Preliminary Results of the Cordilleran Geochemistry Project: A Comparative Assessment of Soil Geochemical Methods for Detecting Buried Mineral Deposits, 3Ts Au-Ag Prospect (NTS 093F/03), Central British Columbia[1]

By Stephen J. Cook[2] and Colin E. Dunn[3]

KEYWORDS: exploration, geochemistry, till, soil, humus, overburden, geochemical survey, geochemical anomaly, Au-Ag epithermal mineralization

INTRODUCTION

Effective mineral exploration in the Nechako Plateau and adjoining regions of central British Columbia has for many years been hindered by thick forest cover, an extensive blanket of till and other glacial deposits and, locally, widespread Tertiary basalt cover. Where undertaken, regional till and lake sediment geochemical surveys have been effective as reconnaissance exploration techniques. However, few publicly available studies have been conducted here into the use of surficial geochemistry to aid in prioritizing regional geochemical anomalies, or in carrying out the most effective geochemical surveys at a property scale in areas of exotic cover. In this respect, BC has lagged far behind other provincial and international jurisdictions in undertaking applied geochemical exploration research.

In response to a call from Geoscience BC for geoscience projects to promote resource investment in BC, this project investigates the geochemical response, in soil and Quaternary materials, of a Au-Ag epithermal prospect (3Ts prospect) in central BC (Fig. 1). This region is highly prospective for the discovery of epithermal Au deposits, among other mineral deposit types, and the low-sulphidization 3Ts prospect is one of the more significant examples of this type in the region. The objective of the project is to determine and recommend the most effective field and laboratory geochemical methods for property-scale evaluation of buried mineral targets in drift-covered terrain, by 1) evaluating the most suitable soil media and horizons for field sampling, and 2) evaluating and comparing commercially available analytical methods.

The study comprises an integrated field and laboratory investigation of comparative soil horizons, analytical digestions and selective extraction methods on soil from transects across two of the 3Ts mineralized vein systems, the Tommy vein and the Ted vein. Geochemical analyses

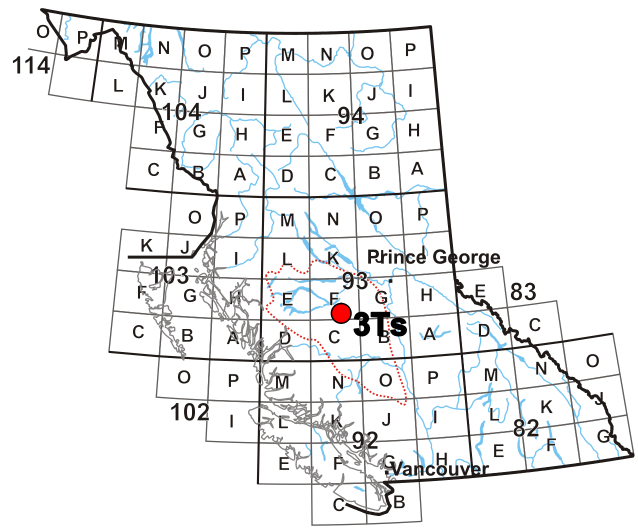

Figure 1. Location of the 3Ts epithermal Au-Ag prospect and the Cordilleran Geochemistry Project study site in the southern Nechako Plateau area of central BC.

were conducted on samples from a range of soil horizons spanning the 3Ts prospect using several commercially available partial and selective extraction methods, including

- aqua regia digestion – inductively coupled plasma–mass spectrometry (ICP-MS),
- Na-Pyrophosphate Leach^{SM},
- Enzyme Leach (EL)^{SM},
- Mobile Metal Ion (MMI)^{SM},
- Soil Gas Hydrocarbons (SGH)^{SM}, and
- Soil Desorption Pyrolysis (SDP)^{SM}.

This progress report will outline the full field and analytical methodology scope of the project, but preliminary results reported here will focus solely on comparative aqua regia digestion – ICP-MS Au and Ag results for LFH horizon humus, B horizon soil and underlying C horizon till.

This project is envisioned as a smaller, more restricted, Cordilleran analogue of the successful central Canadian CAMIRO 'Deep Penetrating Geochemistry' project and its successors. These and similar projects, spearheaded by the Geological Survey of Canada and the Ontario Geological Survey, have provided a wealth of objective data and valuable interpretive results for effective geochemical exploration beneath exotic overburden (*e.g.*, Cameron *et al.*, 2004; Bajc, 1998). No similar, publicly available, comparative

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[1] *Geoscience BC contribution GBC002*

[2] *Cook Geochemical Consulting, Victoria, BC*

[3] *Consulting Geochemist, Sidney, BC*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat PDF format from the BC Ministry of Energy, Mines and Petroleum Resources internet website at http://www.em.gov.bc.ca/Mining/Geolsurv/Publications/catalog/catfldwk.htm geochemical methodology studies have been conducted in the western Cordillera, and it is this vacuum that the project attempts to fill. As well, this project complements the parallel Geoscience BC research project 'Halogens in surface exploration geochemistry: method development' (Dunn *et al.*, 2006); The 3Ts prospect is one of three mineral deposits of varying types selected for this study of halogen geochemical responses in B horizon soil and vegetation.

Project deliverables are to include practical recommendations on the most appropriate field sampling, preparation and analytical techniques for epithermal Au deposit exploration in this environment. Where and what to sample? Which analytical methods reflect the presence of buried mineralization, and which do not? Which of the methods provide the greatest and optimal geochemical contrast for property-scale exploration? Answering these questions will assist mineral exploration companies in conducting the most effective geochemical exploration programs for blind targets, thereby increasing the likelihood of discovery.

Figure 2. South-facing view toward 3Ts Au-Ag project area, showing the Little Adrian Lake drainage and the effects of mountain pine beetle damage on lodgepole pine trees, June 2005.

Figure 3. Typical lodgepole pine and white spruce forest, showing ubiquitous thick cover of surface moss at 3Ts property, eastern portion of Ted vein geochemical orientation line (site 570) near Adrian Lake, July 2005.

LOCATION, ACCESS AND PHYSIOGRAPHY

The 3Ts Au-Ag prospect is located in the Fawnie Creek map area (NTS 093F/03), about 125 km south of Vanderhoof, in the southern Nechako Plateau region of the Interior Plateau of central BC. The property is reached by following the Kenny Dam Road and then the Kluskus Forestry Road south from Vanderhoof for about 161 km, and then by the Green 9000 Road to the old Tsacha exploration road to the former Teck Corporation campsite. As truck access to the property via the Green 9000 Road is prevented by the recent removal of a bridge, current access is by all-terrain vehicle from the Teck campsite along old exploration roads (Fig. 2). Poor access brought about by removal of the bridge caused a significant increase in the time and expense needed to complete the project.

The prospect is located in the Tommy Lakes region of the Naglico Hills, an area of rolling hills, small lakes and ponds, and minor wetland areas (elevation 1065–1250 m). It is just north of the Blackwater River, which separates the Nechako Plateau to the north from the Fraser Plateau to the south. Quartz veining and associated alteration systems are relatively resistant to weathering and locally form small but prominent ridges between Tommy Lake to the north and Adrian Lake to the east. Lodgepole pine (*Pinus contorta*) and white spruce (*Picea glauca*) are the most common trees on the property (Fig. 3). They were the object, in part, of the parallel halogen geochemistry study by Dunn *et al.* (2006). Aspen (*Populus tremuloides*) is also locally present. The dominant lodgepole pine here has, as elsewhere in central BC, been affected by the recent mountain pine beetle infestation.

BEDROCK GEOLOGY AND MINERAL DEPOSITS

Exploration History

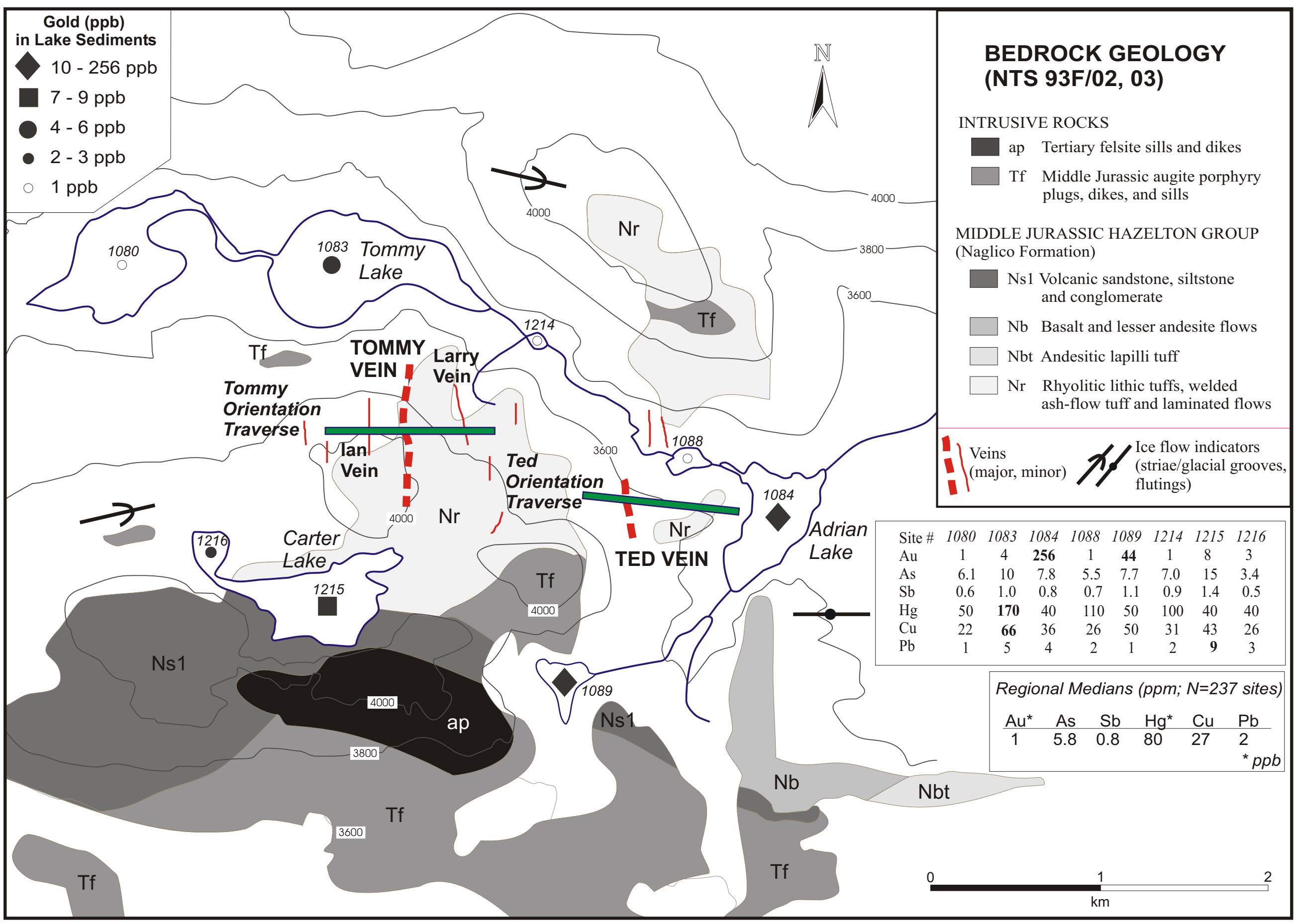
The original Tommy vein discovery of what is now the 3Ts project area was staked in early 1994 by Teck Corporation as the Tsacha property (MINFILE 093F 055; MINFILE, 2005), following the release of BC Geological Survey surface rock geochemical data (up to 3.7 g/t gold and 41.8 g/t silver) by Diakow *et al.* (1994). A bedrock mapping party had discovered an auriferous quartz vein system outcropping on hummocky moss-covered rock knobs in the Tommy Lakes area, and released the gold results at the Cordilleran Roundup conference in Vancouver in January 1994. Other properties staked included the Taken property (MINFILE 093F 068). Release of regional lake sediment geochemical data (Fig. 4) for the southern Nechako area during the summer of 1994 (Cook and Jackaman, 1994) helped bring about additional staking in the area. Initial surface sampling across the Tommy vein by Teck returned assays of up to 61.9 g/t gold and 292.5 g/t silver (Pautler, 1995). Exploration of the Tsacha (Teck) and Taken (Phelps Dodge) properties during the period 1994–1999 expanded the known mineralized vein system to include several additional veins, including the Ted vein. During this period, 81 holes totalling more than 16 000 m were drilled on the Tsacha property, primarily on the Tommy vein. The inferred resource on the Tsacha property is 470 700 t grading 7.4 g/t Au and 65.2 g/t Ag, based on a 4 g/t Au cutoff grade (Wallis and Fier, 2002).

After a period of inactivity, Southern Rio Resources Ltd. staked the adjacent Tam property in 2001, optioned the Tsacha and Taken properties in 2002 from Teck Cominco and Phelps Dodge, respectively, and consolidated the claim groups (~34 km^2) as the 3Ts project. Recent work by Southern Rio has included the continued drilling of the Tommy and Larry veins, and the discovery of several areas of mineralized boulders.

Regional and Property Bedrock Geology

Regional geology of the southern Nechako Plateau was first mapped by Tipper (1963) and more recently by Diakow *et al.* (1994, 1995) and Diakow and Levson (1997). This part of the Stikine Terrane is dominated by volcanic and sedimentary units of the Lower to Middle Jurassic Hazelton Group. These are intruded by the Late Jurassic Capoose batholith to the north, and locally overlain by Eocene volcanic units of the Ootsa Lake Group. Miocene-Pliocene Chilcotin Group basalt flows are present in low-lying areas to the south, obscuring the presence of older, more prospective rock units.

