RECONNAISSANCE TILL GEOCHEMISTRY ON THE CHILCOTIN PLATEAU (92O/5 AND 12)

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KEYWORDS: Drift prospecting, applied geochemistry, mineral exploration, ice-flow direction, till, glaciofluvial sediments, dispersal train, porphyry copper-gold.

INTRODUCTION

As part of the Canada - British Columbia Agreement on Mineral Development (1991-1995), a reconnaissance surficial sediment sampling program was carried out in 1992 and 1993 over the Chilcotin Plateau, in west-central British Columbia (Figure 1). The survey was designed for two purposes: to test the potential of drift prospecting for detecting mineralization, and to determine background metal concentrations in surficial sediments. A total of 118 till and 26 glaciofluvial sediment samples were collected during this survey (Figure 2).

The Chilcotin Plateau was selected for investigation because it hosts several important deposits such as the Fish Lake porphyry copper-gold deposit. It is characterized by an extensive cover of unconsolidated sediments which inhibit the use of conventional exploration methods and glacial ice-flow history in the area is uncomplicated (Figure 3), facilitating the use of drift prospecting methods.

Plouffe and Ballantyne (1994) presented brief notes on the glacial history of the area and the results of geochemical analyses of till and glaciofluvial samples. The objectives of this report are to summarize the ice-flow history, to elaborate on the interpretations of geochemical anomalies in till, and relate geochemical data for till to geophysical and biogeochemical data obtained from other studies. New geochemical data for till samples from the Newton Hill area are also presented.

LOCATION AND PHYSIOGRAPHY

The study area covers two 1:50 000-scale NTS map sheets : 92O/5 and O/12 (Mount Tatlow and Elkin Creek, respectively) and extends over the southern part of a third map 92O/13 which covers the Newton Hill area (Figures 1 and 2). The southwestern part of the study area lies in the

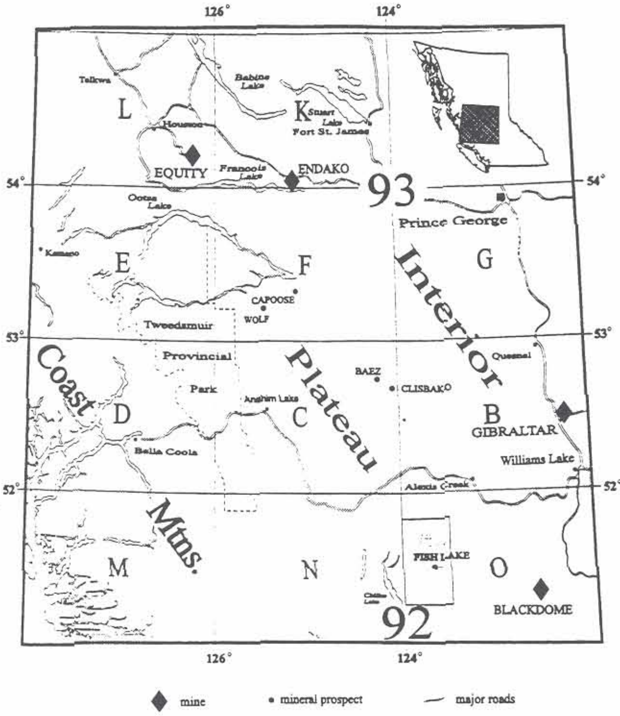

Figure 1. Study area location.

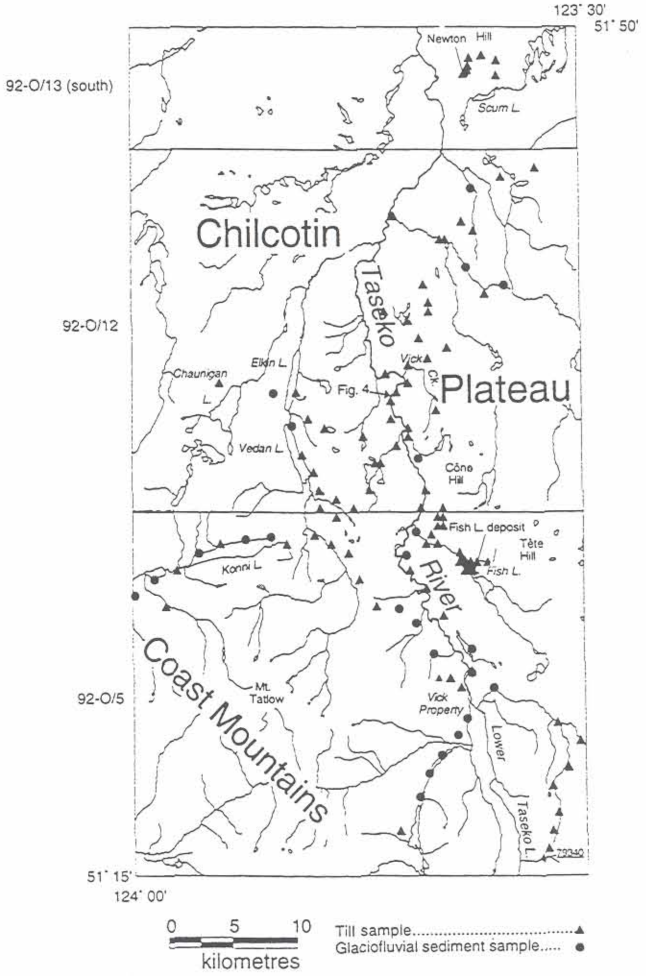

Figure 2. Till and glaciofluvial sediment sample locations.

