehalliston Creek, the site reflects a bedrock source 400 m to the northwest. A pyritic cherty breccia was discovered in 1997 at the southeastern margin of the Silver Lake property (Wells, 1998) and is most likely the source of the enrichment in the till. The till also supports elevated values of antimony, cadmium, molybdenum, mercury and zinc, which are may be associated with the small local bodies of granitic stockwork that were intruded during the emplacement of the Raft Batholith.

The final location discussed here for silver is station 989229 where a value of 1213 ppb silver was determined. The sample was collected from thick basal till several hundred metres from the north shore of Long Island Lake. The only known mineral occurrence nearby is the small zinc, copper and molybdenum Eagle Creek (EC) showing located <1 km to the northeast. The till enrichment lies directly below a steep slope from the EC showing, and may possibly be a result of hydromorphic dispersion. The possibility does exist, however, that there is an unknown source to the northwest (up-ice), along the southern slope of the hill north of Eagle Creek.

## COPPER

Concentrations of copper analyzed by ICP ranged from 1 ppm to 1067 ppm. High mean and median values of 133.95 ppm and 111.6 ppm Cu, respectively, are present. Background copper is high, with some 95 samples with values exceeding 100 ppm. Of the 170 samples analyzed, the top five values ranged between 347 and 1067 ppm and an additional five samples had values between 274 and 298 ppm. Several of the high copper concentrations can be tentatively associated with known mineral occurrences, but at least one high sample has no known or obvious bedrock source.

A copper value of 1067 was obtained from a thick basal till at station 989195. Located about one kilometre east of Deer Lake, abundant mineralized float was noted to be contained within the basal till. The float and high values of copper, gold, silver, molybdenum, bismuth and tellurium are likely attributed to the several proximal MINFILE occurrences that can be found from 500 to 1500 m to the west and northwest. A copper value of 347 ppm was determined from a till sample (989569) several hundred metres to the northeast. This sample is also likely derived from Silver Lake-PGR showing. These samples are excellent examples of down-ice transport and dispersion and provide a model that can be applied in the region. Copper content is 'lower' in till samples directly up-ice and the values determined from stations 989195 and 989569 represent the peak concentration of the copper dispersion down-ice from the Silver Lake-PGR property.

Two high values of copper were obtained at stations 989305 and 989308; 659 and 347 ppm, respectively. The two stations occur within a kilometre of each other along a northeast - southwest axis on the plateau east of Demers Creek. The elevated values of copper, molybdenum, bismuth, mercury, antimony and zinc are likely derived from a new copper discovery on the Worldstock claims (Wells, 1998).

Finally, a copper value of 393 ppm (989320) was obtained from a station located at least three kilometres east from Crater Lake. There are no known mineral occurrences in the area, except for the Anticlimax (molybdenum) showings several kilometres due north. These do not list copper as a known commodity and are unlikely the bedrock source. Station 989320 also supports high values of zinc, cadmium, molybdenum, nickel, antimony and elevated values of arsenic, cobalt and tellurium (see discussion below). The terrain is fairly subdued, and the thick basal till (>5 m) exposed here suggests that the distance to potential source can range from 500 m to several kilometres to the northwest.

## GOLD

The mean and median concentrations of gold (INAA) are quite high, 48.8 ppb and 36 ppb, respectively. Values ranged from <2 to 684 ppb for the 170 samples of till and colluviated till analyzed. There are 15 samples with gold concentrations above 100 ppb! The top five samples (>190 ppb) are discussed in this report. Distribution of the top 10% of the samples (see Appendix F) exhibit a narrow ribbon of elevated gold values trending northwest-southeast within the belt of Nicola Group augite andesite flows, breccias and tuffs extending from Little Fort to north of Friendly Lake (Campbell and Tipper, 1971). The gold concentration appears to be associated with elevated values of copper, bismuth, and antimony. Most of the top 5 concentrations of gold are presently associated with known mineral occurrences with the exception of the highest gold value.

