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A MULTI-MEDIA ANALYSIS OF STREAM GEOCHEMISTRY ON VANCOUVER ISLAND, BRITISH COLUMBIA: IMPLICATIONS FOR MINERAL EXPLORATION

BRITISH COLUMBIA GEOLOGICAL SURVEY

Geofile 2008-8

Forward – Ray Lett, Senior Geochemist, BC Geological Survey

There is a good potential for discovering new metallic mines on Vancouver Island because much of the geology that has formed through the evolution of island arc-related rock suites is a favourable host for a range of mineral deposit types including porphyry Cu-Mo, volcanic massive sulphides and skarn mineralization. In addition to past and present producing mines such as Myra Falls and Island Copper numerous mineral occurrences have been found and are still being developed. Recent studies and bedrock mapping by Nixon *et al.* (2008, 2006 a,b) and till geochemical surveys by Bobrowsky and Sibbick, (1996) over parts of the Island have continued to improved the quality of geoscience information and have thereby increased the likelihood of making new mineral discoveries. Vancouver Island is also ideal for testing new geochemical exploration methods because it not only has varied geology, numerous mineral occurrences and different styles of metallic mineralization, but has also contrasting local climates, different surficial environments and physiographies. These features were incentives for the staff of the applied geochemical unit in the British Columbia Geological Survey to carry out a number of orientation studies in 1987 and 1988 with the aim of improving drainage geochemical survey techniques on Vancouver Island. Results of the studies were fully documented but were never reported at that time. Geofile 2008_8 contains full details of these geochemical studies. While it is tempting to update the report with more recent data it is recognised that the original document is of sufficiently high quality to remain in its original form with only minor editing. Field areas, sampling and analytical techniques are fully described in the text with a summary of the results and a detailed interpretation of the data. In Appendix A are 18 geochemical case histories that form the basis of the Geofile and the raw data as digital MS Excel format tables is compiled in Appendix B. While every effort has been made to ensure that the sample sites in Appendix B are correct there may be location errors because the original field records for the case history areas are missing.

ACKNOWLEDGEMENTS
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INTRODUCTION

Systematic, **reconnaissance scale**[1] stream sediment surveying is globally recognized (Plant *et al., 1988)* as a robust method for defining the mineral potential of large (hundreds to hundreds of thousands of square kilometres), often remote and under-explored areas. In British Columbia, federal and provincially funded Regional Geochemical Surveys (RGS) have been conducted since 1976. Samples comprise of conventional fine-grained stream sediment and water collected from first and second order streams. Sampling density ranges from 1 site per 8 square kilometres to 1 site per 25 square kilometres. The RGS database contains field observations as well as analytical and statistical data, which currently covers 70 per cent of the province. The surveys provide several benefits, including:

- A high-quality geochemical database that is conformable to national standards, compatible to stream surveys conducted by the mineral resource industry, and has applications in land-use, environmental and health studies.
- A source of trace and precious element anomalies which stimulate mineral exploration.
- A background on innovative sampling, preparation and analytical methods in addition to a description of interpretation techniques.

In preparation, geochemical stream orientation studies are conducted in proposed RGS program areas. Orientation studies serve the following purposes:

- Indentify which sediment media are uniformly available.
- Compare alternative sediment sampling, processing and analytical procedures with the conventional RGS procedures in order to select the optimal procedures for the RGS programs.
- Identify processes which influence dispersion and are therefore factors to be considered in interpretations.
- Characterize **dispersion patterns** of the various mineral deposits encountered in the survey area.

[1] Definitions for terms in bold script are given in a glossary following References.

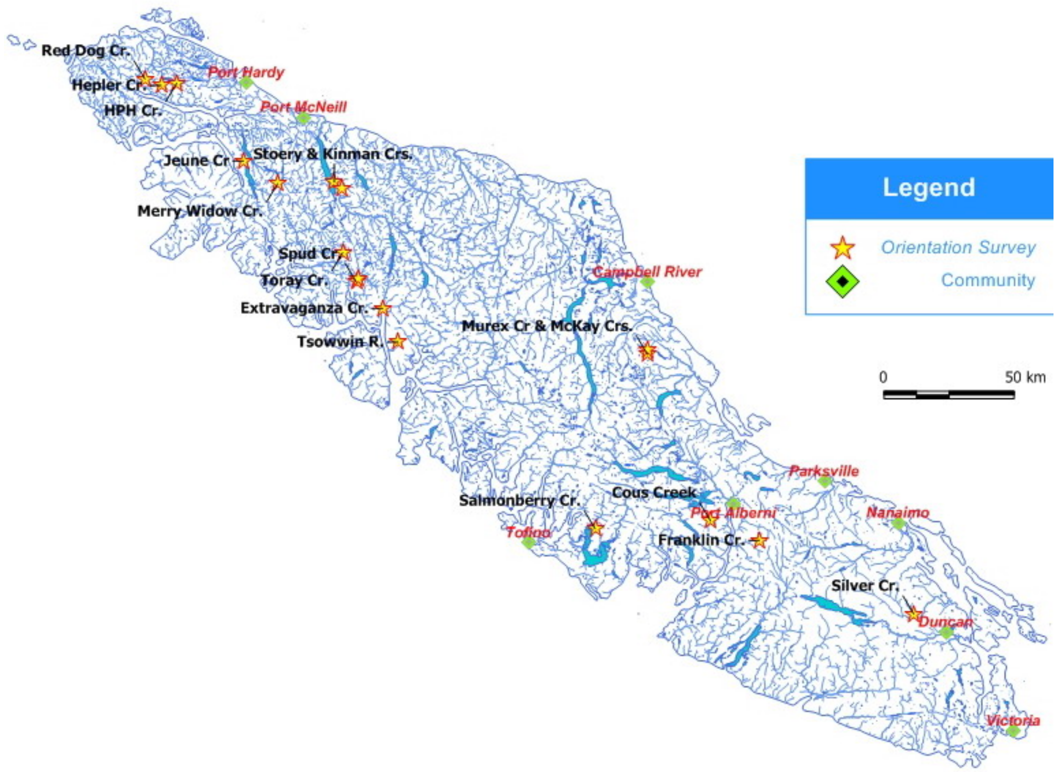

Figure 1. Location map for the orientation surveys described in this Geofile.

Orientation surveys were initiated on northern and southern Vancouver Island in 1987 and 1988 respectively. Eighteen drainages containing mineral deposits (Figure 1) were selected for detailed sampling based on deposit type, physiography and climate. Additional samples were taken in several apparently non-mineralized drainages in order to help establish background concentrations. Sampled media comprised of **moss-mat sediments** (187 samples), conventional fine-grained stream sediment (177 samples), bulk fine-grained stream sediment (100 samples), and bulk sieved stream sediment from low (32 samples) and high-energy (47 samples) sites. Preliminary results reported by Matysek and Day (1988) and Matysek *et al.* (1989) conclude that the prevalent mountainous rain forest environment, and the accompanying high-energy streams produce conventional stream sediment, deficient in fine-grained (-80 mesh) material. Moss-mat sediments were subsequently collected over Vancouver Island for the 1988 and 1989 RGS programs (BC RGS-21 to BC RGS-26) (Gravel and Matysek, 1989; Gravel *et al.,* 1990).

The following Geofile, divided in two parts, builds on the earlier reports. In Part 1, "A Comparison of Sample Media", comparisons define the gross geochemical characteristics of various sediment sample types and size fractions. The media are evaluated regarding general availability, absolute concentrations of major, minor and trace elements, the presence and cause of medium related biases and the ability to distinguish drainages containing mineral deposits. The outcome of part one is a recommended medium for RGS type reconnaissance scale stream geochemistry programs. In Part 2, "Case Studies", the eighteen drainages containing mineral deposits (identified as CS #1 to CS #18) are examined in detail. At this scale the unique geochemical character of each drainage basin can be addressed, dispersion processes can be assessed and the optimal sample medium and pathfinders can be defined. A comparison of element dispersion trains between similar deposit types yield geochemical signatures which may be applicable as property scale guidelines for exploration. Simplified dispersion models are presented which characterize the influence of bedrock and surficial geology, topography and climate on anomaly development for three stereotype environments on Vancouver Island.

DESCRIPTION OF STUDY AREA

Vancouver Island lies off the southwest coast of British Columbia between longitude 123°00' to 128°50' and latitude 48°20' to 51º00'. Elongated about a northwest axis, the island measures 450 by 125 kilometres (at the widest point) and encompasses an area of approximately 33 000 square kilometres which is covered by 1:250000 NTS map sheets 92B, C, E, F, G, K, L and 1021.

REGIONAL GEOLOGY AND MINERALIZATION

The geology of Vancouver Island (Figure 2), as described by Muller (1977), belongs predominantly to the Wrangalian Terrane of the Insular Belt with slivers of Pacific Rim and Crescent terranes of the Pacific Belt found along the west coast and southern tip of the Island. Most lithologic units, regional folds and faults trend parallel to the long axis of the island reflecting a minimum of six phases of deformation (Massey and Friday, 1988) which alternated between compressional (subduction) and extensional (rifting) regimes.

The Sicker Group (Muller, 1980), later redefined by Massey and coworkers (1988, 1989) as the Sicker and Buttle Lake groups, consist mainly of intermediate volcanics and sediments deposited from the Middle Devonian to Permian in a volcanic-arc environment. These, the oldest units on Vancouver Island, form the cores of geanticlines in the Cowichan, Nanaimo and Buttle Lake Uplifts found in the southern and central interior of the island. Smaller exposures of Buttle Lake Group limestone lay in the northern interior and along the west coast near Tofino. The Westcoast Crystalline Complex, Wark and Colquitz gneiss complexes, which form the western and southern margins of the island, contain metamorphosed Sicker and Buttle Lake Group rocks (Muller, 1980) and large volumes of Jurassic intrusives (Isachsen, 1984). The Paleozoic strata are unconformably overlain by the Upper Triassic Karmutsen (basaltic volcanics), Parson Bay (marine clastic and carbonate sediments) and Quatsino (limestone) formations of the Vancouver Group. These units are volumetrically dominant on the island and have been interpreted as a rift sequence (Muller, 1977).

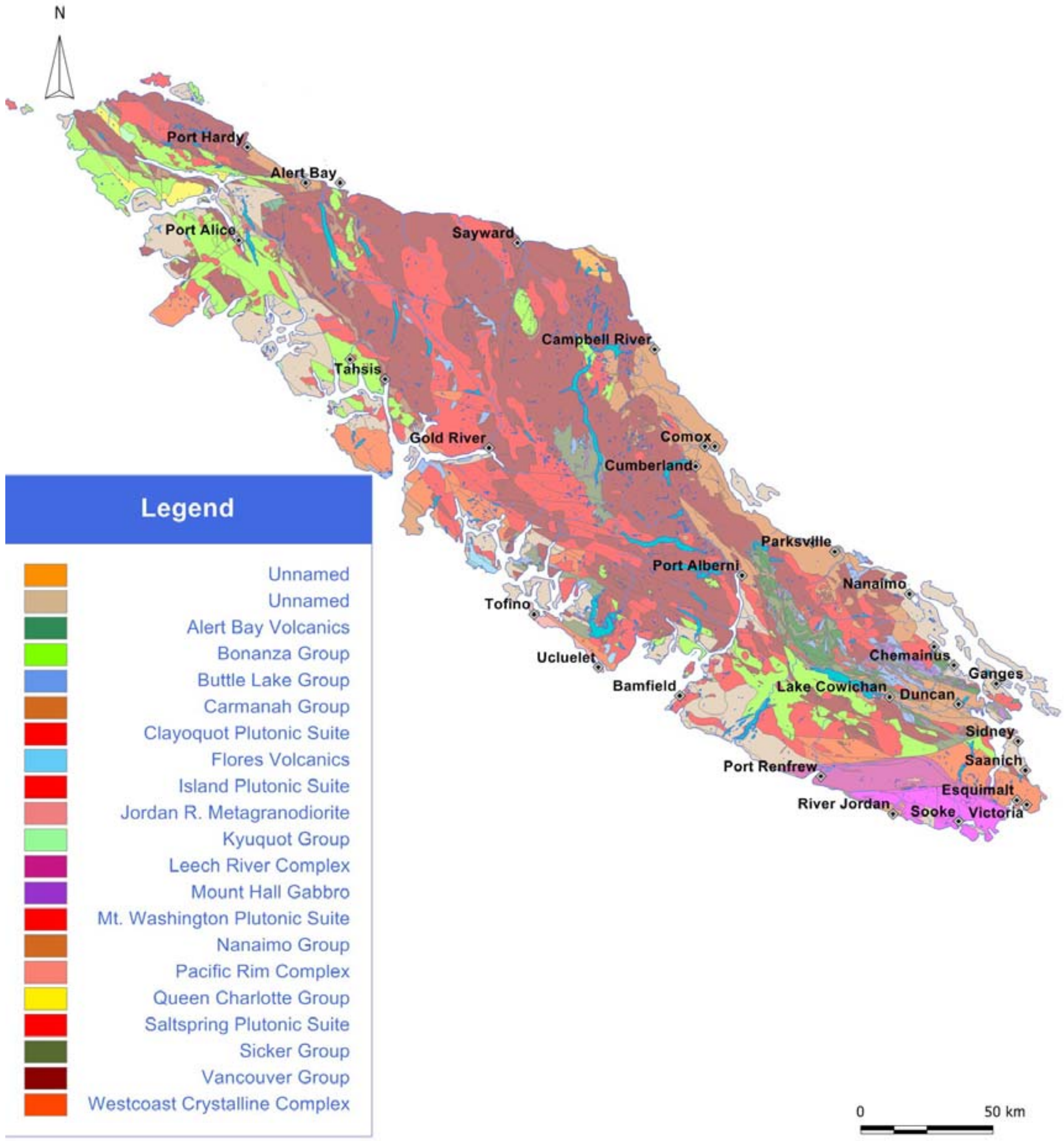

Figure 2. Vancouver Island geology (after Muller et al, 1974)

The primarily felsic Island Intrusions and their extrusive equivalents, the calc-alkaline Bonanza Group volcanics, were emplaced during extensive Jurassic plutonism. This assemblage is interpreted as an island-arc sequence (Muller *et al.,* 1974*).* Accreted to the western and southwestern margin of the island are slivers of a forearc assemblage containing trench and slope sedimentary rocks belonging to the Juro-Cretaceous Leech River and Pacific Rim formations and Eocene basaltic volcanics of the Metchosin Group (Muller, 1977). The development of fault bounded basins along the northern (Queen Charlotte Group) and eastern (Nanaimo Group) margins of the island lead to the deposition during the Lower to Upper Cretaceous of cyclical marine and terrestrial sedimentary sequences containing coal beds (Muller and Jeletzky, 1970). The youngest rocks on Vancouver Island are the Early Tertiary Catface, Tofino and Sooke Intrusions (Muller and Carson, 1969a). They are a volumetrically minor although mineralogically important group occurring as scattered stocks and plugs primarily along the western, southern and eastern margins of the Island (Carson, 1969).

Most base and precious metal deposits on Vancouver Island can be categorized into four basic types: massive sulphides, porphyries, quartz veins and skarns. Table 1 sub-categories deposit types giving examples, commodities, host rocks and related intrusions.

Deposit Category	Sub-Category	Deposit Type	Commodities	Host Lithology	Related Intrusions
Massive Sulphide	Volcano-genic	Myra, Lara	Pb, Zn, Cu, Ag, Au	Felsic flows in upper Sicker group	None
	Magmatic	Tofino Nickel	Ni, Fe, Cu, (Pt, Pd)	Karmutsen Formation volcanics	Feeder zone for Karmutsen rocks
Porphyry	Cu ± Mo	Catface	Cu, Mo		Tertiary "Catface" quartz diorite
	Cu ± Au ± Mo	Mount Washington	Cu, Au, Mo	Karmutsen Formation	Early Tertiary quartz diorite
	Cu ± Mo ± Au	Expo Red Dog	Cu, Mo, Au	Bonanza Group Early Tertiary	Quartz diorite
Quartz Veins	Epithermal	Mount Washington	Au, Ag, Cu, As	Bonanza Group, Sicker Group, Karmutsen Formation	Early Tertiary quartz diorite
	Meso-thermal	Pioneer, Spud Valley	Au, Ag, Cu, Pb, Zn	Bonanza Group, Tertiary Intrusion	Early Tertiary quartz diorite
	Quartz Shears	Thistle, Debbie	Au, Cu, Ag	Sicker Group, Bonanza Group, Leech River Group; along Tertiary shear zones	None apparent
Skarns	Iron - Gold	Merry Widow, Hiller	Fe, Au, Cu, Pb, Zn, Ag	Karmutsen Formation, Quatsino Formation	Jurassic Island Intrusions
	Base metal	HPH 1, Smith Main	Zn, Pb, Cu, Ag, Au	Quatsino and Parson Bay formations, Bonanaza Group	Jurassic Island Intrusions

Table 1. Principal deposit types of Vancouver Island (*(after Muller and Carson, 1969b)

PHYSIOGRAPHY

Holland (1976) identifies two major physiographic units on Vancouver Island; the Coastal Trough and the Insular Mountains (Figure 3). The Coastal Trough is expressed by two subunits, the Nawhitti Lowland north of Quatsino Sound and the Nanaimo Lowland forming the east coast from Sayward to Victoria. These terrains are characterized by flat low-lying coastal plains and the low foothills (< 600 metres a.s.l.) which give rise to the Insular Mountains. Drainages are generally dendritic to rectangular with some lithological control on drainage direction. Roughly 20 per cent of Vancouver Island falls within this physiographic unit.

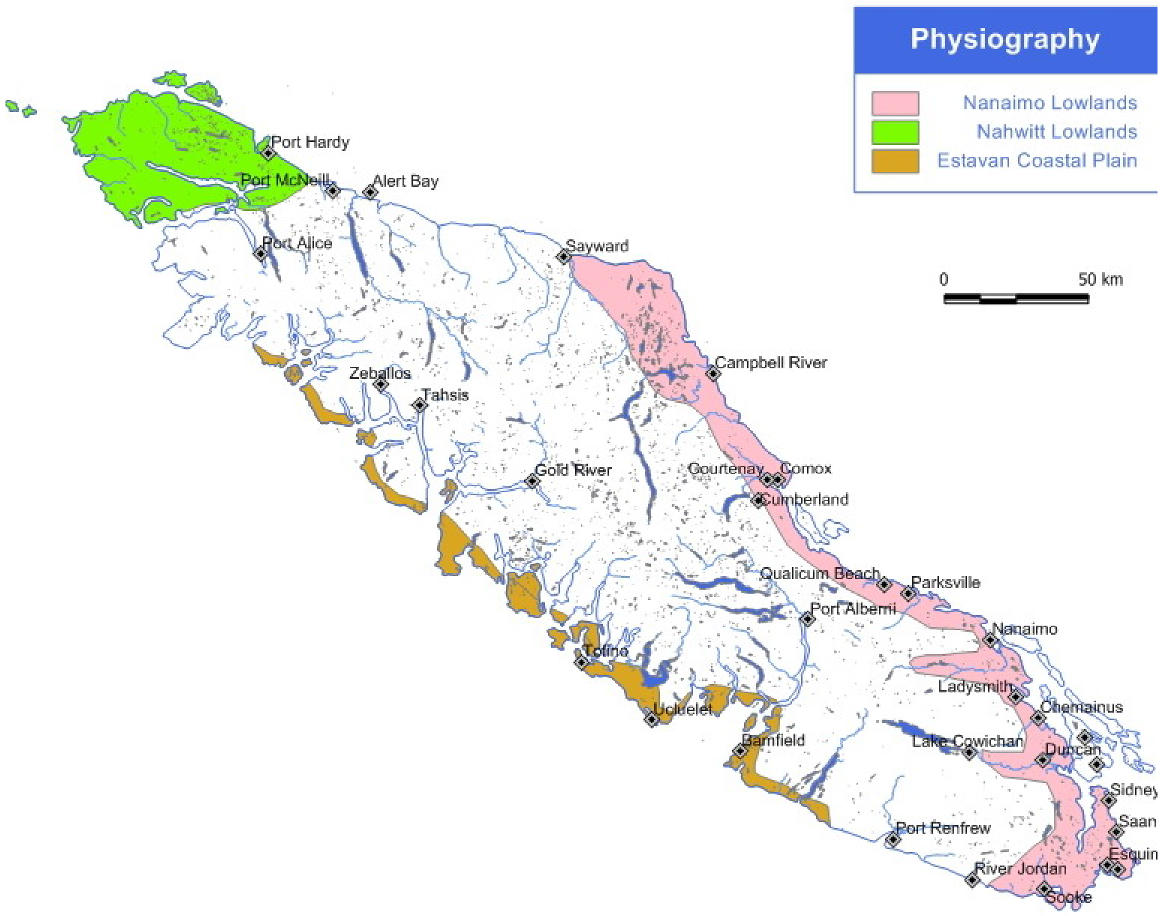

Figure 3. Vancouver Island Physiography (After Holland, 1976)

The Insular Mountain terrain consists of five subunits, of which the Vancouver Island Range and Fiordland are dominant. Both are characterized by U-shaped valleys with steep slopes. Summit elevations rise to 900 metres in the Fiord-land and over 2200 metres in the Vancouver Island Ranges. Drainage is commonly parallel along steep ridges or radial about intrusive centres. The Estavan Coastal Plain, Nimpkish River Valley and Alberni Basin are minor subunits (< 5 per cent of total landmass) characterized by generally low relief and primarily dendritic drainage. The Insular Mountain terrain comprises 80 per cent of Vancouver Island.

SURFICIAL GEOLOGY

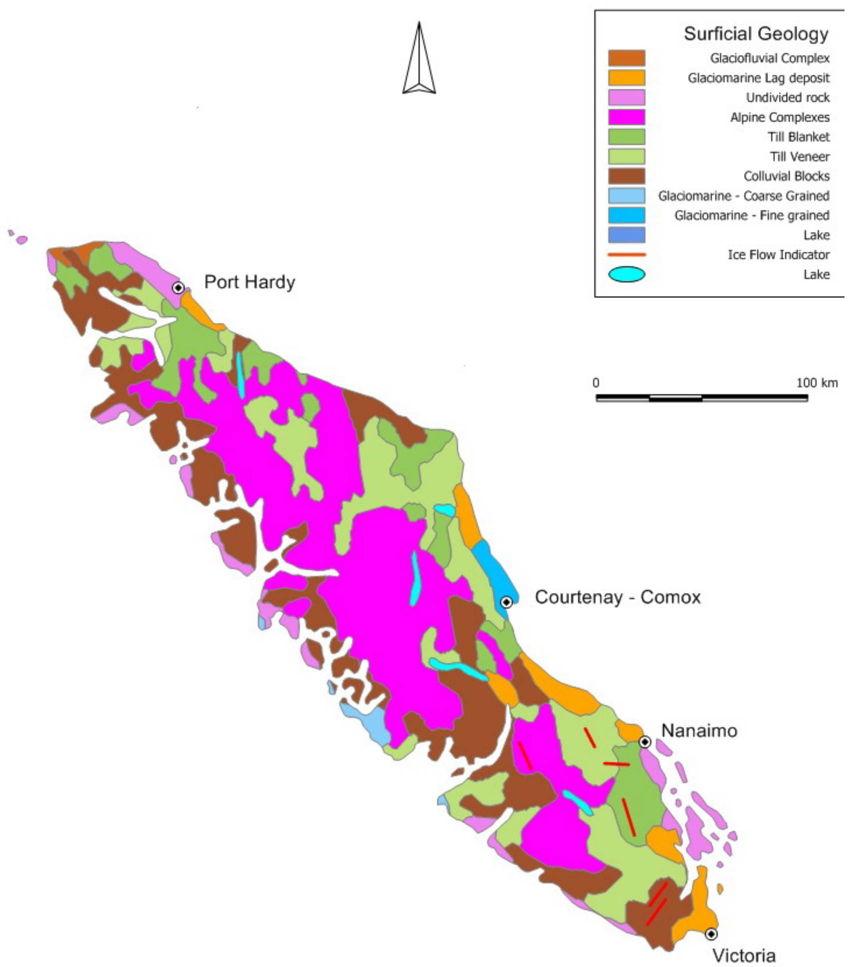

Figure 4. Vancouver Island Surficial geology (After Howes and Nasmith, 1983)

Unconsolidated surficial deposits from three separate glacial and non-glacial intervals are recognized on Vancouver Island (Howes, 1981; Howes and Nasmith, 1983). The majority of surficial deposits however, were formed during, or subsequent to the recent Fraser Glaciation. Onset of the Fraser Glaciation varied from 29 000 years BP (Howes, 1981), to approximately 19 000 years BP (Howes and Nasmith, 1983) from north to south on the island. Ice, accumulating in the Vancouver Island Ranges, flowed along pre-existing valleys either towards the strait of Georgia or the Pacific Ocean during an early phase of alpine glaciation. Ice, having accumulated to a thickness exceeding 15 00 metres in the Strait of Georgia, flowed southwest across the island overriding all except the highest peaks during the glacial maximum, ranging from 20 600 to 15 000 years BP from north to south (Figure 4).

Deglaciation commenced approximately 13 000 years BP. Downwasting ice exposed the uplands and separated the ice sheet into discrete valley glaciers which briefly returned to an alpine flow pattern. Further downwasting resulted in stagnation of the ice masses. Large quantities of meltwater deposited thick sequences of ice contact material and recessional outwash within major valleys. Deglaciation was rapid, the southern tip of Vancouver Island was ice free by 12 100 years BP (Nasmith, 1971) followed by the north and central island by 9 500 years BP (Fulton, 1971). The rate of deglaciation exceeded that of isostatic rebound resulting in marine incursion and sediment deposition in low areas of the Nanaimo and Nawhitti Lowlands, the Alberni Basin and the Estavan Coastal Plain. Subsequently most deposits have been dissected by down-cutting rivers.