Property-scale mapping was carried out by Pautler *et al.* (1999). Hazelton Group rocks hosting epithermal quartz



Site #	1080	1083	1084	1088	1089	1214	1215	1216
Au	1	4	**256**	1	**44**	1	8	3
As	6.1	10	7.8	5.5	7.7	7.0	15	3.4
Sb	0.6	1.0	0.8	0.7	1.1	0.9	1.4	0.5
Hg	50	**170**	40	110	50	100	40	40
Cu	22	**66**	36	26	50	31	43	26
Pb	1	5	4	2	1	2	**9**	3

Regional Medians (ppm; N=237 sites)

Au*	As	Sb	Hg*	Cu	Pb
1	5.8	0.8	80	27	2

* *ppb*

Figure 4. Bedrock geology of the 3Ts epithermal Au-Ag project area, southern Nechako Plateau (NTS 093F/02, 03), showing locations of mineralized veins and 2005 soil orientation traverses over the Tommy and Ted veins; regional geology after Diakow *et al.* (1994, 1995); regional lake sediment geochemical data showing elevated Au concentrations (regional median: 1 ppb) around 3Ts vein system from Cook and Jackaman (1994); glacial striae and flutings from Levson and Giles (1994) and Giles and Levson (1995). Refer to Rhys (2003) for all names of minor veins. Diagram modified from Cook and McConnell (2001).

vein mineralization in the area of the Tsacha and Tam properties are characterized by rhyolite ash-flow tuff and lapilli tuff of the Entiako Formation. Of these, the dominant host unit is a maroon quartz-phyric lapilli tuff approximately 400 m thick. Late Cretaceous felsite sills and a Middle Jurassic augite porphyry plug are exposed to the south of the 3Ts vein system. Lane and Schroeter (1997) reported a preliminary U-Pb zircon date of 73.8 ±2.9 Ma for the biotite-phyric felsite sill that intrudes the Tommy vein. Cretaceous fine-grained diorite sills and dikes are exposed to the north of the vein system near the south side of Tommy Lake. One of these, a shallowly dipping sill that is likely analogous to felsite mapped to the south, is approximately 100–150 m thick and cuts the Tommy and Ted veins at depth. Smaller dikes and sills <5 m in thickness are also commonly observed in drillcore (Rhys, 2003).

Epithermal Au-Ag Mineralization

The 3Ts Au-Ag prospect is a low-sulphidization epithermal Au-Ag prospect that comprises the former Tsacha (MINFILE 093F 055; MINFILE, 2005) and Tam/Taken (MINFILE 093F 068) showings. Epithermal precious metal deposits in central BC have been classified as being hosted by either 1) rocks of Eocene or younger age, primarily felsic volcanic rocks of the Ootsa Lake Group, such as the Wolf (MINFILE 093F 045) or Clisbako (MINFILE 093C 016) prospects, or 2) older Lower to Middle Jurassic Hazelton volcanic rocks (Lane and Schroeter, 1997). The 3Ts vein mineralization here is Late Jurassic in age and belongs to the latter, less well-known group of older epithermal Au deposits. Argon-argon dating of potassium feldspar from the altered margin of the Tommy vein at the University of British Columbia returned a Late Jurassic age of 144.7 ±1.0 Ma (Bottomer, 2003a), similar to that of the Capoose intrusive event.

The Tommy and Ted veins are the best explored of at least nine parallel veins and stockworks that make up the 3Ts quartz vein system (Fig. 4). These, which also include the Larry, Johnny, Ian, Bobby, Barney, Goofy and Alf veins (Tsacha property) and the Mint vein (Tam property), occur over an area of approximately 2 km^2 within the host felsic tuff of the Entiako Formation. In general, subvertically dipping mineralized quartz-calcite-potassium-feldspar veins on the property strike north-northwesterly and exhibit typical epithermal textures, including vein breccia fragments, crustiform banding and comb crystal structures consistent with a shallow depth of formation (Pawliuk, 2005). They are associated with potassium-feldspar(?)-quartz-sericite-pyrite alteration haloes of variable thickness. Gold in quartz vein mineralization has also been intersected below the crosscutting microdiorite sill at both the Tommy and Ted veins, and each remains open at depth beneath this. The Tommy vein is considered to represent a higher level in the hydrothermal system than the Ted vein, based on differences in Ag:Au ratio, base metal content and the extent of wallrock alteration (Bottomer, 2003b). The following descriptions are taken from several sources, including Lane and Schroeter (1997), Southern Rio reports (*e.g.*, Pawliuk, 2005) and the structural study of Rhys (2003).

TOMMY VEIN

The Tommy vein, the largest on the property, is located on the Tsacha claim (MINFILE 093F 055) and is a north-northwesterly-striking, subvertical, quartz-adularia-calcite-potassium-feldspar vein. It is up to 8 m wide (average width 4 m) and has a known strike length of about 640–700 m (Fig. 4). The vein remains open along strike. It exhibits typical epithermal textures, such as breccia features, local crustiform banding, comb crystal structures and drusy cavities, and is cut by a diorite sill at an average depth of about 120 m. The Tommy vein has also been traced below the sill, and an 11.3 m drill intersection at 280 m vertical depth returned 8.83 g/t Au and 62.6 g/t Ag.

The vein shows some local relief (Fig. 5). It consists of massive, clear to milky white crystalline quartz and subordinate calcite with locally developed colloform bands of pale grey chalcedony, adularia and rare amethyst (Lane and Schroeter, 1997), as well as potassium feldspar (Rhys, 2003). Precious metal mineralization occurs as fine-grained disseminations in colloform banding and bladed veins. Massive vein mineralization is typically flanked by quartz stringer, stockwork or breccia zones. It is of the low-sulphidization type and contains less than 1% metallic minerals, including chalcopyrite, pyrite, stephanite, argentite, galena, native gold (±electrum), specularite and magnetite. Hematite and malachite are minor constituents. The Ag:Au ratio in the vein varies form <1 to 50, with a mean of about 10.

Wallrock hydrothermal alteration associated with the Tommy vein is patchy, and clay and sericite alteration are only sporadically and distally developed. Lane and Schroeter (1997) reported narrow and locally intense zones of silicification to be associated with broad zones of weak, red-coloured clay alteration associated with hematite. However, Rhys (2003) stated that both the Tommy and adjacent Larry vein are enveloped by broad zones of pale grey

Figure 5. View of Tommy vein, showing the sampling of LFH horizon humus (site 591), July 2005.

to pink potassium feldspar-quartz-sericite-pyrite alteration extending, in some cases for up to tens of metres into the felsic volcanic host. Alteration was stated to be widest in the central and southern parts of the Tommy and Larry vein system, and weaker in the north. In addition to these, a large (approx. 1000 m by 300–500 m) potassium-feldspar(?)-quartz-sericite-pyrite alteration zone has been mapped within the host rhyolite tuff to the west of the Tommy vein (Rhys, 2003).

The Larry vein, about 200 m east of the Tommy vein, was traversed by the same Tommy geochemical orientation line during this study, as was the Ian vein system to the west. The Larry vein has been traced 590 m along strike and 100–200 m downdip, and is open in all directions. No resource estimate has been completed. Rhys (2003) noted that Larry stockwork more closely resembled a sheeted vein system than a true stockwork.

Figure 6. Sampling site just downslope of the Ted vein (site 559), July 2005.

TED VEIN

The Ted vein is located on the Tam 2 claim (MINFILE 093F 068) about 1 km east-southeast of the Tommy vein. It is a similarly north-northwesterly-striking (150–170°), subvertical, quartz-calcite-sulphide vein with epithermal textures. The vein has been traced along strike for at least 300 m and over an average width of 10 m, and is the widest of the 3Ts veins. It is open along strike both north and south, and to depth. The original Ted vein showing consists of a 50 m wide zone of small outcrops and subcrop (Fig. 6) of altered rhyolite and quartz stockworks, one vein of which reached 15 m in width. Surface rock samples from this showing were reported to contain 1.5 g/t Au, 82 g/t Ag, 0.1% Zn and 0.3% Pb (Schimann, 1994). The Ted vein is of the intermediate-sulphidization type and may represent a lower level within the hydrothermal system than the Tommy vein on the basis of several factors. These include a higher Ag:Au ratio, higher Mn and base metal contents, greater gangue carbonate component and more extensive wallrock alteration (Bottomer, 2003b, pers. comm., 2005).

Initial drilling of the Ted vein by Phelps Dodge in 1996 returned a 6.46 m true width intersection of 8.88 g/t Au and 393.6 g/t Ag (Fox, 1996). The upper contact of the 70 m thick intrusive sill cutting the Ted vein is at 120–140 m depth, and an above-sill initial inferred resource of 273 800 t grading 2.0 g/t Au and 133 g/t Ag has been prepared (Wallis and Fier, 2004). More recent drilling (hole TT-04-37) has encountered Au mineralization beneath the sill, at a depth of 388.3–399.3 m, intersecting 11 m (estimated true width 6.5 m) of quartz-carbonate vein returning 3.74 g/t Au and 59.3 g/t Ag (Pawliuk, 2005).

The following description of the Ted vein is paraphrased from Pawliuk (2005) and Rhys (2003). Quartz-calcite veining varies widely in colour from pale grey to creamy white, is finely banded, and exhibits textural evidence for at least three episodes of veining and brecciation. Vein material typically contains 10–40% variably silicified fragments of rhyolite porphyry wallrock and about 5–10% variably coloured calcite, which occurs as late-stage infilling of brecciated zones and open cavities. Open cavities are reported to form up to 2% of the rock volume. The Ted vein contains approximately 0.5% finely disseminated sulphide minerals, primarily pyrite but also including variable amounts of chalcopyrite, sphalerite, galena, Ag-sulphides, tellurides and sulphosalts. Chalcopyrite and sphalerite occur as irregular wispy masses and 2–5 mm blebs, respectively, and both are rimmed by later sulphosalt (?). Early quartz vein fragments within the Ted vein breccia commonly have greater sulphide and sulphosalt (?) mineral contents than do later generations of quartz-calcite infilling. Disseminated red hematite is also locally present within the vein.

Much higher sulphide concentrations are also locally present. Pawliuk (2005) reported a 0.45 m drill intersection of deep hole TT-04-37 containing 30% galena and 10% disseminated sulphosalt (?); another galena-bearing vein intersected in the same hole returned 171 g/t Ag and 2.27% Pb over a narrow 0.43 m wide intersection.

Hydrothermal alteration of the host rhyolite tuff at the Ted vein is similar to that at the Tommy. Pervasive silicification, and potassium-feldspar-quartz±pyrite alteration, grades outward from the vein to pale bleached alteration (Rhys, 2003).

SURFICIAL GEOLOGY AND SOILS

Regional Surficial Geology and Quaternary History

Surficial geology of the Fawnie Creek and adjacent Tsacha Lake map areas (NTS 093F/02, 03) was mapped by Levson and Giles (1994) and Giles and Levson (1995), respectively. The sediments comprise mainly basal till with subordinate colluvial and glaciofluvial deposits. The entire region was ice covered during the Late Wisconsinan glacial maximum, and ice-flow studies indicate that the dominant glacial direction was to the east-northeast (Giles and Levson, 1994a). Mapped surficial cover at the 3Ts area is mainly thin till veneer (<1 m thick) and thin colluvial veneer (<1 m thick) over discontinuous bedrock. Till veneer predominates in the area around the Tommy vein, whereas colluvium and adjacent areas of till blanket were mapped nearer Adrian Lake in the area of the Ted vein (Levson and Giles, 1994). A drift-prospecting potential map of the Fawnie Creek map area (Giles and Levson, 1994b) highlighted the 3Ts area, among others, as having a high to very high potential for the use of near-surface geochemical methods in tracing surficial sediment back to its bedrock source. Localized areas of exotic glaciofluvial sand and gravel are restricted to small stream valleys between the lakes. Small Holocene organic wetland deposits occur in a few areas of lower relief. No systematic property-scale Quaternary mapping or section interpretation was attempted as part of this study, but profiling of sample pits here generally confirms, at a property scale, the regional mapping results of Levson and Giles (1994).

Till and Soil Development

TILL AND OTHER PARENT MATERIALS

Till is present at most soil profile sites along the Tommy transect, other than over the relatively weathering-resistant Tommy vein. It occurs as both basal and colluviated tills. Basal till (Fig. 7) is typically grey, overconsolidated, locally sandy and is most common on the western part of the transect. In contrast, colluviated till is more widespread on the steeper slope to the east of the Tommy vein. The distribution of parent materials is more complex on the Ted transect line. Most profiles of glacial deposits examined on the Ted transect consist of basal till, but glaciofluvial outwash sand (Fig. 8) was encountered in three pits along the line. These samples were included with till samples for aqua regia digestion and ICP-MS analysis. Several of the Ted basal till horizons are classed as IIC horizons due to the widespread occurrence of coarse, angular, near-surface colluvium deposits over pre-existing till. No samples of C horizon till or other parent material were obtained from four thin rubbly soil sites on the Tommy transect, mostly near the Tommy vein, and from one site on the Ted transect.

SOIL DEVELOPMENT

Two main near-surface soil horizons are found above the widespread basal or colluviated tills at all sample sites: 1) an organic-rich LFH horizon humus layer, and 2) a thin B horizon mineral soil of variable genetic origin. All such soils were classified in accordance with the Canadian System of Soil Classification (Agriculture Canada, 1987).

Samples of LFH horizon humus comprise a mixture of partially decomposed twigs, needles, cones, moss and other fine-grained organic debris above the underlying mineral soil. They are thin, typically in the range of 2–4 cm, and do not exceed 5 cm at any site. The LFH horizon lies beneath a widespread cover of surface moss, which was not sampled here, and is marginally thicker at sites on the more subdued topography of the Ted transect than on the steeper Tommy transect.

The B horizon mineral soils on the 3Ts property are predominantly brunisols (Fig. 9, 10). They take the form of thin, brown to red-brown, near-surface Bm horizons, typically 10–20 cm in thickness. No podzolic Bf horizons were observed at any site, although there is some evidence for local development of eluviated Aej horizons in rare outwash sand and gravel.

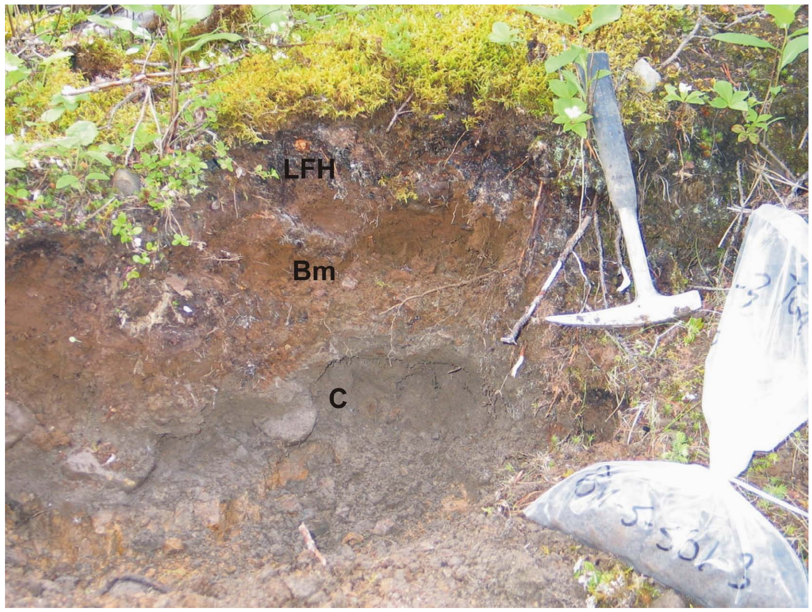


Figure 7. Typical basal till (site 501) from background area at western end of the Tommy orientation line, showing typical brunisolic Bm soil horizon and LFH horizon humus development.