The highest gold value (684 ppb) was obtained from a basal till veneer sample located one kilometre east of Lost Horse Lake. The AA showing, one kilometre to the east of the station, is not considered a possible source. The last work reported on the AA showing, over 25 years ago, only analyzed the soils for Cu, Mo, Pb, Zn and Ag (Aird, 1974). Since the sample was obtained from a thin veneer of basal till, within the subdued rolling topography of the Thompson Plateau (Figure 2), the source bedrock is estimated to be only 50 to 1000 m north-northwest from the station. An elevated value does occur to the west, which suggests there might be multiple point sources of gold in the bedrock. Caution must be exercised in cases like this where bedrock strike is parallel to ice flow direction.

Values of 360 ppb (989195) and 327 ppb (989170) were obtained from thick basal till samples about 500 and 1500 metres southeast of Deer Lake, respectively. Lakeview, PYCU and Silver Lake MINFILE showings are all less than two kilometres up-ice from the stations and are likely the bedrock sources for the elevated gold and copper values at these sites.

Sample 989355 is located directly south of Highway 24, northeast of Latremouille Creek. A value of 248 ppb gold was obtained from basal till. The station is several hundred metres directly down-ice from the Discovery Zone (Hidden Creek Property), a gold-bearing skarn exposed in a new roadcut on Highway 24. Float samples in the vicinity have yielded gold values up to .121 oz/ton (Gruenwald, 1998). However, the float lithology is reported to contrast the known bedrock lithology exposed at the Discovery Zone. It is likely the high gold concentration at station 989355 reflects the Discovery zone as the sample was taken at 1.8 m depth, well into the basal till.

The final location discussed here for gold is station 989185 where a value of 195 ppb was determined. The sample was collected from thin veneer of till overlain by a glaciofluvial veneer. The site is situated about 1.5 kilometres north of Deer Lake and 0.8 kilometres east from Silver Lake. The sample is only 400 m down-ice from the ‘Road Showing’ (PGR Claim), on the Silver Lake Property, which is believed to be the source of the anomaly. The source bedrock contains high grade veins with samples containing gold ranging from 27 g/t to 62.8 g/t (Wells, 1998). The extent of the veining is unknown, but complications can arise since the general vein trend parallels ice flow direction.

## LEAD

Mean and median concentrations of lead (ICP) are 19.32 ppm and 11.6 ppm, respectively. Lead concentrations ranged from a minimum of <3 ppm to a maximum of 780 ppm. Of the 170 samples analyzed, the top five had values >70 ppm. Concentrations of lead are often associated with other elements, such as zinc, arsenic, mercury and cadmium.

The highest concentration of lead was recorded at station 989186 (780 ppm) located one kilometre east of Lost Horse Lake. Here, a sample of basal till from a thin veneer of sediment was obtained over bedrock. The only known occurrences of lead nearby are the Friendly Lake (FL) and the RO, SO occurrences that list lead as a minor occurrence. The high concentration, distance (>3 km) and ice flow direction for the region indicate that these showings are not the source for the anomaly. Given the thin nature of the drift, it is estimated that the source is local, likely ranging from 50 to 1000 m north-northwest. The second highest value of lead (128 ppb) at station 989188 is about 1.3 kilometres directly down-ice from station 989186. It is probably the 'tail' of the dispersion train and reflects dilution of the lead-rich till as it is carried farther from source bedrock.

A lead value of 106 ppm was obtained from a basal till sample at station 989200. The site is located adjacent to Nehalliston Creek, several hundred metres south of Rock Island Lake. There are no known showings nearby, but the site is a few kilometres directly down-ice from the aforementioned till concentrations. They may not share the same bedrock source however, for bedrock strike parallels ice-flow direction. The lead concentration is supported with high concentration of mercury and nickel.

The fourth highest value of lead was obtained from station 989339, where a concentration of 83.6 ppm is present. The sample was collected from a basal melt-out till, adjacent to Lemieux Creek, an area presently considered to be of low mineral potential. The source of the lead is probably from mineralization along Louis Creek Fault, a major fault which separates the Slide Mountain Terrane and the younger rocks of the Intermontane Belt.

The final location discussed here with an elevated value of lead is from station 989226 (72.1 ppm) located on the north side of Long Island Lake, in the southwest corner NTS 92P/9. An elevated zinc concentration was also measured for this sample. There are no recorded mineral occurrences suitably situated to explain this anomalous lead concentration at this station. The most probable bedrock source is inferred to be located along strike with the high silver concentrations (989263 and 989162) that occur a few kilometres to the northwest.

