

## EAGLE BAY PROJECT: TILL GEOCHEMISTRY OF THE ADAMS PLATEAU (82M/4) AND NORTH BARRIERE LAKE (82M/5) MAP AREAS

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**KEYWORDS:** drift exploration, till geochemistry, exploration, Quaternary, Eagle Bay, Adams Lake, Barriere, prospecting, VMS

### INTRODUCTION

Drift exploration studies were undertaken in the summer of 1996 as part of an integrated regional exploration program centred on Devono-Mississippian rocks of the Eagle Bay Assemblage. Volcanogenic sulphide-barite deposits in the area including Rea Gold (MINFILE 082M 191) and Homestake (MINFILE 082M 025) suggest the region has considerable mineral potential. The drift exploration component of the study involved 1:50 000 scale surficial geology mapping (Dixon-Warren *et al.*, 1997a) and till geochemistry sampling on NTS map sheets 82M/4 (Adams Plateau) and 82M/5 (North Barriere Lake) directly northeast of Kamloops (Figure 1). Related studies included mineral deposits research (Höy, 1997), and a stream water survey and geochemical orientation (Sibbick *et al.*, 1997). Recent and successful exploration activity in correlative rocks in the Yukon at properties such as Kudz Ze Kayah and Wolverine provided the impetus for work in the Eagle Bay Assemblage.

The purpose of the drift exploration program was to document the surficial geology of the area and to provide results of a reconnaissance level till geochemistry sampling initiative. The goal of the surficial geology research was to map approximately 2000 square kilometres of rugged, moderately high relief, glaciated terrain by documenting the type and distribution of Quaternary sediments present. Discussion and greater detail is provided in Dixon-Warren *et al.* (1997a), whereas the surficial maps for both sheets are available in Leboe *et al.* (1997) and Dixon-Warren *et al.* (1997b).

The objectives of the till geochemistry project were:

- to define new anomalies which may be used in the discovery of mineralization targets;
- to stimulate new exploration and economic activity;
- to provide information that will be of use in all areas where mineral exploration has been hampered by thick glacial drift cover, and

where traditional prospecting and exploration techniques have proven unsuccessful despite indications of high mineral potential.

The purpose of this paper is to summarize the till geochemistry activities of the 1996 summer field season. We review the setting, sampling techniques and methods of analysis and preliminary results of the research. Brief discussion of the paleo-ice flow history and Quaternary stratigraphy is provided to supplement the analytical results presented elsewhere.

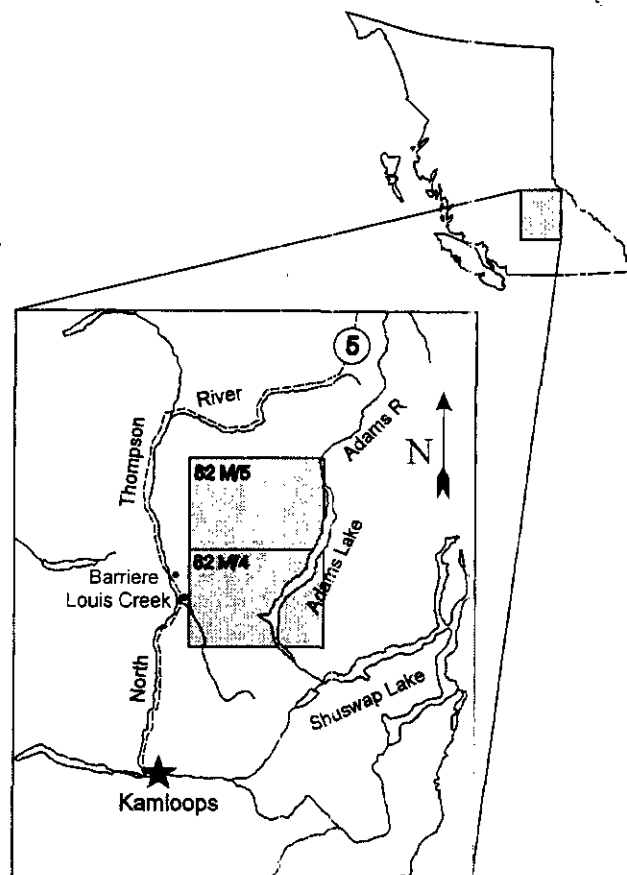


Figure 1. Location of Eagle Bay drift exploration project study area in south-central British Columbia.

## BACKGROUND

Located in south-central British Columbia, the Adams Plateau and North Barriere Lake map area lies in the southern part of the Shuswap Highland, within the Interior Plateau (Holland, 1976). This region is characterized by moderate to high relief, glaciated, and fluviially dissected topography. Elevations range from 450 to 2630 m above sea level (Photo 1). Most of the area is covered by drift of mixed genesis and of variable thickness rarely exceeding a few tens of metres. Ground moraine (various facies of till) dominates the landscape, followed in turn by colluvial, glaciofluvial and fluvial sediments. As such, the area is very amenable to a till geochemistry survey.