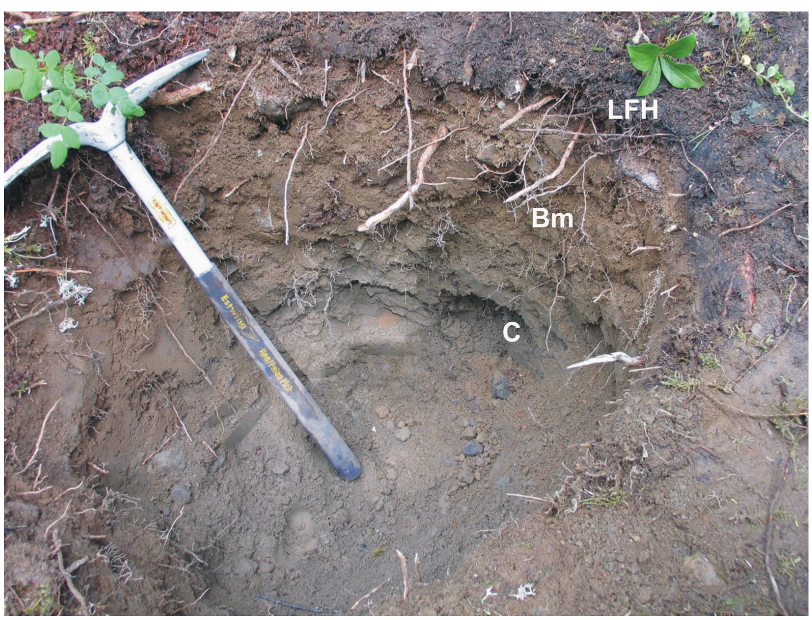


Figure 8. Glaciofluvial outwash sand and Bm soil development (site 576) at western end of the Ted orientation line.

Most Bm horizon soils profiled on the Tommy orientation transect are within relatively simple till or colluviated till parent materials. Four of the soils are, however, developed in angular rubble±colluvium in rocky areas where no till is present; three of these are immediately around the Tommy vein exposure. Soil development is much more complex on the Ted traverse line, where brunisolic B horizons are developed within till, rubble and colluvium (Fig. 11), colluvium (?) and localized glaciofluvial outwash sand parent materials. Furthermore, composite soil profiles are present at several sites where Bm horizons are preferentially developed in coarse, gravelly, near-surface colluvium deposits above IIC horizon till (Fig. 12). The colluvium is from an upslope source, in this case to the south, whereas the underlying till has originated from an up-ice source to the west. Several such sites are present along the eastern part of the Ted transect line near Adrian Lake, all of which have since been stabilized by forest growth.

Figure 9. Typical soil profile in the 3Ts area, showing surface humus (LFH horizon) above brunisolic Bm horizon and underlying C horizon till (site 505), western portion of the Tommy orientation line.

Previous Geochemical Surveys and Studies

The southern Nechako River area, including the Fawnie Creek (NTS 093F/03) map area, was the object of a series of reconnaissance geochemical programs carried out by the BC Geological Survey during the period 1992–1995. These projects, carried out with bedrock mapping programs under the banner of the Interior Plateau Project, included regional lake sediment geochemical surveys (Cook and Jackaman, 1994), lake water geochemical surveys (Cook *et al.,* 1999), Quaternary mapping and till geochemical surveys (Levson *et al.*, 1994; Cook *et al.,* 1995) and till orientation studies (Levson, 2001). Distribution of lake sediment Au results in the Tommy Lakes area clearly outlines the location of the original Tommy vein (Fig. 2). The single lake sediment sample collected from Adrian Lake returned the highest total (INAA) Au value (256 ppb) in that geochemical survey (regional median 1 ppb Au). In all, four small lakes containing moderately elevated to highly elevated gold concentrations in the range 4–256 ppb were found to encircle the small hills hosting the original Tommy Au vein discovery at what is now the 3Ts project. In addition to the high Au concentration, which was confirmed by subsequent INAA reanalysis of the sample, this Adrian Lake sediment was also characterized by very low or background-level abundances of other elements, including As (7.8 ppm), Cu (36 ppm) and Pb (4 ppm). Regional till geochemical data of Levson *et al.* (1994) also show the down-ice dispersal of Au in till from the deposit. Of several till samples collected by the BC Geological Survey in 1993 northeast of the Tommy vein, two returned elevated Au values of 23 ppb.

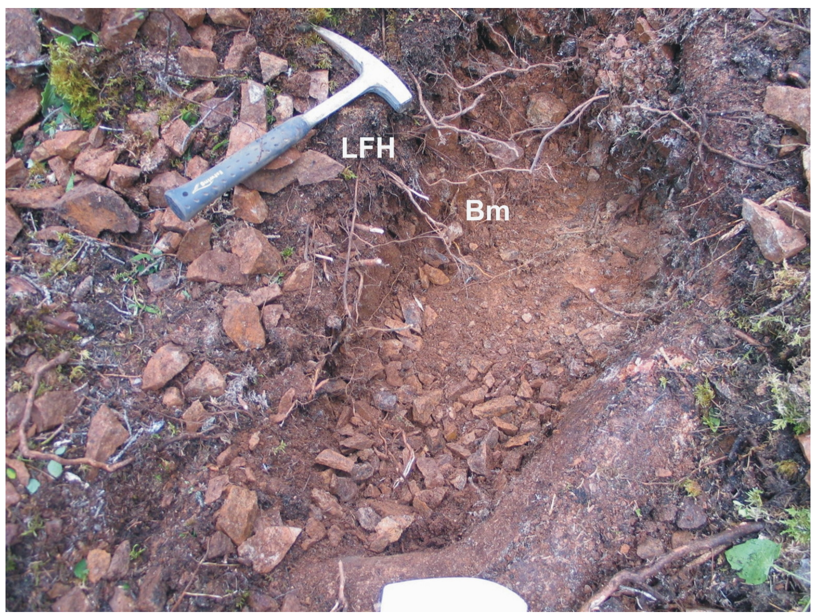


Figure 10. Thin Bm soil horizon developed in rubble and colluvium directly atop bedrock at the Tommy vein (site 591); no till present at this site.

Little in the way of soil geochemical surveys appears to have been conducted near the Tommy vein. However, at least three near-surface B horizon soil geochemical surveys of the adjacent Tam and Taken properties were carried out during 1994–1998 by Fox Geological (Fox, 1994, 1995, 1996, 1999) on behalf of Phelps Dodge and others. They include two overlapping soil grids and subsequent infill work (N = 832 samples). Line orientations of the two grids (east-west and 060°, respectively) are roughly transverse to the strike of the vein systems. However, they are also roughly parallel to the dominant east or northeast-trending ice-flow direction on the property, suggesting the possibility that any Au or Ag geochemical signatures of soil potentially derived from any Au-bearing till dispersal plumes may have been missed in the gaps between the 200 m or 100 m gridline spacings. Nevertheless the soil sampling appears to have been carried out consistently from year to year, and it successfully delineated the areas of the Ted and Mint vein systems.

FIELD AND LABORATORY METHODS

Quality Control – Quality Assurance Procedures

A variety of standard QA-QC procedures was used in both the field and the laboratory to ensure a uniformly high quality of data. A 20-sample block method of sampling was used, in which field duplicates and standards were collected and inserted at regular intervals. Field duplicates (n = 5 pairs) were collected at a rate of 1 every 10 samples, and appropriate CANMET and other control standards inserted at a rate of at least 1 in every 20 samples. For those selective extraction methods for which standards are either unavailable or poorly constrained, such as Mobile Metal Ion (MMI) or Enzyme Leach procedures, multiple insertions of a B horizon bulk sample, prepared as a control, were included as blind drift monitors in batches to monitor analytical precision. This bulk sample was obtained from a soil profile near the Tommy vein. In addition to these proactive QA-QC initiatives, some of the laboratories also reported the results of their internal QA-QC procedures, such as those for internal standards and analytical replicates.

Field Sampling Procedures

Fieldwork at the 3Ts property was conducted during late June to early July 2005. A series of soil profiles (N = 36 sites) were conducted on two approximately 750 m long east-west lines transecting each of the Tommy and Ted veins (Fig. 2). The Tommy transect comprises 20 sites; the Ted transect comprises an additional 16 sites. Sample sites (Fig. 13) are spaced at roughly 50 m intervals, although tighter 25 m site spacings were used nearer the vein systems, and distal sites are locally telescoped to 75–100 m spacings. One of the sites directly over the Tommy vein is offset to the south relative to the sampling line. The eastern end of the Tommy soil transect is at a small wetland area, but the vegetation transect of the halogen geochemistry study continues for another 1.5 km to the east (Dunn *et al.,* 2006).

Three types of organic and mineral samples, exclusive of vegetation (Dunn *et al.,* 2006), were collected at each profile site:

- LFH horizon humus
- B horizon soil
- C horizon till

The two sampling transects were purposely chosen to cross the veins at rather arbitrary points, so as not to bias fieldwork toward those parts of the veins known to be most prospective. All-terrain vehicle road access was utilized

Figure 11. Brunisolic Bm horizon soil developed in loose rubble and colluvium atop weathering bedrock at site 570, near the eastern end of the Ted orientation line; no till present at this site.

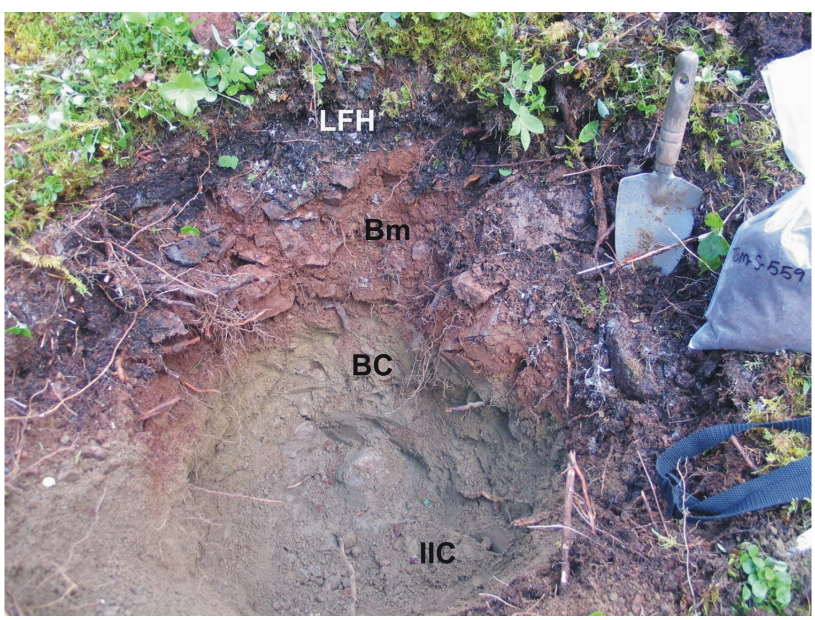


Figure 12. Composite soil profile, showing preferential development of brunisolic Bm horizon within stabilized near-surface angular colluvium atop IIC horizon till; site (559) located immediately down-ice and downslope from Ted vein exposure.

where possible, but was not a major factor in siting of the transects. In all, 7 separate samples were collected at each site for the range of intended analytical procedures; a total of 14 such samples were collected at each field duplicate site.

A single LFH horizon humus sample was collected at each site, using Hubco® breathable bags to prevent rotting of the sample before reaching the lab. Humus samples comprise a mixture of partially decomposed twigs, needles, cones, moss and other fine-grained organic debris above the underlying mineral soil. Surface forest mosses over humus were stripped off prior to humus collection, and were not sampled as part of this study. Humus samples were collected first at each site so as to prevent any inadvertent contamination of this thin horizon (typically <5 cm thick) from the underlying mineral soil. Each site was closely inspected prior to sampling to ensure that it was pristine and there had been no prior surface disturbance. In the case of roadcut sample sites, the LFH sample was taken farther back from the bank to eliminate any possibility of inadvertently collecting material contaminated by soil during earlier road-building operations.

Figure 13. Typical till pit (site 525) in basal till at the eastern end of the Tommy orientation line; note absence of outcrop and the extensive forest moss cover.

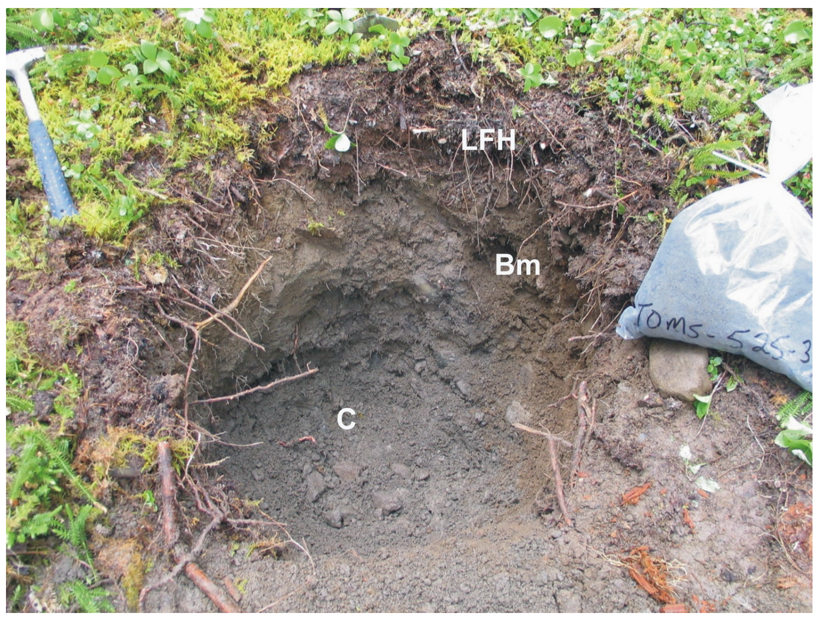


Figure 14. Till profile from same site as previous photo on Tommy orientation line, showing LFH humus and brunisolic Bm soil horizons above grey basal till; sample bag at right is C horizon till sample TOM-S-525-3.