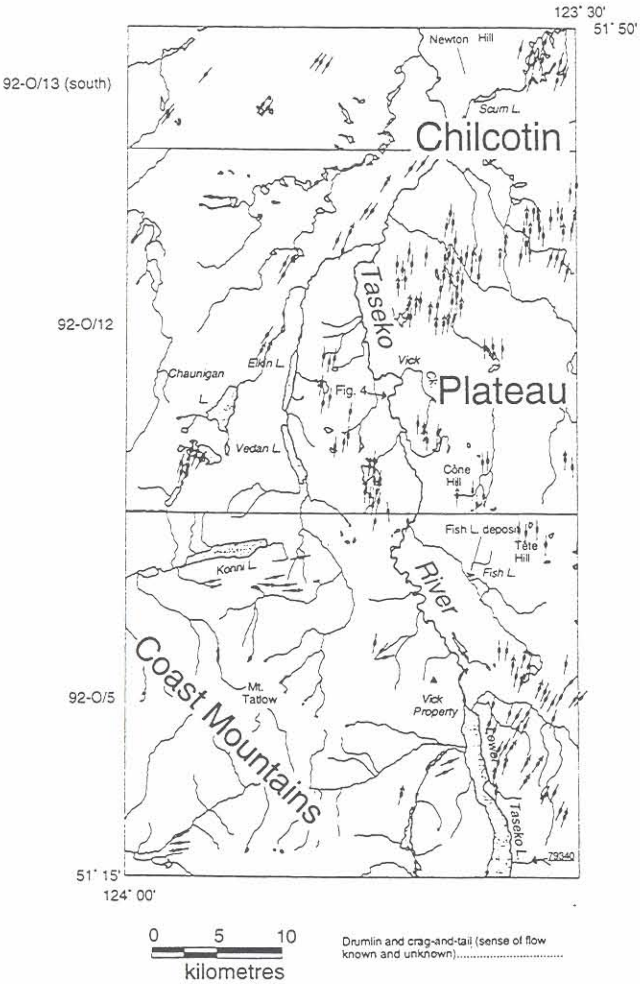

Figure 3. Major physiographic divisions and ice-flow patterns reconstructed from drumlin, fluting, and glacial striation orientations. Modified from Heginbottom (1972), Huntley and Broster (1993) and Plouffe and Ballantyne (1994).

Pacific Ranges of the Coast Mountains (Mathews, 1986) which are characterized by peaks and arêtes with summits of more than 2400 metres above sea level (8000 ft). No sampling was undertaken in the Coast Mountains because of poor accessibility. The remainder of the area, where all sampling was completed, forms part of the Chilcotin Plateau, which has a rolling to relatively flat landscape and an average elevation of 1400 metres (4500 ft). Tête and Cone hills, with elevations of 1818 metres (6000 ft) and 1758 metres (5800 ft) respectively, are prominent topographic features on the plateau surface.

METHODOLOGY

FIELDWORK

At the beginning of the survey, till was selected as the only sampling medium for two reasons. First, as sediment directly deposited by ice, till represents the first derivative of bedrock (Shilts, 1993) and second, the uncomplicated ice-flow history of the area facilitates its use for prospecting purposes. However, it became apparent that most valleys are filled with thick accumulations of glaciofluvial sand and gravel and that till exposures are not present. Consequently, glaciofluvial sediments were sampled in those valleys.

Samples were collected in hand-dug pits, roadside sections and river bluffs at a minimum depth of 1 metre. Care was taken to collect samples below the depth of maximum oxidation (B-horizon) in the transitional zone between the B and C-horizons. During the first year of this survey, detailed sampling was completed on the Fish Lake property, in order to establish the mineralization signature in surficial sediments (Figure 2). Sample intervals along roads average 2 kilometres.

SELECTED GRAIN SIZE FRACTIONS FOR GEOCHEMICAL ANALYSES

Previous studies of metal partitioning in till indicate that base metals tend to concentrate in the clay-size fraction material (DiLabio, 1995; Nikkarinen *et al.*,1984; Shilts, 1984; 1995). At Fish Lake and other test sites, gold in till is concentrated in the silt-size fraction (Delaney and Fletcher, 1993, 1995; DiLabio, 1982a, 1982b, 1985, 1988). Consequently, all geochemical analyses were conducted on the silt plus clay-size fraction (<63 μm, -230 mesh). In order to test the usefulness of the clay-size fraction in comparison to the silt plus clay-size fraction for prospecting in the area, multi-element analyses were also completed on the clay-size fraction of the 1993 samples. The silt plus clay-size fraction was analyzed for 31 elements (Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Sc, Sr, Ti, Tl, U, V, W and Zn) by inductively coupled plasma-atomic emission spectrometry (ICP-AES) following an aqua regia digestion at Chemex Labs Ltd. in North Vancouver, British Columbia, and for 35 elements (Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb and Lu) by instrumental neutron activation analyses (INAA) at Activation Laboratories Ltd. in Ancaster, Ontario. The clay-size fraction was only analyzed by ICP-AES, also following an aqua regia digestion. Data on quality controls are reported in Plouffe and Ballantyne (1994).

Geochemical results for both grain-size fractions (<2 μm and <63 μm) are presented in a spreadsheet format in three ASCII files (tab delimited) together with a sample location file on CD-ROM (Table 1).

BEDROCK GEOLOGY

The study area lies along the eastern margin of the Coast Belt (Riddell *et al.*, 1993b; Monger, 1986). It is underlain by late Paleozoic to Cretaceous bedrock lithologies which were originally deposited in ocean basin, volcanic arc and clastic basin environments (Riddell *et al.*, 1993b). These rocks were accreted to North America dur-

TABLE 1
LIST OF DIGITAL FILES ON CD-ROM

Name of file	Content
README.1ST	Information about files format and content
2ICP.TXT	Geochemical results - clay-size fraction (<2 µm) - ICP-AES (till and glaciofluvial sediment samples)
63ICP.TXT	Geochemical results - silt plus clay-size fraction (<63 µm) - ICP-AES (till and glaciofluvial sediment samples)
63NA.TXT	Geochemical results - silt plus clay-size fraction (<63 µm) - INAA (till and glaciofluvial sediment samples)
LOC.TXT	Sample information: number, type, location (latitude, longitude and UTM coordinates).

ing Jurassic to Cretaceous time. They are intruded by granitic rocks of Cretaceous and Tertiary age and are overlain by Neogene plateau lavas (Riddell *et al.*, 1993b). The two major mineralized zones in the area are located at Fish Lake (porphyry Au-Cu) and Newton Hill (epithermal), in windows through the Eocene cover.