## ZINC

Zinc concentrations (ICP) ranged from a minimum of 16 ppm to a maximum of 768.7 ppm for the 170 samples included in this report. A mean value of 106.2 ppm and median value of 88.4 ppm result from this distribution. The highest ten values of zinc are all greater than 200 ppm. Zinc is often complimented with elevated values of cadmium, mercury, molybdenum and arsenic. Of the top six high zinc values, five are not associated with any known mineral occurrence.

The highest zinc concentration (769 ppm) was obtained from site 989320 which is located about three kilometres east of Crater Lake. As discussed earlier with this site, there is a high concentration of copper as well as cadmium, molybdenum, nickel, cobalt and antimony in the basal till. The zinc content at the Anticlimax showings are poor, and are unlikely sources for such a high concentration of zinc. The site is located at the northern limit of sampling, so there are no up-ice samples to determine the nature of distribution. The source at present remains unknown.

The next three zinc concentrations occur in the vicinity of Lost Horse Lake. Stations 989186, 989184 and 989188 have values of 696, 476 and 418 ppm, respectively. The closest zinc showing is the AA claim, but the property is not in the up-ice direction of the till anomalies. The sites are located at the northern limit of sampling, so there are no up-ice samples to determine the nature of distribution. The sources at present remain unknown but of considerable interest.

The Lemieux Creek Valley is host to the fifth highest zinc concentration (418 ppm). The site is at the eastern edge of the valley, about two kilometres north of Mount Loveway. There are no known mineral showings up-ice, but the zinc concentration is likely related to the Louis Creek Fault, as previously mentioned. Farther down ice, samples from the 1997 till survey illustrate a dispersal plume of zinc stretching over a distance of two kilometres. Samples taken up-ice from this station have low zinc values, suggesting that the bedrock source is likely to be within a kilometre to the north.

The final zinc concentration discussed here is from station 989226. The till sample retrieved at this site resulted in a zinc value of 416 ppm. This multi-element station is complimented with a high value of lead, elevated values of copper and arsenic. As previously mentioned in the lead discussion, there is no known mineral occurrence in the vicinity which can be associated with this sample location.

## ARSENIC

Concentrations of arsenic determined for the 170 samples reported here ranged in value from <2 ppm to a maximum of 326 ppm. The highest five arsenic values were all greater than 145 ppm. Three of the samples are clearly not associated with known mineral occurrences.

The highest arsenic concentration recorded in the region is derived from a basal till deposit collected overlying a pillow basalt at station 989332 (326 ppm). A moderately high gold value (130 ppb) was also obtained from this sample. Situated in the Lemieux Creek valley, near the confluence of the creek draining Lemieux Lake and Lemieux Creek, the station is not related to any known mineral occurrence. The bedrock source is likely related to the Lemieux Creek Fault, where it separates into several splays.

Two high values of As (189 and 147 ppm) occur in the vicinity of Lost Horse Lake, at stations 989184 and 989186, respectively. As discussed earlier, these stations also recorded high values of gold, silver, lead, zinc, cadmium, bismuth and other elevated elements. The bedrock source is likely up-ice, to the northwest. The sites are located at the northern limit of sampling, so there are no up-ice samples to determine the nature of distribution.

A value of 185 ppm As was obtained from a sample of basal till veneer directly overlying bedrock. The station sits within the Hidden Creek showing, and the high value of arsenic is likely derived from the property. At the time of the sample collection, the property was undergoing active trenching. No information is available on the mineralization and nature of this recent work.

The fourth highest recorded value of arsenic was obtained from basal till at a site on the plateau to the west of Lemieux Creek and about four kilometres east of Hardcastle Lake. The arsenic concentration is also complimented with elevated values of nickel and antimony. The site is located at the northern limit of sampling, so there are no up-ice samples to determine the nature of distribution. The source is likely related to the granitic bedrock that hosts Anticlimax (A, B, C) showings, which are known molybdenum occurrences. The granitic stockwork and bodies that occur in this area are related to the emplacement of the Raft Batholith to the north.

## CADMIUM

Cadmium concentrations (ICP) ranged from a low of <0.2 ppm to a high of 10.7 ppm for the 170 samples examined in this report. A mean value of 0.64 ppm and median value of 0.34 ppm result from this distribution of data. There are thirteen samples in the 92.5% and better with minimum values of 1.5 ppm, six samples are above 4 ppm. None of the elevated cadmium values can be clearly associated with known mineral occurrences. In our samples, cadmium is commonly associated with elevated values of molybdenum, zinc, silver, mercury and antimony.