The type and proportion of surficial cover varies between physiographical units (Fulton *et al., 1982).*

Insular Mountains: Approximately 80 per cent of surficial deposits comprise thin (1 to 2 metres) till and colluvium primarily found on middle to upper slopes. Roughly 10 to 15 per cent of surficial deposits constitute thick (> 10 metres) till, colluvium and (glacio-)fluvial sediments occupying lower slopes and valley floors. Very thick (> 40 metres) sequences of advance deposits, till, recessional outwash, post glacial lacustrine and fluvial deposits are restricted (5 to 10 per cent of surface cover) to major valleys such as the Nimpkish.

Coastal Trough*:* In the Nanaimo Lowlands, the foothills to the Vancouver Island Ranges are mantled in thin till which thickens downslope (70 per cent of surficial deposits). Valley bottoms contain fluvial and glaciofluvial sediments derived from reworked colluvium, till and glaciofluvial sediment (5 to 10 per cent). The coastal margin is blanketed by thick (> 40 metres) marine sediments (20 to 25 per cent). In the Nawhitti Lowlands, surficial deposits resemble Nanaimo Lowland overburden but with a higher proportion of glaciofluvial sediments (15 to 20 per cent) and a lower marine sediment component (2 to 5 per cent).

CLIMATE AND SOILS

According to Schaefer (1978), at the regional scale, climate is intrinsically related to soils, both are the product of geographical location and large scale topography. Valentine *et al.* (1978) define three separate soil landscapes (Figure 5) on Vancouver Island.

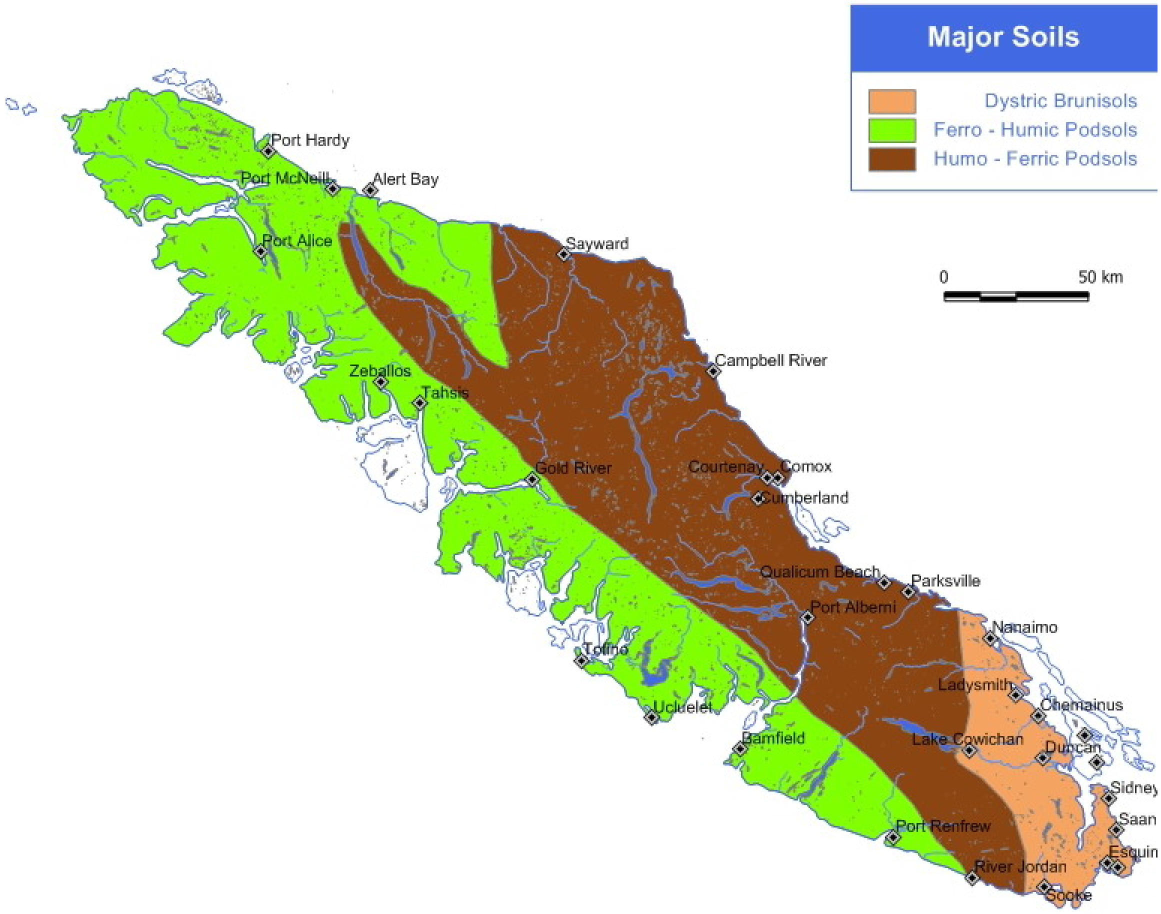

Figure 5. Vancouver Island soils (After Valentine *et al.* 1978)

Ferro-Humic Podzol Landscape*:* Prevailing westerly winds, bringing frequent storms off the Pacific Ocean, produce a wet, mild climate along the western coast and northern third of Vancouver Island. Seasonal fluctuation in temperature is low (<10°C) resulting in mild winters and cool summers (Schaefer, 1978). Precipitation, received primarily as rain at the lower elevations, is abundant (2 500 - 5 000 millimetres annually) and greatest during the winter months. The combination of moisture and temperature produces a classical temperate rain-forest environment. The dominant soil is a ferro-humic podzol. High humidity restricts **evapotranspiration** and results in an excess water balance and the accumulation of thick organic layers (20 - 50 centimetres). The soil is acidic (pH of less than 5.0 is common) and leaches the upper mineral horizon. Organic matter, iron and aluminium, translocated from the upper organic and mineral horizons, accumulates in a dark red to reddish-brown Bhf horizon which often exceeds 1.0 metre in thickness (Junger and Lewis, 1978).

Humo-Ferric Podzol Landscape: The Vancouver Island Ranges create a rain shadow in the central interior and along the eastern coast. A humo-ferric podzol develops in the slightly drier (1 250 to 2 500 millimetres of annual precipitation) and warmer climate. Soils are moist to humid year round. Similar to ferro-humic podzol, leaching of upper mineral horizon (pH of 4.0 to 5.0) causes translocation of iron and aluminum. Unlike the ferro-humic podzol, little or no organic matter is translocated hence a reddish brown Bf horizon develops which may exceed 1 metre in thickness (Junger and Lewis, 1978).

Brunisol Landscape: The southeastern coast, which lies in the rain shadow of the Vancouver Island Ranges and the Olympic Mountains of Washington State, has a near Mediterranean climate. The mean annual temperature of 10°C is the highest in Canada (Schaefer, 1978). Summers are dry and warm, most of the annual precipitation (650 to 1 250 millimetres) is received during the mild winters. Soil moisture is classified as semi-arid (Clayton *et al.,* 1977). Dominant soils are dystric and sombric brunisols which are slightly acidic (pH of 5.5). Iron and aluminium oxides within the Bm horizon are the byproduct of in situ weathering of parent material with little contribution from upper horizons through translocation (Junger and Lewis, 1978).

Media	Conventional Fine-Grained Sediment	Moss-Mat Sediment	Bulk Fine-Grained Sediment	Bulk Sieved Sediment Low-Energy Site	Bulk Sieved Sediment High-Energy Site
Sampling Interval	Conventional fine-grained stream sediment and moss-mat sediment samples were collected at roughly 500 metre intervals, duplicates were generally collected at the most distant downstream station. One site was sampled on background creeks.	Conventional fine-grained stream sediment and moss-mat sediment samples were collected at roughly 500 metre intervals, duplicates were generally collected at the most distant downstream station. One site was sampled on background creeks.	Roughly every 1000 metres and at the most distant downstream station	Samples of screened fine-grained and coarse-grained sediment were collected at the most distant downstream station	Samples of screened fine-grained and coarse-grained sediment were collected at the most distant downstream station
Source Environment	Low-energy sites where fine - grained sediment accumulates. Bank slumps avoided.	Boulders and logs, within active stream channel. Moss growing on bank avoided.	Same as conventional fine-grained sediment.	Same as conventional fine-grained sediment.	High-energy sites, such as point bar heads, characterized by an armour of coarse gravel and cobbles.
Sampling Method	Small plastic shovel used to scoop sediment into Kraft paper sample bag.	Plant mat with sediment layer scraped from substrate, placed in kraft paper sample bag.	Small plastic shovel used to scoop sediment into Kraft paper sample bag.	Raw sediment screened on site to -18 mesh (-1 mm) ASTM, 10 to 50 kilograms of raw sediment must be processed.	Raw sediment screened on site to -18 mesh ASTM, 100 to 300 kilograms of raw sediment must be processed
Site Data	Information collected about location, sample and site characteristics, site sketch and photograph.	Same as conventional fine-grained sediment plus data on mat characteristics.	Same as conventional fine-grained sediment.	Same as conventional fine-grained sediment plus data on amount of raw sediment processed.	Same as screened fine-grained sediment.

Table 2a. Sample collection methods

Media	Conventional Fine-Grained Sediment	Moss-Mat Sediment	Bulk Fine-Grained Sediment	Bulk Sieved Sediment Low-Energy Site	Bulk Sieved Sediment High-Energy Site
Sampling Interval	Oven dry at < 50º	Oven dry at < 50º	Oven dry at < 50º	Oven dry at < 50º	Oven dry at < 50º
Processing	Nil	Mats were pounded then screened with an 18 mesh sieve to recover sediment, plant matter was discarded.	Nil	Nil	Nil
Sieving	One fraction generated, - 80 mesh ASTM (-180 microns).	Same as conventional fine-grained sediment.	Three size fractions generated from each of the bulk fine-grained sediment and bulk sieved fine-grained and coarse-grained sediment samples, in 1987 the -60+ 100 mesh (-250+ 150 microns), -100+200 mesh (-150 +75 microns) and -200 mesh (-75 microns) fractions were generated, in 1988 the -45+80 mesh (-360+ 180 microns), -80+ 170 mesh (-180+90 microns) and -170 mesh (-90 microns) fractions were generated.	Three size fractions generated from each of the bulk fine-grained sediment and bulk sieved fine-grained and coarse-grained sediment samples, in 1987 the -60+ 100 mesh (-250+ 150 microns), -100+200 mesh (-150 +75 microns) and -200 mesh (-75 microns) fractions were generated, in 1988 the -45+80 mesh (-360+ 180 microns), -80+ 170 mesh (-180+90 microns) and -170 mesh (-90 microns) fractions were generated.	Three size fractions generated from each of the bulk fine-grained sediment and bulk sieved fine-grained and coarse-grained sediment samples, in 1987 the -60+ 100 mesh (-250+ 150 microns), -100+200 mesh (-150 +75 microns) and -200 mesh (-75 microns) fractions were generated, in 1988 the -45+80 mesh (-360+ 180 microns), -80+ 170 mesh (-180+90 microns) and -170 mesh (-90 microns) fractions were generated.
Separations	Nil	Nil	Nil	In 1987, screened fine-grained & coarse grained sediment samples were processed by heavy liquid separation (tetrabromoethane s.g. 2.95) before sieving. In 1988 these samples were processed by HL separation after sieving. Magnetic separation into no-magnetic, para-magnetic and magnetic fractions was carried out on the 1987 sample only.	In 1987, screened fine-grained & coarse grained sediment samples were processed by heavy liquid separation (tetrabromoethane s.g. 2.95) before sieving. In 1988 these samples were processed by HL separation after sieving. Magnetic separation into no-magnetic, para-magnetic and magnetic fractions was carried out on the 1987 sample only.

Table 2b. Sample preparation methods

Media	Conventional Fine-Grained Sediment	Moss-Mat Sediment	Bulk Fine-Grained Sediment	Bulk Sieved Sediment Low-Energy Site	Bulk Sieved Sediment High-Energy Site
Digestion	Sub-samples (0.5 g) of conventional fine-grained sediment, moss-mat sediment and bulk fine-grained sediment were digested in 3 ml of Aqua regia ($3HCl:HN0_3:2H_20$) at 95°C for 1 hour then diluted to 10 ml with water.	Sub-samples (0.5 g) of conventional fine-grained sediment, moss-mat sediment and bulk fine-grained sediment were digested in 3 ml of Aqua regia ($3HCl:HN0_3:2H_20$) at 95°C for 1 hour then diluted to 10 ml with water.	Sub-samples (0.5 g) of conventional fine-grained sediment, moss-mat sediment and bulk fine-grained sediment were digested in 3 ml of Aqua regia ($3HCl:HN0_3:2H_20$) at 95°C for 1 hour then diluted to 10 ml with water.		
Analysis	Sample solutions were aspirated into an inductively coupled plasma-emission spectrometer (ICP-ES) for the determination of Ag, Al, Ba, B, Cd, Ca, Cr, Co, Cu, Fe, La, Pb, Mg, Mn, Mo, Ni, P, K, Na, Sr, Th, Ti, W, U, V and Zn. Results are quantitative for base metals and Ag, semi-quantitative for siderophile & lithophile elements and qualitative for refractory elements (e.g. B, Cr and W. Aliquots of the sample solutions were reduced to produce hydrides of As, Sb, Bi, Ge, Se and Te which were determined by ICP-ES. Subsamples (10 g) of conventional fine-grained stream sediment, moss-mat sediment and bulk fine-grained sediment were ignited at 600°C then digested in aqua regia. Gold was extracted using MIBK and determined by AAS.	Sample solutions were aspirated into an inductively coupled plasma-emission spectrometer (ICP-ES) for the determination of Ag, Al, Ba, B, Cd, Ca, Cr, Co, Cu, Fe, La, Pb, Mg, Mn, Mo, Ni, P, K, Na, Sr, Th, Ti, W, U, V and Zn. Results are quantitative for base metals and Ag, semi-quantitative for siderophile & lithophile elements and qualitative for refractory elements (e.g. B, Cr and W. Aliquots of the sample solutions were reduced to produce hydrides of As, Sb, Bi, Ge, Se and Te which were determined by ICP-ES. Sub samples (10 g) of conventional fine-grained stream sediment, moss-mat sediment and bulk fine-grained sediment were ignited at 600°C then digested in aqua regia. Gold was extracted using MIBK and determined by AAS.	Sample solutions were aspirated into an inductively coupled plasma-emission spectrometer (ICP-ES) for the determination of Ag, Al, Ba, B, Cd, Ca, Cr, Co, Cu, Fe, La, Pb, Mg, Mn, Mo, Ni, P, K, Na, Sr, Th, Ti, W, U, V and Zn. Results are quantitative for base metals and Ag, semi-quantitative for siderophile & lithophile elements and qualitative for refractory elements (e.g. B, Cr and W. Aliquots of the sample solutions were reduced to produce hydrides of As, Sb, Bi, Ge, Se and Te which were determined by ICP-ES. Sub samples (10 g) of conventional fine-grained stream sediment, moss-mat sediment and bulk fine-grained sediment were ignited at 600°C then digested in aqua regia. Gold was extracted using MIBK and determined by AAS.	The various size fractions of the screened fine-grained and coarse-grained sediment samples were analysed by instrumental neutron activation (INAA). Sub samples weighting upwards of 100 g were irradiated in a neutron flux field, subsequently gamma radiation from emitting isotopes was measured. Characteristic wavelengths and intensities give quantitative measurements on element abundances. Different laboratories were used for analysis of the 1987 and 1988 samples, elements common to the two laboratories are: Au, Ag, As, Ba, Co, Ce, Cr, Eu, Fe, Hf, Ir, Lu, Mo, Na, Ni, Sb, Sc, Sm.	

Table 2c. Sample analytical methods

PART 1- A COMPARISON OF SAMPLE MEDIA

INTRODUCTION

Paramount to the RGS program, and similar surveys (Plant *et al.,* 1989), is a sample medium which is easily collected, representative of general geochemical trends and generates results comparable to the existing database. In Part 1, comparisons are made: a) between moss-mat and conventional fine-grained stream sediments for absolute element concentrations; b) between moss-mat, conventional fine-grained stream sediment and heavy mineral concentrates from low and high energy environments on the priority ranking of mineralized and non-mineralized drainage basins based on gold concentrations; c) between three size fractions from bulk fine-grained sediment samples for absolute element concentrations; and finally, d) between moss-mat and conventional fine-grained stream sediment field duplicates on their reproducibility of element concentrations. Results of these comparisons determine: whether absolute element concentrations are similar, the presence and cause of medium-specific biases, and the ability of the various media to recognize streams draining mineralized areas.

In several cases, it was noted that completely different conclusions could be drawn for different basins or from different locations within the same basin. For example, two basins of similar geology and physiography could yield contradictory results on the concentrations of various elements in moss-mat and conventional fine-grained stream sediment. Local differences in stream energy, sediment size fraction composition, organic content and bank contamination invariably produces noise which obscure local geochemical trends. At the scale of regional surveys however, gross differences between basins become apparent thus the comparisons presented below are relevant only to this scale.

A. COLLECTION AND PREPARATION

Moss mats were ubiquitous to all streams visited and were usually available in moderate to abundant amounts. Appropriate samples were easily located by traversing upstream. Conventional fine-grained stream sediments could also be located, however in the mountainous rain forest environment, common to the interior and west coast of the island, considerable time was spent checking potential low-energy sites for suitable sediment accumulations. Bulk fine-grained samples which required larger accumulations took correspondingly longer to collect. Bulk sieved samples from high and low-energy sites required the greatest time for collection due to the arduous process of sieving up to 300 kilograms of raw sediment to retrieve a 10 kilogram sample. Collection times of 1 hour or more per site were not uncommon.

Sample processing proved that the yield of -80 mesh sediment was five times greater, on average, from moss-mat sediment relative to conventional fine-grained stream sediment for samples of comparable weight. Heavy mineral separation costs for bulk sieved samples were an order of magnitude greater relative to moss mat and conventional sediment preparation costs.

B. COMPARISON OF CONVENTIONAL FINE-GRAINED STREAM SEDIMENTS AND MOSS-MAT SEDIMENTS

Methods

It is expected that results for these two media should be comparable due to relative similarity of the sediment, size fraction analyzed, and the analytical methods employed. Comparisons are based on a bivariate linear regression method which permits a statistical confidence test for departure from perfect correlation in which the results define a regression line on a Cartesian graph whose slope is 1 and passes through the origin. Reduced major axis regression (RMAR) was selected since it takes into account variability of both the dependant (y) and independent (x) variables. The RMAR equation takes the same form as simple linear regression:

$y = a_1x + a_0$ Where a_1 is the slope of regression and a_0 is the y intercept

To test the significance of the regression, the correlation coefficient (r-value) was calculated and compared to critical values at a confidence level of 95 per cent. In the event the r-value was significantly different from 0 (indicating a significant correlation), the 95 per cent confidence limits of a_1 and a_0 were calculated. The **null** hypothesis is that a_0 is not significantly different from 0, and a_1 is not significantly different from 1. A fixed bias is introduced when a_0 is not equal to 0, a **proportional** bias results when a_1 is not equal to 1.

An underlying assumption of linear regression is that both variables are normally distributed. Since both background and mineralized drainages are included in this study, results were log transformed to approximate normal distributions. Significant outliers were screened from the data set to prevent their biasing the statistical tests. Statistical analyses were conducted separately for the 1987 and 1988 data sets to eliminate between-year analytical variations introduced by changes in laboratory techniques and calibrations.
Results

Results for both data sets are summarized in Table 3.

Slope	**$a_1 < 1$**	**$a_1 = 1$**	**$a_1 > 1$**
Intercept			
$a_o < 0$	Ca, Na, K, Ni_N	Mg, Al	Hg, As_N
$a_o = 0$	BaN, Sr, Ti_N	Mo, Cu, Pb, Zn, Co, Mn, V, La, Se, Cr, Au_N	Au_N, P, W, Ti_S
$a_o > 0$	Fe, Ni_S, Ba_S	Te, As_S, Sb_S	

Table 3. Comparison of regression biases (95% confidence level) for moss-mat sediments and conventional fine-grained sediments[1]

A core of elements comprising cobalt, copper (Figure 6a), chromium, lanthanum, lead, manganese, molybdenum, selenium,vanadium and zinc lack proportional or fixed bias in either the 1987 or 1988 data set. Aluminum, barium, calcium (Figure 6b), magnesium, potassium, sodium and strontium display proportional and/or fixed bias towards conventional fine-grained stream sediments ($a_1 < 1$ and/or $a_0 < 0$) throughout the concentration range. In contrast, moss-mat sediments yield consistently higher concentrations of tungsten and phosphorus in both data sets and significantly higher gold (Figure 6c) in the 1987 data set.

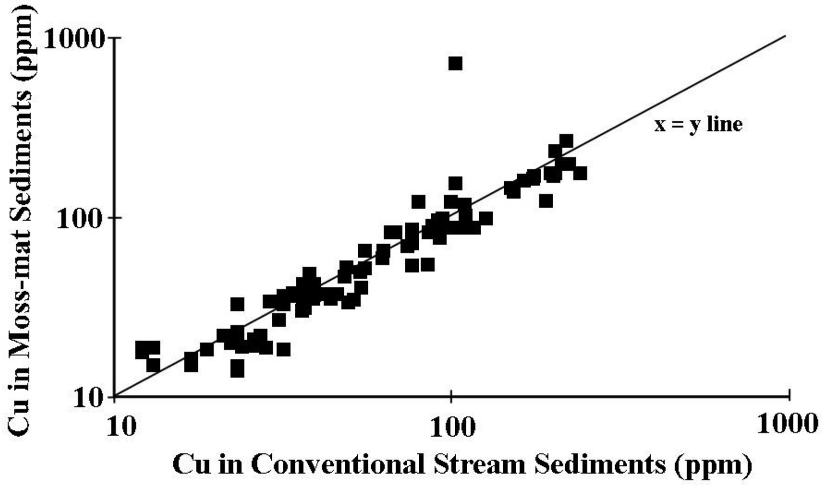

Figure 6a. Example of elements exhibiting no bias – copper.

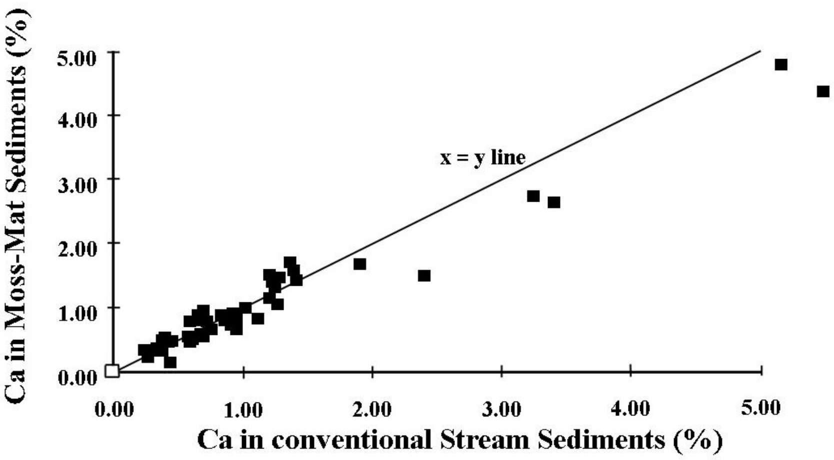

Figure 6b. Example of elements exhibiting proportional bias – calcium.

Iron in moss-mat sediment exceeds conventional fine-grained stream sediment only at low concentrations, the inverse relationship is exhibited by mercury. Some elements reverse their bias between surveys. Titanium demonstrates a proportional bias towards conventional fine-grained stream sediments ($a_1 < 1$) in the 1987 data set and towards moss-mat sediments ($a_1 > 1$) in the 1988 data set. Similarly, arsenic has a proportional bias towards moss-mats sediment in the 1987 data set ($a_1 > 1$) which is not present in the 1988 data set.

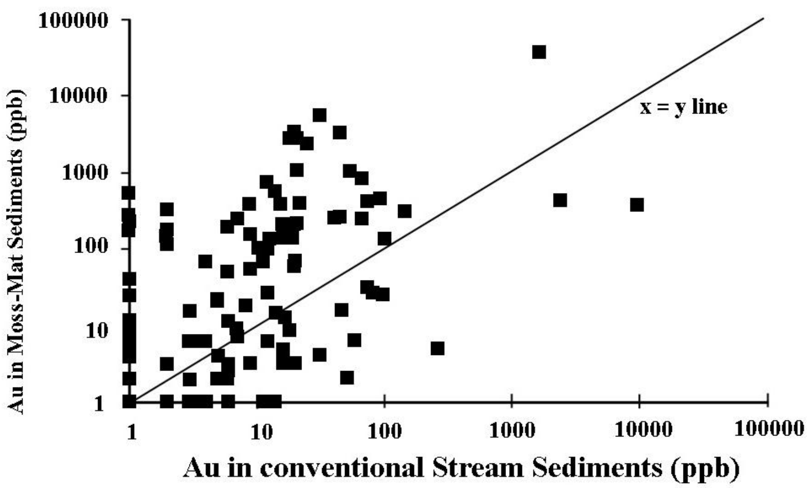

Figure 6c. Example of elements exhibiting bias – gold in moss mat sediment.

Discussion

The results confirm the prediction that concentrations, for a large group of elements, are not significantly different for moss-mat sediments and conventional fine-grained stream sediments. Various elements in this group have chalcophile (cobalt, copper, lead, molybdenum, selenium, zinc), siderophile (cobalt, molybdenum) or lithophile (chromium, lanthanum, manganese, vanadium) characteristics, that is they have an affinity for sulphur, iron or silicates (Levenson, 1974). The relative mobilities (Andrews-Jones, 1968) of these elements, as aqueous phases in the **secondary environment**, range from highly to very highly mobile under all but reducing conditions (molybdenum, selenium, vanadium), to highly mobile under oxidizing acidic environments (cobalt, copper, zinc), to low or immobile under all conditions (chromium, lanthanum, lead, manganese). The varying affinities and mobilities, coupled with the similarity in concentrations would suggest that the nature of the sediment *(i. e.* composition and proportion of various primary and secondary minerals, size range of mineral grains) containing these elements is not biased by media type.

