



## GEOCHEMICAL RESEARCH, 1990: COAST RANGE - CHILCOTIN ORIENTATION AND MOUNT MILLIGAN DRIFT PROSPECTING STUDIES\* (92O, 92N, 93N)

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### INTRODUCTION

The Applied Geochemistry Unit undertook two new research programs in 1990 (Figure 4-5-1). The Coast Range - Chilcotin orientation study examined geochemical characteristics of mineralized drainage basins in the southwest interior of British Columbia. Resultant data interpretation will aid planning for a proposed Regional Geochemical Survey in the Mount Waddington (92N) map area and also serve as a guide for industry on geochemical exploration strategies in this region. The Mount Milligan project is the inaugural program in what is to become a series of drift-prospecting case studies integrating expertise from the applied geochemistry, surficial geology, regional mapping and mineral deposits fields. These studies will evaluate various exploration techniques for more effective mineral exploration in areas of thick glacial drift in British Columbia.

Final output for both the Coast Range-Chilcotin orientation and Mount Milligan drift-prospecting studies will appear in the publication *Exploration in British Columbia 1990*.

### COAST RANGE — CHILCOTIN ORIENTATION STUDY

In anticipation of a Regional Geochemical Survey of the Mount Waddington map sheet (92N), a series of orientation surveys were conducted within map areas 92O (Taseko Lakes) and 92N during the 1990 field season. The Mount Waddington map area contains numerous mineral showings within a variety of physiographic settings, yet remains largely unexplored; between 1985 and 1988, only 0.4 per cent of the assessment reports filed in the province originated in the 92N map sheet. Land-use concerns in the Mount Waddington area may be addressed with the aid of a high-quality, multi-element geochemical database.

Increased knowledge of the effects of geology, mineralogy, climate, surficial materials and physiography upon stream sediment dispersion will increase the effectiveness of a Regional Geochemical Survey. To this end, six deposits were selected to assess the effectiveness of multi-element

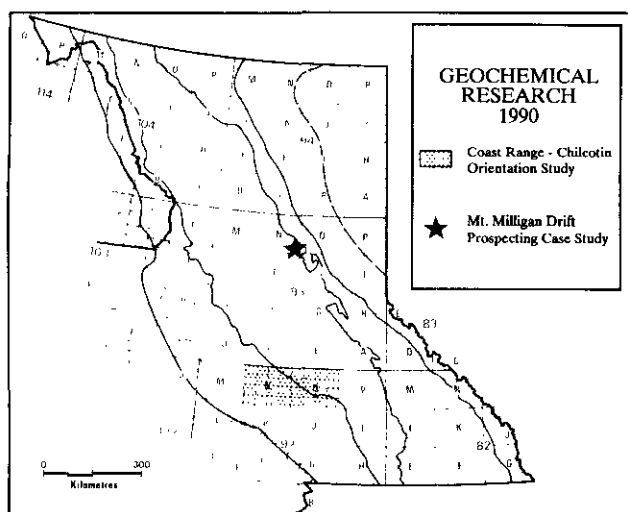


Figure 4-5-1. Location of Applied Geochemistry Unit research programs for 1990.

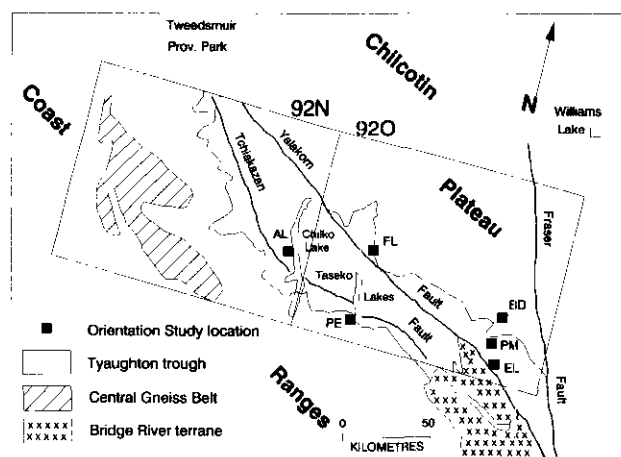


Figure 4-5-2. Geologic setting and orientation study locations Mount Waddington (92N) and Taseko Lakes (92O) map sheets. AL = Alexis; PE = Pellaire; FL = Fish Lake; EL = Elizabeth; PM = Poison Mountain; BD = Black Dome.

\* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

stream-sediment geochemistry within this area (Figure 4-5-2). Five of the six deposits studied are located in the adjacent Taseko Lakes (92O) map area. These five deposits occur in geologic and physiographic settings comparable to the Mount Waddington area and are more accessible.

Objectives of the study are to:

- Typify the downstream dispersion of anomalous elements from the selected deposits.
- Observe the behavior of gold with downstream transport.
- Determine the impact of hydromorphic dispersion (in solution) and scavenging by organic and inorganic compounds in low-energy streams.
- Define the best sample media and analytical procedures for a Regional Geochemical Survey of the Mount Waddington (92N) map sheet.

## DESCRIPTION OF STUDY AREA

### PHYSIOGRAPHY

The Mount Waddington and Taseko Lakes map areas are characterized by a transition from the rugged, heavily glaciated Coast Range mountains to the semi-arid, subdued topography of the Chilcotin Plateau. Within the Mount Waddington map area, Coast Range mountains comprise approximately 75 per cent of the total area. Summit elevations commonly exceed 2500 metres, with intervening valleys averaging 1200 metres above sea level. Upper to mid-slopes are steep; bedrock is either exposed or covered with a thin veneer of till, colluvium and talus. Streams define a trellised pattern and are generally confined to narrow channels cut into bedrock. Valley floors are covered by thick glaciofluvial sediments; broad, gravel floodplains are actively reworked by shifting braided streams. The Chilcotin Plateau consists of flat to rolling terrain, generally at an elevation of 1200 to 1500 metres, dissected by glacially deranged, low-energy drainages with a moderate to high organic component. Precipitation decreases from over 3500 millimetres per year along the western edge of the Coast Range to 400 to 500 millimetres per year on the Chilcotin Plateau.

### GEOLOGY

The Coast plutonic complex, composed of Cretaceous granites and granodiorites, dominates the Mount Waddington area and is a significant feature in the Taseko Lakes map area (Figure 4-5-2). Within the Coast Complex, roof pendants of gneiss, amphibolite, metasediments and meta-volcanics represent metamorphosed remnants of volcanic-arc rocks (Roddick and Tipper, 1985). Bordering the complex to the northeast are rocks of the Tyaughton trough, a back-arc sequence marking the boundary suture between the Stikinia and Wrangellia terranes (McLaren, 1990). The Tyaughton trough, comprising successions of Late Jurassic to Early Cretaceous volcanic and sedimentary rocks, stretches from north of Kleena Kleene southwards to the Fraser River, where it is truncated by the Fraser River fault (Tipper, 1969). Northeast of the Tyaughton trough, Tertiary

(and younger?) basalts and andesites are widespread, forming the subdued terrain of the Interior Plateau.

Several significant faults transect the study area. The Eocene Yalakom fault, a northwest-trending strike-slip fault approximately 300 kilometres long, displaces rocks within the Tyaughton trough by distances exceeding 100 kilometres (Tipper, 1969). A secondary structure, the Tchaikazan fault, parallels the Yalakom for 150 kilometres and has an estimated displacement of 30 kilometres (Tipper, 1969).