The highest cadmium value obtained in this study comes from a basal till sample recovered at station 989342 (10.7 ppm) which is situated in the Lemieux Creek valley. The sample is also high in zinc. Farther down ice, samples from the 1997 till survey illustrate a good dispersal plume stretching over a distance of five kilometres. Samples taken up-ice from this station have low cadmium values, suggesting that the bedrock source is likely to be within a kilometre to the north.

The second highest concentration of cadmium was recorded at station 989320 on the Thompson Plateau west of Lemieux Creek and about four kilometres east of Hardcastle Lake. A cadmium value of 5.7 ppm resulted from the thick basal till sample. High molybdenum, zinc, copper and mercury were also measured in this sample. As noted earlier, this station most likely reflects a bedrock source area originating in the granitic bodies to the north, possibly the Anticlimax showings, where three known mineral occurrences (Anticlimax A, B, C) are possible candidate contributors to the sediment content.

Three values of high cadmium occur in the Lost Horse Lake region at stations 989186 (4.95 ppm), 989188 (4.52 ppm) and 989184 (4.27 ppm). The only nearby mineral occurrence is the Friendly Lake showing, which is a Cu-Mo-Pb occurrence (Hill, 1972). It is unlikely that all three of these stations are derived from a single bedrock source. Unfortunately, the sites are located at the northern limit of sampling, so there are no up-ice samples to determine the nature of distribution. However, given the nature of the multi-element concentrations at these sites, the bedrock source is likely 50 to 1000 m up-ice (north-northwest).

The final station discussed for cadmium provided a value of 4.86 ppm (989316). Located about two kilometres south-southeast from Rock Island Lake, the sample was derived from thick basal till. The sample is associated with high silver, molybdenum and zinc values. As previously discussed, the source is likely a pyritic cherty breccia situated at the southeastern margin of the Silver Lake property.

## MOLYBDENUM

Molybdenum concentrations (ICP) ranged from a low of <0.3 ppm to a high of 22.8 ppm for the 170 samples examined in this report. A mean value of 2.46 ppm and median value of 1.7 ppm result from this distribution of data. There are six samples that are above 10 ppm. The elevated molybdenum values all exist with other high multi-element stations. All of the elevated molybdenum values can be clearly associated with known mineral occurrences.

## NICKEL

Nickel concentrations (ICP) ranged from a low of 11 ppm to a high of 1152 ppm for the 170 samples examined in this report. A mean value of 76.1 ppm and median value of 49 ppm result from this distribution of data. There are five samples are above 325 ppm. All of the elevated nickel values are not associated with known mineral occurrences.

The top 5 nickel concentrations are contained with a small area between the Montigny and Thuya creeks. They likely reflect a mafic to ultramafic rock body that rims the eastern margin of the Thuya Batholith. They form an excellent distribution plume down-ice from the known edge of the Thuya Batholith. The bedrock source likely is a few hundred metres northwest from station 989544 (1152 ppm).

# SUMMARY AND RECOMMENDATIONS

This report presents the results of a drift exploration program integrating surficial geology mapping and till geochemistry sampling north of Kamloops. The results of ICP, INAA and whole rock analyses for 170 till and colluviated till samples are presented and discussed. Collectively, these data provide a good reconnaissance level study of the mineral potential of this glaciated and drift covered region.

Much of the area (NTS 92P/8W and 9W) is covered by unconsolidated sediment of variable thickness ranging from less than one metre to several metres. Areas at the edge of the Thompson Plateau and deeply incised valleys elsewhere support thin veneers of colluvium (1 m) over bedrock on steep slopes. Thicker blankets of colluvium (>1 m) over till occur on mid slope regions. At lower elevations and over much of the flat lying plateau areas, morainal deposits in the form of ablation and basal till can be found. Ablation till is commonly found as a veneer at higher elevations, overlying either basal till or bedrock. Till accumulations range in thickness from less than a metre to over several tens of metres depending on the relief of the underlying bedrock. Fluvial deposits are restricted to the lowest elevations within the various creek and valley bottoms. Sediments often occur within a few metres elevation above present day creeks, streams and rivers. Glaciofluvial and glaciolacustrine sediments occur in the Lemieux Creek valley, often as thin deposits overlying till, but their occurrence is proportionately minor in comparison to till. Glaciofluvial sediments are found in valley settings and as thin veneers over till near meltwater channels. Glaciolacustrine sediments are found in the lowest areas to the east, essentially in association with thicker deposits in the North Thompson valley.