A total of 5 samples of B horizon or adjacent near-surface soil were collected at each site. One B horizon sample was collected for each of aqua regia digestion, Enzyme Leach (EL), Soil Gas Hydrocarbons (SGH), and Soil Desorption Pyrolysis (SDP). In addition, a fifth sample was collected at constant depth of 10–25 cm at each site for Mobile Metal Ion (MMI) analysis. In practice, this constant depth typically, although not always, corresponded to a mixed sample of the Bm horizon with the underlying transitional BC horizon. All soil samples obtained for proprietary selective extractions were sampled and preserved in accordance with the appropriate laboratory protocols. For example, all samples for MMI, SGH and SDP analysis were collected using Zipoc® bags; these were then placed within a protective outer poly bag which was secured with a zap strap. Samples collected for aqua regia digestion were also used for other determinations including LOI, pH and, where applicable, Au fire assay. Note that these B horizon samples are also, in part, the subject of the parallel halogen geochemistry study of Dunn *et al.* (2006). All soils were classified in accordance with the Canadian System of Soil Classification (Agriculture Canada, 1987).

A single C horizon till sample (mean weight 4.85 kg) was collected from shallow oxidized till material at most sites (Fig. 14). Till samples were typically obtained from a depth of approximately 45–60 cm on the Tommy transect, and from about 40–60 cm on the Ted transect. No till samples were obtained from four rubbly near-bedrock sites on the Tommy transect, mostly near the Tommy vein, and from one site on the Ted transect. In addition, a few of the C horizon samples on the Tommy line are of glaciofluvial origin. All samples were collected in large poly bags and secured with a zap strap. All samples were shipped to their respective laboratories in hard plastic cases to prevent any possible damage to the samples.

Field duplicate samples (n = 5 pairs) of all media were typically collected from pits dug a few metres apart at relevant sites. Overstorey vegetation samples were also collected at each site as part of the parallel halogen geochemistry study (Dunn *et al.*, 2006). These biogeochemical samples consisted of lodgepole pine (*Pinus contorta*) outer bark and white spruce (*Picea glauca*) foliage.

Sample Preparation and Analytical Procedures

Samples from each horizon were analyzed for a range of commercially available partial digestions and proprietary selective extractions (Table 1). Aqua regia digestion – ICP-MS multielement analyses and both pH and LOI determinations were common to all three types of soil media, but the majority of the selective extractions were conducted solely on the near-surface B horizon mineral soil samples that have traditionally been used for property-scale geochemical exploration in BC. These included Enzyme Leach (EL), Mobile Metal Ion (MMI), Soil Gas Hydrocarbons (SGH) and Soil Desorption Pyrolysis (SDP), as well as total Au determination by Pb-collection fire assay – ICP-MS. Samples of the LFH horizon humus were also analyzed by Na-pyrophosphate leach and conductivity in addition to aqua regia – ICP-MS. All C horizon samples were analyzed by aqua regia digestion – ICP-MS and for total Au by Pb-collection fire assay – ICP-MS only.

Aqua regia geochemical work on humus, soil and till, as well as Au fire assay, pH, LOI and other determinations, were conducted at Acme Analytical Labs, Vancouver. Specialized proprietary selective extractions were carried out at ALS Chemex, Perth, Australia (MMI); Activation Laboratories, Ancaster, Ontario (EL and SGH); and SDP Pty., Brisbane, Australia (SDP).

SAMPLE PREPARATION

Sample preparation procedures for all humus, soil and till samples prepared and analyzed for trace elements by aqua regia digestion – ICP-MS at Acme Analytical Labs are outlined here. Preparation procedures for those LFH and B horizon soils submitted for proprietary selective extractions (Na-pyrophosphate, EL, MMI, SGH and SDP) are described in the appropriate sections that follow. Note that all sample preparation activities were carried out at the relevant laboratories; no prior preparation work was conducted in the Tatelkuz Lake field camp on any samples.

TABLE 1. SUMMARY OF DIGESTION AND OTHER METHODS USED FOR ANALYSIS OF ORGANIC AND MINERAL SOIL HORIZONS: FIRE ASSAY FUSION, AQUA REGIA, NA-PYROPHOSPHATE, ENZYME LEACH (EL), MOBILE METAL ION (MMI-M), SOIL GAS HYDROCARBON (SGH) AND SOIL DESORPTION PYROLYSIS (SDP)

	LFH Horizon Humus	B Horizon Soil	C Horizon Till
Au by fire assay		X	X
Aqua regia ICP-MS	X	X[1]	X
Na-pyrophosphate	X		
Enzyme Leach		X	
Mobile Metal Ion Multi-element (MMI-M)[SM]		X[2]	
Soil Gas Hydrocarbons (SGH)[SM]		X	
Soil Desorption Pyrolysis (SDP)[SM]		X	
pH	X	X	X
Conductivity	X		
Loss-on-ignition	X	X	X

[1] with halogen geochemistry project of Dunn et al. (2006)

[2] sampled at constant depth, typically from Bm/BC horizons

Note that aqua regia ICP-MS determinations were conducted on both 80 mesh and 230 mesh fractions of B horizon soils.

All LFH horizon humus samples were first allowed to air dry in the field prior to shipping, and were then dried in the laboratory at low heat (40°C), disaggregated within their original bags by pounding with a mallet, and screened to <250 µm (–60 mesh ASTM) using stainless steel sieves.

All B horizon soil samples were dried at low heat (40°C) and sieved in their entirety to <180 µm (–80 mesh ASTM) using stainless steel sieves, with 30 g splits being taken for each of group 1F aqua regia – ICP-MS analysis and group 3B-MS Pb-collection Au fire assay. The widely used –80 mesh soil fraction was used here to facilitate comparisons with most exploration industry soil datasets.

The C horizon till samples were dried at low heat (40°C) and then sieved in their entirety to <63 µm (–230 mesh ASTM) using stainless steel sieves in accordance with standard till preparation procedures of the Geological Survey of Canada and the BC Geological Survey. Splits of 30 g were taken for each of group 1F aqua regia – ICP-MS analysis and group 3B-MS Pb-collection Au fire assay.

AQUA REGIA (AR) DIGESTION

Aqua regia digestions with ICP-MS finish (Acme group 1F) were conducted on all prepared 3Ts humus (LFH horizon), mineral soil (B horizon) and till (C horizon) samples at Acme Analytical Labs, Vancouver. In each case, 30 g analytical subsamples were digested with 180 ml 2-2-2 $HCl-HNO_3-H_2O$ at 95°C for 1 hour, diluted to 600 ml and then analyzed for a 53-element suite by both ICP-MS and ICP-ES on Perkin-Elmer Elan 6000 and SpectroCirus instrumental units, respectively. This relatively weak aqua regia digestion is a partial digestion, providing a partial recovery of numerous silicate-bound and refractory elements such as Ni, Ba and Cr. It is typically near-complete, however, for sulphide-associated elements such as Cu, Zn, Pb, Ag and Co.

Analytical subsamples of 30 g were used in each case here in an attempt to increase sample representativeness and minimize Au particle sparcity effect, but aqua regia – digestible Au as reported here may or may not be complete, depending on the nature of the silicate host. At the time of writing, total Au determinations by Pb-collection fire assay were underway on all mineral soil and till samples to verify earlier results.

Subsequent to this, 20 g of prepared B horizon soil pulp was supplied in most cases to the halogen geochemistry study (Dunn *et al.*, 2006), a further 15–30 g removed for Au fire assay purposes and the remaining <180 µm (–80 mesh ASTM) fraction then further sieved to <63 µm (–230 mesh ASTM) for further group 1F aqua regia – ICP-MS trace element determination of the finer soil fraction. This work was in progress at time of writing.

MOBILE METAL ION (MMI)

The Mobile Metal Ion (MMI) method is a proprietary commercial selective extraction method of Wamtech Pty. Ltd., Australia; analyses are conducted under license at a number of laboratories around the world. There is a paucity of published case studies on the use of MMI geochemistry in the search for epithermal Au deposits in the Cordillera and, in fact, there are only a few such studies of any sort in northern glaciated terrain (*e.g.*, Fedikow, 2005; Bajc, 1998). The MMI-M partial extraction suite was conducted on near-surface soil samples by ALS Chemex at their facility in Perth, Western Australia. The MMI-M method (ALS

Chemex code ME-MS17) is one of several MMI analytical suites that use proprietary leach reagents stated to be suitable for the extraction of target elements, in this case a multielement suite. Analytical finish is by ICP-MS. Results are to be reported by Cook and Dunn (work in progress).

ENZYME LEACH (EL)

The Enzyme Leach (EL) method is a proprietary commercial selective extraction method of Activation Laboratories Ltd., Ancaster, Ontario. Enzyme Leach has attracted much attention from the mineral exploration industry but, as with MMI, most published case studies are confined to nonglaciated areas. Enhanced Enzyme Leach analyses (Actlabs code 7EnhEL) of all B horizon soil samples were conducted by Activation Laboratories using an ICP-MS finish. The method, although proprietary, is considered to be selective for those metals associated with the amorphous manganese oxide phase that coats mineral particles in the near-surface environment. A 1 g sample of <250 µm (–60 mesh) soil material is leached in a glucose oxidaze solution containing a proprietary enzyme, which reacts with and dissolves any amorphous manganese oxide present. Any metals are reported to be complexed with gluconic acid, and the solutions are analyzed using a Perkin-Elmer Elan 6000 or 6100 ICP-MS unit. Results will be reported at a later date by Cook and Dunn (work in progress).

SOIL GAS HYDROCARBONS (SGH)

The Soil Gas Hydrocarbons (SGH) method is a proprietary commercial analytical method of Activation Laboratories Ltd., Ancaster, Ontario. Sample preparation and analysis for SGH was conducted on all B horizon soil samples by Activation Laboratories. Samples were air dried at no more than 40°C, sieved to <250 µm (–60 mesh) and a 0.5 g sample extracted and analyzed by gas chromatography – mass spectrometry. The method, although proprietary, targets a range of 162 organic compounds that are thought to be adsorbed onto clay minerals and amorphous iron and manganese oxides present in the soil. Hydrocarbons in the C5–C17 range are measured, as these are stated to be more robust from a field sampling perspective, and less affected by decaying biogenic material than hydrocarbons in the C1–C4 range. The SGH method has been the subject of a recent CAMIRO research study (Sutherland and Hoffman, 2003), but, to the knowledge of the authors, no published case studies on the use of the SGH method are known from the western Cordillera. Results for 3Ts are to be reported by Cook and Dunn (work in progress).

SOIL DESORPTION PYROLYSIS (SDP)

Soil Desorption Pyrolysis (SDP) is a proprietary commercial analytical method of SDP Pty. Ltd., Brisbane, Australia. The B horizon soil samples were shipped to Australia by air to minimize elapsed time between collection and analysis, and preparation and SDP analysis of the samples was conducted at that facility. The SDP method is stated to measure trace amounts of volatile compounds, such as light hydrocarbons and other gases, which are adsorbed onto clay-size soil particles. Samples are dried at 40°C, the 0.2–2 µm clay-size particle fraction separated using a centrifuge, and total adsorbed gases determined by pyrolysis at 450°C. Study of the SDP response here is timely, as most SDP orientation studies have been confined, with a few exceptions, to deposits in arid desert environments of Australia, Chile and Nevada. Results from the 3Ts prospect will be reported by Cook and Dunn (work in progress).

SODIUM PYROPHOSPHATE LEACH

Sodium pyrophosphate leaches (Acme group 1SLO) were conducted on all LFH horizon humus samples at Acme Analytical Labs, Vancouver. This is a nonproprietary selective extraction method for organic-rich samples that is widely available at commercial laboratories. The procedure used here involves the leaching of a 1 g prepared humus sample with 10 ml 0.1M Na-pyrophosphate ($Na_3P_2O_7$), bottle rolling for two hours and ICP-MS determination of a 58-element analytical suite using a Perkin-Elmer Elan 6000 unit. The leach is selective for elements adsorbed by organic matter (humic and fulvic compounds) and was carried out on organic-rich humus samples only. Results will be reported at a later date by Cook and Dunn (work in progress).

FIRE ASSAY FOR TOTAL AU DETERMINATION

Lead-collection Au fire assays (Acme group 3B-MS) were conducted at Acme Analytical Labs, Vancouver on all 3Ts mineral soil and till samples to 1) verify the presence of elevated Au concentrations in soil; and 2) ascertain, by total decomposition of the samples, what differences, if any, might exist between the partial (aqua regia digestion) and total Au determinations. Fire assays of 30 g subsamples of <180 µm (–80 mesh ASTM) B horizon prepared soil and <63 µm (–230 mesh ASTM) prepared till, with ICP-MS finish, were in progress at time of writing.

OTHER DETERMINATIONS

In addition to the above partial and selective extractions, other determinations, including pH and loss-on-ignition (LOI), were carried out on all organic and mineral soils at Acme Analytical Labs. Conductivity was also determined on only the humus samples.

Soil pH was determined in the lab on a 5 g sample slurry in 10 ml of distilled-deionized water. Field pH was not determined. Loss-on-ignition, an approximate measure of organic matter content, was determined at 500°C. Conductivity of humus samples was measured by conductivity electrode.

PRELIMINARY RESULTS AND DISCUSSION

Quality Control – Quality Assurance Results

For the purposes of this preliminary report, quality control – quality assurance results presented here are limited to an assessment of analytical accuracy and precision for selected elements determined by aqua regia digestion – ICP-MS. Analytical accuracy is monitored by the insertion of control standards of known composition and evaluation of the results. Replicate analyses of these standards also provide an estimation of analytical precision at various concentration levels. Certified CANMET till and lake sediment standards were used, as were a variety of internal till and organic soil standards from both BC Geological Survey and exploration industry sources.

Analytical accuracy for selected elements is well within acceptable limits for most elements of economic interest. For example, multiple insertions (n = 3) of CANMET till standard TILL-3 in the B horizon soil suite returned mean ±1σ results of 1410 ±54 ppb Ag, relative to the recommended value of 1.4 ±0.2 ppm (1400 ±200 ppb) Ag reported by Lynch (1996). At the lower end of the Ag concentration range, multiple insertions of CANMET till standard TILL-1 in each of the B horizon soil (n = 4) and till (n = 3) suites returned mean ±1σ results of 206 ±8 ppb and 210 ±12 ppb Ag, respectively, relative to a recommended value of <0.2 ppm (<200 ppb) Ag. Three insertions of each of TILL-1 and TILL-4 in the till suite returned Cu results of 48.6 ± 1.3 ppm and 224.5 ± 9.5 ppm relative to recommended values of 49 ±2 ppm and 254 ±15 ppm Cu, respectively. Accuracy of humus analyses are similarly within acceptable limits. For example, three insertions of the organic-rich CANMET standard LKSD-4 in the LFH horizon suite returned mean ±1σ results of 209 ±7 ppm Zn, 34.6 ±1.3 ppm Cu and 238 ±4 ppb Ag relative to recommended values of 195 ±16 ppm Zn, 31 ±2 ppm Cu and 0.2 ±0.1 ppm (200 ± 100 ppb) Ag, respectively (Lynch, 1999).