### MINERAL OCCURENCES

At present, 48 mineral prospects, showings or occurrences within the Mount Waddington map area are recorded in MINFILE. Most notable are the Morris mine (Au, Ag, Sb), Alexis (Cu, Hg, Sb) and Daisie (Cu, W, Mo, Zn) prospects. Mesothermal and epithermal veins are the most common deposit type in the region (McLaren, 1990). Pel-laire (MINFILE 92O 045), located 30 kilometres east of Chilko Lake, is a mesothermal(?) gold-silver deposit containing 31 000 tonnes of ore grading 21 grams per tonne gold and 73 grams per tonne silver (Skerl, 1947). Two calcalkaline, copper-gold porphyry deposits [Fish Lake (MINFILE 92O 052) and Poison Mountain (MINFILE 92O 046)] are found within Tyaughton trough rocks to the east of Mount Waddington. Fish Lake has estimated reserves of 200 million tonnes grading 0.5 gram per tonne gold, 1.0 gram per tonne silver and 0.24 per cent copper; whereas Poison Mountain contains 193 million tonnes of ore grading 0.3 gram per tonne gold, 0.33 per cent copper and 0.015 per cent molybdenum (Schroeter and Panteleyev, 1986).

The Mount Waddington map sheet straddles a region of generally high mineral potential in British Columbia; the boundary between the Coast and Intermontane belts. However, few mineral deposits are known within the Mount Waddington area. The high mineral potential suggested by a clustering of mineral deposits north of Whitesail Lake and south of Taseko Lake has been extrapolated by McLaren (1990) into the Mount Waddington sheet. The scarcity of mineral occurrences may be attributed to the inaccessibility of the area. The rugged beauty and inaccessibility have also prompted consideration of parts of the map sheet as recreational or wilderness areas.

### SAMPLING TECHNIQUES AND ANALYTICAL PROCEDURES

Six deposits were selected for detailed stream-sediment orientation studies (Table 4-5-1). These deposits were chosen to represent the most likely styles of mineralization and the characteristic physiographic regimes found in the Mount Waddington map area. Location of the deposit at or near the head of a drainage and the presence of only one known mineral occurrence within that drainage were prerequisites for selection. Sampling involved the collection of 1 to 2-kilogram stream-sediment samples at 500-metre intervals downstream from the deposit. Moss-mat samples were also taken when available. A duplicate sample was

**TABLE 4-5-1  
SUMMARY OF ORIENTATION STUDY  
HIGHLIGHTING DEPOSIT TYPES, GEOLOGY  
AND SAMPLING PROGRAM**

Deposit (MINF #)	Deposit type (Commodities)	Deposit Geology	No. of Samples				Length of Traverse (km)
			Stream	Moss	Bulk	Rock	
Kizobeth (920/012)	Mesothermal vein (Au, Ag, Pb, Zn)	Qtz veins in Blue Creek porphyritic quartz diorite	19	19	1	0	5
Poison Min. (920/046)	Porphyry (Cu, Mo, Au)	Porphyritic stocks intrude Jackass Min. Group	15	1	1	1	55
Blackdome (920/052)	Epithermal vein (Au, Ag)	Qtz veins cut Kingsvale volcanics	21	0	2	0	55
Fish Lake (920/041)	Porphyry (Cu, Au, Sb)	Porphyritic stocks intrude Iyaughton volcanics	16	1	2	1	55
Pellare (920/044)	Mesothermal vein (Au, Ag, Cu)	Qtz veins in Coast Range granodiorite and L. Gref. rocks	7	0	0	0	71
Alexis (920/044)	Epithermal vein (Hg, Cu, Sb)	Faults cut altered U. Cretaceous volcanics	13	9	2	2	4