In terms of the bedrock geology, the area lies within the Kootenay Terrane, supporting economically attractive suites including Paleozoic metasedimentary and meta-volcanic rocks of the Eagle Bay Assemblage and Fennell Formation. As mapped in detail by the BC Geological Survey Branch (Schiarrizza and Preto, 1987), both the Eagle Bay and Fennell transect significant parts of both map sheets. Schiarrizza and Preto (1987) assigned ages of Early Cambrian to Late Mississippian to rocks of the Eagle Bay Assemblage. These consisted of quartzites, quartzose schists, and limestones overlain by calcareous phyllite, calc-silicate schist and skarn or mafic meta-volcanics, which in turn are overlain by felsic meta-volcanic rocks, intermediate locally alkalic metavolcanics and clastic metasediments. The Fennell Formation

comprises oceanic rocks consisting of bedded cherts, gabbro, diabase, pillowed basalt, sandstone, quartz-feldspar-porphyry and conglomerate.

Rocks of the Intermontane Belt border the west, whereas high-grade metamorphic rocks of the Shuswap Complex lie to the east.

The Devono-Mississippian felsic to intermediate metavolcanic rocks of the Eagle Bay Assemblage host polymetallic precious and base metal massive sulphide occurrences; most notably Rea Gold, Samatosum (MINFILE 082M 244) and Homestake mines (Figure 2). There are 79 mineral occurrences in total, 42 of them are on NTS 82M/4 and 37 of them on NTS 82M/5. All "past producer" occurrences (6) and "developed prospects" (3) include Pb, Zn, Ag, and Cu. Seven of these occurrences include Au.

## METHODS

Fieldwork was based out of two camps: one near Tod Mountain for work in NTS 82M/4 and a second at the west end of East Barriere Lake for work in NTS 82M/5. Access to the lower two-thirds of the area is excellent. An extensive network of logging roads intersects most moderate slopes and all plateaus. There is, however, a lack of road access to the very steep slopes on the eastern shore of Adams Lake adjacent to the Adams Plateau, and the extreme southwestern margin of the Adams Plateau map area. The northern reaches of the study area are at



Photo 1. View to northwest along Sinmax Creek, with Homestake in centre of photo. Note high relief, plateau topography.

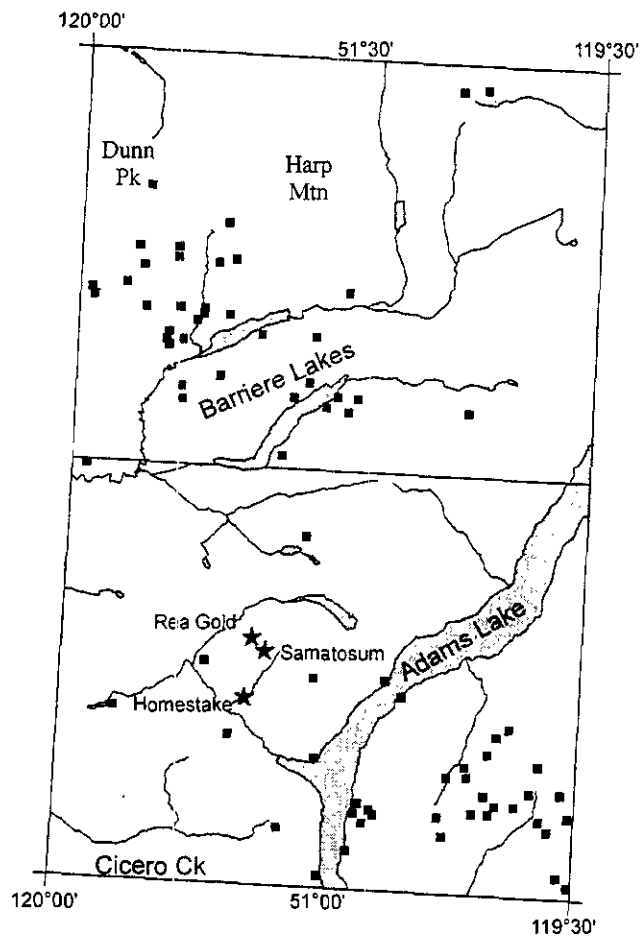


Figure 2. Mineral occurrence locations for NTS 82M/4 and 5 from MINFILE database.

increasingly higher elevation, and close to treeline; consequently, logging roads are infrequent, and access is restricted, especially in the northwest corner near Dunn Peak and Harp Mountain.

The majority of fieldwork was conducted with a 4-wheel drive vehicle along secondary roads and trails of varying condition. Where road or 4-wheel drive track access was blocked or non-existent, traverses were completed on foot.