Examination of precision results shows that analytical precision, as determined by replicate analyses of standards, is generally better than 10% for most trace elements of economic interest, such as Ag, Zn, Pb and Cu. For example, replicate analyses of five sets of CANMET and other standards in the till and mineral soil suites by aqua regia digestion – ICP-MS returned precision results in the range 5.3–11.1% for Ag, 3.1–10.0% for Zn and 3.9–9.8% for Pb. Replicate blind analyses (n = 5) of the B horizon field standard returned very similar precision results of 8.3% for Ag, 5.2% for Zn and 5.1% for Pb. Precision results for these same three elements in the LFH horizon humus suite, as determined by three analyses of LKSD-4, are 3.0% for Ag, 7.1% for Zn and 2.4% for Pb.

Summary Statistics and Overview of Results

Summary statistics for selected elements determined by aqua regia digestion – ICP-MS for each of LFH horizon humus, B horizon soil and C horizon till and other parent materials are shown for the combined orientation lines (Table 2) and for both the Tommy (Table 3) and Ted (Table 4) transects. Discussion here of the results for the geochemical orientation lines will be confined to comparative aqua regia digestion data, particularly Au and Ag, for each of the three soil horizons sampled. Remaining selective extraction and other geochemical results will be reviewed in the final project report (Cook and Dunn, work in progress).

Elevated Au concentrations in mineral soil and humus are present in all Tommy transect horizon suites, and in most Ted transect horizon suites. In most cases, the highest Au concentrations are on the Tommy transect. Here, up to 41 ppb Au is present in LFH horizon humus (median 1 ppb), up to 223 ppb Au in B horizon soil (median 5.3 ppb) and up to 41 ppb Au in C horizon till and other parent materials (median 3.2 ppb). Somewhat lower but nevertheless elevated Au concentrations are also present in Ted transect sample media. These include up to 24 ppb and 85 ppb Au in B horizon soil (median 1.8 ppb) and C horizon till (median 3.1 ppb), respectively. In the case of till, samples from both transects returned similar background median results (3.2 ppb and 3.1 ppb), but the highest concentrations are on the Ted transect. Only LFH humus horizons on the Ted transect failed to yield any elevated Au concentrations (maximum 2.5 ppb).

Box plots showing Au and Ag (ppb) distribution in each of humus, B horizon soil and C horizon till parent materials for the combined Tommy and Ted orientation transects (Fig. 15) indicate that elevated Au concentrations (>50 ppb) are restricted to B and C horizon mineral soil, although one humus sample (41 ppb Au) from directly over the Tommy vein does approach this level. Conversely, all but one of those samples containing >2000 ppb (2 ppm) Ag are organic-rich humus from the LFH horizon; mineral soil had substantially lower background Ag concentrations.

Downprofile Geochemical Variations with Soil Horizon

Some general downprofile geochemical relations are apparent in the summary of statistical results for the combined lines. A few elements (*e.g.*, Mo) have near-constant median concentrations (range of medians 0.82–1.00 ppm) with depth, regardless of soil horizon, but absolute concentrations of most elements increase with increasing depth in 3Ts soil. Median concentration of many elements, including those related to epithermal mineralization (*e.g.*, Au and As), in mineral soil are several times those in organic-rich humus, but there is little difference in median results from one mineral horizon to another. In the case of Au (Fig. 15), for instance, median concentrations in B horizon soil (3.7 ppb) and C horizon till (3.2 ppb) do not differ appreciably from one another, but are 8–9 times that of the overlying humus (0.4 ppb Au). Other elements, including Cu, Ce, Y and Zr, show a more gradual increase in median concentration with increasing depth in the soil profile.

Median concentrations of several elements, notably Ag, Cd, Hg and S, are much higher in surface humus relative to underlying mineral soil. For example, median, or background-level, Ag concentrations are 4 times greater in humus (582 ppb) than in the C horizon (145 ppb), as shown in Figure 15. Similarly, the median concentration of Hg in humus (214 ppb) is more than 10 times that present in B horizon mineral soil (19 ppb) and more than 23 times that of the C horizon (9 ppb). Median loss-on-ignition (LOI) results are similarly much greater in organic-rich humus (90.8%) relative to the underlying B horizon soil (11 times) and C horizon parent material (21 times).

Geochemical Contrast Over Gold Mineralization

Elevated Ag (Fig. 16, 17) and Au (Fig. 18, 19) geochemical responses in all orientation soil media reflect, to varying degrees, the presence of epithermal Au mineralization associated with quartz veins on both the Tommy and Ted properties. In general, Ag tends to form more coherent multisite anomalies, whereas Au, perhaps as a consequence of the particle sparcity effect, more commonly occurs as single-site anomalous values.

The absolute concentrations of elements in soil horizons may be the product of a host of factors, such as bulk composition, lithological origin, surficial cover, topography, weathering and biogeochemical cycling. It is not the absolute magnitude of Au, Ag or other elements in a soil horizon that determines its effectiveness for geochemical exploration, but rather the extent of geochemical contrast

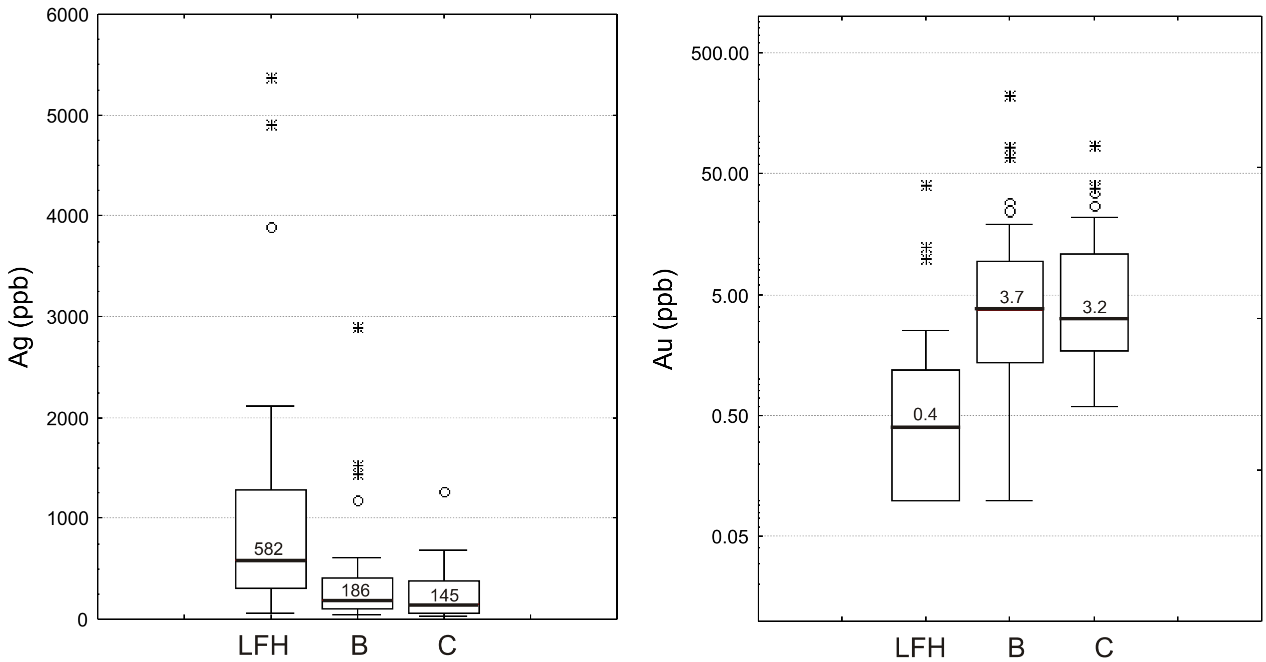


Figure 15. Box plots showing distribution of Ag (left) and Au (right; log scale) in each of humus (n = 36), B horizon soil (n = 36) and C horizon till parent materials (n = 31) for the two combined Tommy and Ted vein orientation transects, 3Ts project. Median Ag and Au concentrations are shown for each. Fifty percent of the data for each lies within the box; the median is denoted by the horizontal line.

between results from mineralized and unmineralized areas. Contrast is measured here with response ratios, which are shown in transect plots for all Ag and Au in humus, B horizon and C soil results at each vein (Fig. 16–19). Response ratios level all sets of results to a common baseline for comparison. They are calculated, for each element, by calculating the ratio for each site concentration to the median value for that orientation line. For example, a response ratio of 1 indicates a sample concentration at the median, or 50th percentile, of the dataset; a response ratio of 4 indicates a concentration of 4 times the median, regardless of the absolute magnitude.

TOMMY VEIN RESULTS

Soil geochemical results at the Tommy vein show highly elevated Ag concentrations in humus of up to 5380 ppb (site 591), which are more than 11 times that of background humus Ag concentrations (median 475 ppb) along the Tommy orientation line. Perhaps even more significantly, elevated levels of Ag in humus in excess of 2000 ppb persist in humus samples down ice and downslope along the line for a further 75–80 m to the east. This pattern mimics a similar, although slightly lower in magnitude and less coherent, Ag distribution in B horizon soil; soil Ag concentrations here of up to 2899 ppb (site 591) have response ratios of 8–16 times background (median 182 ppb) and occur directly over and adjacent to the Tommy vein at two sites. Highly elevated soil Ag concentrations do not persist as far to the east downslope and down ice as they do in humus, but nevertheless provide greater geochemical contrast, as shown by the response ratios (Fig. 16).

Elevated Au values of up to 223 ppb are present in B horizon soil (median 5.3 ppb) at two sites directly above and adjacent to the Tommy vein, and up to 41 ppb in LFH horizon humus (median 1 ppb). Despite the differences in magnitude between Au results in the two sample media, response ratios indicate that geochemical contrast levels of the two are almost identical. Response ratios for soil at two sites are in the range 13–43 times, whereas those for humus at an overlapping set of sites are in the range 10–41 times. Consideration of all adjacent sites with response ratios >5, however, shows that B horizon soil offers a slightly more coherent geochemical response to Tommy vein mineralization than does humus.

There is no direct Ag or Au response in till at the Tommy vein, as no till is developed directly over the outcropping and moss-covered vein along the sampling line (Fig. 5, 10). However, elevated Ag concentrations up to 571 ppb, up to 8 times background levels (median 72 ppb), are present at two down-ice sites to the east. Similarly elevated Au concentrations up to 41 ppb at two sites here would seem to indicate a local down-ice dispersal of mineralized till material from the Tommy vein of approximately 100 m, although the spotty occurrence of till in this area makes it difficult to quantify more precisely.

In addition there is a local Au response in till (39 ppb; site 521) at the Larry vein to the east. Silver concentrations in till here are a modest 363–392 ppb, but these nevertheless correspond to elevated response ratios of approximately 5 times background at three sites over about 60 m at and adjacent to the Larry vein. Corresponding Au response ratios in till are 3–12 times background here. Interestingly, neither humus nor B horizon soil at the Larry vein showed any elevated Ag or Au concentrations.

Conversely, elevated Ag and Au in both humus and B horizon soil do define a single-site anomalous zone (site 518) between the Tommy and Larry veins. Highly elevated Ag concentrations up to 3888 ppb in humus and 1182 ppb in B horizon soil, for example, are reported from predominantly rubble and colluvium; no till was encountered at the

TABLE 2. SUMMARY STATISTICS FOR SELECTED ELEMENTS BY AQUA REGIA DIGESTION – ICP-MS FOR COMPARATIVE SOIL HORIZONS, COMBINED ORIENTATION LINES, ALL DATA

LFH Horizon	**Au**	**Mo**	**Cu**	**Pb**	**Zn**	**Ag**	**Co**	**Mn**	**Fe**	**As**	**U**	**Cd**	**Sb**	**La**	**Al**	**S**	**Hg**	**Cs**	**Nb**	**Y**	**Ce**	**LOI**	**pH**
Humus	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**0.4**	**0.89**	**5.54**	**4.2**	**57.5**	**582**	**0.8**	**885.5**	**0.19**	**0.3**	**0.1**	**0.79**	**0.08**	**0.9**	**0.11**	**0.10**	**214**	**0.42**	**0.28**	**0.45**	**1.4**	**90.8**	**4.6**
Mean	2.28	1.97	5.83	4.49	66.86	1119.47	1.02	1144.47	0.23	0.45	0.25	0.93	0.09	1.98	0.12	0.11	218.31	0.57	0.34	2.68	2.03	89.12	4.82
1s	7.09	6.34	2.51	1.39	35.17	1276.32	0.70	864.28	0.17	0.46	0.60	0.80	0.07	6.21	0.09	0.02	50.35	0.42	0.27	12.14	3.35	6.50	0.56
CV (%)	*311.2*	*321.4*	*43.0*	*30.9*	*52.6*	*114.0*	*68.8*	*75.5*	*74.7*	*101.8*	*236.5*	*85.2*	*77.2*	*314.5*	*70.4*	*19.1*	*23.1*	*74.6*	*78.6*	*453.7*	*165.0*	*7.3*	*11.7*
Minimum	0.1	0.18	3.01	2.57	18.8	54	0.2	235	0.04	0.1	0.1	0.2	0.03	0.5	0.03	0.07	145	0.15	0.07	0.13	0.4	70.4	4
Maximum	40.8	38.9	16.42	8.25	189.3	5380	3.1	3742	0.65	2.5	3	3.66	0.45	38.1	0.46	0.14	344	1.68	1.16	73.28	20.9	96.4	6
N=sites	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36