Gold, mercury and tungsten, which display a proportional bias towards moss-mat sediments, are generally found in **heavy detrital minerals** (native gold, cinnabar, scheelite). This group of minerals are apparently preferentially concentrated in moss-mat sediment. In the following case studies (presented in Part 2), wherein anomalous gold concentrations are present, gold levels in moss-mat sediment are one to two orders of magnitude greater than in companion conventional fine-grained stream sediment. Visual interpretation of the scatter diagram for gold in the 1988 data set suggests a strong proportional bias towards moss-mat sediment. The unexpected statistical interpretation of non-bias is due to high variability leading to wide confidence limits on a_0 and a_1 and a low (although statistically significant) correlation coefficient. The ability of aquatic moss to accumulate heavy minerals has not been reported in the literature available to the authors. Biogeochemical studies, by other authors, have concentrated either on the absorption of various elements into the plant structure (Erdman and Modreski, 1984; Jones, 1986; Shacklette, 1965, 1984) or on the base metal content of trapped sediment (Smith, D.C., 1978; Smith, S.C., 1986). The rough surface presented by moss mats growing on boulders or logs are likely sites for **settling** or **entrainment** sorting during floods when the mats are inundated. Intuitively, chromium, iron and titanium, which commonly occur as high density minerals (chromite, magnetite, titanite or ilmenite), would belong to above group. Very likely, the presence of more readily digested, moderate density ferromagnesian and secondary minerals obscures any moss-mat enrichment trend which may exist at a regional scale. In the case studies to follow however, these elements are seen to be concentrated in some moss-mat sediment samples, particularly those associated with iron skarn deposits.

Phosphorous, which is consistently enhanced in moss-mat sediment in both data sets, occurs most abundantly as apatite, a calcium phosphate mineral of moderate density (2.5 to 3.2 *s.g.)* and therefore unlikely to be enriched by hydraulic sorting. The enhanced concentrations are probably due to the presence of moss plant fibres in the analyzed sub-sample. Comparative analyses of phosphorous in ashed terrestrial mosses and their substrata (soil, rock or plant matter) by Shacklette (1965) on 1 553 sample pairs, indicated an average moss to substratum concentration ratio of 480. Other elements in that study which displayed high plant ash to substratum ratios were: copper (400), barium (200), lead (200), potassium (200), magnesium (150), calcium (100), manganese (100), zinc (80), aluminium (45), nickel (33) and strontium (25). A comparable multi-element study on aquatic mosses is not available, however abnormally high phosphorus and potassium concentrations in organic rich (LOI values > 60 %) moss-mat sediment samples from Spud Creek (CS #8) and Toray Creek (CS #10), suggests similar behaviour.

The suite of elements which are consistently enriched in conventional fine-grained stream sediment (aluminium, barium, calcium, magnesium, potassium, sodium and strontium) are all lithophile and common constituents of a wide variety of silicate minerals. Their relative mobilities vary from high under all conditions (calcium, magnesium, sodium, strontium) to low under all conditions (barium, potassium) to very low or immobile under all conditions (aluminium). The reason for these enrichments is open to considerable speculation. Enhancement of low or immobile lithophile elements would suggest that the sediment, for these elements, is inherently different between media types. Ideally, the source, using Fieldes and Swindales (1954) sequence for increasing resistance to weathering of primary minerals, would be: olivine > augite - hyperstene > hornblende > zeolites > biotite - muscovite > feldspars > quartz. The main contributors are likely the mafic chain silicates and phyllosilicates (Church *et al*., 1987). A relative enhancement of phyllosilicates in conventional fine-grained stream sediments would suggest that very fine-grained (silt and clay) or high surface area to weight ratio minerals may not be effectively trapped in moss mats, further research is required to resolve this issue.

In several of the following case studies, substantial enrichment of the highly mobile lithophile elements in conventional stream sediments, occur in association with carbonate-rich lithology. Hypothetically, weathering of the carbonate lithology, particularly near contacts with acid generating rocks, could release these elements as aqueous phases. Precipitation as sediment grain coatings may occur at some distance from the contact. Conventional stream sediment, in constant contact with mineralized stream and ground water, could develop thicker grain coatings relative to the aquatic mosses collected in this study which grow above the normal water level and are therefore removed from potentially enriched solutions. In addition, sediment trapped in mosses may tend towards lower a pH (relative to local stream sediment) due to exposure to rain and the decay of organic matter in the mat. The extent of this effect is unknown and needs to be quantified.

C. COMPARISON OF HEAVY MINERAL CONCENTRATES WITH OTHER MEDIA

Methods

Direct comparisons of element concentrations can not be made between **the heavy mineral concentrates** (HMC) produced from the bulk sieved sediment samples from low and high-energy sites and the non-concentrated sediment from moss-mat and conventional fine-grained stream samples. However, comparisons can be made on the relative ability of the various media to distinguish mineralized and non-mineralized (i.e., background) drainage basins. Identification of non-mineralized basins as anomalous and failure to recognize mineralized basins are important errors in the economics of mineral exploration and anomaly follow-up. Only gold results are considered in the following comparison.

Gold concentrations of the heavy mineral concentrates span several orders of magnitude. Results are standardized by recalculating the concentrations of the heavy mineral concentrates (Au_{HMC}) to the original sieved sample weight (Au_{TOTAL}) thereby correcting for noise introduced by variance in the abundance of common heavy minerals such as magnetite and ferromagnesian silicates.

$$Au_{TOTAL} = (Au_{HMC} \times Wt_{HMC})/Wt_{TOTAL}$$

Wt_{HMC} and Wt_{TOTAL} are the weights of the heavy mineral concentrate and the total sample. Values of AU_{TOTAL} were calculated for samples collected from both high and low-energy environments in the stream.

Priority ranking of streams for the four media types is based on Au_{TOTAL} results for heavy mineral concentrates from high-energy sites. This medium is assumed to most likely detect gold, if present (Day 1988). This comparison does not include 1988 orientation survey results since bulk sieved sediment samples from low-energy sites were not collected. The priority rankings are presented in Figure 7 and Table 4. Moss-mat and conventional stream sediment results are in parts per billion (ppb). The results for Au_{TOTAL} in Figure 7 are in parts per trillion to permit comparison of all data on the same graph.

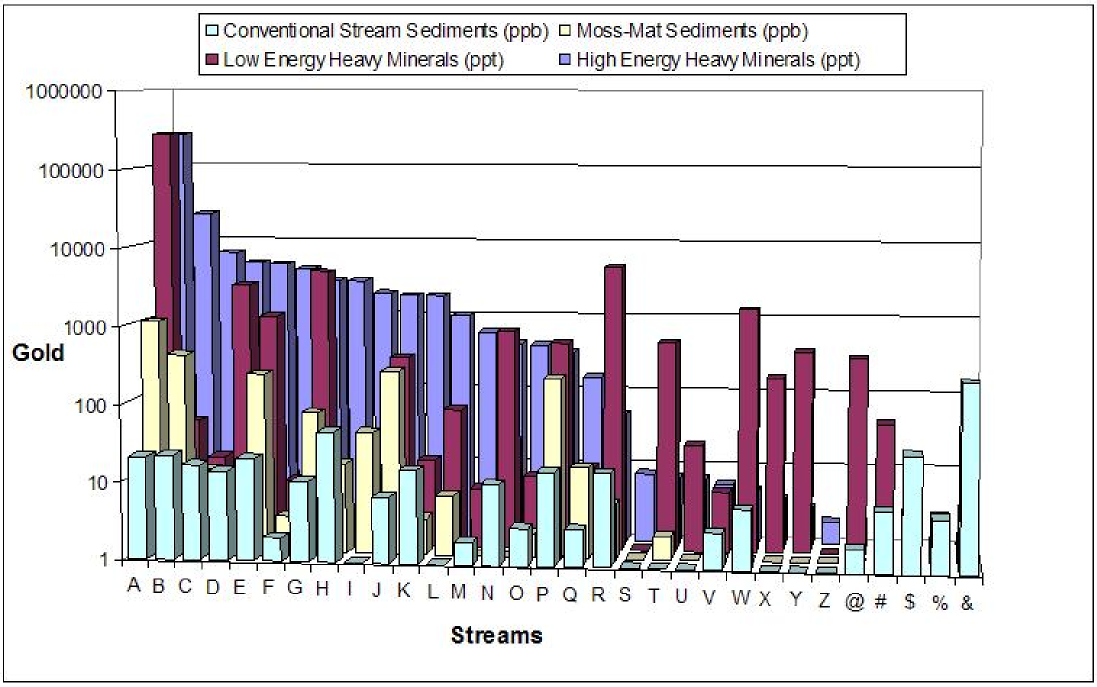

Figure 7. Priority ranking of streams for gold content in heavy mineral concentrates, moss-mat sediment and conventional fine-grained stream sediments.

Results

High-energy heavy mineral concentrates provide an adequate classification of mineralized and non-mineralized basins. This medium yields the highest gold concentrations for Spud (CS #8) and Goldvalley Creeks (CS #9) whose watersheds contain several past producing gold mines. Also ranked highly are Hepler Creek (CS #2) which drains the Expo copper-porphyry deposit area, Jeune Creek (CS #4) and Merry Widow Creek (CS #5) whose watersheds contain gold bearing skarn deposits. The three Zeballos area background streams (TB, Little Zeballos and Nomash River) however, compare with the results for Red Dog Creek (CS #1) which drains the Red Dog copper-porphyry deposit area and Tsowwin River (CS #12) whose drainage contains two auriferous quartz-vein deposits. This suggests regionally elevated gold values may be associated with the Zeballos Stock. Perry River also gave a highly ranked (6th) result.

CREEK NAME	CODE	HIGH ENERGY HEAVY MINERALS (ppb)	LOW ENERGY HEAVY MINERALS (ppb)	MOSS-MAT SEDIMENTS (ppb)	CONVENTIONAL STREAM SEDIMENTS (ppb)
Artlish	&	na	na	5	260
Rainier	%	na	na	4	5
Toray	**$**	**na**	**na**	**4**	**31**
T2	#	0.001	0.051	2	6
Nahwitti	@	0.002	0.364	1	2
Yootook	Z	0.002	na	1	1
Nl	Y	0.003	0.427	1	1
N7	X	0.004	0.195	1	1
Craft	W	0.005	1.478	1	6
Vieux	V	0.006	0.006	1	3
N6	U	0.007	0.025	1	1
T3	T	0.007	0.546	2	1
N9	S	0.008	na	1	1
Extravagant	**R**	**0.051**	**5.133**	**5**	**16**
Kinman	**Q**	**0.155**	**0.012**	**15**	**3**
HPH	**P**	**0.331**	**0.511**	**210**	**16**
Mead	O	0.415	0.009	2	3
Storey	N	0.432	0.735	1	11
Akery	M	0.617	0.006	1	2
Nomash	L	1.028	0.066	6	1
TB	K	1.829	0.014	3	16
Red Dog	**J**	**1.861**	**0.316**	**250**	**7**
Malaspina	I	2.013	na	39	1
Tsowwin	**H**	**2.826**	**na**	**15**	**48**
Little Zeballos	G	2.888	4.251	69	11
Perry	F	4.1	0.007	3	2
Merry Widow	**E**	**4.831**	**1.083**	**215**	**21**
Jeune	**D**	**4.925**	**2.815**	**1**	**14**
Hepler	**C**	**6.778**	**0.014**	**12**	**17**
Spud	**B**	**22.697**	**0.042**	**376**	**22**
Gold Valley	**A**	**262.674**	**274.2**	**1010**	**21**
Notes	na = no sample collected. Creek basins in bold letters contain mineral deposits See text for explanation of heavy mineral concentrates				

Table 4. Comparison of Gold Content of Heavy Minerals, Moss-mat Sediments and Conventional Fine Grained Sediments

In comparison, results from the low-energy heavy mineral concentrates are highly erratic. Although the highest gold concentrations occur in Goldvalley Creek, low-energy sediments from Spud Creek, Hepler Creek and Red Dog Creek yield much lower concentrations than several background creeks. In general, definition between mineralized and non-mineralized basins is poor.

Gold concentrations in moss-mat sediments exhibit a narrower range of **contrast** than the HMC samples, but nonetheless span four orders of magnitude. This medium yields a similar overall identification of basins known to contain gold deposits as the high-energy heavy mineral concentrate samples. The contrast between mineralized and background basins in the Zeballos area is also comparable to the high-energy heavy mineral concentrates. This medium also identified HPH Creek (CS #3) as gold bearing (ranked 5th) but produced low gold results for Hepler Creek, Jeune Creek and Toray Creek (CS #10).

Conventional stream sediments yield a ranking of the top seven streams comparable to the high-energy heavy mineral concentrates however the highest concentration was detected in a background sample from the Artlish River. Although the results span three orders of magnitude, contrast between mineralized and background basins is weak.

Discussion

Differences between gold results in various media can be attributed to at least three different sources of variability, namely:

1) Rare grain sampling ("nugget") effects.
2) Mineralogical effects, such as the form of gold, and its' size fraction distribution.
3) The tendency for accumulation or deficiency of gold in certain stream environments.

The **"nugget effect"** (Clifton *et al.,* 1969) has been previously identified as a factor to be considered in sampling stream sediments on Vancouver Island (Day and Fletcher, 1986). The "nugget effect" becomes less pronounced when the number of gold grains increases per unit volume of sub-sample (either by pre-concentrating from a larger sample or by a reduction in the size of gold grains). Heavy mineral concentrates from high-energy sites should display a minimal effect due to double concentration (natural and analytical).

Contrast between mineralized and non-mineralized basins is very poor for the low-energy heavy minerals which produce generally erratic results suggesting severe nugget effects with this type of sample.

Extreme effects are expected for conventional fine-grained stream sediments due to the routine analysis of small (10 to 30 grams) sub samples of un-concentrated sediment (Harris, 1981). For example, gold analysis of second and third sub-sample splits from Goldvalley Creek (CS #9) conventional fine-grained stream sediment samples gave considerably higher average concentrations (2 166 and 6 214 ppb respectively) compared to the initial analyses (631 ppb) with the effect evident at low (GV-SS-06: 1st analysis - 2 ppb; 3rd analysis - 420 ppb) and high (GV-SS-02: 1st analysis – 1 660 ppb; 3rd analysis 32 950) concentrations. Ineffective sub-sample splitting may be compounding the "nugget effect" in Goldvalley Creek samples.

Moss-mat sediments may be less susceptible to "nugget effects" (relative to conventional fine-grained stream sediments), assuming that the comparatively higher concentrations are a product of more gold grains rather than selective trapping of larger gold grains. Further study on gold grains size distribution in moss-mat sediment is required to resolve this issue. The high result (210 ppb) for HPH Creek may be due to a sporadic coarse gold particle.

The form and size of gold may result in significant differences between media. Heavy mineral samples may not define fine-grained gold anomalies (<50 microns) due to the difficulty of separating this size fraction by gravity methods such as heavy liquid (Day, 1988; Harris, 1981) or panning (Giusti, 1986; Wang and Poling, 1983). Estimation of gold concentrations in heavy mineral concentrates from low-energy sites would be critically effected since a high proportion of the gold at these sites would be fine grained (Fletcher, 1990). Conventional fine-grained sediments, and moss-mat sediments may be more appropriate under these circumstances. Red Dog Creek (CS #1), for example, was ranked 4th by moss-mat sediments. High-energy heavy mineral concentrates yielded a rank of 7th, similar to the Zeballos area background streams while low-energy heavy mineral concentrates produced a rank of 12th, well below numerous background streams. The gold in Red Dog Creek is known to be fine and uniformly distributed in conventional fine-grained stream sediments. The authors have used this material as a low anomalous gold standard (average 30 ppb) for several years in several hundred analyses. Similarly, the anomalous moss-mat sediment result for HPH Creek may be due to "nugget effects" or could indicate a significant fine gold component associated with these base-metal skarns.

Finally, the differences between media concentrations demonstrate, to some extent, the differential accumulation of gold in certain environments. Day and Fletcher (1989) showed that gold (particularly the coarser size fractions) is commonly enriched in high-energy sites such as gravel bar heads compared to low-energy sites such as bar tails. In the following survey, this is apparent when comparing average concentrations. High-energy heavy mineral concentrates contain at least one order of magnitude more gold relative to low-energy heavy mineral concentrates. There are several contradictory examples which may be related to the gold grain size fraction distribution in the various deposits, heavy mineral separation problems and "nugget effects".

The difference in concentrations between moss mat and conventional fine-grained sediments is well developed in the mineralized basins. Ideally, moss mats growing on boulders or logs well above the creek bed act as local high-energy sites when inundated during floods. The roughness of the mat surface may allow for selective entrapment of high density minerals in a similar manner to that proposed by Fletcher (1990) for gravel bar heads. The strong contrast between mineralized and background basins and general agreement with high-energy heavy mineral concentrates on stream ranking would support this hypothesis.

D. COMPARISON OF SIZE FRACTIONS

Methods

Analytical results for the three size fractions from bulk fine-grained sediment samples were examined to determine how the concentrations are partitioned. Cumulative bar charts were generated using ratios of mean concentrations in each size fraction standardized to 100 per cent. Standard deviations and coefficient of variations were also calculated. The element patterns from non-mineralized basins were examined to determine a partitioning pattern which might be classified as background. Associations of elements which partition similarly may help to define element speciation. Elements, other than gold, having coefficients of variation exceeding 20% were excluded from this study since they would likely generate ambiguous results. Results for mineralized basins were then examined in a similar manner for selected elements. Mineralized-basin and background results were compared to determine the presence and cause of deposit related partitioning trends. Deposits were grouped upon the four basic types defined in the Description of Study Area.

Results

The partitioning of element concentrations between size fractions in background streams is presented in Figure 8 and Table 5 in a sequence of decreasing partitioning in the fine fraction. As would be anticipated, most elements display generally increasing concentrations with decreasing sediment grain size. The degree of increase varies with each element. Gold and titanium mark opposite ends of the spectrum with gold showing the greatest partitioning (concentration contrast of 2.5: 1 between fine and coarse fractions) and titanium the least (0.9:1 concentration contrast). Gold also displays the greatest coefficient of variation of any element in all three fractions (72.9 % in coarse; 70.2 % in medium; 46.7% in fine). Elements of similar chemical nature are seen to cluster in the sequence. Lithophile elements generally associated with common silicates (aluminium, barium, calcium, lanthanum, manganese, strontium) are strongly partitioned towards the fine fraction (average fine to coarse fraction contrast of 1. 4: 1).

Lithophile and siderophile elements (chromium, iron, magnesium, titanium, vanadium) found in common heavy detrital and ferromagnesian minerals are evenly partitioned (average fine to coarse fraction contrast of 1:1). The chalcophile elements (cobalt, copper, molybdenum, nickel and zinc) as a group display moderate partitioning towards the fine fraction (average contrast of 1.2: 1).

Element	Fine			Medium			Coarse		
	X	S	V	X	S	V	X	S	V
Au	50.80%	23.70%	46.70%	29.20%	20.50%	70.20%	20.10%	14.60%	72.90%
LOI	45.50%	5.40%	11.80%	31.90%	2.80%	8.70%	22.70%	3.60%	16.10%
As	42.00%	5.20%	12.40%	31.30%	3.80%	12.30%	26.70%	3.50%	13.00%
Ba	40.30%	3.00%	7.30%	32.80%	2.30%	6.90%	26.90%	2.50%	9.40%
Sr	39.30%	4.20%	10.60%	32.80%	1.90%	5.90%	27.80%	3.40%	12.10%
P	38.90%	5.10%	13.10%	32.20%	2.20%	7.00%	28.90%	4.10%	14.30%
Mn	38.60%	3.50%	9.00%	33.20%	1.90%	5.80%	28.10%	3.30%	11.60%
Ca	38.40%	5.00%	12.90%	32.80%	1.90%	5.80%	28.70%	3.80%	13.20%
La	38.30%	3.40%	8.80%	33.20%	2.60%	7.70%	28.60%	3.00%	10.70%
Al	38.00%	4.10%	10.70%	32.40%	1.50%	4.70%	29.60%	3.60%	12.30%
Cu	37.60%	5.80%	15.50%	32.10%	3.60%	11.20%	30.30%	5.20%	17.10%
Mo	37.60%	6.60%	17.50%	32.20%	4.00%	12.60%	30.30%	4.50%	14.90%
K	36.30%	4.70%	13.10%	34.10%	3.90%	11.50%	29.60%	3.10%	10.40%
Zn	36.30%	3.90%	10.70%	32.70%	1.50%	4.60%	31.00%	3.60%	11.50%
Ni	36.20%	6.20%	17.10%	32.00%	8.10%	25.50%	31.80%	5.00%	15.90%
B	35.90%	10.40%	29.00%	31.50%	11.50%	36.50%	32.60%	10.30%	31.70%
Co	35.80%	3.30%	9.30%	33.20%	1.80%	5.40%	30.90%	3.00%	9.80%
Cr	35.50%	4.00%	11.20%	33.30%	2.60%	7.80%	31.20%	3.40%	10.80%
Fe	35.40%	3.80%	10.60%	32.20%	2.00%	6.10%	32.30%	3.50%	11.00%
Te	35.10%	6.60%	18.80%	32.20%	5.40%	16.70%	32.70%	5.50%	16.80%
Mg	33.80%	4.40%	12.90%	33.00%	1.10%	3.40%	33.20%	4.30%	12.90%
V	33.50%	4.80%	14.30%	33.60%	2.60%	7.80%	32.80%	4.70%	14.40%
Ti	31.80%	4.00%	12.50%	34.30%	1.40%	4.10%	33.80%	3.40%	10.20%

Coarse = -60+100 mesh ASTM   Medium = -100+200 mesh ASTM   Fine= -200 mesh ASTM
X = mean   S = standard deviation   V = coefficient of variation

Table 5 Partitioning of ICP Determined Elements in Three Size Fractions from Background Streams

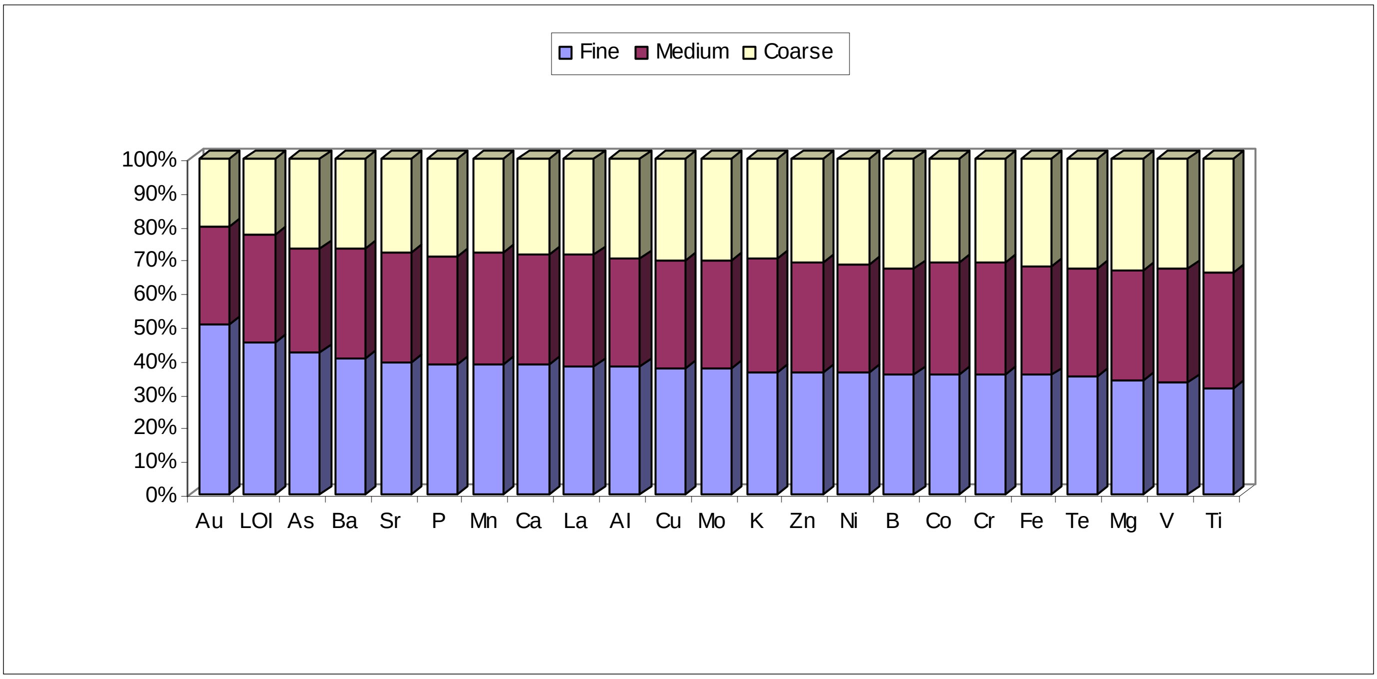

Figure 8. Partitioning of ICP determined elements in three size fractions from background streams

The sequence of elements (Figure 9a and Table 6), arranged in decreasing partitioning in the fine size fraction, for creek sediments from the one massive sulphide deposit examined is very similar to the background sequence. However, the partitioned concentrations in the fine fraction exhibit a 2 to 7 per cent decrease (relative to the background norm) for all elements except gold (18% increase), arsenic (6% increase) and barium (2 % increase).