Initial work consisted of compiling and evaluating all existing terrain information available for the area. Soil and landscape maps produced by the Resource Analysis Branch of the British Columbia Ministry of Environment (Kowall, 1975a, 1975b) provided background data on the type of materials likely to be encountered. Regional Quaternary mapping studies completed by the Geological Survey of Canada (e.g. Fulton *et al.*, 1986) contributed further information on the types and distribution of sediments which may occur in the region. Regional ice



Photo 2. Example of striated bullet-shaped boulder lying on till surface.

flow was determined from Fulton *et al.* (1986) using their 1:250 000 surficial geology map of the Seymour Ar.n. Airphoto analysis contributed to paleo-ice-flow determinations from the identification of rare drum:incid features and lineations on plateaus. Detailed local ice-flow directions were obtained by measuring the orientation of striations or grooves on bedrock surfaces, and apparent till fabric was determined from the orientation of bullet-shaped boulders (Photo 2).

Air photographic interpretation and 'pretyping' followed the methodology of RIC (1996) and the terrain classification system of Howes and Kenk (1988). Air photos at a scale of 1:40 000 (approx.) (flight lines 15BCC-95009, 95014 and 95017) were used in the map generation. Final terrain maps were produced at a scale of 1:50 000. Preliminary polygon interpretations were verified through ground-truthing. About half of the polygons were evaluated on the ground, thereby corresponding to a Terrain Survey Intensity Level B (Resources Inventory Committee, 1996).

At each ground-truthing field station some or all of the following observations were made: GPS-verified UTM location, identifying geographic features (*i.e.* creek, cliff, ridge), type of bedrock exposure if present, unconsolidated surface material and expression (terrain polygon unit), general slope, orientation of striations/grooves on bedrock or of bullet-shaped boulders.

Bulk sediment samples (1-5 kg in size) were collected for geochemical analysis over much of the study area. Emphasis was placed on collecting basal till deposits (first derivative products according to Shilts, 1993), although ablation till, colluviated till and colluvium was also collected under certain circumstances. Natural exposures and hand excavation were used to obtain samples from undisturbed, unweathered C horizon (parent material) deposits. At each sample site, the following information was recorded: type of exposure (gully, roadcut, etc.), depth to sample from top of soil, thickness of A and B soil horizons, clast percentage, matrix or clast-supported diamicton, consolidation, matrix texture, presence or absence of structures, bedding, clast angularity (average and range), clast size (average and range), clast lithologies, and colour. The sample was evaluated as being derived from one of five categories; basal till derived from the Eagle Bay Assemblage, basal till derived from the Baldy Batholith, colluviated/reworked basal till, ablation till, or colluvium. Sediment samples were submitted to Eco Tech Laboratories in Kamloops for processing. This involved air drying, splitting, and sieving to <63µm. The pulps, <63µm sample and unsieved split were subsequently returned to the BCGS. The <63µm fraction of each sample was further divided into 10 and 30 gram portions. The smaller portion was sent to Acme Analytical Laboratory, Vancouver, where samples were subjected to aqua regia digestion and analysis for 30 elements by ICP (inductively coupled plasma emission spectroscopy) and for major oxides by LiBO<sub>2</sub> fusion - ICP (11 oxides, loss on ignition and 7 minor elements). The larger portion was sent to Activation Laboratories, Ancaster, Ontario, for INA (thermal neutron activation analysis) analysis for 35 elements (Table 1).

**TABLE 1: ANALYTICAL METHODS EMPLOYED AND ELEMENTS ANALYZED FOR TILL GEOCHEMISTRY SURVEY.**

ANALYSIS	ELEMENTS
Whole Rock	SiO <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , CaO, MgO, Na <sub>2</sub> O, K <sub>2</sub> O, MnO, TiO <sub>2</sub> , P <sub>2</sub> O <sub>5</sub> , Cr <sub>2</sub> O <sub>3</sub> , LOI, Ba, Ni, Nb, Sr, Sc, Y, Zr
INA	Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu
ICP	Mo, Cu, Pb, Zn, Ag, Ni, Co, Mn, Fe, As, U, Au, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, B, Al, Na, K, W

Pebble samples were collected at a number of till sample stations for lithologic provenance studies. Between 105 and 110 clasts were collected at each station from within the trench dug for diamicton sampling. (A higher number than 100 clasts was collected to anticipate miscounts, non-identification and specimen destruction). Pebbles were returned to camp daily, split and are now stored in the Department of Earth Sciences, Simon Fraser University pending future identification. Sampling focused on the Adams Plateau map area and the southern margin of the North Barriere Lake map, in order to limit data collected to tills representative of the Eagle Bay Assemblage.