B Horizon	**Au**	**Mo**	**Cu**	**Pb**	**Zn**	**Ag**	**Co**	**Mn**	**Fe**	**As**	**U**	**Cd**	**Sb**	**La**	**Al**	**S**	**Hg**	**Cs**	**Nb**	**Y**	**Ce**	**LOI**	**pH**
Soil	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**3.7**	**1.00**	**8.68**	**12.3**	**103.0**	**185.5**	**9.8**	**558.5**	**3.24**	**6.1**	**0.3**	**0.36**	**0.26**	**8.55**	**1.53**	**0.01**	**19**	**2.12**	**2.99**	**4.37**	**15.55**	**8.3**	**5.2**
Mean	15.62	1.31	10.30	21.62	136.58	384.94	9.35	745.69	3.34	10.98	0.48	0.65	0.37	9.53	1.43	0.02	22.22	3.39	2.90	5.78	18.19	8.93	5.18
1s	39.70	1.36	5.74	23.36	145.18	563.14	1.97	596.73	0.99	13.92	0.75	0.85	0.29	4.69	0.43	0.02	11.67	2.72	0.88	6.92	7.17	2.96	0.57
CV (%)	*254.2*	*103.7*	*55.7*	*108.0*	*106.3*	*146.3*	*21.1*	*80.0*	*29.6*	*126.8*	*154.9*	*129.6*	*80.0*	*49.2*	*30.0*	*103.6*	*52.5*	*80.2*	*30.5*	*119.8*	*39.4*	*33.2*	*11.1*
Minimum	0.1	0.68	5.38	7.45	37.4	38	4.8	229	2.09	2.6	0.2	0.14	0.14	4	0.49	0.01	6	0.91	0.37	1.03	7.5	5.3	3.8
Maximum	223.1	8.89	33.58	112.5	891.1	2899	14.7	2668	8.27	78	4.5	4.26	1.56	30.4	2.22	0.09	62	10.99	5.5	43.6	43.7	20	6.5
N=sites	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36

C Horizon	**Au**	**Mo**	**Cu**	**Pb**	**Zn**	**Ag**	**Co**	**Mn**	**Fe**	**As**	**U**	**Cd**	**Sb**	**La**	**Al**	**S**	**Hg**	**Cs**	**Nb**	**Y**	**Ce**	**LOI**	**pH**
Till	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**3.2**	**0.82**	**13.10**	**11.0**	**61.9**	**145**	**9.5**	**368**	**3.14**	**6.4**	**0.4**	**0.11**	**0.28**	**12.4**	**1.45**	**0.01**	**9**	**1.27**	**1.16**	**8.13**	**29.9**	**4.3**	**6.2**
Mean	11.15	0.84	13.09	21.18	66.08	250.19	9.20	362.42	3.12	8.97	0.48	0.13	0.36	12.42	1.41	0.02	11.19	2.80	1.41	8.49	29.99	4.75	6.11
1s	18.00	0.21	2.39	43.30	15.17	272.05	1.29	70.31	0.27	8.38	0.29	0.07	0.27	2.58	0.38	0.03	7.39	2.59	0.74	2.44	6.16	1.56	0.38
CV (%)	*161.5*	*24.5*	*18.3*	*204.5*	*23.0*	*108.7*	*14.0*	*19.4*	*8.6*	*93.4*	*59.4*	*57.9*	*77.2*	*20.7*	*26.9*	*191.5*	*66.0*	*92.7*	*52.1*	*28.8*	*20.5*	*32.8*	*6.3*
Minimum	0.6	0.58	8.32	6.45	41.8	30	6.9	150	2.46	4.7	0.3	0.06	0.2	8.3	0.53	0.01	5	0.61	0.52	4.75	18.4	2.8	5.1
Maximum	84.9	1.67	19.1	250.2	124.5	1271	12.3	549	3.56	52.2	1.7	0.46	1.6	18.8	2.1	0.2	36	9.12	3.34	17.2	45.2	9.2	6.8
N=sites	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31

TABLE 3. SUMMARY STATISTICS FOR SELECTED ELEMENTS BY AQUA REGIA DIGESTION – ICP-MS FOR COMPARATIVE SOIL HORIZONS, TOMMY ORIENTATION LINE

LFH Horizon	Au	Mo	Cu	Pb	Zn	Ag	Co	Mn	Fe	As	U	Cd	Sb	La	Al	S	Hg	Cs	Nb	Y	Ce	LOI	pH
Humus	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**1.0**	**1.04**	**5.94**	**4.2**	**59.6**	**474.5**	**0.9**	**885.5**	**0.21**	**0.4**	**0.1**	**0.92**	**0.07**	**0.85**	**0.10**	**0.10**	**188.5**	**0.58**	**0.33**	**0.45**	**1.45**	**90.7**	**5.0**
Mean	3.89	1.08	6.04	4.59	74.54	1087.15	1.09	1195.10	0.22	0.41	0.12	1.20	0.07	0.91	0.11	0.11	200.10	0.66	0.37	0.50	1.54	89.84	5.00
1s	9.28	0.37	1.67	1.58	39.44	1362.36	0.65	864.84	0.15	0.32	0.07	0.94	0.02	0.39	0.06	0.02	43.53	0.45	0.26	0.25	0.86	4.72	0.57
CV (%)	*238.9*	*34.4*	*27.6*	*34.5*	*52.9*	*125.3*	*59.8*	*72.4*	*65.2*	*77.1*	*58.3*	*78.4*	*33.2*	*43.4*	*53.8*	*18.5*	*21.8*	*69.3*	*70.7*	*49.7*	*55.9*	*5.3*	*11.3*
Minimum	0.1	0.53	3.82	2.57	29.6	54	0.4	241	0.04	0.1	0.1	0.39	0.03	0.5	0.03	0.08	145	0.15	0.09	0.18	0.5	78.2	4.2
Maximum	40.8	1.89	10.81	8.25	189.3	5380	2.5	3132	0.6	1.5	0.4	3.66	0.13	1.8	0.23	0.14	301	1.68	0.89	1.16	3.3	95.4	6
N=sites	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

B Horizon	Au	Mo	Cu	Pb	Zn	Ag	Co	Mn	Fe	As	U	Cd	Sb	La	Al	S	Hg	Cs	Nb	Y	Ce	LOI	pH
Soil	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**5.3**	**0.94**	**8.84**	**11.5**	**113.0**	**182**	**10.1**	**593.5**	**3.27**	**6.0**	**0.3**	**0.39**	**0.21**	**9.3**	**1.60**	**0.01**	**20**	**1.90**	**3.26**	**5.46**	**19.9**	**8.8**	**5.4**
Mean	24.34	1.47	10.50	18.25	132.61	460.00	9.91	791.65	3.59	12.61	0.38	0.69	0.32	9.76	1.63	0.01	24.50	3.66	3.19	5.58	19.82	9.67	5.34
1s	51.79	1.80	6.07	18.22	57.04	685.15	0.98	564.70	1.17	17.88	0.26	0.70	0.33	3.55	0.26	0.00	13.08	3.21	0.42	2.47	7.14	3.49	0.47
CV (%)	*212.8*	*122.3*	*57.8*	*99.8*	*43.0*	*148.9*	*9.9*	*71.3*	*32.6*	*141.8*	*69.2*	*101.6*	*103.0*	*36.4*	*16.2*	*0.0*	*53.4*	*87.8*	*13.2*	*44.2*	*36.0*	*36.1*	*8.7*
Minimum	0.6	0.68	5.38	7.45	77.2	70	7.8	262	2.85	2.7	0.2	0.17	0.14	6.2	1.03	0.01	9	0.91	2.21	3.03	11.7	6.4	4.7
Maximum	223.1	8.89	33.58	82.72	321.3	2899	11.5	2455	8.27	78	1.3	3.2	1.56	22.4	2.22	0.01	62	10.99	3.94	14.97	43.7	20	6.5
N=sites	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

C Horizon	Au	Mo	Cu	Pb	Zn	Ag	Co	Mn	Fe	As	U	Cd	Sb	La	Al	S	Hg	Cs	Nb	Y	Ce	LOI	pH
Till	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**3.2**	**0.83**	**13.51**	**10.7**	**64.4**	**72**	**9.5**	**383.5**	**3.23**	**6.4**	**0.4**	**0.12**	**0.26**	**13**	**1.51**	**0.01**	**7.5**	**1.30**	**1.03**	**8.71**	**33.15**	**4.2**	**6.2**
Mean	9.20	0.81	13.64	10.90	69.68	181.13	9.47	394.19	3.25	7.48	0.40	0.14	0.28	13.33	1.53	0.01	9.38	2.39	1.29	8.86	33.40	4.69	6.08
1s	12.80	0.07	1.77	3.42	16.22	175.82	1.06	51.22	0.19	2.46	0.05	0.09	0.07	2.39	0.25	0.00	4.16	2.04	0.78	1.52	5.16	1.46	0.29
(CV%)	*139.1*	*8.7*	*13.0*	*31.4*	*23.3*	*97.1*	*11.1*	*13.0*	*6.0*	*32.9*	*12.9*	*68.3*	*26.1*	*18.0*	*16.3*	*0.0*	*44.4*	*85.4*	*60.6*	*17.1*	*15.4*	*31.0*	*4.8*
Minimum	0.8	0.69	10.75	6.78	57.1	30	8.1	334	2.98	4.7	0.3	0.06	0.2	9.5	1.17	0.01	5	0.61	0.56	6.25	23.1	3.1	5.5
Maximum	40.6	0.92	16.3	19.2	124.5	571	11.6	549	3.56	13.3	0.5	0.46	0.47	18.8	2.1	0.01	16	7.48	3.34	11.85	45.2	8.3	6.7
N=sites	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

TABLE 4. SUMMARY STATISTICS FOR SELECTED ELEMENTS BY AQUA REGIA DIGESTION – ICP-MS FOR COMPARATIVE SOIL HORIZONS, TED ORIENTATION LINE

LFH Horizon	**Au**	**Mo**	**Cu**	**Pb**	**Zn**	**Ag**	**Co**	**Mn**	**Fe**	**As**	**U**	**Cd**	**Sb**	**La**	**Al**	**S**	**Hg**	**Cs**	**Nb**	**Y**	**Ce**	**LOI**	**pH**
Humus	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**0.1**	**0.75**	**4.55**	**4.1**	**48.9**	**620.5**	**0.7**	**849.5**	**0.17**	**0.3**	**0.1**	**0.48**	**0.09**	**0.9**	**0.11**	**0.10**	**233**	**0.39**	**0.24**	**0.43**	**1.40**	**91.5**	**4.5**
Mean	0.27	3.09	5.57	4.36	57.26	1159.88	0.93	1081.19	0.23	0.51	0.43	0.60	0.11	3.31	0.14	0.10	241.06	0.46	0.31	5.40	2.65	88.21	4.60
1s	0.60	9.56	3.32	1.14	27.19	1202.87	0.77	887.61	0.20	0.60	0.88	0.38	0.10	9.29	0.11	0.02	50.21	0.37	0.29	18.16	4.95	8.29	0.49
CV (%)	*223.1*	*309.5*	*59.7*	*26.0*	*47.5*	*103.7*	*82.8*	*82.1*	*86.7*	*119.1*	*206.6*	*62.8*	*84.1*	*280.6*	*82.3*	*20.5*	*20.8*	*79.9*	*91.8*	*336.6*	*186.9*	*9.4*	*10.7*
Minimum	0.1	0.18	3.01	2.6	18.8	234	0.2	235	0.04	0.1	0.1	0.2	0.05	0.5	0.04	0.07	149	0.2	0.07	0.13	0.4	70.4	4
Maximum	2.5	38.9	16.42	6.35	117.2	4907	3.1	3742	0.65	2.5	3	1.37	0.45	38.1	0.46	0.14	344	1.67	1.16	73.28	20.9	96.4	5.5
N=sites	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

B Horizon	***Au***	***Mo***	***Cu***	***Pb***	***Zn***	***Ag***	***Co***	***Mn***	***Fe***	***As***	***U***	***Cd***	***Sb***	***La***	***Al***	***S***	***Hg***	***Cs***	***Nb***	***Y***	***Ce***	***LOI***	***pH***
Soil	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**1.8**	**1.05**	**8.41**	**14.3**	**79.75**	**185.5**	**9.1**	**463**	**2.98**	**6.6**	**0.3**	**0.29**	**0.36**	**7.55**	**1.17**	**0.01**	**19**	**2.20**	**2.66**	**3.40**	**13.80**	**7.5**	**5.0**
Mean	4.72	1.10	10.05	25.84	141.53	291.13	8.64	688.25	3.03	8.93	0.61	0.61	0.43	9.25	1.17	0.02	19.38	3.05	2.53	6.04	16.16	8.01	4.98
1s	7.20	0.34	5.49	28.61	212.16	358.41	2.62	648.56	0.61	6.26	1.09	1.02	0.24	5.93	0.46	0.02	9.24	1.98	1.16	10.20	6.89	1.85	0.64
CV (%)	*152.5*	*30.6*	*54.6*	*110.7*	*149.9*	*123.1*	*30.4*	*94.2*	*20.0*	*70.0*	*178.0*	*168.3*	*56.5*	*64.1*	*39.6*	*100.7*	*47.7*	*64.9*	*45.7*	*169.0*	*42.7*	*23.1*	*13.0*
Minimum	0.1	0.68	6.61	7.47	37.4	38	4.8	229	2.09	2.6	0.2	0.14	0.19	4	0.49	0.01	6	0.96	0.37	1.03	7.5	5.3	3.8
Maximum	24.4	1.99	29.45	112.52	891.1	1523	14.7	2668	4.05	27	4.5	4.26	0.94	30.4	2.09	0.09	40	8.03	5.5	43.6	37.2	11.5	6.3
N=sites	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

C Horizon	***Au***	***Mo***	***Cu***	***Pb***	***Zn***	***Ag***	***Co***	***Mn***	***Fe***	***As***	***U***	***Cd***	***Sb***	***La***	***Al***	***S***	***Hg***	***Cs***	***Nb***	***Y***	***Ce***	***LOI***	***pH***
Till	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	*ppb*	*ppm*	*ppm*	*ppm*	*ppm*	*%*	
Median	**3.1**	**0.78**	**12.14**	**16.5**	**58.5**	**156**	**9.0**	**329**	**3.00**	**6.8**	**0.4**	**0.11**	**0.31**	**11**	**1.21**	**0.01**	**10**	**1.25**	**1.43**	**7.32**	**28.5**	**4.5**	**6.2**
Mean	13.23	0.88	12.50	32.14	62.25	323.87	8.91	328.53	2.98	10.55	0.57	0.12	0.44	11.45	1.29	0.03	13.13	3.23	1.54	8.09	26.35	4.80	6.14
1s	22.59	0.29	2.86	61.28	13.45	337.94	1.48	73.47	0.27	11.78	0.40	0.05	0.38	2.47	0.46	0.05	9.52	3.09	0.69	3.16	5.03	1.71	0.47
CV (%)	*170.8*	*33.0*	*22.9*	*190.7*	*21.6*	*104.3*	*16.6*	*22.4*	*9.1*	*111.6*	*69.3*	*39.4*	*85.9*	*21.6*	*35.8*	*184.1*	*72.5*	*95.6*	*44.5*	*39.1*	*19.1*	*35.5*	*7.7*
Minimum	0.6	0.58	8.32	6.45	41.8	55	6.9	150	2.46	5.2	0.3	0.06	0.23	8.3	0.53	0.01	5	0.78	0.52	4.75	18.4	2.8	5.1
Maximum	84.9	1.67	19.1	250.2	92.6	1271	12.3	476	3.38	52.2	1.7	0.22	1.6	17.6	2.02	0.2	36	9.12	2.7	17.2	34.9	9.2	6.8
N=sites	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15

site. It is not presently known whether these precious metal concentrations reflect the location of a previously unknown zone or are simply the product of downslope colluviation of mineralized material from the Tommy vein.