Tipper (1978) presents a regional bedrock geology map of the area which was revised by more recent mapping (Hickson, 1993; Hickson and Higman, 1993; Riddell *et al.*, 1993a, 1993b). The Fish Lake area was also mapped in detail by Wolfhard (1976) as part of mineral exploration investigations. The reader is referred to these publications and to Schiarizza and Riddell (1997, this volume) for more detailed descriptions of the bedrock geology.

GLACIAL GEOLOGY

Heginbottom (1972), Huntley and Broster (1993) and Plouffe and Ballantyne (1994) present data on patterns of glacial ice-flow within the study area during the Fraser Glaciation (*i.e.* the last glaciation) which are summarized below and in Figure 3. At the onset of the glaciation, valley glaciers advanced to the north, south and west from accumulation zones in the Pacific Ranges. During the initial stage, when ice was thin, glaciers where confined to the major valleys and flow patterns were controlled by topography. As ice accumulated, valley glaciers coalesced into piedmont glaciers which soon invaded the higher areas. At the glaciation climax, ice on the Chilcotin Plateau was flowing to the north, north-northeast and northeast (Figure 3).

Deglaciation is thought to have taken place by a combination of processes: rapid frontal retreat towards the accumulation zones and ice stagnation (Fulton, 1967, 1991). In some places, ice in the valleys influenced and modified the drainage pattern. For example, meltwater channels in Vick and Fish Creek valleys formed at a time when Taseko valley was plugged by ice so that the northward drainage was taking place on higher ground and along the ice margin. Drainage into the Taseko valley was re-established when the obstructing ice melted. Thick

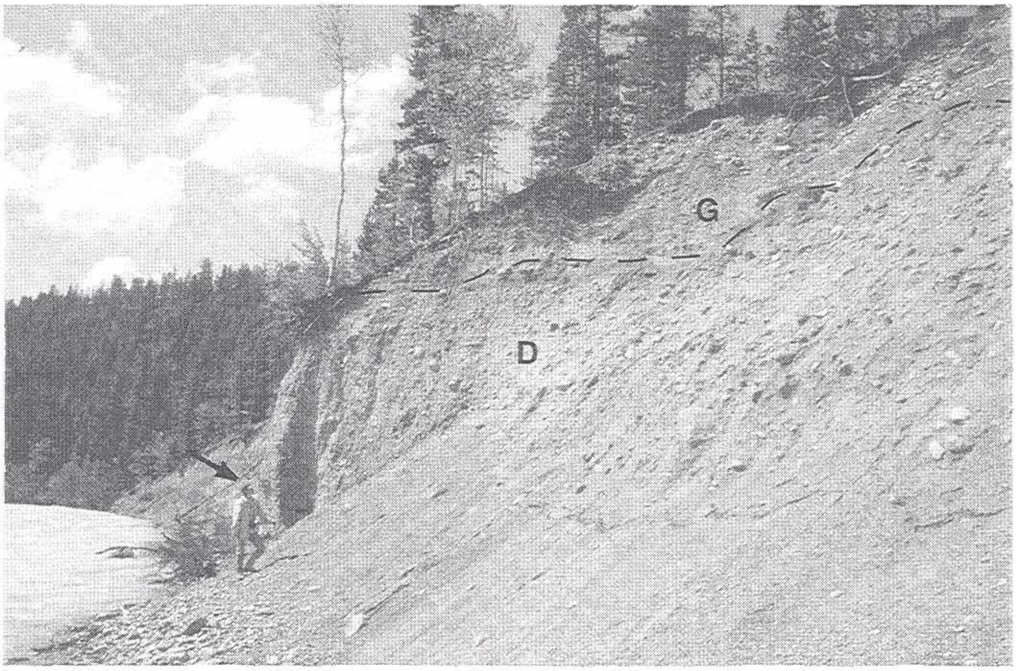

Photo 1. Glaciofluvial sediments (G) underlain by a diamicton (D) along Taseko River (*see* Figure 2 for location).

accumulations of glaciofluvial sand and gravel were deposited in the valley during ice retreat (Photo 1).

RESULTS

Geochemical results for till and glaciofluvial sediments are treated separately in this report, for the following reasons:

- The two sediment types have been transported by different media (till by ice and glaciofluvial sediments by ice and water) and, consequently, have been transported over differing distances and directions.
- Within the study area, glaciofluvial sediments are consistently more sandy and, hence, more porous than till. As a result, the depth of oxidation is greater in glaciofluvial deposits and, consequently, they contain a greater proportion of iron and manganese oxides. Shilts (1972) demonstrates that metal concentrations in glaciofluvial sediments are commonly higher than in the surrounding till, which he attributes to the coprecipitation of metals with iron and manganese oxides and hydroxides during weathering. These conclusions seem to be applicable to this study area as background base metal concentrations are slightly higher in glaciofluvial sediments than in till. For example, the average copper concentration in till away from mineralized zones is 44 ppm and in glaciofluvial sediments 61 ppm.

FISH LAKE MINERALIZED ZONE AND VICINITY

A multi-element geochemical anomaly has been detected in till directly overlying the Fish Lake porphyry copper-gold deposit. It consists of high levels of gold (16 ppb), arsenic (15 ppm), copper (166 ppm), nickel (70 ppm) and antimony (2.3 ppm) (Figures 4 to 8). Moderately high cobalt (18 ppm) and chromium (62 ppm) concentrations are also present, but of smaller extent (Figures 9, 10). High gold (37 ppb) and copper (162 ppm) levels were also detected in the glaciofluvial sediments (Figures 11,12). This multi-element anomaly extends to the northwest of