## RESULTS

A total of 660 field stations were examined for ground truthing over the total area during the course of this survey. The resultant field checking density based on full map sheets is one station per 2.5 km<sup>2</sup> for NTS 82M/4 and one station per 3.6 km<sup>2</sup> for NTS 82M/5. Excluding inaccessible areas, field checking density increases to one station per 2.0 km<sup>2</sup> and one station per 2.3 km<sup>2</sup> for NTS 82M/4 and M/5, respectively.

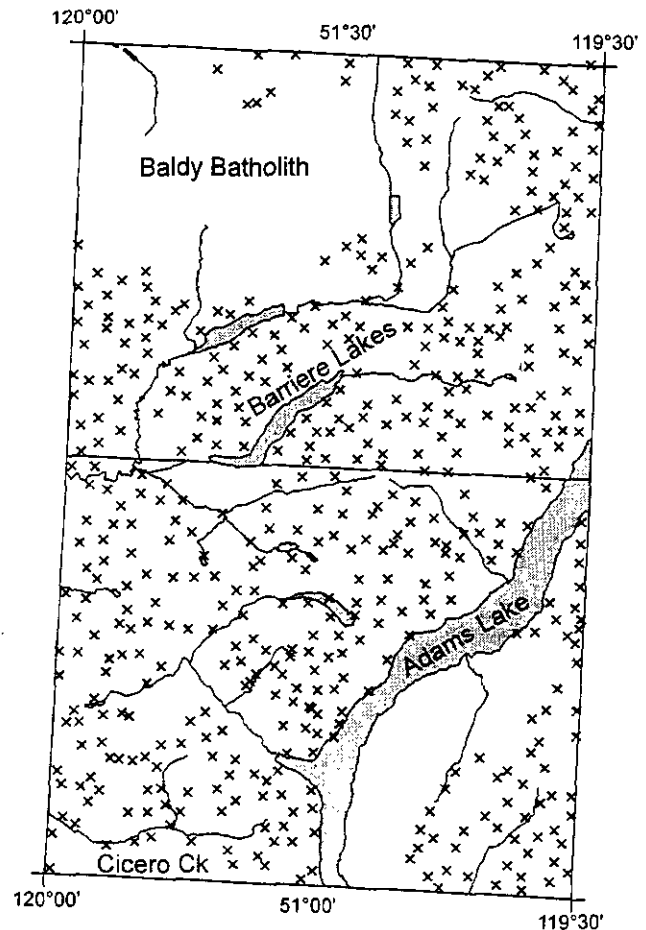


Figure 3. Location of till geochemistry sampling locations.

A total of 96 pebble lithology stations were eventually sampled for provenance during this survey. Sampling density averaged one per 11 km<sup>2</sup>, although not equally distributed, since a higher concentration of stations occur in the southwest part of NTS 82M/4. Excluding inaccessible areas, pebble sampling density is about one per 9 km<sup>2</sup>. Results of the identification are pending, but will be used to calculate transport distances and infer paleo-ice dynamics (*cf.* Bobrowsky, 1995).

A total of 535 bulk sediment samples were initially collected for the till geochemistry study (Figure 3). Of these, 526 samples were considered acceptable for the objectives of this survey. Samples were collected at an average depth of 1.9 m below soil surface. Till sample density averaged one per 3.8 km<sup>2</sup> for the total survey area. Excluding inaccessible regions, sampling density averages one per 2.6 km<sup>2</sup>. This level of sampling provides a high level of reconnaissance information for the region.

Most of the samples taken for geochemical analysis were representative of basal till, most likely lodgement till (Photo 3). Of the 526 samples, 413 or 79% represented this sediment type (Table 2). Two types of basal till were recognized, one reflecting an origin predominantly seated in Eagle Bay Assemblage rocks (M1), and the other derived from Baldy Batholith rocks (M3). Basal till which has undergone slight downslope movement was classed as colluviated till (CM). Samples taken from this type of deposit accounted for 76 or 14% of the total. Together, these three groups (93%) represent the highest quality media to sample for drift exploration. Also valid, but more difficult to interpret were the remaining 37 or 7% of the samples which were collected from ablation till (M2) and colluvium (C).

**TABLE 2: FREQUENCY, PERCENT AND DISTRIBUTION OF SEDIMENT TYPE SAMPLED FOR TILL GEOCHEMISTRY SURVEY.**

UNIT	DESCRIPTION	#	%
M1	Lodgement till derived from Eagle Bay Assemblage	340	65%
M3	Lodgement till derived from Baldy Batholith	73	14%
M2	Ablation till, generally derived from Baldy Batholith	17	3%
CM	Colluviated/reworked till	76	14%
C	Colluvium	20	4%
Total		526	100%

Results and interpretation of the till geochemistry survey for this study appear elsewhere (Bobrowsky *et al.*, 1997).