Quaternary geology plays an important role in mineral exploration studies in areas of glaciated terrain. The principles of drift exploration rely on an accurate understanding of the regional geological history, the distribution of various types of sediment, the genesis of individual deposits and the relationship of sediment cover to bedrock lithology (Liverman, 1992). Terrain and surficial geology mapping provides the first step towards attaining this understanding, whereas ground-truthing, including stratigraphic and sedimentologic descriptions, further the process. Sampling for till geochemistry and clast lithologies provides two mechanisms to recognize glacial dispersal trains and consequently infer potential mineral occurrences covered by drift. But the successful integration of these data with the surficial geology studies is the key for determining their location.

It is recommended that terrain and surficial geology mapping precede the complementary aspects of drift exploration studies which rely on till geochemistry and pebble lithology analysis. Such mapping not only identifies where preferred sediments for sampling occur, but also provides information regarding drift thickness and paleo-ice flow direction. Unique deposit types must be identified and consistency in sampling such deposits must be maintained to ensure comparability of the results. For example, one recent study of glacial dispersal of till constituents clearly illustrated how both flow-paths and transport distances differed between various types of morainic landforms, further emphasizing the need for good associated surficial mapping (Aario and Paeuraniemi, 1992).

A total of 181 bulk sediment samples (including duplicates) were initially collected for the till geochemistry study. Of these, 170 or 96% were considered acceptable for the objectives of this survey and the results are presented here. Ablation till only accounted for 14 samples or 8%. Samples were collected at an average depth of 1.6 m below soil surface. Till sample density averaged one per 2.45 $km^2$ for the total survey area. Assuming average transport lengths of 1.0 kilometre for geochemical anomalies (*cf.* Salminen and Hartikainen, 1985) this level of sampling provides a high level of reconnaissance information for the region.

Most of the samples taken for geochemical analysis were representative of basal till, most likely lodgement till. Of the 181 samples, 160 or 88% represented this sediment type. Basal till which has undergone slight downslope movement was classed as colluviated till (CM). Samples taken from this type of deposit accounted for 7 or 4% of the total.

Previous geochemical studies provide an indication as to the style of mineralization, configuration of anomaly plumes and regional dispersal patterns one can expect for a particular area. Examples of property scale geochemical sampling are described in detail by Paulen (1999b).

The distribution of high concentrations of several elements were discussed in detail earlier in this report. Here we summarize the elements and sample locations to further emphasize which locations warrant additional attention. Table 3 lists the 5 or 6 till sample numbers whose concentrations were high for each of seven key elements. As evident in this table, a number of sample locations occur repeatedly, indicating that high multi-element concentrations were determined for the respective samples. Those samples which could not be readily associated with a known mineral occurrence are underlined in this table. These key sites should be the focus of additional exploration attention as detailed under the individual element discussions. Future reconnaissance level till geochemistry and surficial mapping should be pursued in the region given the high mineral potential that this area displays.

## ACKNOWLEDGMENTS

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**TABLE 3**

**SUMMARY OF HIGHEST CONCENTRATION TILL SAMPLES FOR KEY ELEMENTS**

| ELEMENT | SAMPLE NUMBERS |
|---|---|
| SILVER | 989186, 989569, 989163, 989316, 989162, 989229 |
| COPPER | 989195, 989305, 989320, 989569, 989308 |
| GOLD | 989186, 989195, 989170, 989355, 989185 |
| ARSENIC | 989332, 989184, 989354, 989322, 989186 |
| LEAD | 989186, 989188, 989200, 989339, 989226 |
| CADMIUM | 989342, 989320, 989186, 989316, 989188, 989184 |
| NICKEL | 989544, 989565, 989529, 989528, 989566 |
| MOLYBDENUM | 989184, 989320, 989316, 989342, 989195, 989308 |
| ZINC | 989320, 989186, 989184, 989188, 989342, 989226 |

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