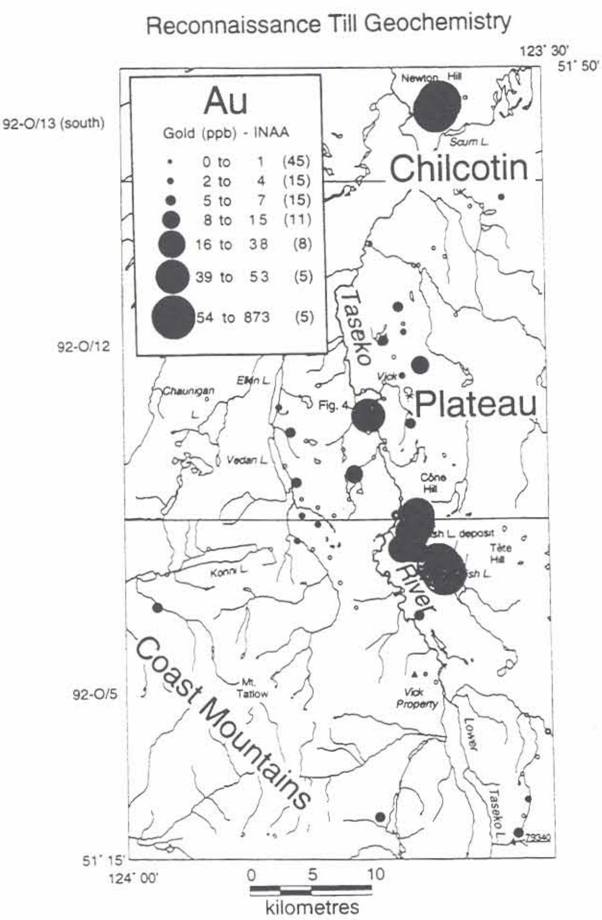

Figure 4. Gold in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by instrumental neutron activation technology.

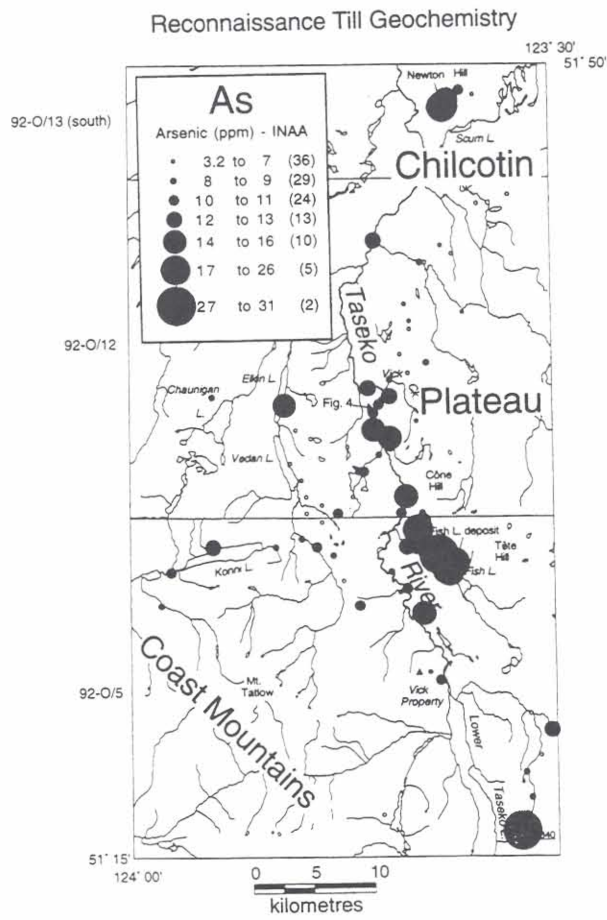

Figure 5. Arsenic in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by instrumental neutron activation technology.

Fish Lake, where Pioneer Metals Corporation identified drilling targets in the basis of soil geochemical and induced polarization anomalies (D. Dunn, personal communication, 1994). Although this multi-element anomaly in till does not directly overlap with biogeochemical anomalies (Dunn, 1997, this volume), high levels of gold, arsenic and nickel were detected in needles of lodgepole pine tree-tops in the near vicinity.

TASEKO VALLEY

A single sample significant gold anomaly (45 ppb) in till was detected in Taseko valley directly west of Vick Creek. There are moderate levels of arsenic (15 ppb) and high concentrations of mercury (1000 ppb) to the south (Figure 5). Of economic significance is the fact that this anomaly is located on the flank of a total field aeromagnetic anomaly (Teskey, *et al.*, 1997, this volume) and on the northern end of a major gamma ray potassium anomaly which parallels the Taseko valley [Shives, 1995, (Figure 13]. However, the potassium anomaly may be related to the presence of thick, well drained accumulations of glaciofluvial sand and gravel as gamma ray emissions are generally greater from dry soils (Shives *et al.*, 1995). High concentrations of zinc (151 ppm) and cobalt (20 ppm) in the till, and of nickel and molybdenum in needles from tree tops (Dunn, 1997, this volume), were also detected near the aeromagnetic anomaly. No mineral occurrences are shown on bedrock maps for this sector of the Taseko River (Hickson, 1993; Hickson and Higman, 1993).

VICK PROSPECT

The Vick prospect is located northwest of Lower Taseko Lake (Figure 2) and consists of a series of northeast-striking gold, silver and copper-bearing quartz-sulphide veins which extend from the top of the hill to its east face (Riddell *et al.*, 1993b). Two till samples collected east of the prospect in the Taseko valley have higher concentrations of gold (15 ppb), arsenic (11 ppm), cobalt (24 ppm), chromium (67 ppm), copper (69 ppm), mercury (530 ppb) and nickel (63 ppm) than at least 90% of the samples collected in this project (Figures 4 to 10). Anomalous levels of these elements in till are closely associated with high