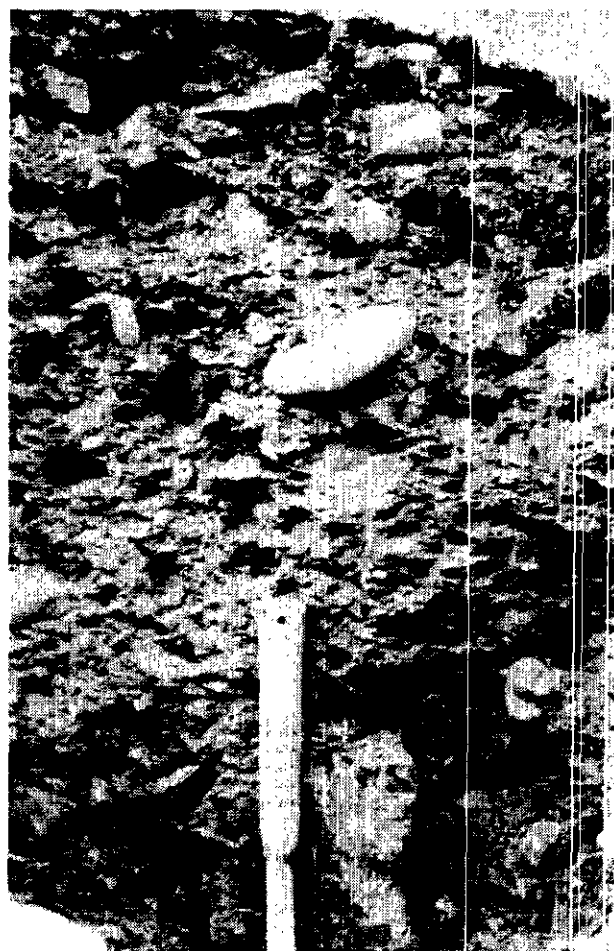


Photo 3. Example of basal till deposit representative of commonly sampled materials during Eagle Bay drift exploration project.

Previous geochemical studies provide an indication as to the style of mineralization, configuration of anomaly plumes and regional dispersal patterns one can expect for this area. Three examples of property scale geochemical sampling from two separate occurrences are presented here as analogues to the expected regional dispersal patterns.

At the Silver 1 property, located directly south of the confluence of Homestake and Sinmax creeks, B Horizon soil samples illustrate two forms of geochemical anomaly patterns (Richards, 1989). The cobalt plume shows a fan-shaped down-ice dispersal pattern with a sharp apex and broader fan tail extending about 500 m in length from the northwest to the southeast. The direction of this anomaly parallels the regional ice flow pattern and reflects strong clastic dispersion in the basal till media (Figure 4). At the same property, arsenic displays a less distinct dispersal pattern. In this case, although the long axis of the plume