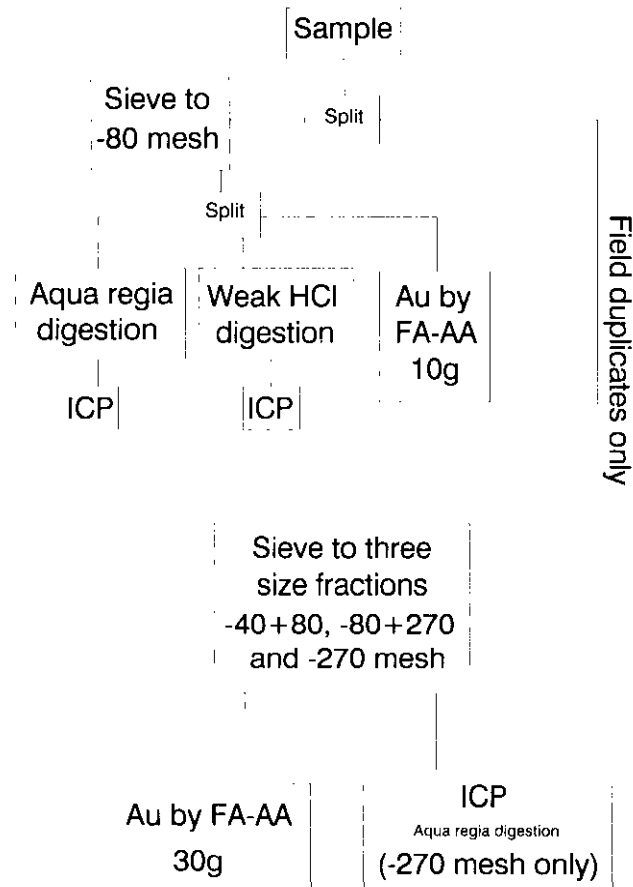


Figure 4-5-3. Flow chart detailing methods and specifications for analysis of orientation study samples.

collected at every second site. Bulk sediment samples for heavy mineral analysis were collected at the lowermost sample site of each drainage (Table 4-5-1). Major tributaries or adjacent streams draining similar geology but lacking known mineralization were sampled for background determinations.

Procedures for sample preparation and analysis are shown in Figure 4-5-3. Strong acid digestions are to be used on all samples. However, in cases where a hydromorphic component is suspected, a weak (10% HCl) digestion will also be employed.

### PRELIMINARY CONCLUSIONS

Several preliminary conclusions can be drawn from the 1990 RGS orientation survey:

- The area is relatively inaccessible and will require extensive helicopter support to complete a Regional Geochemical Survey or other field programs.
- Moss-mat sampling is feasible, however, the sporadic distribution of mats may prevent its use on an RGS-style pay-per-sample survey.
- The presence of similar geologic environments found to the northwest and southeast of the map sheet suggest that areas of high mineral potential exist within the Mount Waddington map area.
- An RGS program covering the Mount Waddington map area would provide an excellent database for the resolution of potential land-use issues.

### MOUNT MILLIGAN: A DRIFT-PROSPECTING CASE STUDY

Considerable research in drift prospecting in areas of continental glaciation has led to its regular use by industry in exploration programs in eastern and central Canada. Conversely, a lack of research on drift prospecting in areas of alpine glaciation, with particular reference to British Columbia, has impeded its use in this province. Notable exceptions include studies by Hoffman and Fletcher (1972), Mehrtens *et al.* (1973), Bradshaw (1975), Levinson and Carter (1979) and Hicock (1986). Most geochemical investigations, although recognizing the general nature of overburden, have rarely conducted in-depth analysis. The following case study, and those to follow, will attempt to provide guidelines that can be applied by the exploration community in British Columbia. The Mount Milligan copper-gold deposits were chosen for a detailed drift-prospecting study on the basis of several attributes:

- The deposit model (alkaline copper-gold porphyry), although known for some time (Barr *et al.*, 1976), is presently of great interest to the exploration community. Activity in the northern Quesnel trough which hosts these deposits has more than quintupled in the last five years (E.L. Faulkner, personal communication, 1990).
- Given the scale (up to 300 million tonnes) of these deposits, mineralized dispersion trains in glacial drift should be detectable by exploration geochemistry.
- The main orebodies are entirely covered by stratified and unstratified glacial drift of variable thickness which presents a challenge to routine exploration geochemical methods. There is potential for discovery of other alkaline porphyry deposits in the area, buried under similar drift.