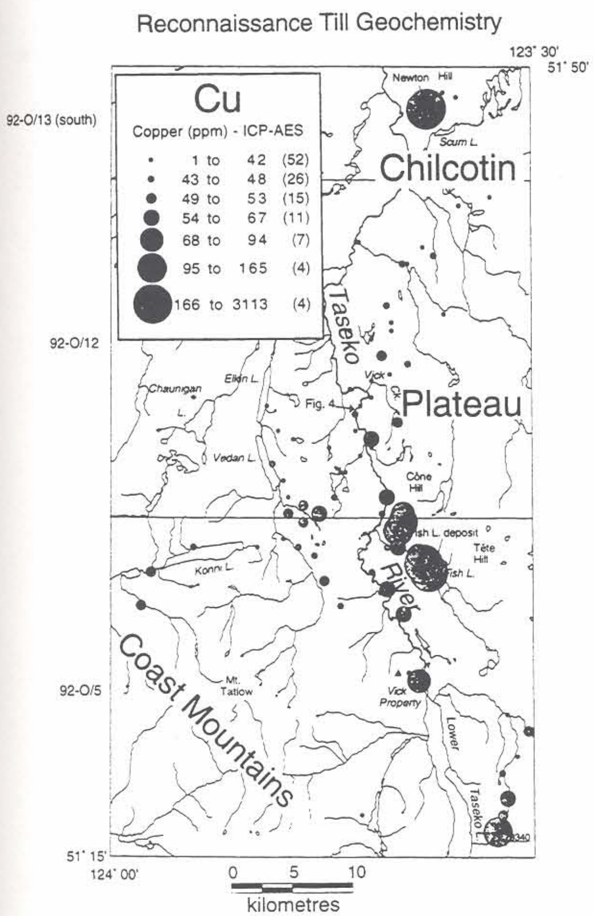

Figure 6. Copper in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by inductively coupled plasma-atomic emission spectrometry.

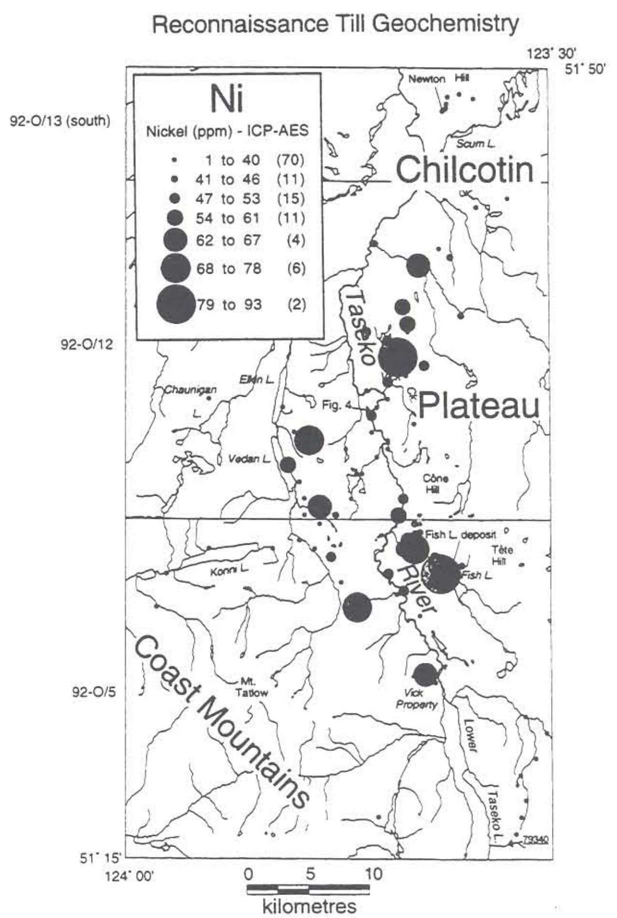

Figure 7. Nickel in the silt plus clay size fraction >63µm - 230 mesh) of till. Analyses completed by inductively coupled plasma-atomic emission spectrometry.

concentrations of arsenic, cesium and copper measured in needles of lodgepole pine tree-tops in the same area (Dunn, 1997, this volume). Although the orientation of glacial striations or macro ice-flow indicators have not been measured in this area, it is likely that debris from the veins was transported to the east and northeast by ice flowing out of the Pacific Ranges down into the Taseko valley. Thus, high metal levels measured in till and in needles of lodgepole pine were probably derived from the mineralized veins.

TILL GEOCHEMISTRY VS. REGIONAL GEOCHEMICAL SURVEY (RGS)

Following the re-analysis of stream sediment samples collected during the Regional Geochemical Survey, an important coincident copper-arsenic-gold anomaly was detected in an unnamed creek east of Lower Taseko Lake (sample 793140; Figure 2; Jackaman *et al.*, 1992). Till samples collected down-ice from the creek watershed also contained high arsenic (31 ppm), copper (100 ppm) and zinc (154 ppm) levels (Figures 5, 6 and 14). A fault and two hornblende feldspar porphyry bodies have been mapped by Riddell *et al.* (1993a) in the vicinity. The source of the till and stream sediment anomalies is possibly linked and may be related to an unknown mineral occurrence.

NEWTON HILL

The Newton Hill area is underlain by Upper Cretaceous sedimentary and volcanic bedrock which has been intruded by felsic dikes, sills and stocks of Eocene age (Durfeld, 1991). These rocks are affected by hydrothermal alteration, with kaolinite and sericite being the dominant replacement minerals. The alteration event is thought to be related to the Eocene intrusion and occurred with pyritization and gold-copper mineralization. Soil sampling conducted in 1987, 1988 and 1989 showed gold and pathfinder element anomalies (Ag, As, Cu and Hg; Durfeld, 1991).

Till samples collected on Newton Hill and to the north and northeast (*i.e.* down-ice) contain high concentrations of gold (720 ppb), arsenic (23 ppm), copper (437 ppm), mercury (500 ppb), antimony (6.1 ppm) and zinc (188 ppm) (Figures 4, 5, 6, 8, 14 and 15). These geochemical anomalies in the till are also concordant with the high potassium,