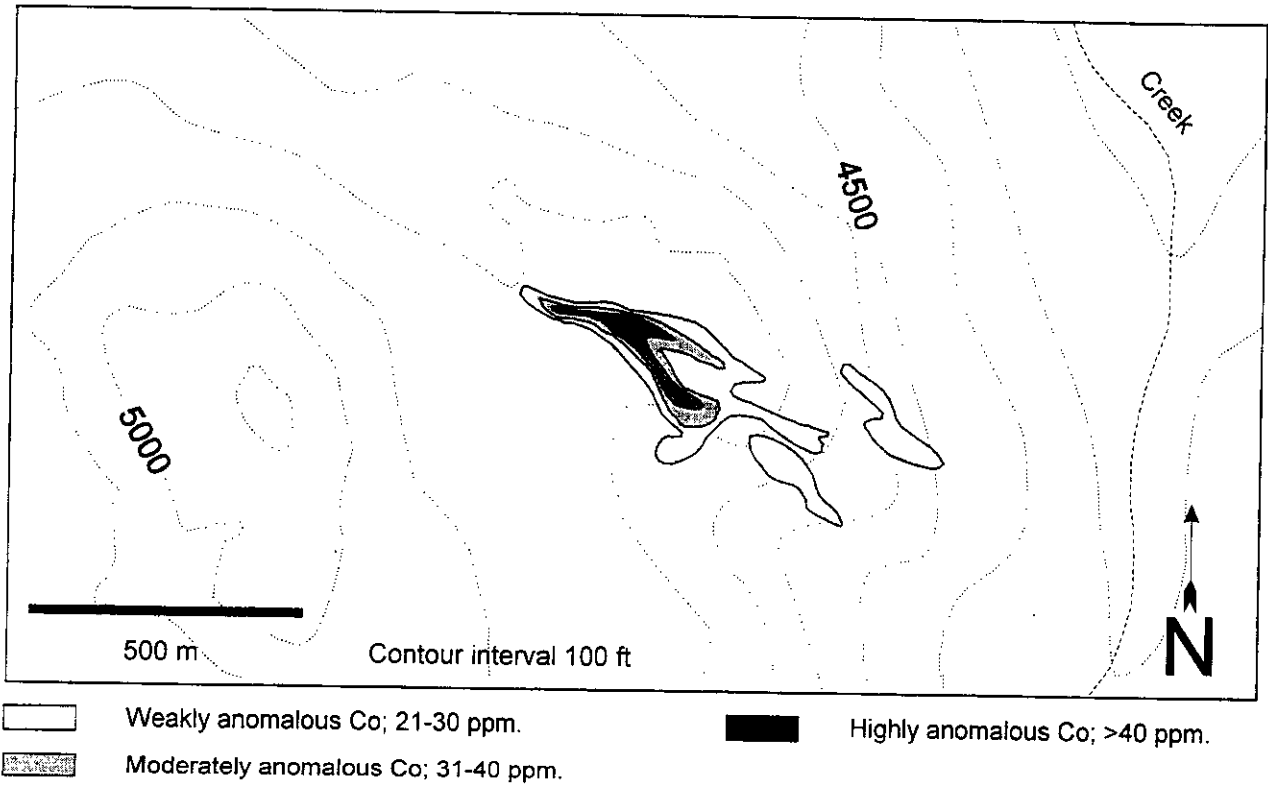


Figure 4. Cobalt soil anomaly for the Silver 1 property. Modified after Richards, 1986.

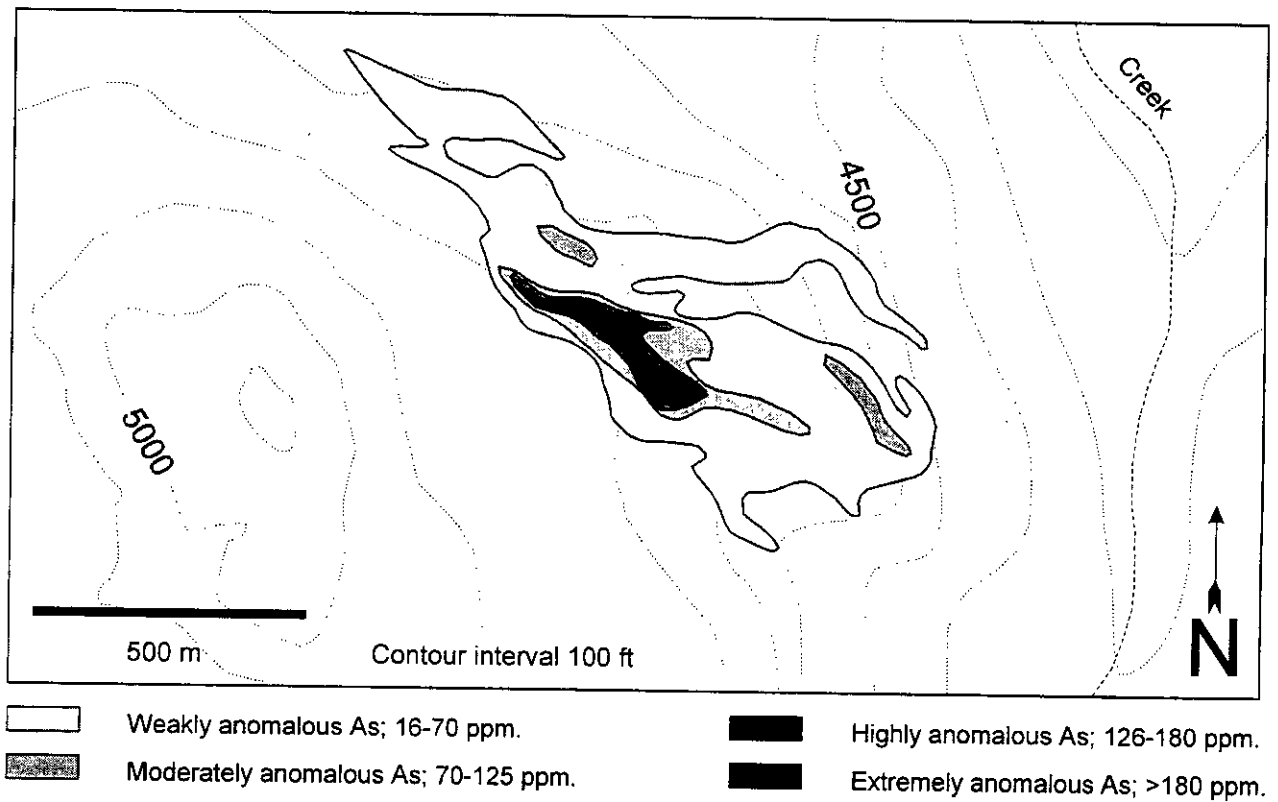


Figure 5. Arsenic soil anomaly for the Silver 1 property. Modified after Richards, 1986