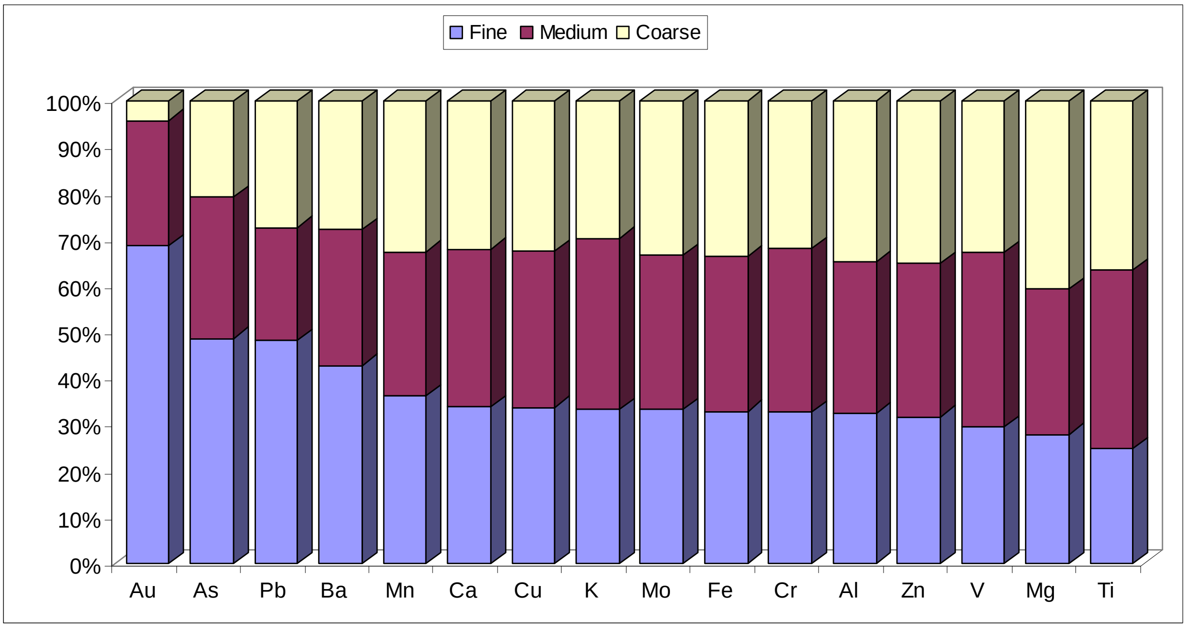

Figure 9a. Partitioning of selected elements in three size fractions from sediment in streams draining basins containing a massive sulphide deposit.

The partitioning sequence of elements for sediments from drainages containing porphyry deposits (Figure 9b and Table 6) bears some similarity with the background sequence. Arsenic, calcium, manganese, molybdenum, potassium and zinc display marginal decreases (1 to 3 %) in the partitioned concentration of the fine fraction relative to the background norm. Aluminium, copper, magnesium and titanium exhibit either a negligible (< 1 %) increase or decrease. Barium, chromium, iron and vanadium display marginal increases (1 to 3 %). Gold defines a moderate increase of 6 per cent in the fine fraction.

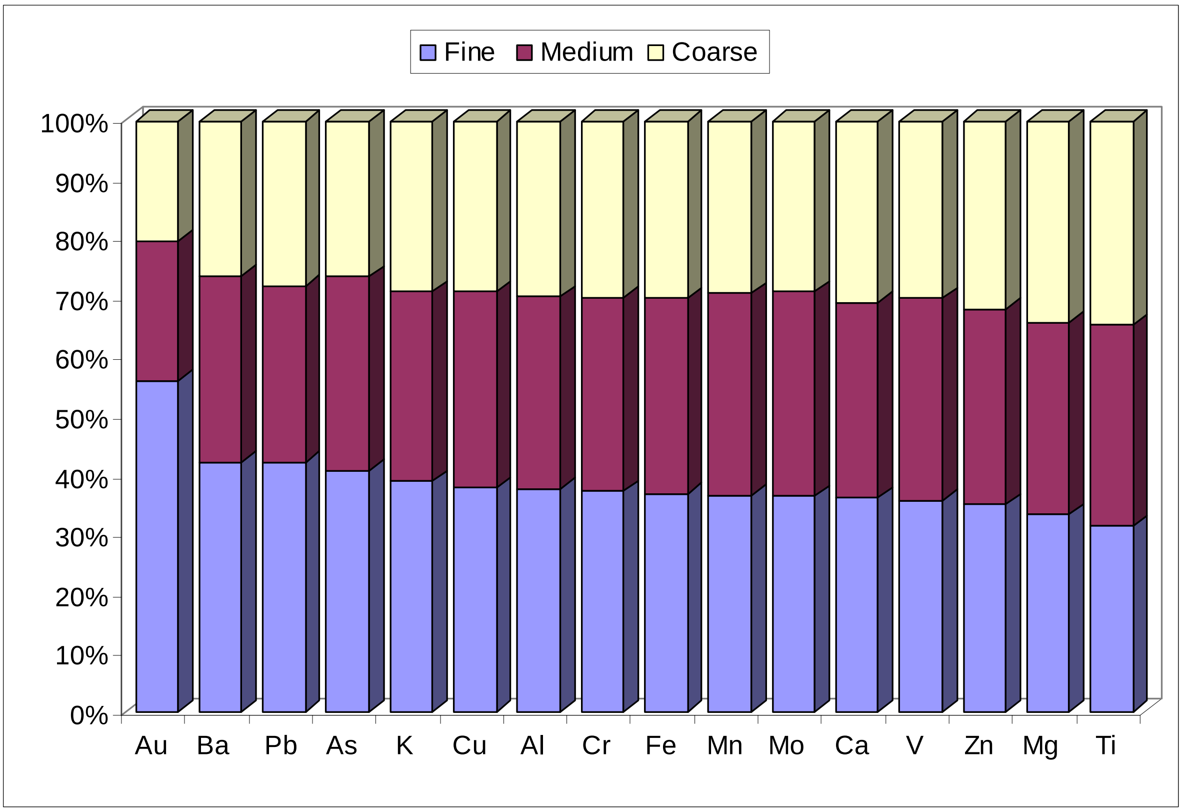

Figure 9b. Partitioning of selected elements in three size fractions from sediment in streams draining basins containing porphyry deposits.

The arrangement of elements for drainages bearing quartz vein deposits (Figure 9c and Table 6) is nearly identical to the background arrangement. A 4 to 5 per cent increase for partitioned concentrations in the fine fraction is seen for all elements except gold which decreases by 4 per cent. The partitioning of element concentrations between size fractions for creeks draining skarn deposits, produces a sequence (Figure 9d and Table 6) very near to the background arrangement. Most elements display a negligible (< 1 %) to marginal increase (1 to 3 %) in the partitioned concentration of the fine fraction. Gold however, displays a 20 per cent decrease and is strongly partitioned towards the medium size fraction (48.4%).

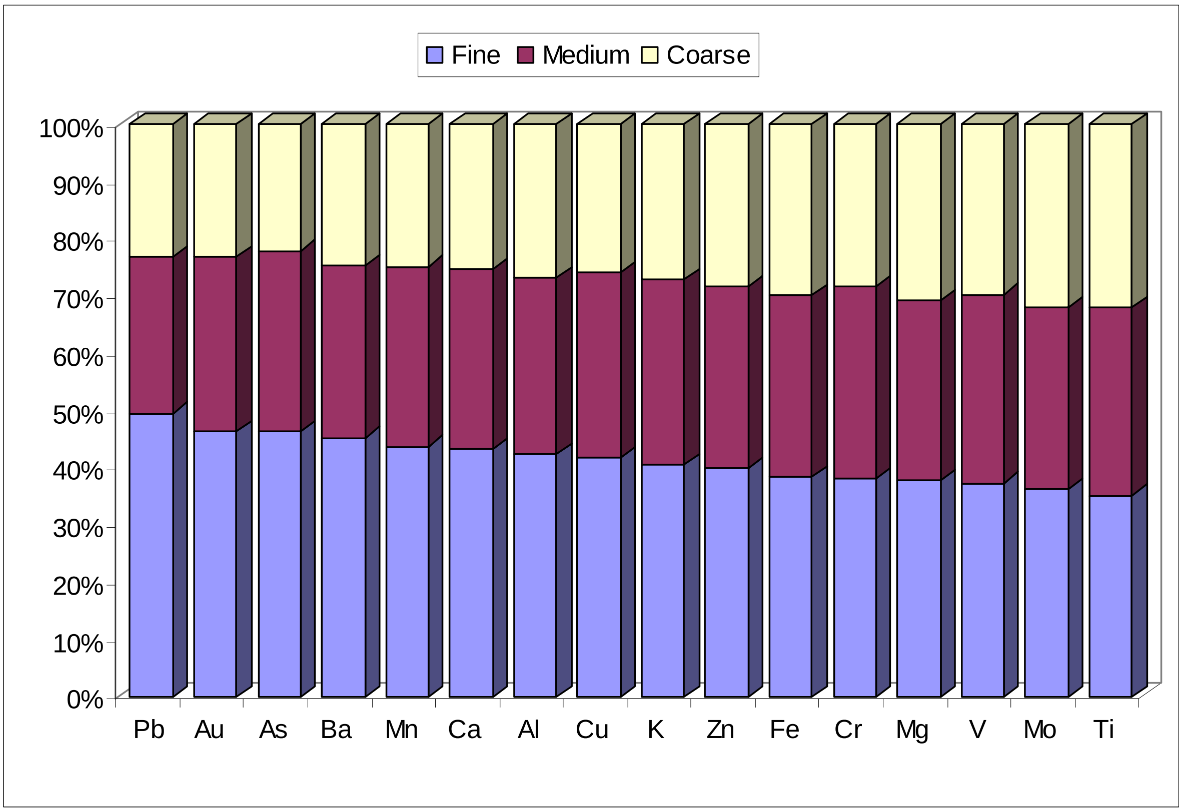

Figure 9c. Partitioning of selected elements in three size fractions from sediment in streams draining basins containing quartz vein deposits.

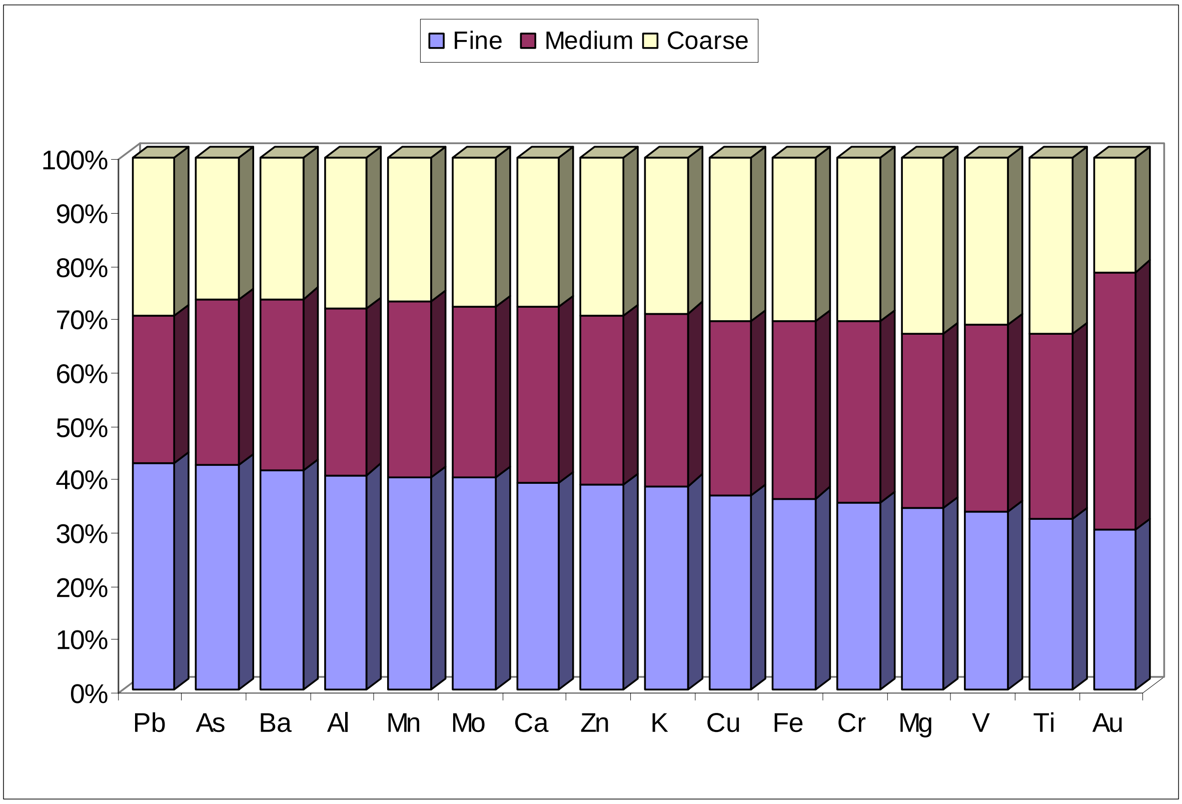

Figure 9d. Partitioning of selected elements in three size fractions from sediment in streams draining basins containing skarn deposits.

Discussion

The consistency in the partitioning of concentrations for lithophile elements associated with common silicates, towards higher concentrations in the finer fractions, is expected based on the greater surface area (per unit volume of sediment) from which these elements can be moderately to weakly leached by aqua regia. The near equal partitioning of concentrations for elements generally associated with heavy detrital or ferromagnesian minerals indicates a greater absolute concentration of these minerals in the coarse faction to offset the effect of greater surface area to volume ratios at finer fractions. The partitioning association seen for these elements and plausible explanations given are consistent with the results seen for the comparison of conventional fine-grained stream sediment and moss-mat sediment.

The comparison of partitioning of chalcophile element concentrations between size fractions for various deposits exhibited surprisingly little inter-deposit and deposit to background pattern variations at the gross scale. For example, the difference in the partitioning of copper in the fine fraction of sediments from skarn (36.6 %) and porphyry deposits (37.9%) is minor and well within one standard deviation of the background value (mean = 37.6%, s.d. = 5.8%). Intuitively, considerably higher concentrations of copper and possibly zinc would be expected in the fine fraction of porphyry deposits. The highly oxidizing and acidic weathering environment generally associated with porphyry deposits (Sato, 1960a) should result in the decomposition of various sulphides and the release of metal cations (Sato, 1960b). Some of the elements are quickly oxidized (i.e. iron as $Fe(OH)_3$ lead as PPS_4) and precipitate at or near the deposit, other metal cations (i.e. Cu^{2+}, Zn^{2+}) have a greater **Eh-pH** field of solubility in the **weathering environment** and will be **hydromorphically** dispersed. At some distance from the deposit these cations will either precipitate as hydroxides or be scavenged by clay particles, organic matter and hydroxides of iron and manganese. Whether the agent of precipitation be hydroxides as grain coatings, finely comminuted and decomposed organic matter or clay, a greater proportion of these materials in the fine fraction should give correspondingly higher concentrations (Tessier, *et al.,* 1982). Individual bulk samples do exhibit this effect. For example, bulk sample MK-BS-09, from the upper reaches of McKay Creek (CS #14) which drains the Mount Washington Copper deposit, contains copper concentrations of 555 ppm, 976 ppm and 1 357 ppm in the coarse (-45 +80 mesh), medium (-80+ 170 mesh) and fine (-170 mesh) fractions respectively which gives a fine to coarse concentration contrast of 1:2.4. Mitigating factors at the gross scale would be the inclusion of numerous background samples and incomplete separation of the size fractions during dry sieving. The degree of influence of the latter factor is unknown and needs to be quantified. Similarly, sediment from skarn deposits in regions of dominantly carbonate lithology might be expected to contain proportionally higher concentrations in the medium and coarse fractions (relative to the background proportions) due to a less oxidizing (relative to porphyry deposits) - neutral to alkaline weathering environment. This effect is evident in isolated examples, such as bulk sample MW-BS-0l from Merry Widow Creek (CS #05) which gave copper concentrations of 193 ppm, 151 ppm and 126 ppm in the coarse, medium and fine fraction respectively. Mitigating factors at the gross scale would be inclusion of numerous background samples and rapid physical and chemical comminution of mineral grains.

	Fine	Medium	Coarse		Fine	Medium	Coarse
Au	68.70%	27.10%	4.20%	**Pb**	49.60%	27.30%	23.20%
As	48.70%	30.50%	20.80%	**Au**	46.40%	30.60%	23.10%
Pb	48.20%	24.50%	27.30%	**As**	46.30%	31.60%	22.10%
Ba	42.90%	29.30%	27.90%	**Ba**	45.30%	30.10%	24.60%
Mn	36.30%	31.10%	32.60%	**Mn**	43.70%	31.50%	24.80%
Ca	34.00%	34.00%	32.00%	**Ca**	43.20%	31.60%	25.20%
Cu	33.80%	33.90%	32.40%	**Al**	42.30%	30.80%	26.90%
K	33.40%	37.00%	29.70%	**Cu**	41.70%	32.50%	25.80%
Mo	33.30%	33.30%	33.30%	**K**	40.60%	32.40%	27.00%
Fe	32.90%	33.60%	33.50%	**Zn**	39.90%	31.70%	28.40%
Cr	32.80%	35.40%	31.80%	**Fe**	38.50%	31.70%	29.90%
Al	32.50%	32.70%	34.70%	**Cr**	38.20%	33.60%	28.30%
Zn	31.70%	33.10%	35.10%	**Mg**	37.70%	31.40%	30.80%
V	29.60%	37.70%	32.70%	**V**	37.30%	33.00%	29.70%
Mg	27.90%	31.40%	40.70%	**Mo**	36.20%	31.90%	31.90%
Ti	24.70%	38.70%	36.50%	**Ti**	35.20%	32.80%	32.00%

	Porphyry				Skarn		
	Fine	**Medium**	**Coarse**		**Fine**	**Medium**	**Coarse**
Au	56.00%	23.60%	20.40%	**Pb**	42.50%	27.70%	29.80%
Ba	42.30%	31.40%	26.30%	**As**	42.30%	30.90%	26.90%
Pb	42.30%	29.80%	27.90%	**Ba**	41.20%	32.20%	26.60%
As	40.80%	32.80%	26.40%	**Al**	40.40%	31.30%	28.30%
K	39.10%	32.10%	28.90%	**Mn**	40.00%	32.90%	27.10%
Cu	37.90%	33.20%	28.90%	**Mo**	39.90%	32.00%	28.10%
Al	37.80%	32.50%	29.70%	**Ca**	38.90%	32.90%	28.10%
Cr	37.30%	32.80%	29.90%	**Zn**	38.50%	31.80%	29.80%
Fe	36.90%	33.10%	30.00%	**K**	38.40%	32.30%	29.30%
Mn	36.70%	34.10%	29.20%	**Cu**	36.60%	32.50%	30.80%
Mo	36.50%	34.60%	28.90%	**Fe**	36.00%	33.00%	30.90%
Ca	36.20%	33.00%	30.80%	**Cr**	35.20%	34.10%	30.80%
V	35.80%	34.20%	30.00%	**Mg**	34.30%	32.50%	33.30%
Zn	35.10%	33.00%	31.90%	**V**	33.60%	34.80%	31.60%
Mg	33.40%	32.50%	34.10%	**Ti**	32.20%	34.50%	33.20%
Ti	31.40%	34.10%	34.50%	**Au**	30.10%	48.40%	21.50%

Table 6 Partitioning of Selected Elements in Three Size Fractions for Sediments from Basins Containing Mineral Deposits Partitioning of ICP Determined Elements in Three Size Fractions From Background Streams. 1988 dataset: Coarse = -45+80 mesh; Medium = -80+170 mesh; Fine = -170 mesh.1987 dataset: Coarse = -60+100; Medium = -100+200 mesh; Fine = -200 mesh

Gold alone displays strong variation in its' partitioning between size fractions for the various deposits. Generally, gold displays enriched concentrations in the finest fraction due to hydraulic sorting which tends to prevent the accumulation of coarse gold at fine sediment sites (Fletcher,1990). For deposits in which the average gold grain size is very fine (< 50 microns), such as copper-gold porphyries (Cuddy and Kesler, 1982; Don Harris regarding the Mount Milligan and Kerness alkaline gold-copper porphyries, pers. comm., 1991), the effect would be most pronounced. The proportionally higher concentration of gold in the medium size fraction (-100+200 mesh) of sediment derived from skarn deposits may be due to larger gold grains associated with this deposit type. However, Ray (1990) reports that gold in auriferous skarns generally occurs as very fine (<50 microns) inclusions. Potentially, the carbonate-rich environment associated with skarn deposits restricts weathering of the host mineral and release of included gold.

E. SITE DUPLICATE ANALYSIS

The ability to recognize variability due to regional or local geochemical trends over within-site variability is an important consideration when selecting a sampling medium and analytical method. Only the field component of sampling variability was evaluated for this study. Field duplicates of conventional fine-grained stream sediment and moss-mat sediment were collected at roughly 10 per cent of all sites. A balanced analysis of variance (ANOVA) was conducted for only those sites with duplicate samples. The F -ratio was compared to critical values at a 95 per cent confidence level. Probabilities that local (within site) variability is statistically significant when compared to regional (between site) variation are summarized in Table 7. A high probability (> 5 %) implies that regional trends are likely to be obscured by "noise" due to sampling in different parts of the stream. Both media show extremely low within site variability compared to regional variability, for most elements. Moss-mat sediments display significant within site variability for bismuth, germanium and tellurium. Concentrations for these elements are very low but detectable. Source of the higher variability in moss-mat sediments is unknown.

Element	Moss-Mat Sediment	Conventional Stream Sediment	Element	Moss-Mat Sediment	Conventional Stream
Au	<0.5	na	Ag	<0.5	2.5
Al	<0.5	<0.5	As	<0.5	<0.5
B	<0.5	<0.5	Ba	<0.5	<0.5
Bi	>10.0	<0.5	Ca	<0.5	<0.5
Cd	na	na	Co	<0.5	<0.5
Cr	<0.5	<0.5	Cu	<0.5	<0.5
Fe	<0.5	<0.5	Ge	>10.0	na
Hg	<0.5	<0.5	K	<0.5	<0.5
La	<0.5	<0.5	Mg	<0.5	<0.5
Mn	<0.5	<0.5	Mo	<0.5	<0.5
Na	<0.5	<0.5	Ni	<0.5	<0.5
P	<0.5	<0.5	Pb	1	<0.5
Sb	<0.5	<0.5	Se	<0.5	<0.5
Sr	<0.5	<0.5	Te	>10.0	<0.5
Ti	<0.5	<0.5	V	<0.5	<0.5
Zn	<0.5	<0.5			

Note

na = significant number of alayses are below detection limit

Table 7. Analysis of Variance for Field Duplicates. Probability of Significant Within-Site Variability Relative to Regional Trends

PART 2 - CASE STUDIES

INTRODUCTION

In Part 1, the gross geochemical characteristics of the various sample media were evaluated in view of the requirements for a representative sample medium for reconnaissance-scale stream geochemistry surveys such as the British Columbia RGS program. In Part 2, individual case studies were examined in detail and interpreted. At this scale the unique character of each basin can be addressed and the optimal sample medium and pathfinders defined. Capsule summaries for each case study (see Appendix A) give information* on geology and mineralization, geochemical results for moss-mat and conventional fine-grained stream sediments and interpretations for element dispersion patterns. Dispersion patterns are presented as plots of concentration versus distance for key elements in each case study. Comparison of element dispersion trains within case studies and between case studies may yield geochemical signatures applicable as guidelines for exploration on a local or property scale.

METHOD

DEFINING ANOMALOUS TRENDS

In any geochemical survey, regardless of the sample media (i.e. soil, lake sediment, vegetation, etc.), establishing background is necessary for defining anomalous trends. Typically, a sufficient number of samples of homogenous nature are collected from within, and exterior to, the region of suspected mineralization such that a statistical range of background concentrations are defined. Stream environments provide a special challenge. The influence of macro-environment factors such as topography, climate and surficial geology together with the lithological mixture and degree of bedrock exposure may produce unique background ranges for each watershed. Applying threshold values calculated from a regional database (i.e. RGS) as the sole means of anomaly definition can severely over or underestimate the mineral potential in any given drainage basin. Anomalous dispersion trains were defined on three criteria: a) element associations which could be characterized as mineralization or background related, b) dispersion pattern shapes which match an anomaly dilution pattern, and c) concentrations in excess of thresholds defined by the Vancouver Island RGS database and background creeks included in this study.

Element Associations: Frequently the association an element displays with other elements may reveal considerable information regarding its mode of occurrence and the processes controlling its dispersion. Element associations were defined based on similarity in dispersion patterns as could be resolved by visual examination. Prominent features such as a sample giving abnormally high or low concentrations for a suite of elements, were verified by referring to field notes and available geology maps of the area. Hierarchical cluster analysis using Pearson linear correlation coefficients had been

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* Information on geology, mineralization and location of deposit (s) was derived from the British Columbia Ministry of Energy, Mines and Petroleum Resources MINFILE database.

conducted for defining associations but found to be generally ineffective. Frequently a single prominent feature attributable to site or sample induced noise (e.g. highly organic or abnormally coarse sample) resulted in a false association being defined.

***Dispersion Pattern Shapes**:* Hawkes (1976), based on his empirical formula[**] for a weathering deposit in a uniformly eroding drainage basin, demonstrated that anomalous element concentrations in stream sediment would define an exponential dilution curve leading from the deposit. Although Hawkes's model is overly simplified, the dilution pattern does become evident at concentrations which sufficiently exceed background noise (Axtmann and Luoma, 1991). Fletcher (1990) points out that the model does not hold for heavy minerals which form placers. Gold accumulating at high energy sites (e.g. bar heads) can offset downstream dilution producing a flat or increasing (in the case of a flattening stream gradient) dispersion curve. Fletcher notes that fine gold sampled from low-energy sites (e.g. bar tails) is not preferentially accumulated and adheres to Hawkes's dispersion model. Hawkes's model is used to evaluate the anomalous dispersion trains for most elements while Fletcher's work is used to evaluate the dispersion of gold and other elements suspected of placer accumulation.