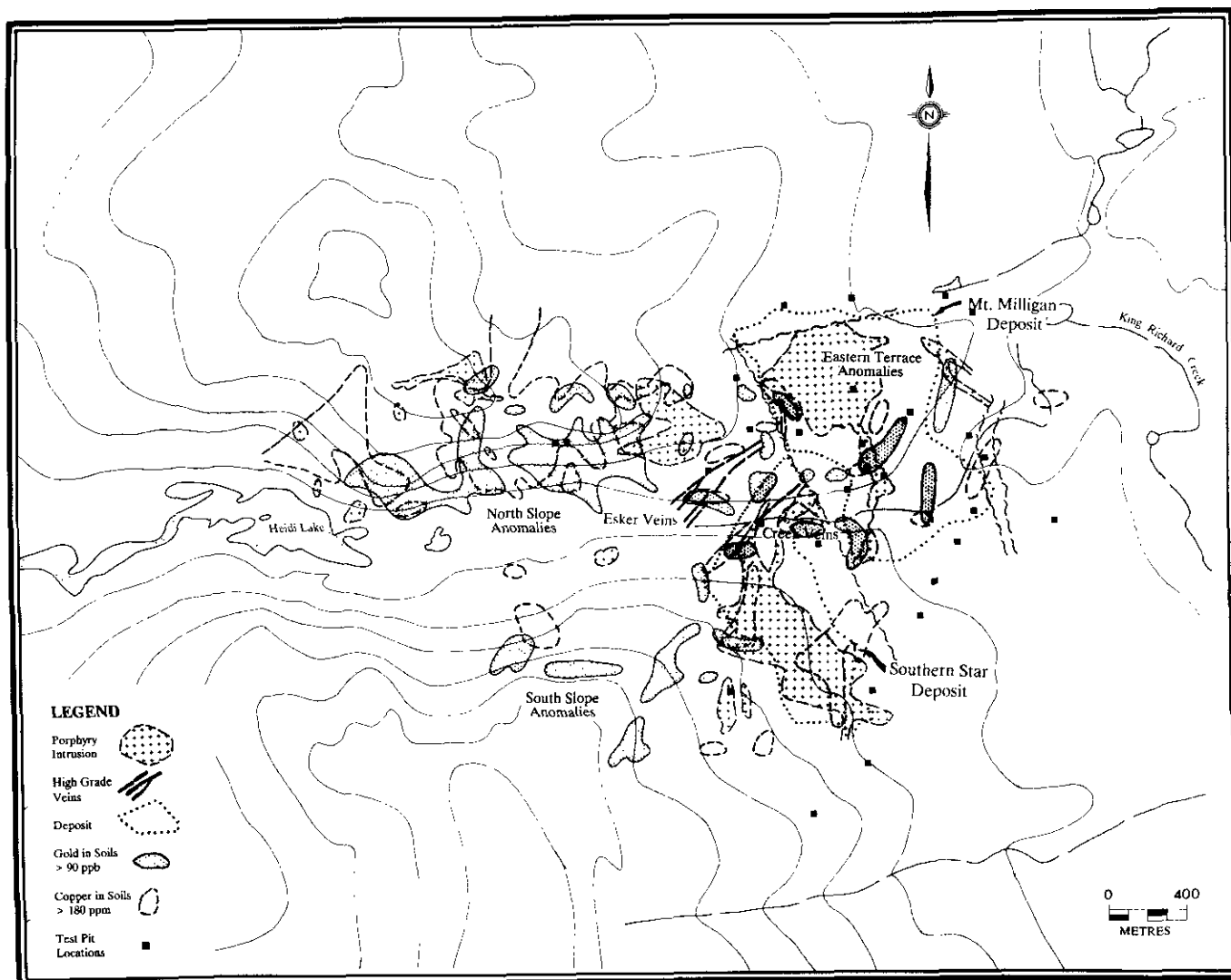


Figure 4-5-4. Summary of Mount Milligan soil geochemistry for copper and gold, and location of test pits.