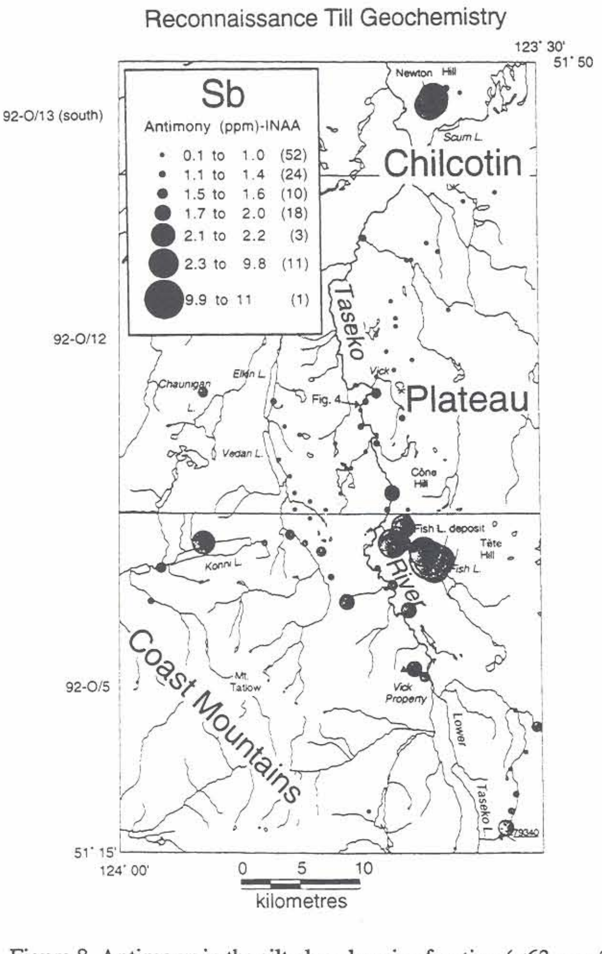

Figure 8. Antimony in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by instrumental neutron activation technology.

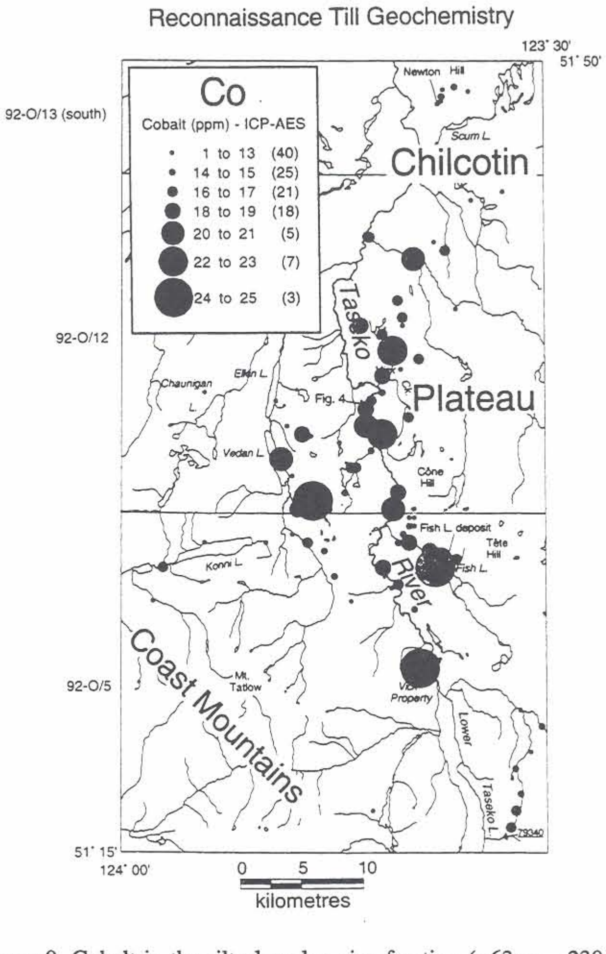

Figure 9. Cobalt in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by inductively coupled plasma-atomic emission spectrometry.

uranium and thorium concentrations measured for Newton Hill (Shives, *et al.*, 1995) and a significant total field aeromagnetic anomaly (Teskey, *et al.*, 1997, this volume) (Figure 13).

DISCUSSION

GLACIAL TRANSPORT

The Chilcotin Plateau is characterized by a thick cover of poorly indurated Tertiary sedimentary and volcanic bedrock which was extensively eroded by ice and water during the last glaciation. In contrast, the intrusive rocks hosting porphyry mineralization of the Fish Lake deposit were less susceptible to glacial erosion. They are massive, have a small outcrop area and are located in a low-lying area. It can therefore be assumed that unmineralized debris in the ice was diluting any small amount of mineralized material derived from the mineralized zone. The till sample density in the Fish Lake area is not high enough to reliably establish the length of the glacial dispersal train of detectable gold and base metals (see DiLabio, 1990). However, because of the effects of dilution, the geochemical anomalies in till in the Fish Lake area are all very small in area. Likewise, results of the airborne gamma ray survey do not show a potassium anomaly over the Fish Lake deposit (Shives, 1995), suggesting that the altered zone is masked by unmineralized debris derived from the surrounding Tertiary bedrock.

Unlike the Fish Lake deposit, the mineralized zone on Newton Hill was more readily available for glacial erosion as the altered rocks are poorly indurated and located on a topographic high. Consequently, if the mineralized zone on Newton Hill is the sole source of gold, the minimum length of the gold dispersal train is estimated at 1.1 kilometres.

A major impediment to mineral exploration in the area is the thick Eocene volcanic and sedimentary bedrock cover. Fish Lake (porphyry Au-Cu) and Newton Hill (epithermal), the two major known mineralized zones, occur in windows through the Eocene cover. A combination of geochemical (surficial sediments and plants) and geophysical exploration techniques in conjunction with bedrock geology mapping might serve to define more inliers of economic significance within the Eocene volcanics.