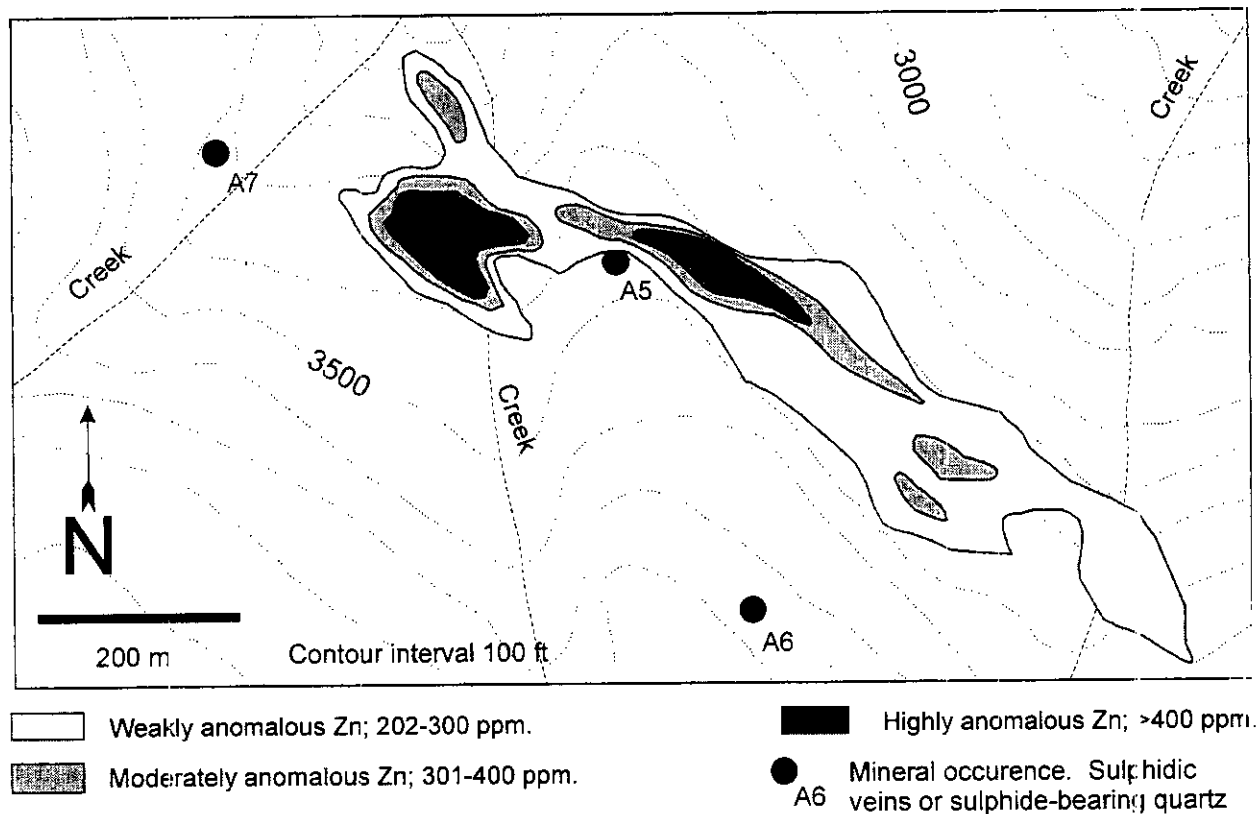


Figure 6. Zinc soil anomaly for the Kamad 3 property. Modified after Marr, 1989.

parallels regional ice flow from northwest to southeast and thus reflects typical clastic dispersal, a secondary downslope northeasterly component has been overprinted on the initial shape. Here, hydromorphic dispersion may have modified the original shape creating an anomaly over one km long and 500 m wide (Figure 5). Cobalt illustrates a single vector (ice-parallel) configuration, whereas arsenic illustrates a compound two vector configuration consisting of ice parallel plus downslope directions.

At the Kamad 3 property, also near the confluence of Homestake and Sinmax creeks, but about two kilometres north of Silver 1, a zinc anomaly shows a classic cigar-shaped dispersal plume (Marr, 1989). As in the previous cases, the form parallels regional ice flow to the southeast (Figure 6). This particular anomaly is about one kilometre long and 200 m wide. Although the anomaly crosses a slope and follows the contours of the land, there is no secondary downslope dispersion as in the case of arsenic in the previous example. A possible minor hydromorphic extension to the dispersal plume may be present at the head of the anomaly where it crosses a small creek.

## GLACIAL HISTORY

The success of the regional drift exploration program requires the proper integration of consistent C horizon till geochemical data within the framework of a well-defined Quaternary geologic history.