## EXPLORATION HISTORY

The Mount Milligan property lies along a northwest-trending mountainous ridge 60 kilometres north of Fort St. James. Initially explored in the 1970s as a porphyry copper prospect and subsequently dropped, the property was acquired in 1983 as an alkaline copper-gold porphyry target using the QR deposit as a model. Exploration from 1984 to 1986 defined several exploration targets (Figure 4-5-4):

- Broad copper-gold soil anomalies in thin colluvium and till mantling the northern and southern slopes (North and South Slope anomalies) of a minor east-trending valley.
- Discontinuous copper-gold anomalies following the meltwater paleocurrent direction in ice-contact moraine and stratified drift covering a terrace immediately east of the valley (Eastern Terrace anomalies).

- High-grade copper-gold ( $\pm$ arsenic, silver, lead, zinc and molybdenum) mineralization in quartz veins exposed along the banks of King Richard Creek (Esker and Creek zones) flowing from the minor valley and dissecting the eastern terrace.

By 1990 two well-mineralized alkaline porphyry stocks, the Mount Milligan and Southern Star deposits, and several smaller plugs, had been defined by extensive diamond-drilling (over 200 000 metres). Collectively, ore reserves are estimated at over 300 million tonnes grading 0.5 gram per tonne gold and between 0.25 per cent copper (DeLong *et al.*, 1991, this volume). Disseminated and stockwork sulphides are hosted by monzonite stocks and the surrounding cogenetic latite and andesite volcanics. For a complete overview of regional geology, local geology and mineralization, the reader is referred to contributions by Nelson *et al.* (1991) and DeLong *et al.* (1991) in this volume.



Plate 4-5-1. View of Test Pit 75; 5-metre section comprising glacial outwash overlying till. Samples were collected from the B and C soil horizons and from immediately above and below the outwash/till contact (dashed line).

## PROGRAM DESIGN

Interpretation of soil anomalies prior to discovery of the main orebodies held that the North and South Slope anomalies were essentially formed *in situ* and the Eastern Terrace anomalies were dispersion trains of mineralized glaciofluvial sediments derived from either the Esker and Creek zones or a source on the North Slope. Subsequently the Eastern Terrace anomalies were found to directly overlie the Mount Milligan deposit; whether the anomalies are due to the underlying mineralization or simply coincidental was unclear. In addition, a bedrock source for the North Slope anomalies had not yet been located; could these anomalies be derived from a distant source? A drift-prospecting program was designed to study geochemical and surficial geology indicators which would determine direction, relative distance travelled and thus potential source areas for the various anomalies.

To resolve these questions, the following program was conducted during July, 1990:

- Surficial mapping of glacial stratigraphy in road-cut, drill-pad and test-pit exposures.

- Surficial mapping and airphoto interpretation of a 1:50 000-scale map area centred on the Mount Milligan deposits.
- Pebble counting to determine contributing lithologies in available till sections.
- Sampling and counting of mineralized boulders in test pits.
- Sampling of soil and various glacial stratigraphic horizons in drill-pad and test-pit exposures.
- Bulk soil sampling in the North Slope anomaly.
- Profile sampling of a trench traversing the Esker Creek zone.

## SAMPLING PROGRAM

Test pits (22) and drill-pad cut faces (4) were profile sampled. Two-kilogram samples were collected from the B, upper C and lower C soil horizons and any distinctly different glacial horizons (Plate 4-5-1). Comparison of the B and C horizons will demonstrate if soil forming processes obscure geochemical trends. Comparison of samples from stratified versus unstratified material may aid in distinguishing between these parent materials. Computer-assisted regeneration (*i.e.* outwash versus unstratified till) of geochemical patterns using original data (1984-1985), but subdivided on overburden type, may help to interpret dispersion trends and potential source areas.

Gold grains from bulk soil samples (12) collected from strongly anomalous sites on the North Slope and the Esker zone will be recovered and examined by scanning electron microscopy (SEM). Shape and concentration of grains collected from basal till have been employed with success in eastern Canada to determine distance of travel from source (Averill, 1978; Averill and Zimmerman, 1984; Gray, 1983; Sauerbrei *et al.*, 1987).

Soil and rock-chip samples were collected down profile at intervals of 0.5 metre at sites spaced 20 metres apart along a trench which exposes the Esker Vein zone. This study will demonstrate the rapidity of anomaly dilution with vertical and horizontal distance from source in outwash material, much in the manner of Levinson and Carter (1979).