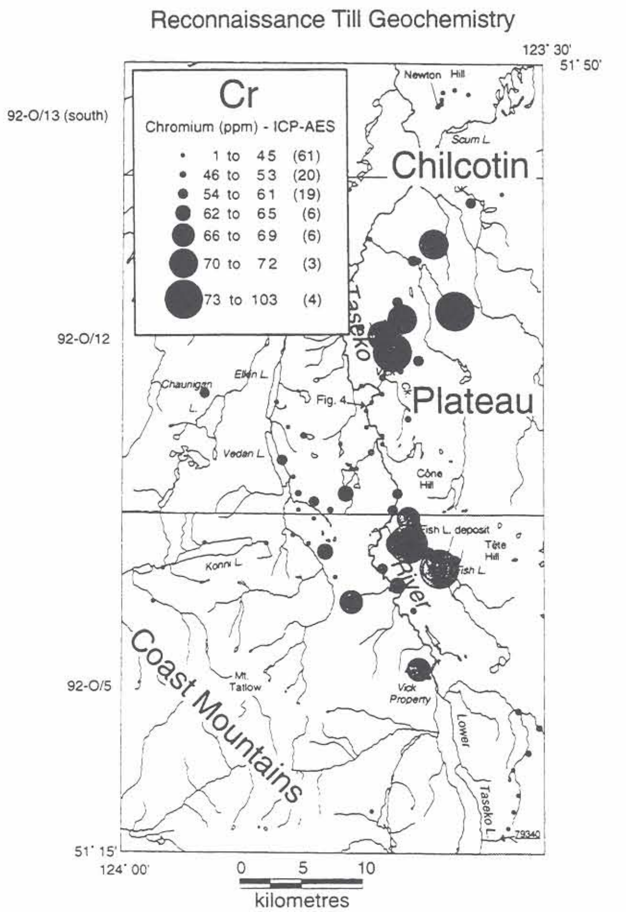

Figure 10. Chromium in the silt plus clay size fraction (63µm — 230 mesh) of till. Analyses completed by inductively instrumental neutron activation analyses.

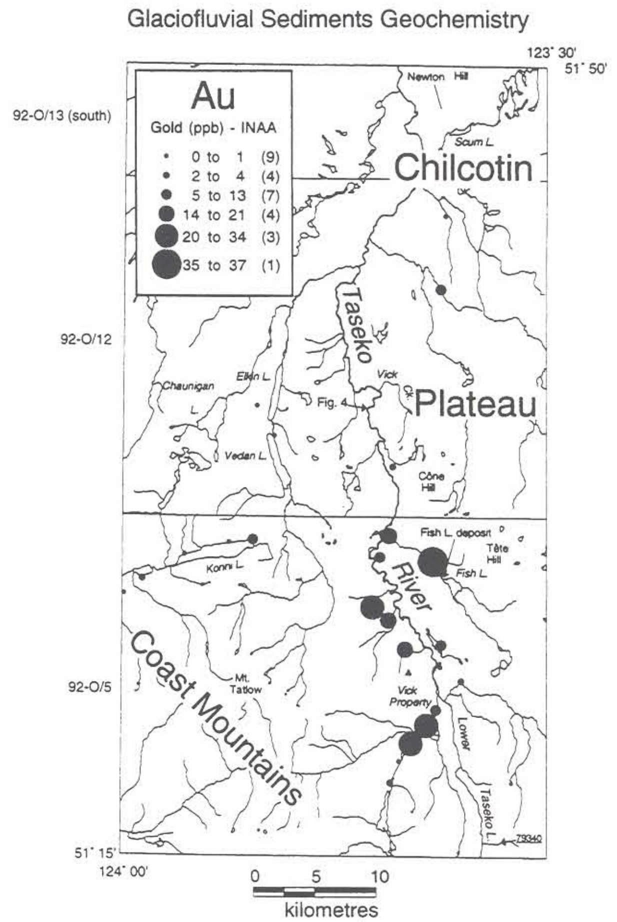

Figure 11. Gold in the silt plus clay (63µm — 230 mesh) size fraction of glaciofluvial sediments. Analyses completed by instrumental neutron activation analysis.

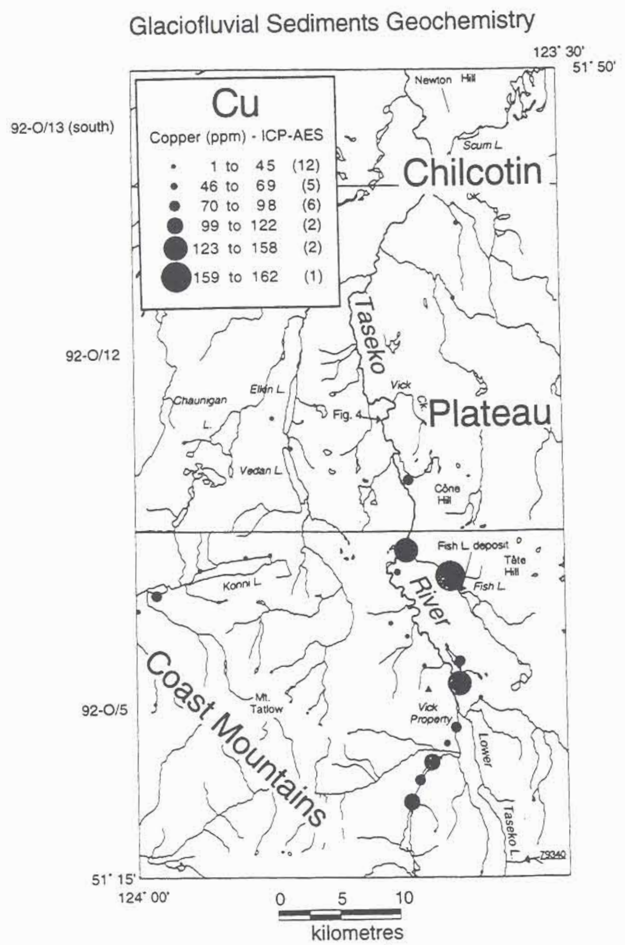

Figure 12. Copper in the silt plus clay (<63µm - 230 mesh) size fraction of glaciofluvial sediments. Analyses completed by inductively coupled pasma-atomic emission spectrometry.