TED VEIN RESULTS

Gold and silver in humus, B horizon soil and till all reflect the presence of precious metals mineralization at the Ted vein to varying degrees, although the magnitudes of the

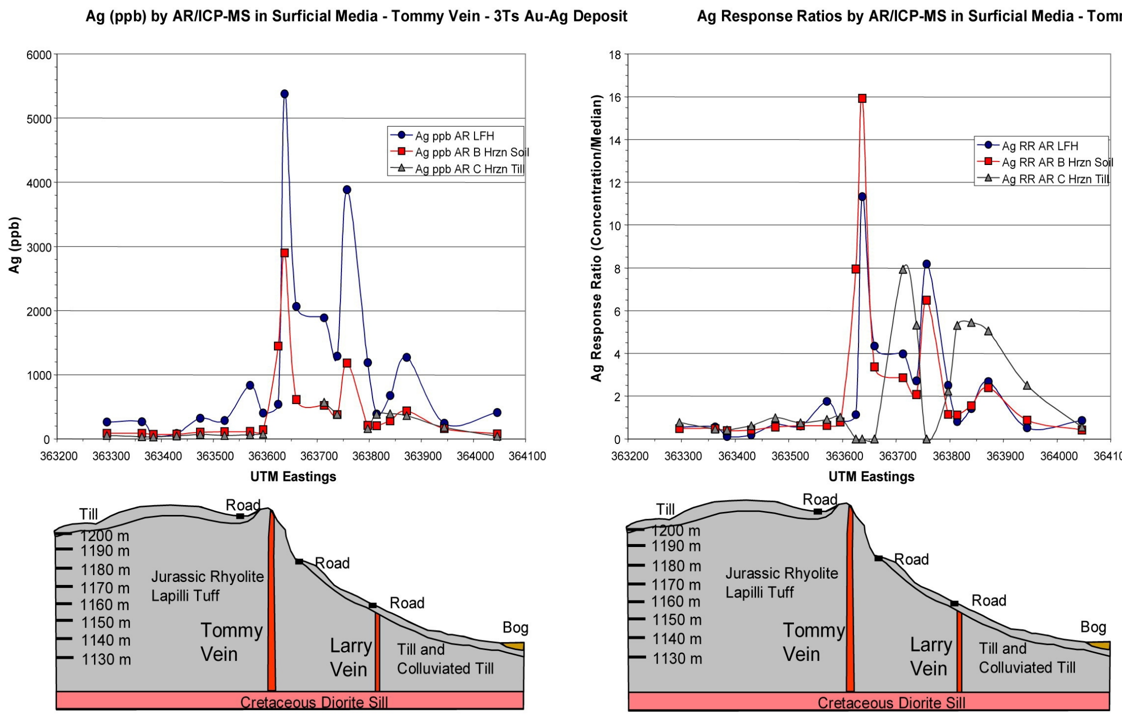


Figure 16. Distribution of Ag concentrations (left) and calculated response ratios (right) in humus, B horizon soil and C horizon till and other parent materials along the east-west Tommy vein orientation transect.

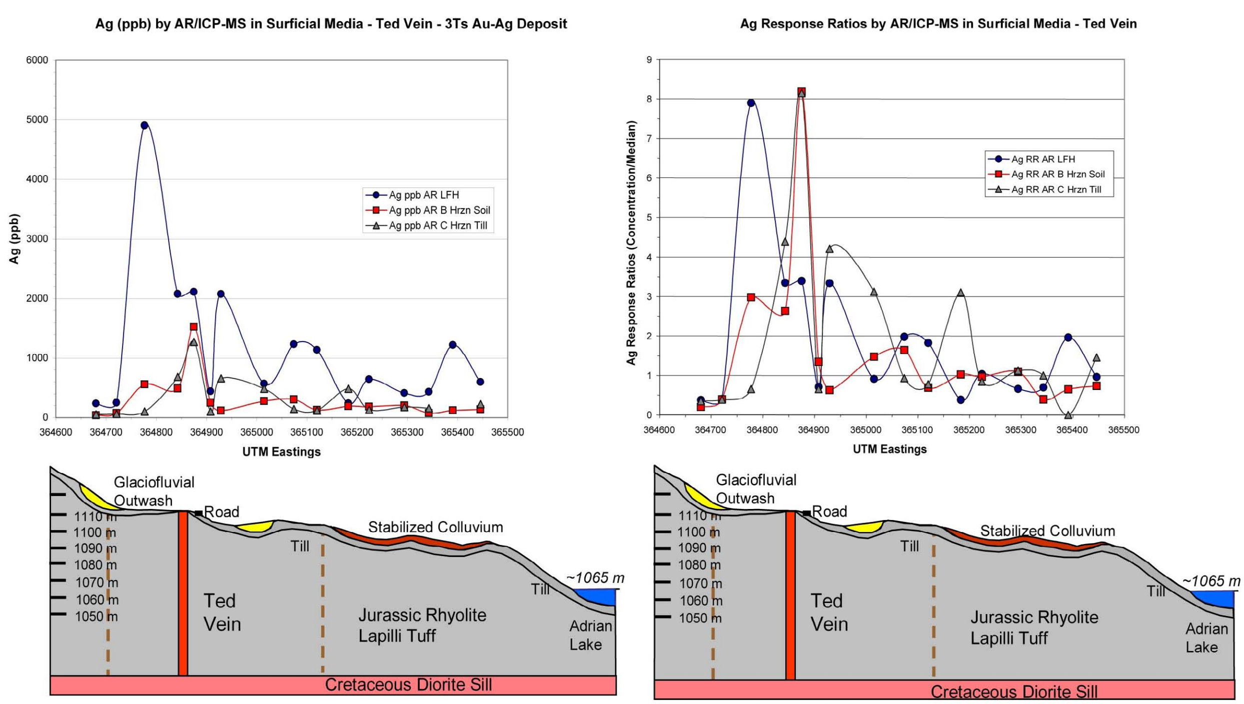


Figure 17. Distribution of Ag concentrations (left) and calculated response ratios (right) in humus, B horizon soil and C horizon till and other parent materials along the approximately east-west Ted vein orientation transect.

geochemical responses for these elements are slightly less than those reported for the Tommy vein. Conversely, soil at Ted vein contains higher concentrations of certain base metals such as Zn (maximum 891 ppm) and Pb (maximum 113 ppm) than does soil at the Tommy vein. These results are consistent with the reported higher sulphide mineral content of the Ted relative to the Tommy vein, where disseminated sulphide minerals are not always observed to be present (Rhys, 2003). Such aqua regia base metal relations are not the subject of this preliminary report, which centres on precious metals geochemistry results, but they will be addressed in the final project report (Cook and Dunn, work in progress).

The Ted vein is bracketed by two orientation sites (sites 558 and 559), with the highest precious metals con-

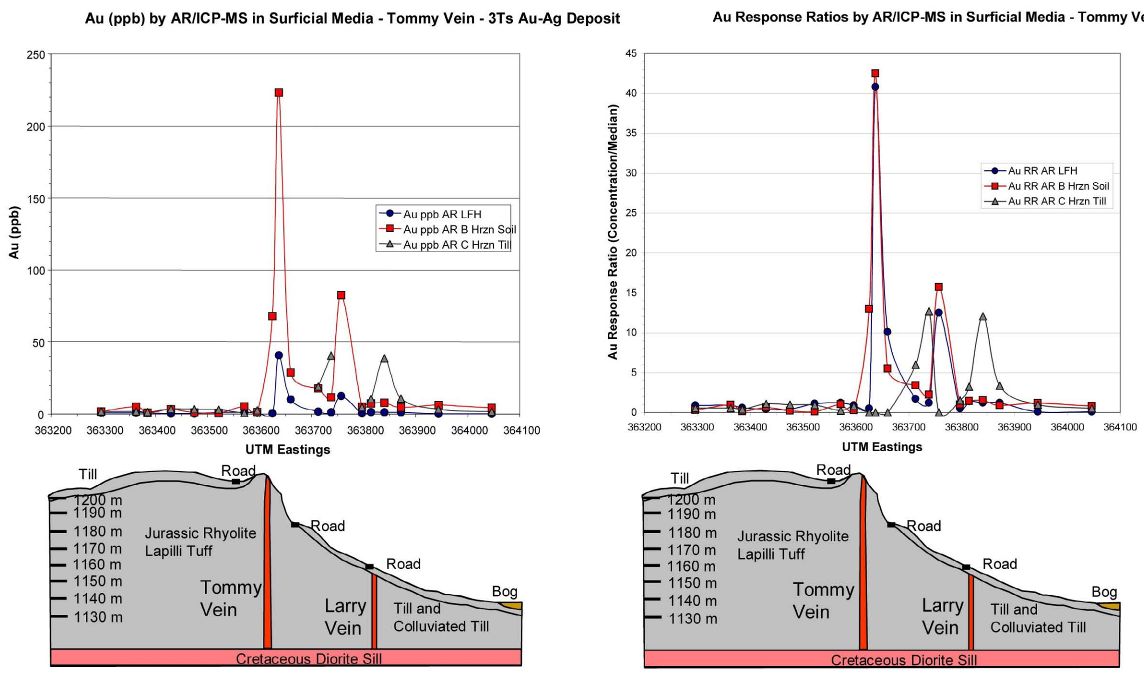


Figure 18. Distribution of Au concentrations (left) and calculated response ratios (right) in humus, B horizon soil and C horizon till and other parent materials along the east-west Tommy vein orientation transect.

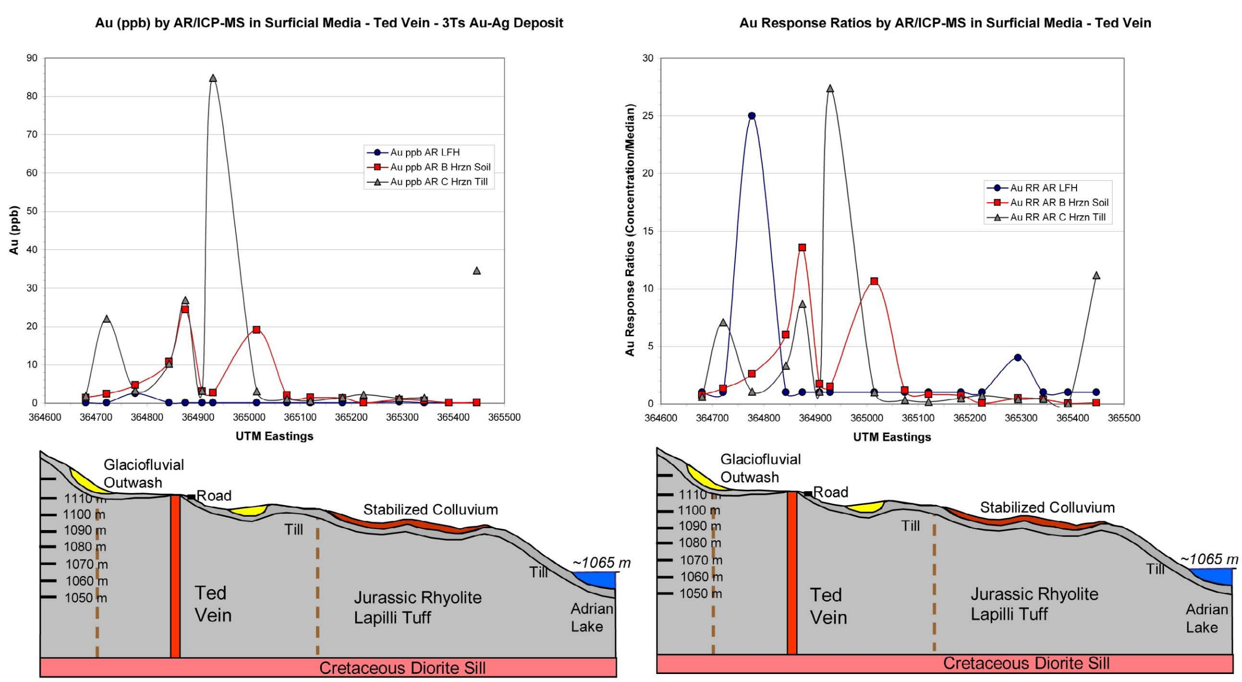


Figure 19. Distribution of Au concentrations (left) and calculated response ratios (right) in humus, B horizon soil and C horizon till and other parent materials along the approximately east-west Ted vein orientation transect.

centrations generally reported at the easternmost of the two (site 559; Fig. 6, 12), immediately downslope and down ice. Elevated Au concentrations are present in a B horizon soil (24.4 ppb; site 559) at the Ted vein and at two sites in C horizon till (26.9–84.9 ppb), both above and down ice of the vein. These correspond, at site 559 closest to the vein, to highly elevated response ratios of 9 and 14 times background in soil and till, respectively. In the case of Ag, elevated values are present in all three media, particularly at the easternmost site 559. Silver concentrations of 1523 ppb in B horizon soil (median 186 ppb) and 1271 ppb in till (median 156 ppb) both represent response ratios of about 8 times those of background values. Silver concentrations in LFH horizon humus at both of the Ted vein sites are also very high, in the order of 2000 ppb, but yield response ratios of only about 3 times due to the relatively high Ag background concentrations in humus on the Ted orientation line (median 621 ppb) relative both to the underlying mineral soil and to humus on the Tommy. Interestingly, there are no coincident elevated Au concentrations in LFH horizon humus at the Ted vein, although Au concentrations up to 41 ppb were reported from similar humus above the Tommy vein (Fig. 5).