Concentrations: Finally, case study results were evaluated against background and threshold concentrations derived from the Vancouver Island RGS database and background creeks included in this study. The 50th and 90th percentile values, taken from the appropriate lithology in the Vancouver Island RGS database, were employed as background and threshold levels for compatible elements[*]. Non-compatible or non-RGS suite elements were given average concentrations from background creek samples. Thresholds for these elements were arbitrarily set at 2 standard deviations or 1.5 X background (which ever was greatest). Elements giving an excessive number of below detection limit results were assigned background and threshold values of 1 X and 5 X the detection limit respectively. Threshold for gold was set at between 10 to 25 ppb depending on the lithology, these are deemed to be significant concentration levels for conventional stream sediments based on results in this study.

DISCUSSION

DEPOSIT RELATED ELEMENT ASSOCIATIONS, DISPERSION TRAIN LENGTHS AND OPTIMAL SAMPLE MEDIUM

Each deposit type has characteristic element associations. The association may vary depending on individual deposit mineralogy, the location of the deposit relative to the stream and the relative element mobilities in the local environment. Table 8 presents the

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[**] The general format of the formula is:

$$Me_m A_m = A_a(Me_a - Me_b) + A_m Me_b$$

Where:

Mem is the metal content of the mineralized source;
Mea is the metal content of an anomalous sediment;
Meb is the metal content of a background sediment
Am is the area of the mineralized source
Aa is the area of the watershed upstream of the anomalous site.

Cont…

Assumptions made for the model are: a single mineralized source, uniform background concentration, uniform rate of erosion, no feedback between water and sediment, no sampling error and no contamination

[*] Day *et al.* (1988) compared an ICP determination package against the routine RGS determination methods using a large number of stream sediment samples and found the the following elements gave comparable results: cobalt, copper, iron, lead, manganese, molybdenum, nickel, silver and zinc. Arsenic, antimony and bismuth were determined by hydride emrnission in both this study and the RGS program

general association of pathfinder and potential pathfinder elements for the main deposit types.

Porphyry and stockwork deposits are the most amenable to stream geochemistry. In the four case studies examined of this type, upwards of 14 pathfinder elements have been identified. Base metal and iron skarns are second only to porphyries in the number of elements (up to 12) that may target these deposits. Auriferous quartz veins may present the greatest challenge with as few as two elements indicating the presence of a deposit.

Generalized anomalous dispersion lengths based on deposit type is not easily quantified. The geometry was rarely idealized wherein a single deposit lies at the top of the drainage basin and is intersected by the creek. Often anomalous dispersion patterns may represent two or more sources. The pattern may be further complicated by sample and site related noise. Anomaly lengths were optimistically defined as the stretch of stream containing more than one anomalous site between two background sites or between a background site and the starting or ending point in a traverse. The effects of climate and topography on dispersion lengths could not be quantified.

Consistently long, well defined anomalous dispersion trains are characteristic of the porphyry deposits examined (Table 8). In each case study, several elements displayed anomalous concentrations along the entire sample traverse, a distance which ranges from 3.8 to 5.9 kilometres. The long dispersion trains are attributed to the large size of these deposits and a generally oxidizing - acidic weathering environment which can aid hydromorphic dispersion of elements mobile under these conditions. In three case studies (CS #1, CS #13, CS #14) hydromorphic dispersion has likely been enhanced by mining and exploration activity. Anomalous dispersion trains from skarn deposits are estimated at between 2 to 3 kilometres. The shorter dispersion lengths (relative to porphyries) is due in part to the smaller average deposit size and potentially to limited hydromorphic dispersion of elements with low mobilities in neutral to alkaline weathering environments. Dispersion train lengths of 2 to 8 kilometres were encountered for auriferous quartz-vein deposits. As seen in Franklin River, the small deposit size may be a limiting factor on elements (i.e. copper) other than gold. The single volcanogenic massive sulphide case study (Silver Creek) gave inconclusive results due to a 2.5 kilometre gap between the deposit and the first downstream sample station. Background concentrations of most pathfinders at this site suggests that anomalous dispersion trains, if present, are less than 2.5 kilometres in length for this particular deposit.

The optimal sample medium is generally independent of deposit type (Table 8). The exception is the quartz vein type deposit which, as a group, displays a majority of pathfinder elements having relatively enhanced concentrations in moss-mat sediment. In both porphyry and skarn deposits, the optimum sample medium varies between individual deposits. Apparently one of the determining factors, as seen in Merry Widow Creek (CS #5) and Murex Creek (CS #13), is the exposure of mineralization in the creek channel. Detrital sulphides eroded from the deposit can be preferentially trapped by moss mats. It follows that deposits which are characterized by elements that form heavy resistate minerals (native gold, cassiterite, scheelite) will be best defined by moss-mat sediments.

At several locations of suspected hydromorphic dispersion, concentrations of elements which are mobile, under the prevailing weathering environment, are notably higher in conventional stream sediment (e.g. arsenic, lead, selenium in Hepler Creek - CS #2). This effect may be muted at other areas of suspected hydromorphic dispersion (e.g. arsenic and copper in McKay Creek - CS #14) or entirely absent (e.g. most anomalous elements in Red Dog Creek - CS #1). One plausible explanation would be the geometry of the stream and the deposit. At Hepler, a large basin lies upstream of the deposit. During floods, moss mats will receive a considerable volume of barren sediment derived from exterior to the deposit area. Although barren sediment is deposited on the stream bed, ground water emanating from the deposit may enrich the trace metal content of this material. Moss which grows above the normal stream water level, would not be similarly enriched. At McKay Creek and Red Dog Creek, the deposits found at the head of the basin or the upstream basin is relatively small, as such, sediment within the moss mat is derived primarily from the deposit area.

Results of the individual case studies basically confirm the observations of Part 1 in that a strong correlation does not exist between the optimum sample medium and most pathfinder elements (Table 8). Two notable exceptions are antimony and gold which, when present in anomalous concentrations, are invariably enhanced in moss-mat sediment. Anomalous antimony was present in nine case studies, in every case it is preferentially enhanced in moss-mat sediment. The average concentration is marginally higher in most case studies. Substantial contrast between the two media is seen in Murex and McKay Creeks (CS #13, 14) wherein concentrations are two to three times higher in moss-mat sediment near the deposits. The element is likely present as detrital grains of native metal, sulphides (e.g. stibnite), sulphosalts (e.g. tetrahedrite) and oxides (e.g. senarmonite).

Detrital antimony minerals have been reported in placers near deposits containing those minerals (Boyle and Jonasson, 1984). The average gold concentrations in moss-mat sediments exceed conventional stream sediment contents, frequently by one or two orders of magnitude, in sixteen of eighteen case studies. Gold concentrations did not exceed 20 ppb in the two case studies where concentrations were higher in conventional stream sediment. As seen in Part I (Figure 7), the concentration of gold in background creeks is comparable to that of conventional fine-grained stream sediments, hence contrast between mineralized and non-mineralized basin is considerably greater for moss-mat sediments. Anomaly to background contrasts for the remaining elements were generally comparable between media as would be predicted by the results of the media comparisons in Part 1.

Invariably, when gold is noted in the deposit description, it forms an optimal pathfinder. Gold ranked first in average anomaly contrast in ten of eighteen case studies and no less then third in seven of the remaining studies. Only base metal skarns as a group exhibit an element (lead) other than gold as the best pathfinder. Gold is also the most consistent in anomaly length ranking first in eleven of sixteen creeks (two creeks were not rated on dispersion train lengths) and no less than third in four of the remaining five creeks. The longest gold anomaly is 8 kilometres as defined by moss-mat sediment in the Franklin River (CS #17). However the dispersion patterns are rarely smooth and conforming to Hawkes's anomaly dilution curve. As noted in Part 1, gold experiences severe nugget effects, consideration must be given to the nature of the deposit being sought, the type of sample collected and the optimal stream site location.

Deposit Type	Case Study	Pathfinder Elements	Potential Pathfinder Elements	Maximum Anomaly Lengths (km)	Optimum Sample Media	
					Moss-Mat Sediments	Conventional Stream Sediments
Porphyry and Stockwork	1	Au, Cu, Mo, Se, Te	Ag, As, Bi	4.5	Au, Ag, Bi, Cu, Mo, Se, Te	As
	2	Au, Bi, Mo, Pb, Se, Te	As, Ba, Cu, Fe	3.8	Au, Ba, Bi	As, Cu, Fe, Mo, Pb, Se, Te
	13	Au, Ag, As, Bi, Cu, K, Mo, Pb, Sb, Se	P, W, Zn	5.8	Au, Ag, As, Bi, Cu, K, Mo, Sb, W	P, Pb, Se, Zn
	14	Au, Ag, As, Bi, Cu, K, Mo, Pb, Sb, Se, Te	Co, P, Zn	5.5	Au, Ag,Bi, P, Sb, Se	As, Co, Cu, K, Mo, Pb, Te, Zn
Quartz Veins	8	Au,As	Ag, Bi, Hg, Zn	1.9	Au, As, Ag, Hg, Pb	Bi, Zn
	9	Au, Ag, As, Pb	Bi, Hg, Sb	2.4	Au, Ag, Bi, Hg, Sb	As, Pb
	12	Au, As, Pb	Ag, Hg	3.4	Au, As, Hg	Ag, Pb
	15	Au, As, Sb	Bi, Pb, Zn	3.7	Au, As, Pb, Sb, Zn	Bi
	17	Au	Cu	8	Au	Cu
Skarns	3	Au, B, Pb, Se, Zn	Ag, As, Sb	1.75	Au,Sb	Ag, As, B, Pb, Se, Zn
	4	As, Pb, Sb, Zn	Au, Ag, Bi, Ba	2	Bi, Sb	Au, Ag, As, Ba, Pb, Zn
	5	Au, Ag, As, Cu, Fe, Sb, V	Co	2.1	Au, Ag, As, Co, Cu, Fe, Sb, V	
	6	Au, Cu, Pb, Zn	Ag, As, Cr	?	Au, Ag, Pb, Zn	As, Cu, Cr
	7	Au, Bi, Cu, Pb, Zn	B, Cr, Se, Te, W	2.6	Au, Pb, Se, Te	B, Bi, Cr, Cu, W, Zn
	10	Au, As, Bi, Co, Cu, Fe, Mo, Pb, Sb, Se	B, Zn	3.1	Au, As, B, Sb	Bi, Co, Cu, Fe, Mo, Pb, Se, Zn
	11	Au, As, Pb, Se	Ag, Cu, Zn	1.2	As, Cu, Pb, Se	Au, Ag, Zn
Volcanogenic Massive Sulphide	18	Au, Ba, Bi, Pb	As, Sb	?	Au, Bi, Pb, Sb	As, Ba

Table 8. Summary of pathfinders, anomaly lengths and optimum media

ELEMENT DISPERSION MODELS FOR VANCOUVER ISLAND

The interaction of bedrock and surficial deposits with climate, topography and living organisms controls the dispersion of elements in the weathering environment. The presence and form of anomalous dispersion trains in a stream are also dependent upon the influence of past glacial transport and the geometry between the deposit and creek. Quantifying the influence of each factor (geology, topography, climate, glacial transport and geometry) in each case study goes beyond the scope of this study. However, generalizations are possible based on selected case study observations. Three stream environment models (Table 9 and Figures 10 to 12) with two modifiers are proposed which idealize the interrelationship between the various factors and the dispersion of elements in streams on Vancouver Island. The models are conceptual and need rigorous testing to prove their validity and are therefore intended as general guidelines to exploration using stream geochemistry.

Model 1 (Figure 10) constitutes a mountainous rain forest environment as would be found over 80 to 90 per cent of Vancouver Island representing most of the Insular Mountains physiographic terrain and the foothills to this terrain in the northern Nanaimo and Nawhitti Lowland terrains. Slopes above the creeks are generally moderate to steep and comprise exposed bedrock or are covered by a veneer of locally derived colluvium, till and talus. Stream gradients are generally moderate to steep ranging from 6 to 25 degrees. The active stream channel is lined by large boulders and bounded by banks composed of eroding till, colluvium or exposed bedrock. Alluvial banks are rare. Narrow bedrock lined canyons are common to terrains underlain by limestone. Channel pattern varies from braided to stretches of alternating high and low velocity herein referred to as shoots-and-pools. Waterfalls over bedrock and log jams are common.

The climate is cool and wet receiving 2 000 to 4 000 millimetres of rain annually. Storms are particularly frequent during the winter months and intense which drastically increases the sediment transport capacity of the streams. Soils are moist year round and comprise acidic - organic rich podzols.

Stream sediment is well sorted and generally coarse. Sites of accumulation are of comparatively low energy such as bar tails, the lee side of large boulders lining the bank and immediately upstream of log jams. Moss mats, growing on top of and on the downstream side of boulders and logs in the active channel, are common in shaded areas. Sediment accumulates in the lower half to two thirds of the mat which may grow to 10 centimetres or more in thickness. Height of the mat above the stream bed varies from several decimetres to over 1 metre.

Dispersion in the terrain surrounding the creek is driven by mechanical (gravity slumping) and hydromorphic processes in the weathering environment. The degree of hydromorphic influence and elements mobilized is dependent upon the nature of the weathering environment. Regions having bedrock and surficial deposits with a low acid neutralizing capacity will tend towards an acidic weathering environment (Type A) due to acids generated in the soils and by the chemical breakdown of sulphides and ferromagnesian minerals (Sato, 1960a; 1960b) in bedrock and overburden. A high potential exists for hydromorphic dispersion of trace metals mobile under these conditions. Regions having a moderate to high acid neutralizing capacity due to a carbonate lithology or carbonate rich surficial deposits, will tend towards a neutral to alkaline weathering environment (Type B). Chemical breakdown of sulphides is comparatively reduced and liberated cations of many trace metals may precipitate at or near their source.

Model	Terrains	Surficial Deposits	Climate	Comments on Stream and Dispersion Characteristics
1	Insular Mountains and foothills in the Nanaimo Lowland, mountainous with moderate to steep slopes	Thin, locally derived till and colluvium	Wet	Active bed and bank erosion, sediment is mainly coarse. This environment promotes mechanical and hydromorphic transport of trace metals from the surrounding slopes to the streams. In the streams, mechanical dispersion predominates. Primary and secondary mineral grains are abraded, dispersed and rapidly diluted.
2	Nawhitti Lowland, rolling hills of low to moderate relief	Thin to thick drift of local to exotic derivation	Wet	Surficial deposits may be only partly incised. Creeks contain fine to coarse grained sediment. Mechanical erosion and dispersion occurs predominantly during storms, hydromorphic dispersion within streams and the surrounding terrain takes on greater importance particularly in environments of thick exotic drift. Dispersion patterns in this environment could be complicated by the influence of exotic drift, seepage anomalies from blind deposits and the development of false anomalies due to scavenging by ferromanganous hydrous oxides and organic matter.
3	Southeastern coast, rolling hills of low to moderate relief	Generally thick marine sediments, pockets of thin till	Dry	Surficial deposits may be only partly incised. Creeks contain fine to coarse grained sediment. Limited mechancial and hydromorphic erosion and dispersion. Dispersion patterns may relate to local bedrock features but complications are expected due to thick drift of unknown provenance.

Type	Weathering Environment	Comments
A	Acidic	The underlying lithology and the overlying drift have a limited capacity to neutralize acids generated in the soil profile and by oxidation of sulphides and ferromagnesian minerals in the overburden and bedrock. The acidic environment will speed the chemical breakdown of other sulphides. This environment promotes the hydromorphic transport of mobile (S, Mo, Zn, Ag) and intermediately mobile (Cu, Co, Ni, As) trace metal cations and compounds. For example, the weathering of abundant sulphides in a porphyry deposit can result in an acidic weathering environment which causes the mobilization of metal cations such as Cu2+ which may form a supergene enrichment zone at depth.
B	Neutral to Alkaline	The underlying lithology and the overlying drift have a large capacity to neutralize acids generated in the weathering environment. A carbonate-rich lithology or overburden derived from a lithology such as the Parson Bay or Quatsino Formation could produce a neutral to alkaline weathering environment. This environment inhibits hydromorphic transportation, normally mobile elements (S, Mo, Zn, Ag) become intermediately mobile while others (Fe, Cu) become immobile.

Table 9. Stream environments for Vancouver Island

Minerals related to the deposit and present within the creek may constitute primary minerals which are resistant to weathering or have developed a protective armour of a secondary mineral phase; and secondary minerals which have formed at or near the deposit or have been precipitated, co-precipitated, chelated or adsorbed by other minerals and organic matter in the region where groundwater mixes with the stream environment. The trace metal composition and content of ground water entering the mixing zone will depend upon the weathering environment in the surrounding terrain. Dispersion in the stream environment may be primarily mechanical. Anomalous dispersion trains may be short due to rapid dilution by barren material. The dilution rate is determined in part by the size of the basin upstream of the deposit, and the size of the deposit exposure. Influx of barren sediment from a major tributary downstream of the deposit may result in sudden cut-off of the anomaly.

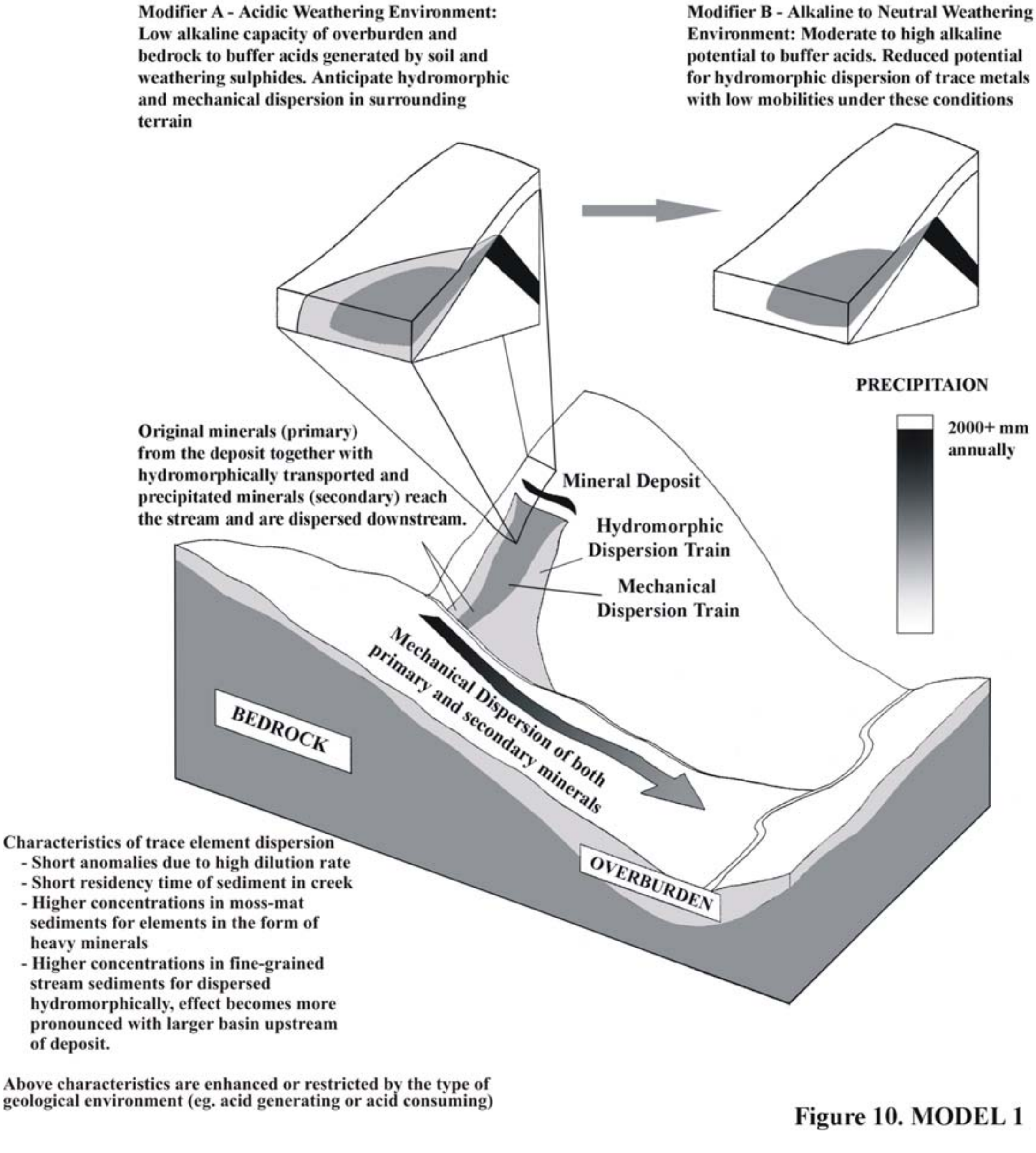

Figure 10. Model 1- mountainous rain forest environment

Conventional stream sediments in contact with, or derived from, the zone of mixing between groundwater and the stream environment may display greater enrichment in secondary minerals relative to moss mats which are preferentially not collected from this zone. Contrast between the two sample media for these minerals will be determined in part by the volume of barren sediment passing through the deposit area. Minerals with a moderate to high specific gravity tend to be preferentially accumulated in moss-mat sediment. Anomalies of this type may be enhanced by the presence of an eroding deposit within the creek channel or a favourable glacial transport direction which may have deposited mineralized material in or near the drainage channel.

Model 2 (Figure 11) constitutes a rain forest environment in a lowland area found primarily in the Nawhitti Lowland physiographic terrain and representing 10 to 15 per cent of Vancouver Island.

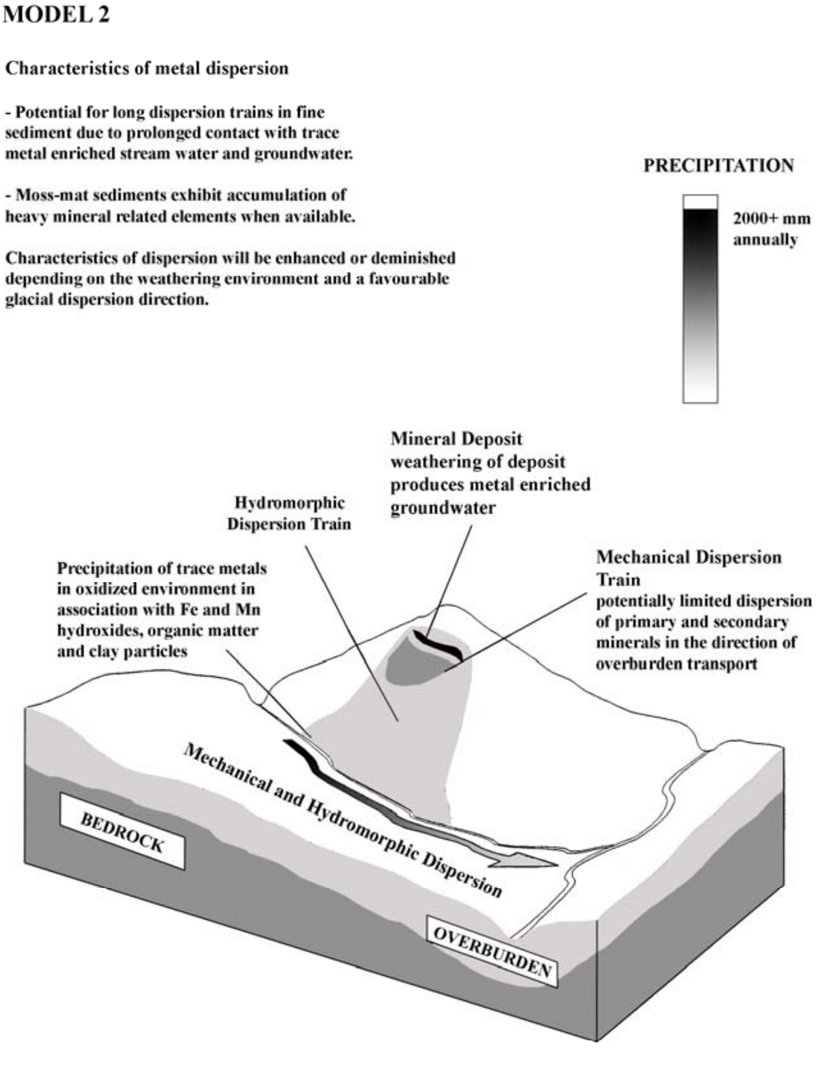

Figure 11. Model 2 - rain forest environment

Slopes above the creeks are gentle to moderate and covered with a veneer or blanket of colluvium and till. Stream gradients are low to moderately low ranging from 1 to 6 degrees. The active stream channel is lined by small boulders, cobbles and gravel. Banks are composed of alluvium, till and colluvium. Exposed bedrock is rare in areas other than terrains underlain by limestone. Channel pattern varies from braided to meandering with occasional shoots-and pools stretches. Waterfalls due to log jams are common.

Climate and soils are very similar to the mountainous rain forest environment. Conventional stream sediment is considerably more abundant and finer while moss mats are considerably less abundant relative to the mountainous rain forest environment. Height of the moss mat above the stream bed rarely exceeded 50 centimetres.

Mechanical dispersion by gravity slumping in the terrain surrounding the creek will be less effective (relative to Model 1 areas) due to lower slope gradients. A favourable (or unfavourable) glacial direction may have a comparatively greater impact on the presence of mechanically dispersed mineral grains in the stream. As in Model 1, the type of weathering environment (A or B) will determine the degree of hydromorphic processes in the surrounding terrain and the presence and nature of hydromorphically derived anomalies within the stream.

Similar to Model 1, conventional stream sediments may display a greater enrichment of secondary minerals while moss mats preferentially accumulate high specific gravity minerals. Contrast between background and anomalous concentrations may increase in conventional stream sediment due to a higher content of fine-grained sediment.