According to Fulton and others (Fulton and Smith, 1978; Ryder *et al.* 1991), the present-day landscape of south-central British Columbia is the result of two cycles of glaciation, one interglacial and intensive early Holocene erosion and sedimentation. Although not necessarily present in the study area, the following lithologic units and their correlative geologic climate units have been identified in south-central British Columbia. The oldest deposits in the region, thus far identified at only two locations some 60 and 100 km to the south, are the interglacial Westwold Sediments. These deposits consist of cross-stratified gravely sand, capped by marl, sand, silt and clay all of which are equivalent in age to the Highbury Non-glacial Interval in the Fraser Lowland (Sangamonian).

Next in age are Okanagan Centre Drift deposits, consisting of coarse, poorly stratified gravel, laminated silt and till, presently recognized at Heffley Creek, (20 km to the south of the study area) and elsewhere farther south. These sediments were deposited during the Okanagan Centre Glaciation, equivalent to the Semiahmoo Glaciation in the Fraser Lowland (Early Wisconsinan).

Middle Wisconsinan, Olympia Non-Glacial Interval Bessette Sediments overlie the Okanagan Drift deposits. They consist of nonglacial silt, sand and gravel with some organic material and in some cases up to two tephras.

The Kamloops Lake Drift overlies the Bessette Sediments, and underlies the present-day surface cover of postglacial deposits. This unit consists of silt, sand, gravel and till deposited during the Fraser Glaciation (Late Wisconsinan).

The surface and near-surface sediments mapped in the Adams Plateau and Barriere Lakes areas directly result from the last cycle of glaciation and deglaciation (Fraser Glaciation), and ensuing postglacial activity. Regional ice flow, as determined from Fulton *et al.* (1986) ranges from south to southeast. This regional flow direction was observed in several locations in both map areas. Ice flow was also diverted locally in several of the valleys. For example, along the Barriere River valley at the boundary of NTS maps 82 M/4 and 82 M/5, striations on a bullet shaped boulder embedded in till indicate that ice flowed to the east, parallel to the valley orientation. Similar down-valley deflection of ice flow is recorded on bullet-shaped boulders within the Fadear Creek valley, and western Sinmax valley, where regional southeast flow was deflected eastward (Photo 2).

Existing radiocarbon dates provide a tentative chronology for glaciation and deglaciation of the Adams Plateau region. Late Wisconsinan ice first covered the area sometime after  $20230 \pm 270$  years BP. Dates of 11.3 ka and 10.1 ka indicate that deglaciation began shortly before this time in the lowland areas of this region (Dyck *et al.*, 1965).

## DRIFT EXPLORATION IMPLICATIONS

The moderately high relief and clearly defined valley systems contribute to a well suited landscape for drift exploration. Excluding exposed bedrock peaks, much of the non-lowland areas are mantled by colluvium often less than a metre thick or, more commonly, locally derived basal till. Basal till deposits are often less than several metres thick and commonly directly overlie bedrock. Moreover, till observed in both map sheets appears to be representative of the last glaciation to have affected the region. Sediments older than Late Wisconsinan were not observed.

The above characteristics are positive signs for both reconnaissance and property scale drift prospecting work. Basal till is clearly recognized as the most ideal sediment sampling media for drift prospecting (Shilts, 1993) and in this study area it represents the dominant sediment type. Thin deposits of basal till usually reflect a more proximal

source area for the sediment. If the surficial sediments are all Late Wisconsinan or postglacial in age, then there are no complications of multiple ice flow directions to interpret. Finally, the ice flow direction is generally south to southeast over highland and mid-slope areas or vary south to east within confined valley settings.

Existing geochemical anomalies from known mineral occurrences indicate that the dispersal plumes conform to classic down-ice shapes, usually proximal to the source bedrock. This implies that the anomalous values detected through this reconnaissance survey will be very useful for future exploration activity. Moreover, clastic dispersal patterns associated with these anomalies will most likely strongly parallel ice flow, they may possibly be imprinted with only minor hydromorphic downslope effects and they will probably occur within tens of metres of the source rock.

## SUMMARY

A drift exploration project was initiated and completed during the summer of 1996 focusing on surficial geology mapping and till geochemistry surveying over rocks of the Eagle Bay Assemblage northeast of Kamloops. Two 1: 50 000 scale terrain geology maps have been completed for the area, showing the type and distribution of surficial sediments present. A total of 526 samples were collected for the till geochemistry survey and subjected to ICP, INA and whole rock analysis.

The results of this research indicates that the local terrain is highly favourable for drift exploration studies. Dispersal plumes of known geochemical anomalies conform to traditional down-ice, cigar-shaped configurations. Drift cover, although extensive, consists primarily of thin basal till deposits. Local and regional ice flow patterns range from south to southeast and are easily determined in the field at the site level. Integration of the surficial geology maps and reconnaissance till geochemistry results should now be pursued at the property scale of exploration to locate potential mineral deposits now obscured by surficial sediments.

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