Elevated Au and Ag concentrations in both B horizon soil and till at site 559 on the Ted orientation line are of very similar magnitude (*e.g.*, 24–27 ppb Au), even though the soil in this composite profile is developed in a stabilized colluvial sediment (Fig. 12) rather than the underlying IIC horizon till. This is likely, in this particular case, due to the site being both downslope of (to the northeast) and down ice of (to the east) the same Ted vein. Elsewhere, the lower background Au concentrations of B horizon soil on the Ted line (median 1.8 ppb) relative to those on the Tommy line (median: 5.3 ppb) may be, at least in part, due to the widespread presence, overlying the till, of now-stabilized surface colluvium from a southerly, apparently unmineralized source area. Similar relations were reported by Cook and Fletcher (1994) for varying Pt contents of ultramafic colluvium overlying till in the Tulameen area of southern BC.

Perhaps the most intriguing aspect of precious metals distribution on the Ted orientation line is the very high Ag content (4907 ppb) of humus at one site (574), located west of the Ted vein. This highly elevated Ag concentration is the highest on Ted line and corresponds to a response ratio of almost 8 times the median concentration in humus (621 ppb). This LFH horizon is developed on a till-based soil profile in relatively flat terrain. The Au concentration, although only 2.5 ppb, is nevertheless the highest of any of the sixteen humus samples on the Ted line (median: 0.1 ppb) and it yields a response ratio of 25 times background. The underlying B horizon soil contains only background Au levels but does yield an elevated Ag content of 554 ppb, the second highest on the line after the Ted vein itself, with a response ratio of almost 3 times background (median 186 ppb). The proximity to adjacent humus sites on the Ted line with high Ag suggests two possible explanations. It may reflect the presence of a parallel or peripheral mineralized zone. Alternatively, given the similar site elevation to the adjacent Ted vein, it may instead simply reflect local hydromorphic scavenging of metals derived from weathering of Ted vein mineralization.

In addition to the above, locally elevated single-site Au concentrations of unknown origin occur in till on the Ted line, both near its western end (22 ppb) and at its eastern end (34.6 ppb). Neither B horizon soil nor humus are similarly enriched in Au at these sites.

PRELIMINARY CONCLUSIONS

Preliminary results from a geochemical orientation study carried out at the 3Ts epithermal Au-Ag prospect in central BC show that Au and Ag determined by aqua regia digestion – ICP-MS in humus, B horizon soil and C horizon till all reflect, to varying degrees, the presence of Au in epithermal quartz vein mineralization at both the Tommy and Ted veins. In addition to this, Au and Ag in till alone reflect the presence of the Larry vein, which is transected by the Tommy orientation line.

Results suggest that, for property-scale geochemical exploration, B horizon mineral soil and LFH horizon organic-rich humus offer similar levels of geochemical contrast for aqua regia – digestible Au and Ag, with the B horizon soil offering slightly superior contrast overall. Brunisolic Bm horizon soil is commonly developed around the 3Ts property, primarily in the basal and colluviated tills that are the dominant glacial parent material in the area. However, they are also found to be developed in rubbly near-bedrock colluvium, stabilized colluvium and glaciofluvial sediments, underlining the importance of the proper identification of Quaternary deposits in interpreting source directions of any anomalous geochemical patterns.

Geochemical results vary slightly from vein to vein with variations in primary mineralogy, topography and surficial cover. In general aqua regia – digestible Au and Ag results at the Tommy vein show slightly greater geochemical contrast, as measured by response ratios, than do those at Ted vein. At the Tommy vein, Au response ratios for B horizon soil and humus over the vein are almost identical. Elevated Ag results in humus provide a larger geochemical footprint, but elevated Ag in B horizon soil offers slightly better anomaly contrast over the mineralization. Rubbly B horizon soil and LFH humus are developed directly over subcopping and outcropping quartz vein mineralization here, and likely incorporate a significant component of near-residual mineralized fragments. There is no direct till response, as neither basal nor colluviated till is preserved directly over the vein. However, elevated Au and Ag values in till immediately to the east are tentatively interpreted to represent, at least in part, glacially transported material that was locally derived from the Tommy vein.

Surficial cover is more complex on the Ted orientation line. Localized glaciofluvial outwash sediments and more widespread stabilized near-surface colluvium are present in addition to basal and colluviated tills. As with the Tommy vein results, B horizon mineral soil here provides the best overall anomaly contrast for property-scale geochemical exploration. Gold and silver in humus, B horizon soil and till all reflect the presence of precious metals mineralization at the Ted vein to varying degrees, although the magnitudes of the geochemical responses are slightly less than those reported for Tommy vein. In addition, highly elevated Au and Ag concentrations are present in both B horizon soil and C horizon till, both above and down ice of the vein. Elevated Ag is similarly present in LFH horizon humus here, although Au itself is absent. Readers are referred to the companion paper of Dunn *et al.* (2006) for additional information on corresponding lodgepole pine and white spruce biogeochemical results at 3Ts.

Although the results of this study demonstrate that the locations of both the Tommy and Ted veins may be successfully delineated using mineral soil and organic-rich humus, they do not necessarily indicate that similar, but blind, deposits may be detected at greater depths. The felsic tuff that hosts epithermal Au-Ag mineralization at 3Ts is only poorly exposed at surface beneath the widespread till veneer, stabilized colluvium and abundant forest moss cover that hinder effective prospecting here. However, the positive aqua regia – digestible geochemical results here are strongly influenced by the near-surface outcropping and subcropping of subvertical, highly resistant quartz veins beneath a thin near-residual soil. Continuation of further field studies in areas where the Tommy and Ted veins are known to exist at greater depth may, however, help provide some of these answers.

A final report to Geoscience BC, incorporating comparative results of all analytical methods employed in this study (Cook and Dunn, work in progress), will be submitted by March 31, 2006. The final report will ascertain which of the partial and selective extraction methods described here delineate the presence of mineralization and provide the greatest levels of geochemical contrast over each of the Tommy and Ted veins at the 3Ts prospect. Specific field sampling and analytical recommendations will be provided for conducting the most effective property-scale geochemical surveys for similar epithermal Au deposits in the BC interior plateau.

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REFERENCES

Agriculture Canada (1987): The Canadian system of soil classification (second edition); *Agriculture Canada*, Expert Committee on Soil Survey, Publication 1646, 164 pages.

Bajc, A.F. (1998): A comparative analysis of Enzyme Leach and Mobile Metal Ion selective extractions: case studies from glaciated terrain, northern Ontario; *Journal of Geochemical Exploration*, volume 61, pages 113–148.

Bottomer, L. (2003a): Epithermal gold-silver mineralization in the Nechako plateau, central British Columbia; North West Mining Association, Annual Meeting, Program with Abstracts, December 2003.

Bottomer, L. (2003b): The 3Ts epithermal gold-silver project, Nechako region, central BC; Cordilleran Round-Up 2003, Program with Abstracts, January 2003.

Cameron, E.M., Hamilton, S.M., Leybourne, M.I., Hall, G.E.M. and McClenaghan, M.B. (2004): Finding deeply buried deposits using geochemistry; *Geochemistry: Exploration, Environment, Analysis*, volume 4, pages 7–32.

Cook, S.J. and Fletcher, W.K. (1994): Platinum distribution in soil profiles of the Tulameen ultramafic complex, southern British Columbia, Canada; *Journal of Geochemical Exploration*, volume 51, pages 161–191.

Cook, S.J. and Jackaman, W. (1994): Regional lake sediment and water geochemistry of part of the Nechako River map area (93F/2, 3; parts of 93F/6, 11, 12, 13, 14); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-19, 31 pages.

Cook, S.J. and McConnell, J. (2001): Lake sediment geochemical methods in the Canadian shield, cordillera and appalachia; *in* Drift Exploration in Glaciated Terrain; McClenaghan, M.B., Bobrowsky, P.T., Hall, G.E.M. and Cook, S.J., Editors, *The Geological Society of London*, Special Publication 185, pages 125–149.

Cook, S.J., Jackaman, W., Lett, R.E.W., McCurdy, M.W. and Day, S.J. (1999): Regional lake water geochemistry of parts of the Nechako plateau, central British Columbia (93F/2, 3; 93K/9, 10, 15, 16; 93L/9, 16; 93M/1, 2, 7, 8); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1999-5.

Cook, S.J., Levson, V.M., Giles, T.R. and Jackaman, W. (1995): A comparison of regional lake sediment and till geochemistry surveys: a case study from the Fawnie Creek area, central British Columbia; *Exploration and Mining Geology,* volume 4, no 2, pages 93–110.

Diakow, L.J. and Levson, V.M. (1997): Bedrock and surficial geology of the southern Nechako plateau, central British Columbia (NTS 93F/2, 3, 6, 7); *BC Ministry of Energy, Mines and Petroleum Resources,* Geoscience Map 1997-2.

Diakow, L.J., Webster, I.C.L., Levson, V.M. and Giles, T.R. (1994): Bedrock and surficial geology of the Fawnie Creek map area (NTS 93F/3); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-2.

Diakow, L.J., Webster, I.C.L., Whittles, J.A., Richards, T.A., Levson, V.M. and Giles, T.R. (1995): Bedrock and surficial geology of the Tsacha Lake map area (NTS 93F/2); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1995-16.

Dunn, C.E., Cook, S.J. and Hall, G.E.M. (2006): Halogens in surface exploration geochemistry: evaluation and development of methods for detecting buried mineral deposits (NTS 093F/03), central British Columbia; *in* Geological Fieldwork 2005, *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 2006-1 and *Geoscience BC*, Report 2006-1.

Fedikow, M.A.F. (2005): Discriminating barren and productive geophysical targets using partial digestion soil geochemistry: discovery of the Hunt gold zone, Manitoba, Canada; *Association of Applied Geochemists*, 22nd International Geochemical Exploration Symposium, Program and Abstracts, page 51.

Fox, P.E. (1994): Geochemical report on the Taken claim, Omineca Mining Division; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 23758, 29 pages.

Fox, P.E. (1995): Geological report on the Taken 1 claim, Omineca Mining Division; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 24203, 21 pages.

Fox, P.E. (1996): Diamond drilling, geological and soil geochemical report on the Tam property, Omineca Mining Division; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 24710, 92 pages.

Fox, P.E. (1999): Geological, geochemical and geophysical report on the Taken property, Omineca Mining Division; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 25810, 33 pages.

Giles, T.R. and Levson, V.M. (1994a): Surficial geology and drift exploration studies in the Fawnie Creek area (93F/03); *in*

Geological Fieldwork 1993, *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1994-1, pages 27–37.

Giles, T.R. and Levson, T.M. (1994b): Drift prospecting potential of the Fawnie Creek area (93F/03); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-10.

Giles, T.R. and Levson, T.M. (1995): Surficial geology and Quaternary stratigraphy of the Tsacha Lake area (93F/02); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1995-10.

Lane, R.A. and Schroeter, T.G. (1997): A review of metallic mineralization in the Interior Plateau, central British Columbia (parts of NTS 93C, B and F); *in* Interior Plateau Geoscience Project: Summary of geological, geophysical and geochemical studies, Diakow, L.J., Newell, J.M. and Metcalfe, P., Editors, *BC Ministry of Energy, Mines and Petroleum Resources*, Paper 1996-2.

Levson, V.M. (2001): Regional till geochemical surveys in the Canadian Cordillera: sample media, methods and anomaly evaluation; *in* Drift Exploration in Glaciated Terrain, McClenaghan, M.B., Bobrowsky, P.T., Hall, G.E.M. and Cook, S.J., Editors, *Geological Society of London*, Special Publication 185, pages 45–68.

Levson, V.M. and Giles, T.R. (1994): Surficial geology and Quaternary stratigraphy of the Fawnie Creek area (93F/03); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-9.

Levson, V.M., Giles, T.R., Cook, S.J. and Jackaman, W. (1994): Till geochemistry of the Fawnie Creek map area (93F/03); *BC Ministry of Energy, Mines and Petroleum Resources*, Open File 1994-18.

Lynch, J. (1996): Provisional elemental values for four new geochemical soil and till reference materials TILL-1, TILL-2, TILL-3 and TILL-4; *Geostandards Newsletter*, Volume 20, no 2, pages 277–287.

Lynch, J. (1999): Additional provisional elemental values for LKSD-1, LKSD-2, LKSD-3, LKSD-4, STSD-1, STSD-2. STSD-3, STSD-4; *Geostandards Newsletter*, Volume 23, no 2, pages 251–260.

MINFILE (2005): MINFILE BC mineral deposits database; *BC Ministry of Energy, Mines and Petroleum Resources*, URL <http://www.em.gov.bc.ca/Mining/Geolsurv/Minfile/> [Nov 2005].

Pautler, J.M. (1995): 1995 Spotlight Session on Interior Plateau of British Columbia; *Cordilleran Roundup*, Abstracts, page 42.

Pautler, J.M., Smith, S.W. and Lane, R.A. (1999): Exploration and geology of the Tsacha epithermal gold deposit; *in* Exploration and Mining in British Columbia 1998, *BC Ministry of Energy, Mines and Petroleum Resources*, pages B1–B10.

Pawliuk, D.J. (2005); Summary report on the Ted vein diamond drilling program — November 2004, Tam property, 3Ts Project, Omineca Mining Division; report prepared for Southern Rio Resources, April 2005, filed on SEDAR July 8 2005, 28 pages.

Rhys, D. (2003): Tsacha and Tam properties — structural study; internal consulting report prepared by Panterra Geoservices Inc. for Southern Rio Resources, July 10, 2003, 18 pages.

Schimann, K. (1994): Geological and geochemical report on the Tam claims, Omineca Mining Division; *BC Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 23746, 20 pages.

Sutherland, D. and Hoffman, E.L. (2003): SGH — a new soil gas hydrocarbon technique for mineral exploration under deep cover; *Geological Association of Canada – Mineralogical Association of Canada*, Joint Annual Meeting, Program with Abstracts, 1 page.

Tipper, H.W. (1963): Nechako River map-area, British Columbia; *Geological Survey of Canada*, Memoir 324, 59 pages.

Wallis, C.S. and Fier, N.E. (2002): Technical report on the Tsacha property, British Columbia; report prepared for Southern Rio Resources, filed on SEDAR February 11, 2003.

Wallis, C.S. and Fier, N.E. (2004): Technical report on the Tam property, British Columbia; report prepared for Southern Rio Resources, filed on SEDAR September 2, 2004.