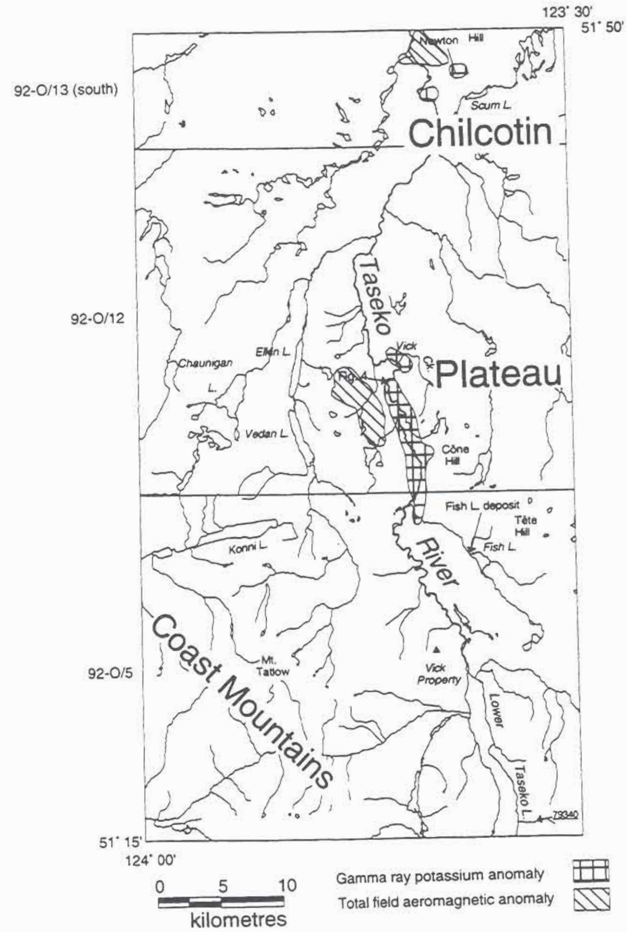

Figure 13. Gamma ray, potassium (approximately >0.92%K) and total field aeromagnetic (approximately >57 500 n tesla) anomalies in the Fish Lake area, as mentioned in the text. Data from Teskey, *et al.*, (1996, this volume).

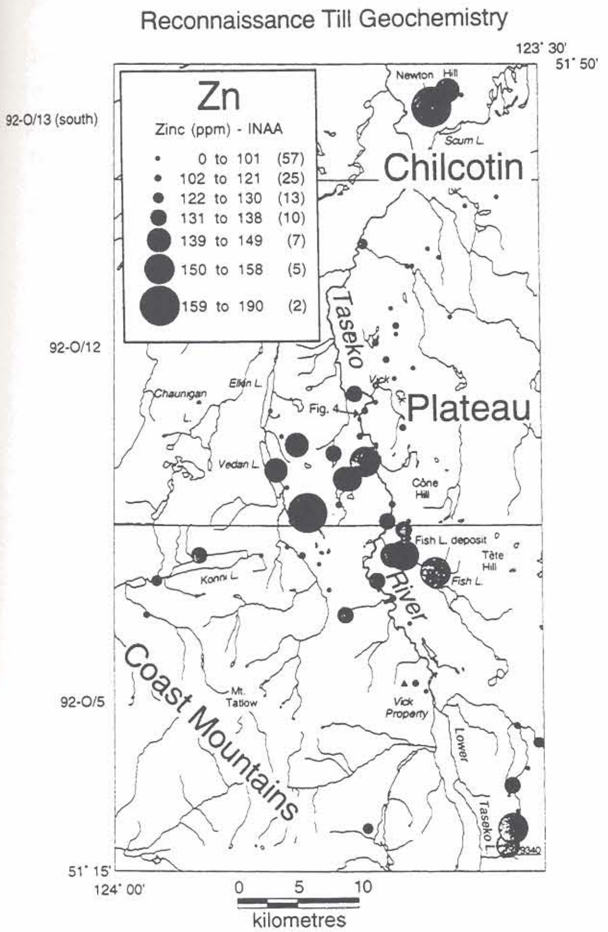

Figure 14. Zinc in the silt plus clay size fraction (<63µm - 230 mesh) of till. Analyses completed by instrumental neutron activation analysis.

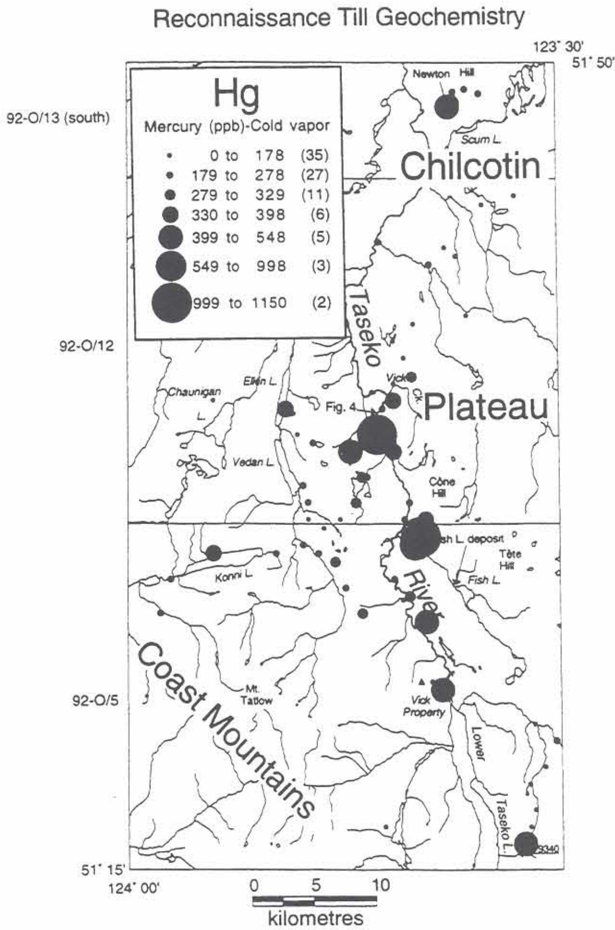

Figure 15. Mercury in the silt plus clay size (<63µm - 230 mesh) of till. Analyses completed by instrumental neutron activation analysis.

FUTURE ENVIRONMENTAL ASSESSMENT

The data presented in this and other reports [Plouffe and Ballantyne, 1994; Dunn (1997, this volume)] provide baseline information on background concentrations of metals and thus, serve as an aid to mineral exploration. These data may also be useful in the future for environmental assessment work in the area, as they demonstrate that natural metal background concentrations in surficial material in the Taseko valley vary over short distances. For example, the high levels of mercury in till encountered sporadically in the area (Figure 15) may be related to the presence of faults (Azzaria, 1992; Rasmussen, 1993; Plouffe, in press) or cinnabar occurrences.

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