Model 3 (Figure 12) constitutes a Mediterranean-like climate in a lowland area found primarily in the southern Nanaimo Lowlands and representing 5 per cent or less of Vancouver Island. Geochemical conditions within this environment are unknown and must be postulated since no case study was conducted in it. The topography and surficial cover is similar to the Nawhitti Lowlands but with large flat coastal plains underlain by thick marine deposits. The active stream channel will likely be lined by small boulders, cobbles and gravel. Banks will be composed of alluvium, till, colluvium and deeply incised marine sediment. The channel pattern will likely vary from braided to meandering with occasional shoots-and pools stretches.

The climate is mild and comparatively dry receiving less than 1 250 millimetres of rain annually. Soils consist of semi-arid mildly acidic brunisols.

Conventional stream sediment may be abundant, however moss mats may be relatively scarce due to the low stream gradients and moderately dry climate.

As in Model 2, mechanical dispersion by gravity slumping in the terrain surrounding the creek may be less effective due to lower slope gradients and past glacial transport may have a comparatively greater impact on the presence of mechanically dispersed mineral grains in the stream. The degree of hydromorphic processes in the surrounding terrain and the presence and nature of hydromorphically derived anomalies within the stream will be determined by the lack of soil moisture in addition to the type of weathering environment.

As in the previous models, conventional stream sediments may display a greater enrichment of secondary minerals while moss mats preferentially accumulate high specific gravity minerals. A longer residency time for sediment within the drainage due to fewer storms and low stream gradient, may permit chemical breakdown of primary mineral grains within the stream.

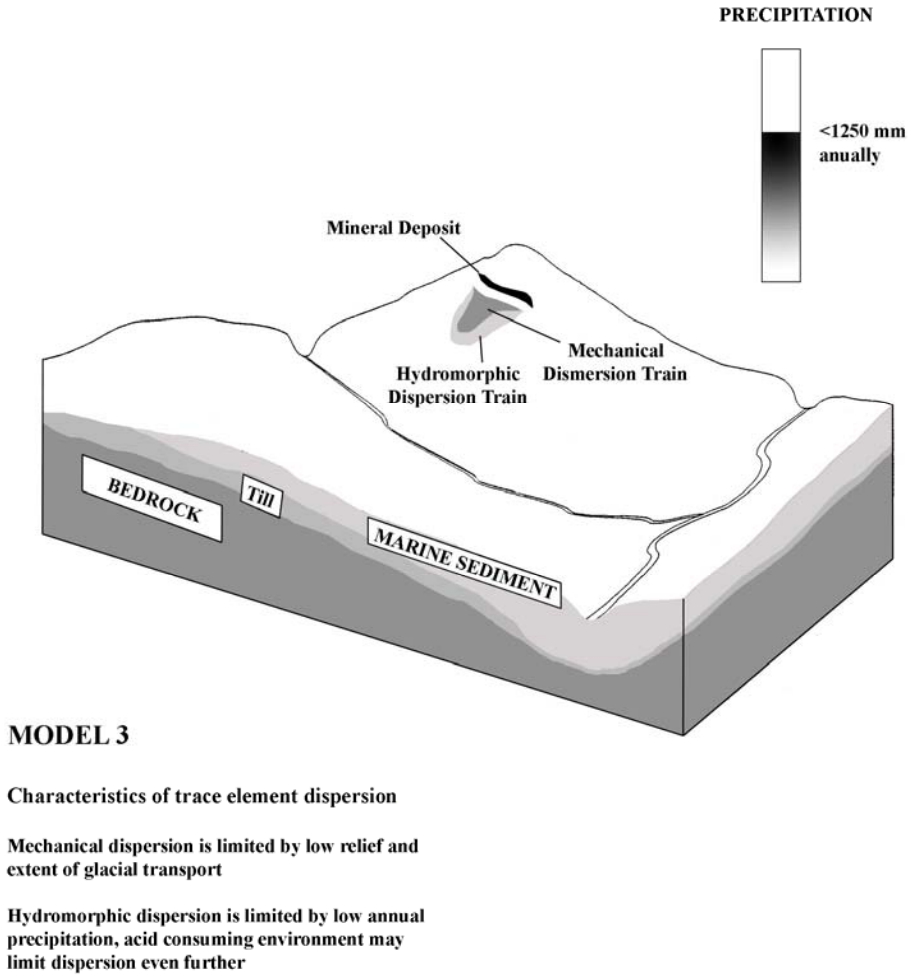

Figure 12. Model 3 - Mediterranean-like climate

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions pertain to reconnaissance scale geochemical stream surveys such as the RGS program.

- Moss mats were ubiquitous to all streams visited, were easily collected and yielded a greater proportion of fine-grained sediment relative to conventional stream sediment samples. Bulk fine-grained samples required considerable searching for low-energy sites with sufficient accumulation of sediment. Bulk sieved samples took up to one hour to collected and required process of up to 300 kilograms of raw sediment.

- Results from comparison of moss-mat sediments and conventional fine-grained stream sediments suggest that on a regional scale the two media will produce very similar results for the majority of elements determined in the RGS program. Elements occurring in high density minerals, such as gold and tungsten, are expected to be enriched in moss-mat sediments. Tin, although not determined in this study but routinely included the RGS suite of elements, would likely be enriched in moss-mat sediments. Lithophile elements found in common silicate minerals and carbonates are enriched in conventional stream sediment perhaps due to a proportionally greater content of the very-fine size fraction and the development of thicker precipitate coatings on grains.

- In general, moss-mat sediments show many of the advantages of both heavy mineral samples and conventional fine-grained stream sediments. While heavy minerals collected from high energy environments are a suitable tool for evaluating regional gold potential due to good contrast between anomalous and background areas, and good detection of weaker anomalies (for example, elevated gold in areas lacking showings in the Zeballos area), sampling is arduous and processing expensive. In addition heavy mineral samples may not be suitable for fine-gold deposits, and interpretation of concentrations of metals not typically associated with heavy minerals is difficult. Conventional fine-grained sediments yielded poor anomaly contrast for gold and in several instances were not available. Moss-mat sediments displayed good gold anomaly contrast several kilometres downstream of mineralization at typical RGS sampling densities. The nugget effect may be less severe relative to other media, if higher concentrations translate into more gold grains. In addition, this medium provides useful results for base metals, and is suitable for detection of fine-gold deposits.

- Comparison of element concentrations between three size fractions from bulk fine-grained stream sediment samples indicate that, although absolute concentrations are higher in the fine fraction for most elements, contrast between background creeks and creeks containing mineral deposits in their watershed are not significantly improved relative to the coarser fractions. In some instances (i.e. gold in sediments draining skarn deposits) contrast is worse in the fine fraction.

- Pertaining to property scale exploration on Vancouver Island, the optimal sample media can be independent of most deposit types and most elements. The optimum sample media was frequently determined by the geometry between the deposit and the drainage basin. Trace metals which may precipitate or be scavenged in the zone of mixing between groundwater and the stream environment are commonly enhanced in conventional fine-grained stream sediment relative to moss-mat sediment. This effect can be either enhanced or reduced based on the prevailing weathering environment (acidic or neutral to alkaline) and possibly by the volume of barren sediment passing through the deposit area. Contrast for this type of anomaly can be improved by using a wet-sieved fine size fraction and a selective digestion which attacks loosely bound metal and hydroxides of iron and manganese. Elements which are being transported as heavy mineral grains, whether primary or secondary in nature, give enhanced concentrations in moss-mat sediments relative to conventional stream sediments. This effect will be enhanced by the presence of a mechanically eroding mineral deposit within the stream channel. Both coarse (-40 + 80 mesh) and fine size fractions (-170 mesh) should be analyzed to avoid a not-to-uncommon pitfall of tossing out coarse mineralized particles with the sample rejects.

- Most case studies have shown that gold is the most reliable element for defining mineralization based on contrast and dispersion length. This pertains as well to deposits in which gold is an accessory element. If gold is associated with the exploration target, moss mats should be collected in addition to any other sample media.

- Applying three criteria (association, anomaly shape and concentration) for defining anomalous trends permitted the identification of subtle enrichments which would have been overlooked by using regionally defined thresholds only. Conversely, apparently anomalous features could be identified as an artifact of sample or site induced noise. Element associations generally proved to be the most useful criteria. At subtly anomalous concentrations, media and site related noise can mask the anomalous pattern. Moss mats, more so than conventional stream sediments, influence the shape of dispersion patterns and element associations by virtue of their apparent preferential trapping of heavy minerals. At moderate to highly anomalous concentrations, dilution patterns approximating an exponential decay curve were usually clearly evident.

This study has identified several areas requiring further research particularity regarding the nature of sediment in moss mats. A comparative study should be conducted on paired moss mat and conventional stream sediments which would encompass:

1) proportional distribution of sediment in various size ranges,
2) the primary mineralogy at these various size ranges,
3) the presence and cause of a bias in pH,
4) the distribution of gold in various size ranges, and
5) sequential extractions to identify the speciation of elements which display media bias.

The object of the proposed study would be to gain further understanding of geochemical patterns associated with the two media and to refinements in sampling, preparation and analysis which would optimize anomaly contrast.

REFERENCES

Axtmann, E.V. and Luoma, S.N. (1991): Large-Scale Distribution of Metal Contamination in the Fine Grained Sediments of the Clark Fork River, Montana, U.S.A., *Applied Geochemistry*, Vol. 6, pp. 75-88.

Andrews-Jones, D.A (1968): The Application of Geochemical Techniques to Mineral Exploration, *Colorado School of Mines*, Mineral Industry Bulletin 11, No. 6.

Bobrowsky, P.T. and Sibbick, S.J. (1996): Till geochemistry of Northern Vancouver Island; *British Columbia Ministry of Energy, Mines and Petroleum Resources* Open File 1996-7, 26 pages.

Boyle, R.W. and Jonasson, LR. (1984): The Geochemistry of Antimony and its use as an Indicator Element *in* Geochemical Prospecting, *Journal of Geochemical Exploration*, Vol. 20, pp. 223-302.

Carson, D.J.T. (1969): Tertiary Mineral Deposits of Vancouver Island, *Canadian Institute Mining Metallurgy*, Transactions, Vol. LXXII, pages 116-125.

Church, S.E., Mosier, E.L. and Motooka, J.M. (1987): Mineralogical Basis for the Interpretation of Multi-Element (ICP-AES), Oxalic Acid and Aqua Regia Partial Digestions of Stream Sediments for Reconnaissance Exploration *Geochemistry, Journal of Geochemical Exploration*, Vol. 29 (1/3), pp. 207-233.

Clayton, J.S., Ehrlich, W.A., Cann., D.B., Day, J.H., Marshall, LB. (1977): Soils of Canada, Research Branch, *Agriculture Canada*, Ottawa.

Clifton, H.E., Hunter, R.E., Swanson, F.J. and Phillips, R.L. (1969): Sample Size and Meaningful Gold Analysis, *United States Geological Survey*, Professional Paper 625C, 17 pages.

Cuddy, A.S. and Kesler, S.E. (1982): Gold in the Granisle and Bell Copper Porphyry Copper Deposits, British Columbia, in Precious Metals in the Northern Cordillera, AA. Levenson editor, Symposium Proceedings - *Association of Exploration Geochemists and Geological Association of Canada Cordilleran Section*, pages 139-155.

Day, S.J. (1988): Sampling Stream Sediments for Gold in Mineral Exploration, Southern British Columbia. *University of British Columbia* Unpublished M.Sc. Thesis, 232 pages.

Day S.J. and Fletcher K. (1986): Particle Size and Abundance of Gold in Selected Stream Sediments, Southern British Columbia, Canada, *Journal of Geochemical Exploration,* Vol. 26 (3), pages 203-214.

Day, S.J. (1989): Effects of Valley and Local Channel Morphology on the Distribution of Gold in Stream Sediments from Harris Creek, British Columbia, Canada, *Journal of Geochemical Exploration*, Vol. 32, pages 1-16.

Day, S.L, Matysek, P.F. and Johnson, W.M. (1988): The Regional Geochemical Survey: Evaluation of an ICP Package, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pp. 503-508.

Erdman J.A. and Modreski, P.L (1984): Copper and Cobalt in Aquatic Mosses and Stream Sediments from the Idaho Cobalt Belt, *Journal of Geochemical Exploration*, Vol. 20 (1), pages 75-84.

Farley, A.L. (1979): Atlas of British Columbia: People, Environment and Resource Use, *University of British Columbia Press*, Vancouver, Canada.

Fieldes, M. and Swindales, L.D. (1954): Chemical Weathering of Silicates in Soil Formation, New Zealand *Journal of Science and Technology*, Vol. 36B, pages 140-154.

Fletcher, W.K. (1990): Dispersion and Behaviour of Gold in Stream Sediments, *B. C. Ministry of Energy, Mines and Petroleum Resources*, Open File Report 1990-28, 30 pages.

Fulton, R.J., Clague, J.J and Ryder, J.M. (1982): Surficial Geology Canadian Cordillera, Parts of NTS 92 and 102, *Geological Survey of Canada*, Open File 837.

Giusti, L. (1986): The Morphology, Mineralogy and Behaviour of "Fine-Grained" Gold from Placer Deposits of Alberta: Sampling and Implications for Mineral Exploration, *Canadian Journal of Earth Science*, Vol. 23, pages 1 662-1 672.

Gravel, J. L and Matysek, P.F. (1989): 1988 Regional Geochemical Survey, Northern Vancouver Island and Adjacent Mainland (92E, 92K, 92L, 102I), *B. C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pp. 585-591.

Gravel, J.L., Jackaman, W. and Matysek, P.F. (1990): 1989 Regional Geochemical Survey, Southern Vancouver Island and Lower Mainland (92B, 92C, 92F, & 92G), *B. C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pp. 503-510.

Harris, J.F. (1981): Sampling and Analytical Requirements for Effective use of Geochemistry in Exploration for Gold, in Precious Metals in the Northern Cordillera, A.A. Levenson editor, Symposium Proceedings - *Association of Exploration Geochemists and Geological Association of Canada Cordilleran Section*, pages 53-67.

Hawkes, H.E. (1976): The Downstream Dilution of Stream Sediment Anomalies, *Journal of Geochemical Exploration*, Vol. 6 (3), pages 345-358.

Holland, S.S. (1976): Landforms of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin 48, 138 pages.

Howes, D.E. (1981): Terrain Inventory and Geological Hazards, Northern Vancouver Island, *British Columbia Ministry of Environment*, Assessment and Planning Division, Bulletin 5.

Howes D.E. and Nasmith H.W. (1983) Quaternary geology of southern Vancouver Island, *Geological Association of Canada*, Annual Meeting, Victoria, Canada, Field trip guide book, Stop 2:1, 25 pages.

Isachsen, C. (1984) Geology, geochemistry and geochronology of the west coast crystalline complex and related rocks, Vancouver Island, *British Columbia, University of British Columbia*, Masters Thesis, 144 pages.

Junger, LR. and Lewis, T. (1978): The Coast Mountains and Islands, in The Soil Landscapes of British Columbia, K.W.G. Valentine, P.N. Sprout, T.E. Baker and L.M. Lavkulich editors *British Columbia Ministry of Environment*, Victoria, BC pages 101-121.

Levenson, A.A. (1974): Introduction to Exploration Geochemistry, Applied Publishing Ltd, Wilmette, Illinois, U.S.A., page 62-63.

Massey, N.W.D. and Friday, S.J. (1988): Geology of the Chemainus River - Duncan Area, Vancouver Island (92C/16;92B/13), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pp. 81-92.

Massey, N.W.D. and Friday, S.J. (1989): Geology of the Alberni - Nanaimo Lakes Area, Vancouver Island (92F/1W, 2E and part of 92F/7), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pp. 61-74.

Matysek, P.F. and Day, S.J. (1988): Geochemical Orientation Surveys: Northern Vancouver Island, Fieldwork and Preliminary Results, B. C. Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1987, Paper 1988-1, pp. 493-502.

Matysek, P.F.Day, S.J. and Gravel, J.L, (1989): Applied geochemical subsection highlights of 1988 activities; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Paper 1989-1, pp. 579-584.

Muller, J.E. (1977): Geology of Vancouver Island, *Geological Survey of Canada*, Open File 463.

Muller, J.E. (1980): The Paleozoic Sicker Group of Vancouver Island, British Columbia, *Geological Survey of Canada*, Paper 79-30, 23 pages.

Muller, J.E. and Carson, D.J.T. (1969a): Geology and Mineral Deposits of Albernie Map Area, Vancouver Island and Gulf Islands, British Columbia, *Geological Survey of Canada*, Paper 68-50, 52 pages.

Muller, LE. and Carson, D.J. T. (1969b): Geology and Mineral Possibilities of Vancouver Island, Proceedings, *Prospectors and Developers Association, Annual Meeting*, Toronto.

Muller, J.E. and Jeletsky, J.A. (1970): Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and GulfIslands, British Columbia, *Geological Survey of Canada*, Paper 69-25, 77 pages.

Muller, J.E., Northcote, K.E. and Carlisle, D. (1974): Geology and Mineral Deposits of Alert-Cape Scott Map Area, Vancouver Island, British Columbia, *Geological Survey of Canada*, Paper 74-8, 77 pages.

Muller, J.E., Cameron, B.E.B. and Northcote, K.E. (1981): Geology and Mineral Deposits of Nootka Sound Map-Area, Vancouver Island, *British Columbia, Geological Survey of Canada*, Paper 80-16.

Nixon, G.T. Payie, G.J. Snyder, L.D. Long, S. Finnie, A. Friedman, R.M. Archibald, D.A. Orchard, M.J. Tozer, T. Poulton, T.P and Haggart, J.W. (2006): Geology of the Alice Lake Area, Northern Vancouver Island, NTS (92L/6), *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geoscience Map 2006-1.

Nixon, G.T. Hammack, L.J. Koyanagi, V.M. Payie, C.J. Haggart, J.W. Orchard,M.J. Tozer, T. Archibald, D.A. Friedman, R.M. Palfy J. and Cordey, F. (2006): Geology of the Quatsino - Port McNeill Area,, Northern Vancouver Island, NTS 92L/11, 12E, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geoscience Map 2006-2:

Nixon, G.T., Larocque, J., Pals, A., Styan, J., Greene, A.R. and Scoates, J.S.:(2008): High-Mg lavas in the Karmutsen flood basalts, northern Vancouver Island, stratigroahic setting and metallogenic significance; *British Columbia Ministry of*

Energy, Mines and Petroleum Resources, Geological Fieldwork 2007, Paper 2008-1, pages 175-190.

Plant, J.A., Hale, M and Ridgeway, J, (1989): Regional geochemistry based on stream sediment sampling; In Proceeding of Exploration,'87. Third Decennial International Conference on Geophysical and Geochemical Exploration for Minerals and Groundwater, Editor, Garland, D.G.,*Ontario Geological Survey* Special Volume 3, pages 384 - 404.

Ray, G.E., Etlinger, A.D. and Meinert, L.D. (1990): Gold Skarns: Their Distribution, Characteristics and Problems in Classification, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 237-246.

Sato, M. (1960a): Oxidation of Sulphide Ore Bodies, I. Geochemical Environments in Terms of Eh and pH, *Economic Geology*, Vol. 55, pages 928-961.

Sato, M. (1960b): Oxidation of Sulphide Ore Bodies, II. Oxidation Mechanisms of Sulphide Minerals at 25°C, *Economic Geology*, Vol. 55, pages 1 202-1 231.

Schaefer, D.G. (1978): Climate, in The Soil Landscapes of British Columbia, K.W.G. Valentine, P.N. Sprout, T.E. Baker and L.M. Lavkulich editors, *B.C. Ministry of Environment*, Victoria, B.C., pages 3-10.

Shacklette, H.T. (1965): Element Content of Bryophytes, *United States Geological Survey*, Bulletin 1198D, 21 pages.

Shacklette, H.T. (1984): The Use of Aquatic Bryophytes in Prospecting, *Journal of Geochemical Exploration*, Vol. 21, pages 89-93.

Smith, D.C. (1976): Storvatnet and Rettbekken - Moss-Trapped Stream Sediment as a Prospecting Medium, *Journal of Geochemical Exploration*, Vol, 5 (3), pages 338-341.

Smith, S.C., (1986): Base Metals and Mercury in Bryophytes and Stream Sediments from a Geochemical Reconnaissance Survey of Chandalar Quadrangle, Alaska, *Journal of Geochemical Exploration*, Vol. 25 (3), pages 345-365.

Stevenson, J.S. (1950): Geology and Mineral Deposits of the Zeballos Mining Camp, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin 27, 145 pages.

Tessier, A., Campbell, P.G.C. and Bisson, M. (1982): Particulate Trace Metal Speciation in Stream Sediments and Relationships with Grain Size, *Journal of Geochemical Exploration*, Vol. 16 (2), pages 77-104.

Valentine, K.W.G., Sprout, P.N., Baker, T.E. and Lavkulich, L.M. (1978): The Soil Landscapes of British Columbia, K.W.G. Valentine, P.N. Sprout, T.E. Baker and L.M. Lavkulich editors, *British Columbia Ministry of Environment*, Victoria, B. C., 197 pages.

Wang and Paling, (1983): Methods for Recovering Fine Placer Gold, *Canadian Institute Mining Metallurgy*, Bulletin 76, pages 47-56.

GLOSSARY

Reconnaissance scale
Surveys conducted over tens to thousands of kilometres in order to detect mineral possibilities. Sampling usually involves 1 sample per 1 km^2 to 100 km^2.

Biophile – Affinity for vegetation e.g. moss, vacular plants.

Dispersion patterns
The resultant pattern of certain minerals and elements as they have been redistributed, fractionated and mixed with other materials. Factors such as climate, relief, rock types, life processes, and time influence dispersion patterns.

Moss-mat sediments
Fine-grained stream sediment trapped beneath moss-mats growing on branches, boulders or along the stream bank during periods of high water levels or floods.

Evapotranspiration
The combination of evaporation and plant transpiration of water from the earth's surface into the atmosphere.

Null hypothesis
(H_0) The hypothesis of "no difference" used for statistical tests in order to support an alternate hypothesis (H_1) if H_0 is refuted.

Proportional bias

Secondary environment
The environment in which elements are introduced to once weathered from their original-sourced environment.

Heavy detrital minerals
Heavy minerals (such as gold) that have been weathered and moved by natural water processes, usually within the bed-load.

Settling
The process involved in particles (sediment) falling through the water and depositing at the bottom.

Entrainment
The process involved in incorporating sediment into flowing water.

Heavy mineral concentrates
A concentration of heavy minerals separated from low and high-energy sediments by sieving.

Contrast
The difference or dissimilarity between two different samples (sample media or duplicates).

Nugget effect

A characteristic of gold-bearing sediment where erratic and localized gold concentrations are observed, often in areas where there is a small number of gold grains per unit area.

Eh-pH
The stability of aqueous electrochemical systems based on its electric potential (Eh) and its H^+ concentration (pH). Eh-pH diagrams, also known as Pourbaix diagrams, are used to map out the equilibrium phase of the system under the given conditions.

Weathering environment
The classification of the environment from which weathering takes place, based on climate and the physical environment, and often attributes to the speciation, mobility and availability certain elements.

Hydromorphically
The movement of ions in solution.