## SAMPLE PREPARATION AND ANALYSIS

Samples were submitted to Acme Analytical Labs, Ltd., Vancouver. A flow-chart highlighting methods and specifications for analysis of the various samples is given in Figure 4-5-5.

## TRACE METALS

Determination of 30 trace, minor and major elements by inductively coupled plasma-emission spectroscopy (ICP-ES) will be conducted on the -40+80 mesh (-425 to +180 microns) and -80 mesh (-180 microns) size fractions of soil and unweathered overburden samples and on rock chips crushed and pulverized to -100 mesh (-150 microns). Results will determine the contribution of bould-

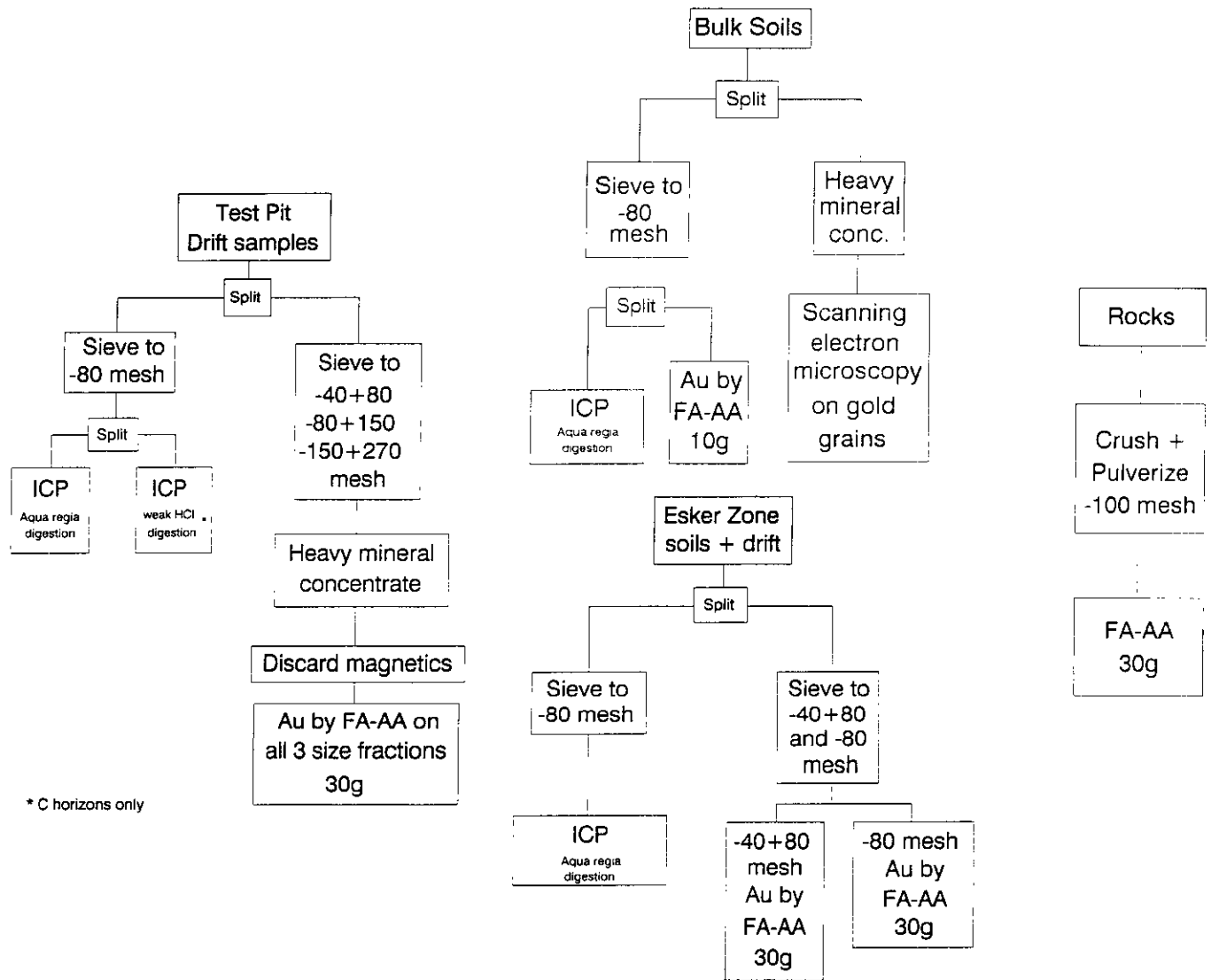


Figure 4-5-5. Flow chart detailing methods and specifications for analysis of drift-prospecting samples.

ders, coarse sand and matrix to the development of soil anomalies. Samples will be digested using hot aqua regia. To determine the hydromorphic component of anomalies, till samples (-80 mesh) will also be digested by warm dilute (10%) hydrochloric acid followed by ICP analysis.

## GOLD

All soil, till and rock-chip samples will be analyzed for gold by fire assay using an atomic absorption determination. Till samples will be sieved to three size fractions (-40+80 mesh, -80+150 mesh and -150+270 mesh), concentrated by heavy liquid separation (2.96 SG) and separated into magnetic and nonmagnetic fractions, 30 grams of each size fraction will be analyzed. This will determine relative proportions of course to fine gold and reduce the influence of the nugget effect. Soil and till samples from the North Slope and Esker zones will be sieved into coarse (-40+80 mesh)

and fine (-80 mesh) size fractions, 30-gram unconcentrated subsamples will be analyzed. Rock-chip samples will be crushed and pulverized to -100 mesh and 30-gram subsamples of the oversize and undersize will be analyzed. As mentioned above, bulk soils will be concentrated by heavy liquid separation followed by extraction of gold grains for SEM examination.

## SUMMARY OF PRELIMINARY RESULTS

Sample analyses are incomplete at the time of writing, however, some preliminary statements on surficial geology can be made, based on field observations.