Ministry of Energy
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Resources

A MULTI-MEDIA ANALYSIS OF STREAM GEOCHEMISTRY ON VANCOUVER ISLAND, BRITISH COLUMBIA: IMPLICATIONS FOR MINERAL EXPLORATION –

APPENDIX A

Geofile 2008-8

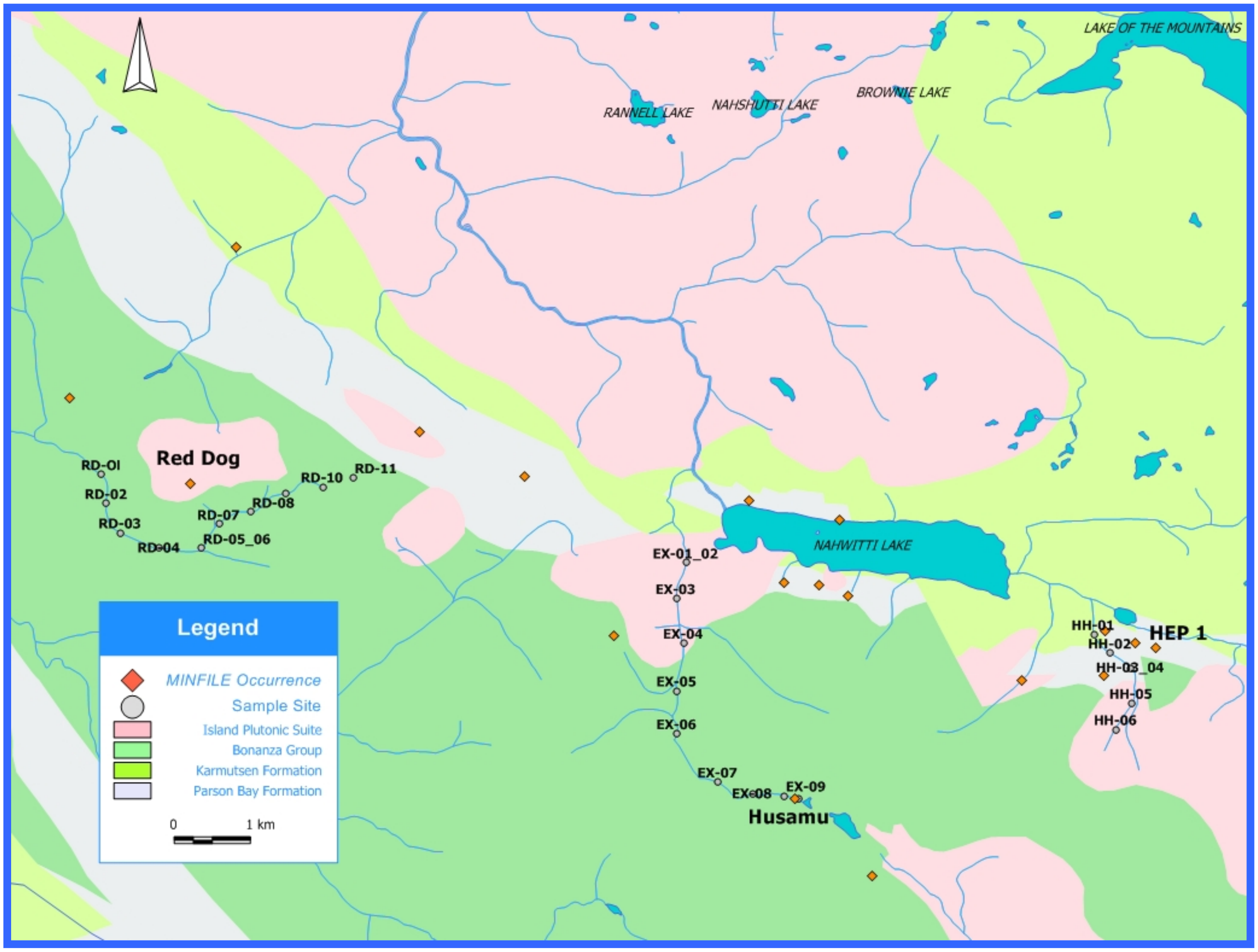

Figure A1-1. Red Dog, (RD-) Heppler Creek (EX-) and HEP (HH-) Sample Sites

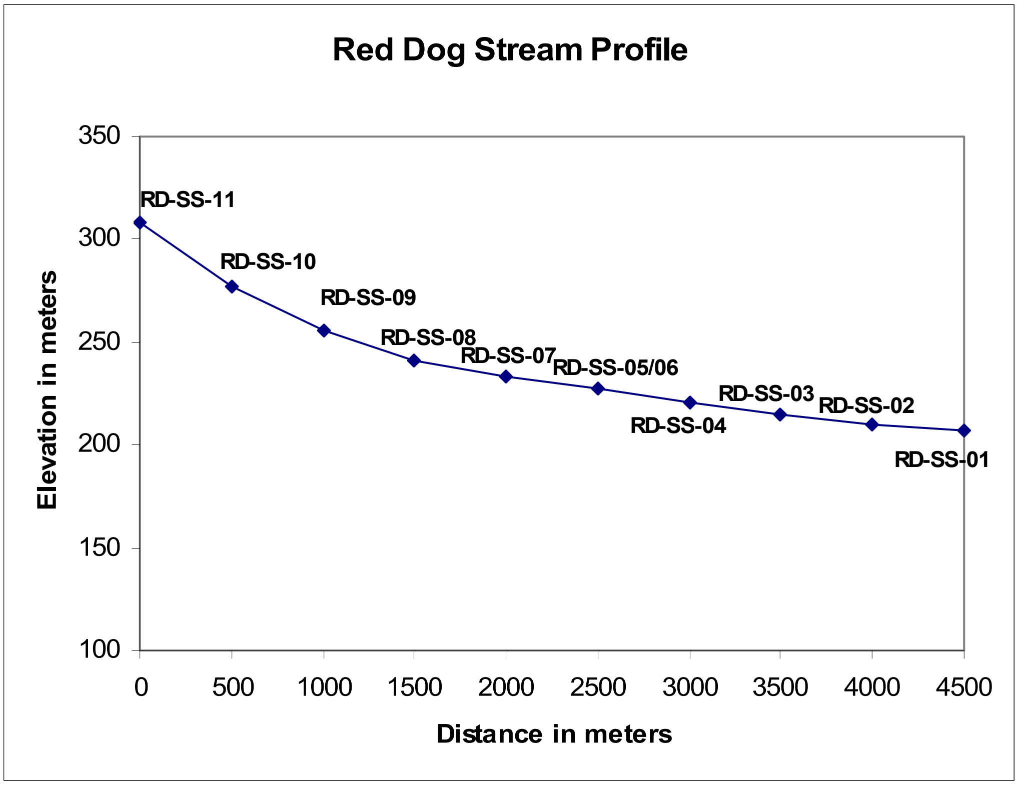

Figure A1-2 – Red Dog Stream Profile

RED DOG CREEK - PORPHYRY DEPOSIT

DEPOSIT NAME: ***Red Dog*** *MINFILE #:* 092L 200

LOCATION: NTS – 92L 12 LAT. - 50°42'48" LONG. - 127°58'00" UTM NORTH – 5618050 UTM EAST – 573000

STATUS*:* Prospect ***COMMODITIES:*** Copper, Gold, Molybdenum, Silver,

SIGNIGICANT AND ASSOCIATED MINERALS*:* Chalcopyrite, Boronite, Molybdenite, Chalcocite, Pyrite, Magnetite

LOCAL GEOLOGY*:* Red Dog Creek drains a basin underlain predominantly by volcanics and sediments of the Lower Jurassic Bonanza Group (*Figure A1-1).* Locally, the bedded tuffs, lapilli tuffs, massive tuffs and tuff breccias have been intruded by diorite, quartz diorite and quartz feldspar porphyry of the Jurassic Island Intrusions.

ALTERATION AND MINERALIZATION: In the main deposit area, Bonanza Group rocks have been altered to hornblende biotite hornfels surrounding silicified shear zones. To the southwest, the Bonanza Group rocks are either intensely silicified and brecciated or partially altered to pyrophyllite, pyrite, sericite, zeolite and kaolinite. In the main deposit area, chalcopyrite is disseminated or concentrated along fractures whereas molybdenite is most abundant on fracture surfaces and in quartz-sericite veins along shear zones. Sporadic copper mineralization accompanying magnetite is hosted by siliceous breccia in the southwest zone. Unclassified reserves are estimated at 45 million tonnes grading 0.32 percent copper and 0.41 grams per tonne gold.

LOCAL ENVIRONMENT: The Red Dog deposit lies in the Nawhitti Lowland physiographic terrain characterized by low hills giving a local relief of 300 metres. Summits are well rounded and range from 500 to 650 metres above sea level. Surficial cover comprises a veneer of thin (< 1 metre) till over the upper slopes which becomes a continuous blanket exceeding 10 metres thickness along the lower slopes. Ice flow indicators define a northwest direction of travel and hence the creek lies immediately up ice of the deposit. The present climate is cool and moderately wet with annual precipitation in excess of 2 000 millimetres. Soils are predominantly humo-ferric podzols.

STREAM CHARACTERISTICS: Red Dog Creek undergoes a 150 metre vertical drop along the 3.7 km sampled course (Figure *A1-2).* In profile, Red Dog Creek is seen to have a moderate gradient (6 degrees) in its' upper course marked by till banks and frequent water falls due to log jams. The lower course has a low gradient (1.4 degrees) marked by banks composed of alluvium, and a braided stream channel.

SAMPLE PATTERN*:* Ten sites were sampled for moss-mat sediment and conventional fine-grained stream sediment (Figure *A1-1).* Bulk fine-grained sediment was collected at every second site. Bulk sieved samples of coarse and fine-grained sediment from high and low-energy sites were collected from site RD-01. Within-site duplicate samples of conventional fine-grained stream sediment were collected at RD-05. Abundant fine-grained stream sediment was found throughout the stream traverse. Moss mats were in scarce to moderate supply at each site.

RESULTS

Element Associations and Dispersion Curve Shapes

Three dispersion patterns have been defined in both moss-mat and conventional fine-grained stream sediment.

Elements which define the first pattern comprise Au (*Figure A1-3a*), Ag, Cu (*Figure A1-3b*), Mo (*Figure A1-3c*), Se and possibly As (*A1-3d*), Te, Hg and LOI. Concentrations, in general, increase from RD-10 to RD-08, then remain relatively constant. Concentrations are comparable between media types except for Mo which is moderately higher in moss-mat sediment and Au which averages one order of magnitude higher in moss-mat sediments.

The dispersion trains for Al, Ba, La, Mg and possibly Sr and P define a common pattern which is essentially flat. Concentrations of the above elements are consistently higher in conventional stream sediments.

The third pattern, defined by Ca, Co, Cr, Fe, Ni, Pb, Sr, Ti, and V, exhibits decreasing concentrations with distance downstream in both media. The dispersion trains for Mn (*Figure A1-3f*) and Zn (*Figure A1-3e*) define concentrations which decrease downstream in moss-mat sediment but increase downstream in conventional fine-grained stream sediment. Concentrations of elements displaying the third pattern are marginally higher in conventional stream sediments.

Comparison to Background

Background and threshold values were calculated for sediment derived dominantly from Bonanza Group rocks (*Table A-1*). Elements which exceed threshold at one or more sites comprise Au, Bi, Cu, Mo, Se and Te.

INTERPRETATION

The association, flat dispersion curve shapes and limited concentration ranges displayed by elements in the second and third patterns suggests that these elements reflect background.

Elements defining the first pattern are interpreted as anomalous and related to the deposit based on the association and concentrations. The dispersion pattern is atypical for dilution from a single mineralized source (i.e. concentrations do not decrease with distance downstream) suggesting possible contribution from other sources.

Hydromorphic dispersion would be anticipated within the stream due to the acidic - oxidizing conditions in the weathering environment surrounding the deposit. The stream water is weakly acidic giving pH values of 5.0 to

5.5. The neutralizing capacity of the Bonanza Group rocks is unknown but likely limited. Evidence for hydromorphic dispersion is inconclusive at best. Concentrations of Cu and other moderately to highly mobile elements are comparable or only marginally higher in the fine size fraction of bulk samples relative to the coarser size fractions. In addition concentrations of mobile elements are comparable to slightly higher in moss-mat sediment. In case studies to follow, areas of suspected hydromorphic dispersion generally display higher concentrations in conventional stream sediment.

The mineralization at Red Dog is best identified by Au, Mo, Se, Te and Cu which are anomalous along the entire length of the sampled creek. These elements together with Ag and Bi are generally higher in moss-mat sediment relative to conventional fine-grained stream sediment. The best pathfinder element is Au in moss-mat sediment in terms of average contrast (average concentration value divided by the background value). As and Ag having similar patterns to the above elements may also be anomalous however their concentrations are below threshold at every site in both media.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	2 - 550 ppb	2	10	128.3	4.5 km
Mo	Moss	13 - 24 ppm	1	5	20.2	4.5 km
Se	Moss	2.8 - 8.5 ppm	0.5	0.9	11.7	4.5 km
Te	Moss	0.8 - 1.7 ppm	0.2	0.5	6.1	4.5 km
Cu	Moss	143 - 260 ppm	37	70	5	4.5 km
Bi	Moss	0.3 - 1.0 ppm	0.1	0.5	6.3	2.5 km
Ag	Moss	0.1 - 0.4 ppm	0.1	0.5	2.6	?
As	Stream	5.1 - 8.5 ppm	9	22	0.8	?

Table A-1 . Summary Table of Pathfinder Elements

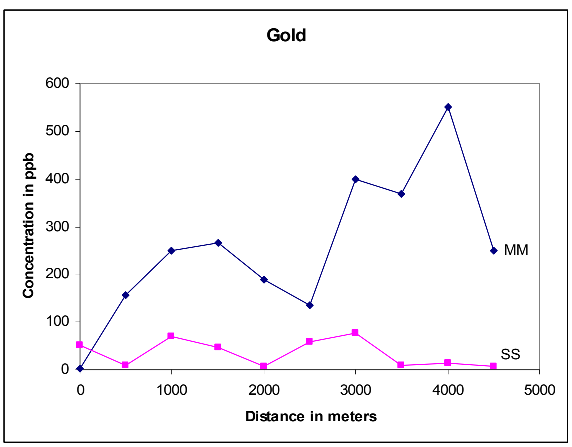

Figure A1-3a

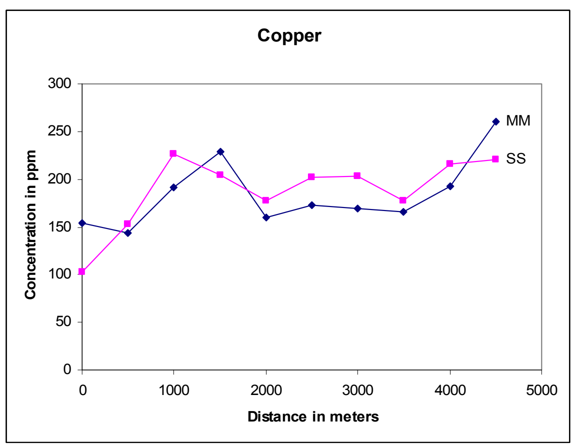

Figure A1-3b Cu

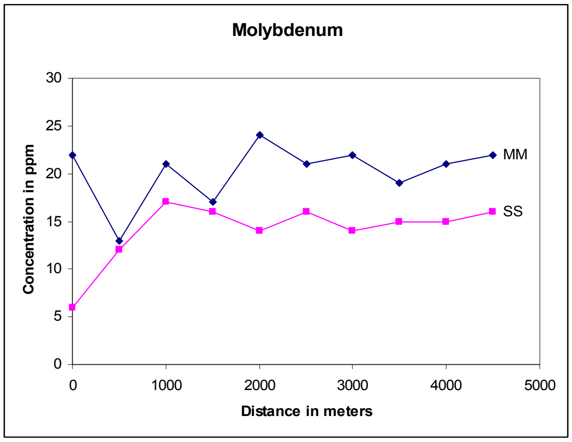

Figure A1-3c Mo

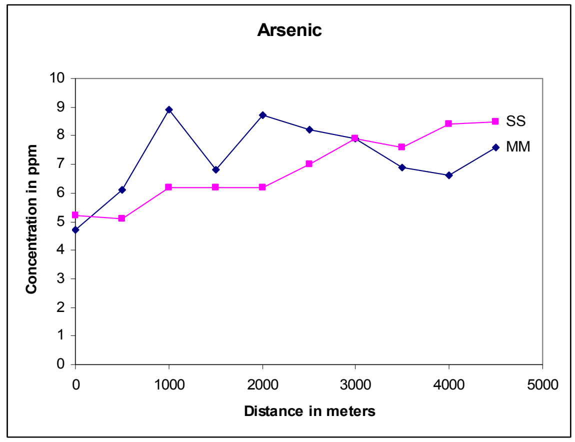

Figure A1-3d As

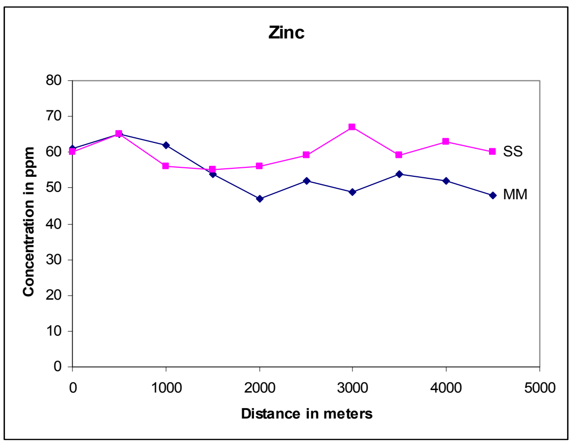

Figure A1-3e

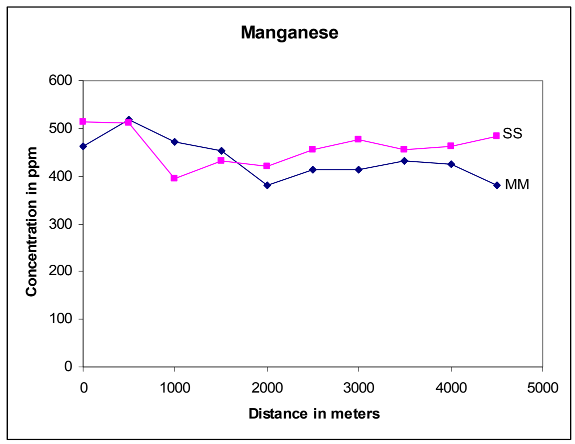

Figure A1-3f

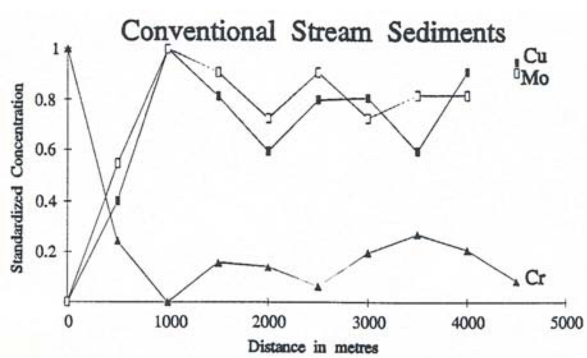

Figure A1-3g

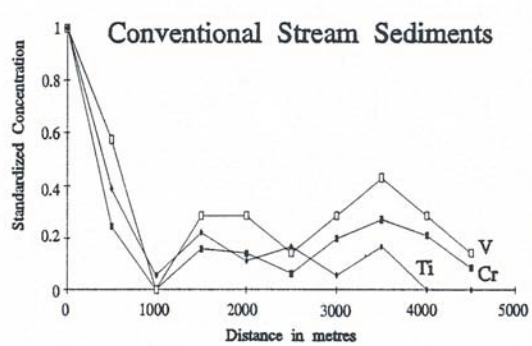

Figure A1-3h

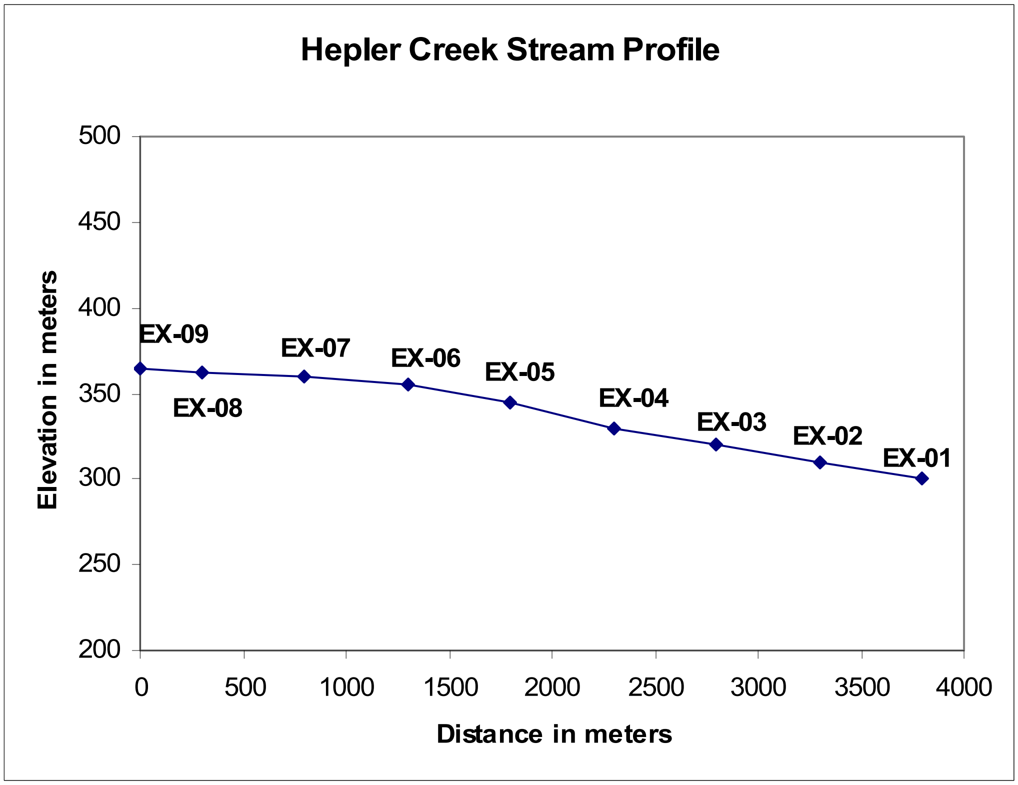

Figure A2-2 Hepler Creek Stream profile

HEPLER CREEK – PORPHYRY DEPOSITS

DEPOSIT #1 NAME*: *Expo, Hushamu *MINFILE #:* 092L 240

LOCATION: NTS – 92L12 LAT. - 50º40'32" LONG. - 127º51'32" UTM NORTH – 5614150 UTM EAST – 580800

STATUS: Prospect ***COMMODITIES:*** Copper, Gold, Molybdenum

SIGNIGICANT AND ASSOCIATED MINERALS: Chalcopyrite, Molybdenite, Pyrite, Magnetite

DEPOSIT #2 NAME: Hep, Cypress *MINFILE #:* 092L 078

LOCATION: NTS – 92L12 LAT. - 50º41'39" LONG. - 127º53'27" UTM NORTH – 5616175 UTM EAST – 578350

STATUS: Prospect ***COMMODITIES:*** Copper Molybdenum

LOCAL GEOLOGY*:* The upper Hepler Creek drainage basin (above site EX-04) is underlain by andesitic breccia, tuff, lapilli tuff and flows of the Lower Jurassic Bonanza Group (*Figure A1-1*). Locally, the Bonanza rocks are intruded by quartz monzonite stocks and dykes of generally diorite composition. The lower basin (below site EX-04) is entirely underlain by a felsic stock of the Island Intrusions.

ALTERATION AND MINERALIZATION: At the Expo deposit, Bonanza Group volcanics have been intensely silicified in an area interpreted as an explosive volcanic centre. An inner alteration assemblage of pyrite, pyrophyllite, clay and sericite grades outwards to argillic, sericitic and finally propylitic alteration zones. Disseminated chalcopyrite is associated with the intensely silicified centre. Indicated reserves are reported to be 52 million tonnes grading 0.32 per cent copper, 0.41 grams per tonne gold and 0.008 per cent molybdenum. Three kilometres to the northwest lies the Hep deposit in a region of propylitized Bonanza Group volcanics. Disseminated chalcopyrite and lesser bornite accompany pyrite along the intersection of two shear zones in the volcanics. Molybdenite is observed along fractures. Estimated reserves are reported at 45 thousand tonnes grading 0.8 per cent copper. The deposit is drained by the headwaters of Hepler Creek.

LOCAL ENVIRONMENT*:* Hepler Creek drains a region of the Pemberton Hills near the southern boundary of the Nawhitti Lowlands physiographic province. Summits are well round and range from 650 to 900 metres above sea level. The study area has moderate to gentle slopes and a local topographic relief of 480 metres. Surficial deposits comprise a veneer of thin (< 1 metre) till and colluvium along moderate slopes which becomes a continuous till blanket on gentle and lower slopes. Ice flow indicators define a northwest direction of travel thus mineralized material could have been eroded into Hepler Creek. The present climate is cool and wet with annual precipitation in excess of 2 000 millimetres.

STREAM CHARACTERISTICS: Hepler Creek undergoes a 65 metre vertical drop along the 3.8 km sampled course (*Figure A2-2*). In profile, Hepler Creek is seen to have a low gradient (2 degrees) in its' lower reaches and a very low gradient (1 degree) in its' upper reaches. Banks are comprised of till, alluvium and occasional bedrock outcrops. The channel displays a braided pattern which is occasionally interrupted by waterfalls due to log jams.

SAMPLE PATTERN: Nine sites were sampled for moss-mat sediment and conventional fine-grained stream sediment (*Figure A2-1*). Bulk fine-grained sediment was collected at every second site. Bulk sieved samples of coarse and fine-grained sediment from high and low-energy sites were collected from site EX-01. Site duplicate samples of conventional fine-grained stream and moss-mat sediment were also collected at the above site. Moderate to abundant fine-grained stream sediment was found throughout the sampled stream course. Moss mats were in scarce to moderate supply at each site.

RESULTS

Element Associations and Dispersion Curve Shapes

Three dispersion patterns have been defined for both moss-mat and conventional fine-grained stream sediment.

The dispersion trains for As (*Figure A2-3b*), Ba, Bi, Fe, Pb (*Figure A2-3c*), Sb, Se (*Figure A2-3a*) and Te define a common pattern of decreasing concentrations with distance downstream. Concentrations are substantially higher in conventional stream sediment relative to moss-mat sediment upstream of site EX-05. The dispersion pattern for Au (*Figure A2-3d*) in both media defines a jagged curve with little symmetry between media and generally higher concentrations in moss-mat sediment. Both patterns define generally increasing concentrations with distance downstream. The third group of elements which includes Mo (*Figure A2-3e*) and Cu (*Figure A2-3f*) display a distinct stepped pattern with a marked increase in concentrations downstream of site EX-05. Concentrations of Co, Cr, Ni, Ti and V are higher in moss-mat sediment while Al, Ca, Cu, Mg, Mn (*Figure A2-3g*), P, Sr and Zn are higher in stream sediment. Concentrations of Mo are comparable between the two media. The similarity in dispersion patterns for elements such as Cr, Ti and V (*Figure A2-3h*)* are a likely product of a geochemical trend (i.e. change in underlying lithology) overprinted by sediment composition variation related to stream energy.

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*Standardized dispersion curves were used to compare patterns wherein concentrations at each site are recalculated using the formula:

xn = (xi – xmin) / xrange   Where xn is the new standardized value
xi is the original value at each site
xmin is the minimum xi value for the stream
xrange is the range of xi values in the stream

Applying this formula resets the concentration range for all elements to between 0 and 1

Comparison to Background

Background and threshold concentrations were calculated for sediment derived dominantly from the Bonanza Group (*Table A-2*). Elements which exceed threshold at one or more sites are Au, Ba, Bi, Cu, Fe, Mo, Pb, Se and Te.

INTERPRETATION

The association, dispersion curve shapes and concentrations relative to background for elements in the third group suggests that most of these elements (excluding Mo and possibly Cu) reflect background related to lithology with variations introduced by stream energy at the sample site and variable moss mat efficiency in trapping heavy minerals. The change in background base level concentrations between EX-06 and EX-05 is due to an influx of sediment derived from an area with substantially different background concentrations. Two tributaries (one draining the Hep deposit) enter between sites EX-06 and EX-05 and are likely responsible.