The Mount Milligan area was glaciated during the last glacial episode and all glacial features observed in the study area are associated with this event. Ice-flow indicators such as drumlinoids and striae suggest a southwest to northeast direction of ice advance across the area. The surficial



Plate 4-5-2. Site of 19 000 ppb (0.54 oz/ton) gold soil anomaly on North Slope. Note the veneer (15-30 cm) of colluvium overlying bedrock. Bulk samples were collected from B-horizon soils for recovery of gold grains. Cursory field panning of duplicate samples produced numerous visible grains.

deposits, which may attain tens of metres in thickness, consist mainly of matrix-supported diamictons in the form of a till blanket, as well as glaciofluvial deposits of sand and gravel. The latter generally exhibit a southwest trend as defined by sinuous esker ridges and broad outwash plains; the dominant meltwater paleocurrent direction obtained from outwash sediments is to the northeast. Till veneer and colluvium deposits frequently mantle the steeper slopes of hills and valleys, whereas isolated deposits of fine glaciolacustrine sand, silt and clay are found in several topographic depressions. Thickness of surficial cover varies considerably over the copper-gold deposits, from less than 1 metre to in excess of 90 metres. Test pits, which were dug to a general depth of 2 to 3 metres, exposed a complex stratigraphic sequence. For a more complete discussion of the Quaternary geology and its relationship to drift prospecting, the reader is referred to Kerr and Bobrowsky (1991).

Several gold anomaly sites visited on the North Slope suggest local derivation. Surficial deposits, comprising till and colluvium, varied from 0.1 to 1 metre in thickness (Plate 4-5-2) and contained predominantly angular clasts of the underlying lithology.

Abundance, shape, size and composition of mineralized clasts encountered in test pits over the Mount Milligan deposit indicate incorporation of local material into till and outwash. Distance of travel in some instances may be relatively short, clasts of easily comminuted, oxidized supergene material were encountered in the upper layer of a till sheet in one test pit. The first drill-hole intercept of the supergene cap lies 150 metres to the southwest.

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