The association, dispersion curve shapes and concentrations for elements in group 1 and 2 indicate an anomalous assemblage related to mineralization. The anomaly dilution curve described by Hawkes (1976) is clearly defined by As, Pb and Se. The significantly lower concentrations of these elements in moss-mat sediment near the Expo deposit may be the result of preferential hydromorphic enrichment of conventional fine-grained stream sediment in contact with trace-metal rich ground water. The sudden decrease between sites EX-06 and EX-05 could be due to the influx of comparatively barren material from the tributaries in this area.
Although the Expo is primarily a copper-molybdenum porphyry deposit, concentrations of these elements are unexpectedly low relative to porphyry deposits at Red Dog (CS #01) and Mount Washington (CS #13 & CS #14). Hypothetically, the high sulphide content of the deposit (reportedly up to 25 per cent) and low acid neutralizing capacity of the lithology and surficial deposits may result in strongly acidic stream environment resulting in extensive mobilization of Cu and Mo.

The mineralization at Expo is best identified by Au, Bi, Mo, Pb, Se and Te which are anomalous along the entire length of the sampled creek. Of these, Se and Pb present the easiest dispersion pattern to interpret and the highest average contrast. The mineralization at Hep may be responsible for the marked increase in Mo, Cu and Te in moss-mat sediment at site EX-05. The optimal sample media in terms of highest average contrast is conventional find-grained stream sediment for anomalous elements other than Au, Bi and Ba.

Anomalous Element	Optimum Media	Range	Back-ground	Thres-hold	Average Contrast	Anomaly Length
Pb	Stream	21 - 68 ppm	1	8	35.8	3.8 km
Au	Moss	14 - 132 ppb	2	10	27.3	3.8km
Se	Stream	4.4 - 13.8 ppm	0.5	0.9	17.5	3.8 km
Bi	Moss	0.6 - 1.5 ppm	0.1	0.5	10.8	3.8 km
Mo	Stream	6 - 10 ppm	1	5	8.6	3.8 km
Te	Stream	0.5 - 1.4 ppm	0.2	0.5	5.4	3.8km
As	Stream	9.7 - 50.5 ppm	9	22	2.4	1.8 km
Cu	Stream	51 - 106 ppm	37	70	2.2	2.8 km
Ba	Moss	44 - 66 ppm	32	45	1.6	1.8 km
Fe	Stream	5.1 - 19.3 ppm	5.5	7.2	1.6	1.8 km

Table A-2 Hepler Creek - Summary Table of Pathfinder Elements

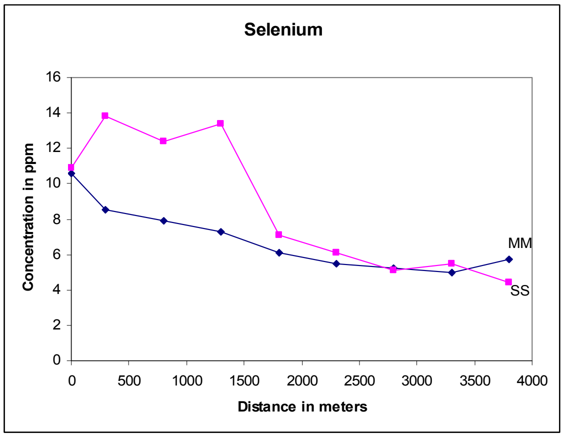


Figure A2-3a

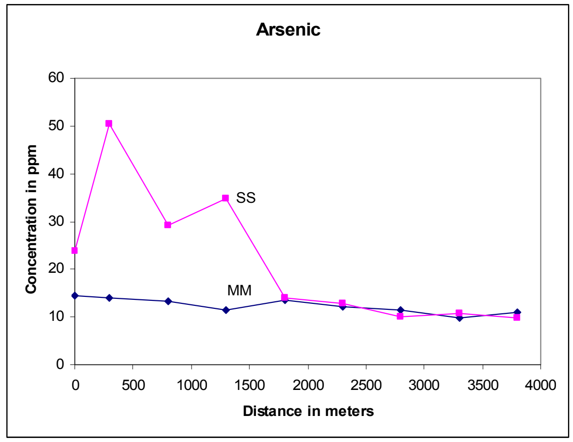


Figure A2-3b

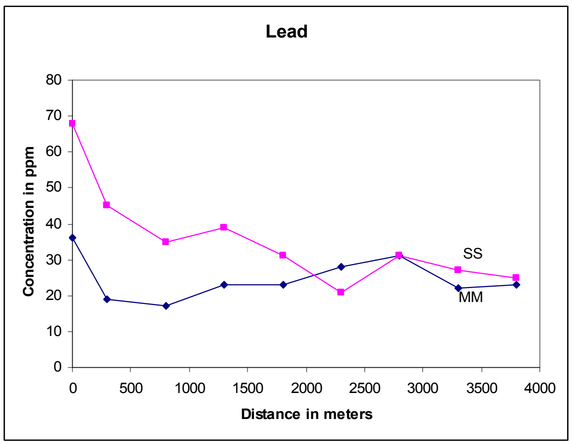


Figure A2-3c

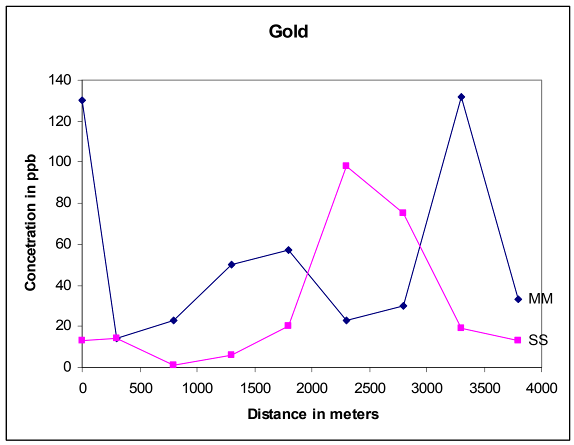


Figure A2-3d

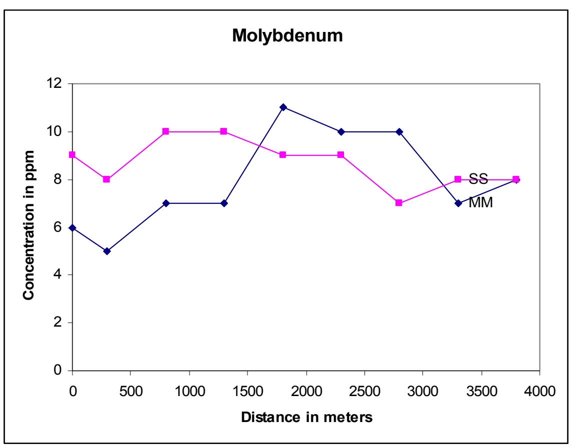


Figure A2-3e

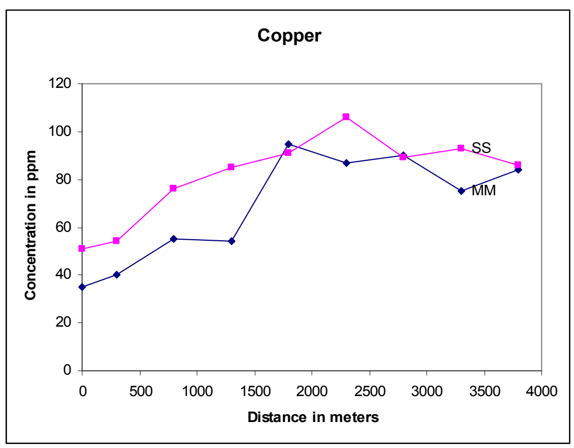


Figure A2-3f

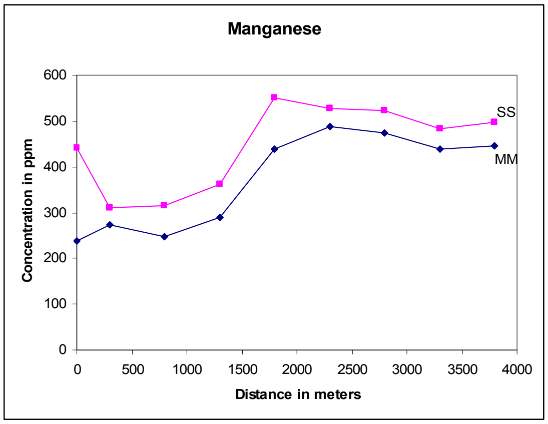


Figure A2-3g

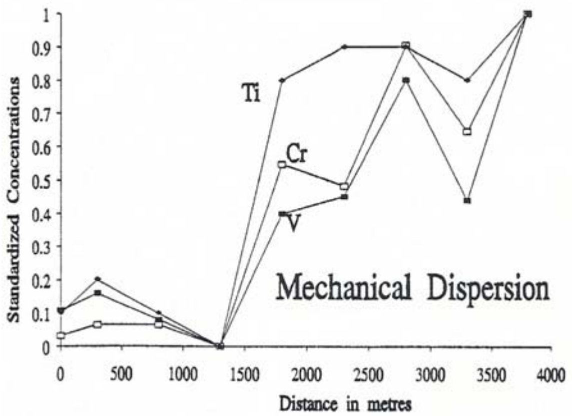


Figure A2-3h

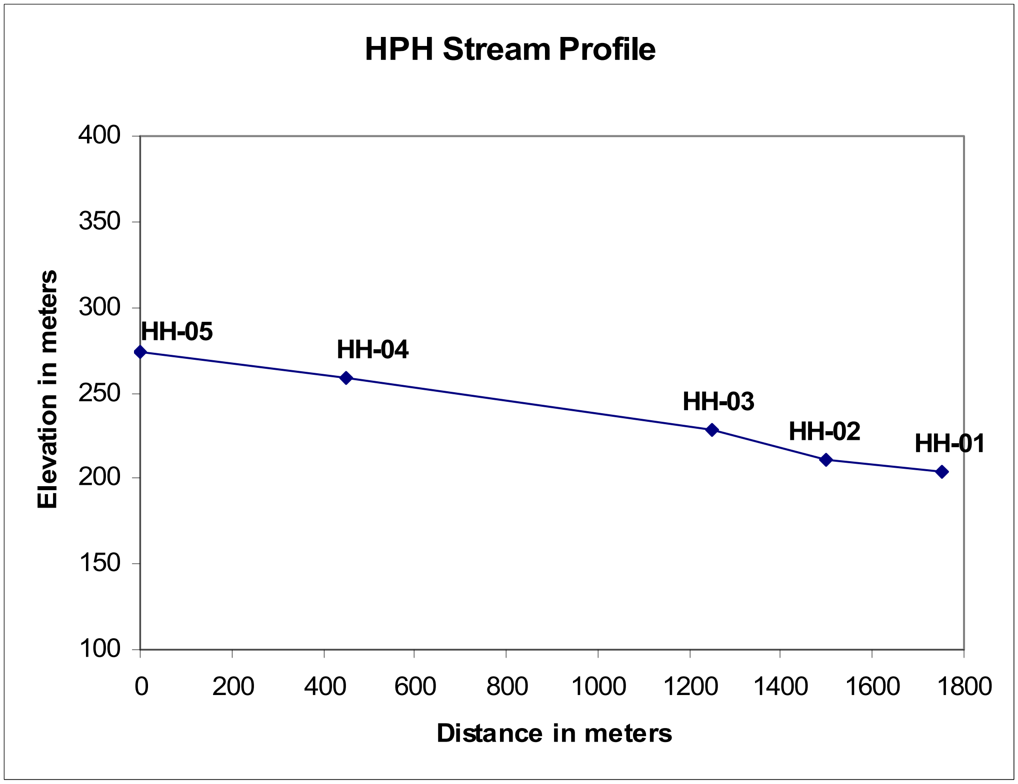


Figure A3_2. HPH Stream profile

HPH CREEK – BASE-METAL SKARN

DEPOSIT NAME: ***HPH 1, Nahwitti Lake*** *MINFILE #:* 092L 069

LOCATION: NTS – 92L12 LAT. - 50º41'42" LONG. - 127º47'38" UTM NORTH – 5616380 UTM EAST – 585180

STATUS: Prospect ***COMMODITIES:*** Silver, Lead, Zinc, Copper, Gold, Iron

SIGNIFICANT AND ASSOCIATED MINERALS*:* Galena, Sphalerite, Chalcopyrite, Magnetite, Tetrahedrite, Dyscrasite. Pyrite, Pyrrhotite

LOCAL GEOLOGY*:*
The HPH Creek drainage basin is underlain by northwest trending belts of Upper Triassic Vancouver Group rocks comprising limestone of the Quatsino Formation, marine sediments of the Parson Bay Formation and rift related submarine mafic volcanics of the Karmutsen Formation (*Figure A1-1*). Locally the above rocks have been intruded by felsic stocks of the Late Jurassic Island Intrusions.

ALTERATION AND MINERALIZATION*:* In the main deposit area, Quatsino limestone has been silicified and altered to skarn in the vicinity of a felsic dyke. Mineralization comprises the replacement of limestone by massive to disseminated magnetite, pyrite and pyrrhotite with lesser amounts of galena, sphalerite and chalcopyrite. Mineralization is irregular and exposed over an area of 80 metres by 3 metres. Analysis of a 2 metre chip sample produced a grade of 3 734 grams per tonne silver, 38.1 percent lead and 10.6 percent zinc, other samples gave 0.69 grams per tonne gold, and 0.01 percent copper. The deposit is located on a ridge between sites HH-03 and HH-04. A smaller lead-zinc skarn showing (HPH Bluff) is 400 metres upslope of site HH-05.

LOCAL ENVIRONMENT*:* HPH Creek drains a region of the Pemberton Hills along the southern boundary of the Nawhitti Lowlands. Summits are rounded and range from 600 to 700 metres above sea level. The study area has gentle slopes and a local relief of 200 metres. Surficial cover consists of a moderate to thick blanket of till and colluvium. Thick glaciofluvial deposits fill the main valley immediately to the north. Ice flow indicators define a northwest direction of travel thus HPH Creek is down ice of the HPH1 deposit but up ice of the HPH Bluff deposit. The present climate is cool and moderately wet with annual precipitation in excess of 2 000 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS*:*
HPH Creek undergoes a 70 metre vertical drop along the 1.75 km sampled course (*Figure A3-2*). In profile, HPH Creek is seen to have a fairly constant gradient of 3 degrees with a slightly steeper section of 6 degrees near site HH-03. The steeper section is marked by steep colluvium banks and bedrock canyons, the remainder of the creek is marked by banks of till or alluvium.

SAMPLE PATTERN:
Five sites were sampled for moss-mat sediment and conventional fine-grained stream sediment (*Figure A1-1*). Bulk fine-grained sediment was collected at every site excluding HH-02. Bulk sieved samples of coarse and fine-grained sediment from high and low-energy environments were collected at site HH-0l. Duplicate samples of conventional fine-grained stream sediment and moss-mat sediment were collected at HH-03. Fine-grained stream sediment and moss mats were in scarce to moderate supply in the lower to middle reaches of the creek, both media became more abundant in the upper reaches.

RESULTS

Element Associations and Dispersion Curve Shapes

Two dispersion patterns in moss-mat sediment and four patterns in conventional fine-grained stream sediment have been defined. Most elements in moss-mat sediment describe a double peak pattern with elevated concentrations at sites HH-03 and HH-0l. The inverse pattern is defined Al, Bi, Cr, Mg and Mo in moss-mat sediment wherein enhanced concentrations are seen at HH-02. In conventional stream sediment, Ag, As, B, Cu, Ni, Pb, Sb, Se and Zn define a pattern in which concentrations increase with distance downstream. Concentrations in conventional stream sediment exceed moss-mat sediment levels at all sites for most elements excluding As, Pb and Sb which are significantly higher in moss-mat sediment at HH-03. A unique pattern is described by Au in conventional stream sediments. Concentrations are generally low except for a moderate increase at HH-02. The third pattern in conventional steam sediments, displayed by Cr, Fe and V, defines decreasing concentrations with distance downstream following a sharp drop between sites HH-05 and HH-04. Concentrations are compatible between the two media. The fourth and final pattern in conventional fine-grained stream sediments depicts generally increasing concentrations of Al, Ba, Ca, Co, Mn and Sr with distance downstream with a sharp increase at site HH-01. Concentrations are substantially higher for each of these elements in conventional stream sediments.

Comparison to Background

Background and threshold concentrations have been calculated for sediment derived dominantly from the Quatsino Formation (Table A-3). Elements which exceed threshold at one or more sites in either or both media are Au, Ag, As, B, Pb, Sb, Se and Zn.

INTERPRETATION

The symmetry in moss-mat sediment dispersion patterns for most elements is interpreted as largely due to variations in site energy overprinting regional geochemical trends. The change in background base level concentrations between HH-04 and HH-03 can be attributed to a change in lithology from a region dominated by the Bonanza Group and Island Intrusions to a region primarily underlain by the Quatsino and Karmutsen formations.

The influence of lithology is well defined by elements of the third (*Figure A3-3a*) and fourth (*Figure A3-3b*) groups in conventional stream sediments. The decreasing in Cr, Fe and V content and increasing Ca, Ba, and Sr may reflect sediment with a progressively decreasing content of ferromagnesian silicates and increasing carbonates. The sharp increase in concentration of the fourth group elements at HH-0l may be the result of sediment entirely derived from the Quatsino Formation. The high organic content (15.8 per cent) at this site may also influence the content of these elements.

The patterns displayed by Au (*Figure A3-3c*), B (*Figure A3-3d*), Pb (*Figure A3-3e*), Se (*Figure A3-3f*) and Zn (*Figure A3-3g*) and possibly those of Ag, As (*Figure A3-3h*) and Sb are interpreted as anomalous and related to the HPH deposit based on concentrations and element association. Detrital Pb and As mineral grains are suspected at site HH-03 based on contrast between media concentrations. Increasing concentrations of these elements in conventional fine-grained stream sediment downstream of HH-03 may be the result of physical comminution (i.e. smaller mineral grains would be less prone to hydraulic sorting).

The increase at site HH-0l for Au, Ag, As, Cu, Ni, Pb, Sb and Zn in moss-mat and conventional stream sediment (for some elements) may be the result of a nearby mineralized source or simply the effect of a flattening stream gradient causing accumulation of very fine-grained sediment (with adsorbed trace elements) and placer accumulation of Au.

Hydromorphic processes will have a variable influence in the dispersion of trace elements within the HPH drainage basin. Areas underlain by a carbonate-rich lithology or carbonate derived glacial deposits should experience limited hydromorphic dispersion of elements normally mobile under an acidic weathering environment, such as suggested by Pb and As at site HH-03. Conversely, areas underlain by intermediate to felsic intrusions and volcanics lack the acid neutralizing capacity of the carbonate rich areas should see a greater hydromorphic influence.

The HPH deposit is best defined by Au, B, Pb, Se and Zn which exceed their thresholds at most sites downstream of the mineralization in one or both media. The HPH Bluff deposit may be the source of anomalous Pb and Sb concentrations upstream of site HH-03. For the following table, the average contrast was calculated using samples collected downstream of mineralization (HH-03 to HH-0l).

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Pb	Stream	8 - 37 ppm	1	7	28.2	1.75 km
Au	Moss	1 - 210 ppb	2	10	37.4	0.5 km
B	Stream	7 - 34 ppm	8	12	3.6	0.5 km
Se	Stream	1.4 - 2.5 ppm	0.7	1.1	3.2	0.5 km
Zn	Stream	65 - 237 ppm	88	146	2.2	0.5 km
Ag	Stream	0.2 - 0.8 ppm	0.1	0.5	4.7	?
As	Stream	11.4 - 27.2 ppm	10	27	2.3	?
Sb	Moss	0.4 - 0.8 ppm	0.1	0.8	7	?

Table A-3. HEP Creek - Summary Table of Pathfinder Elements

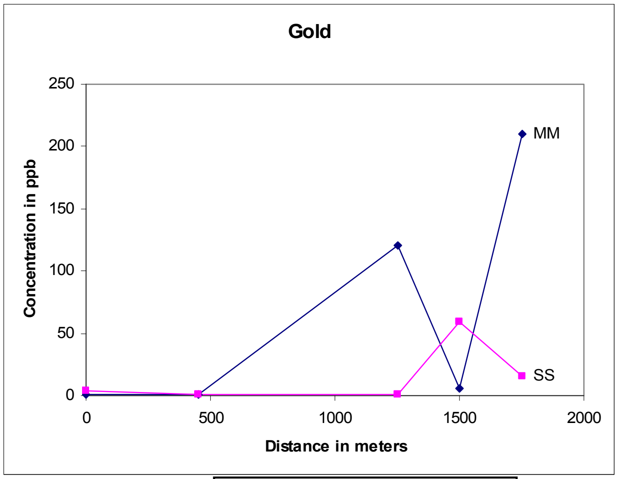


Figure A3-3a

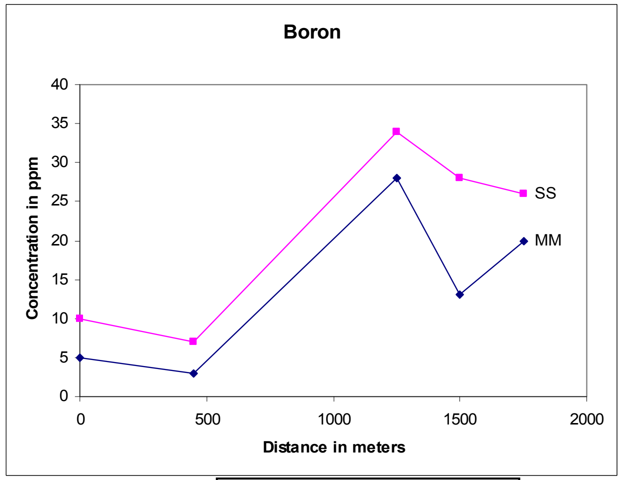


Figure A3-3b

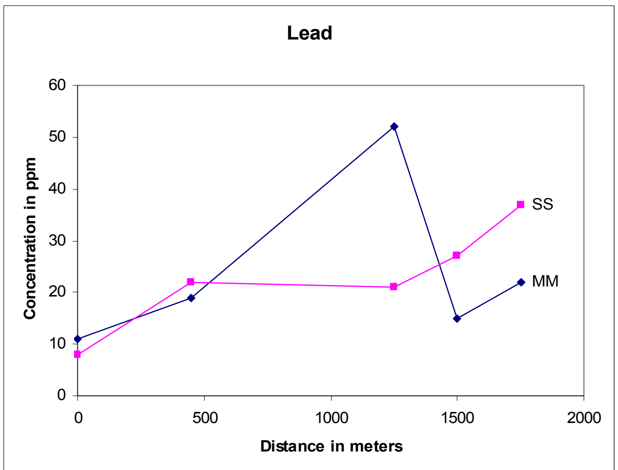


Figure A3-3c

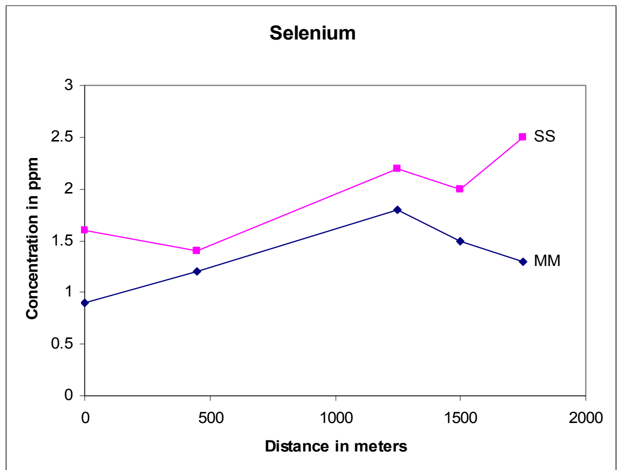


Figure A3-3d

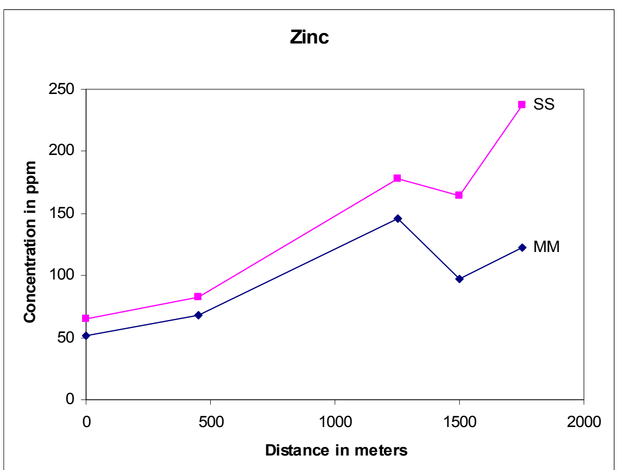


Figure A3-3e

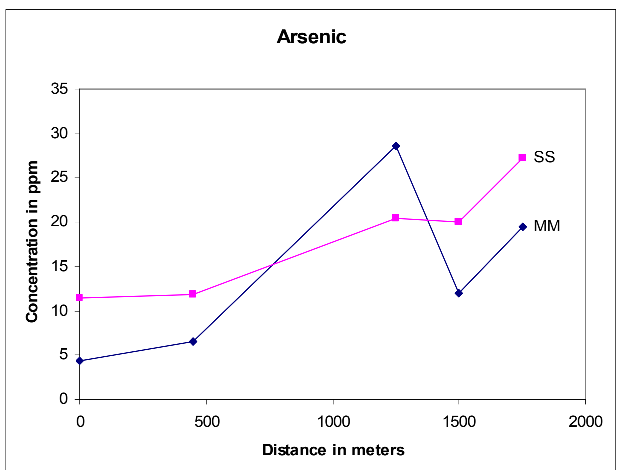


Figure A3-3f

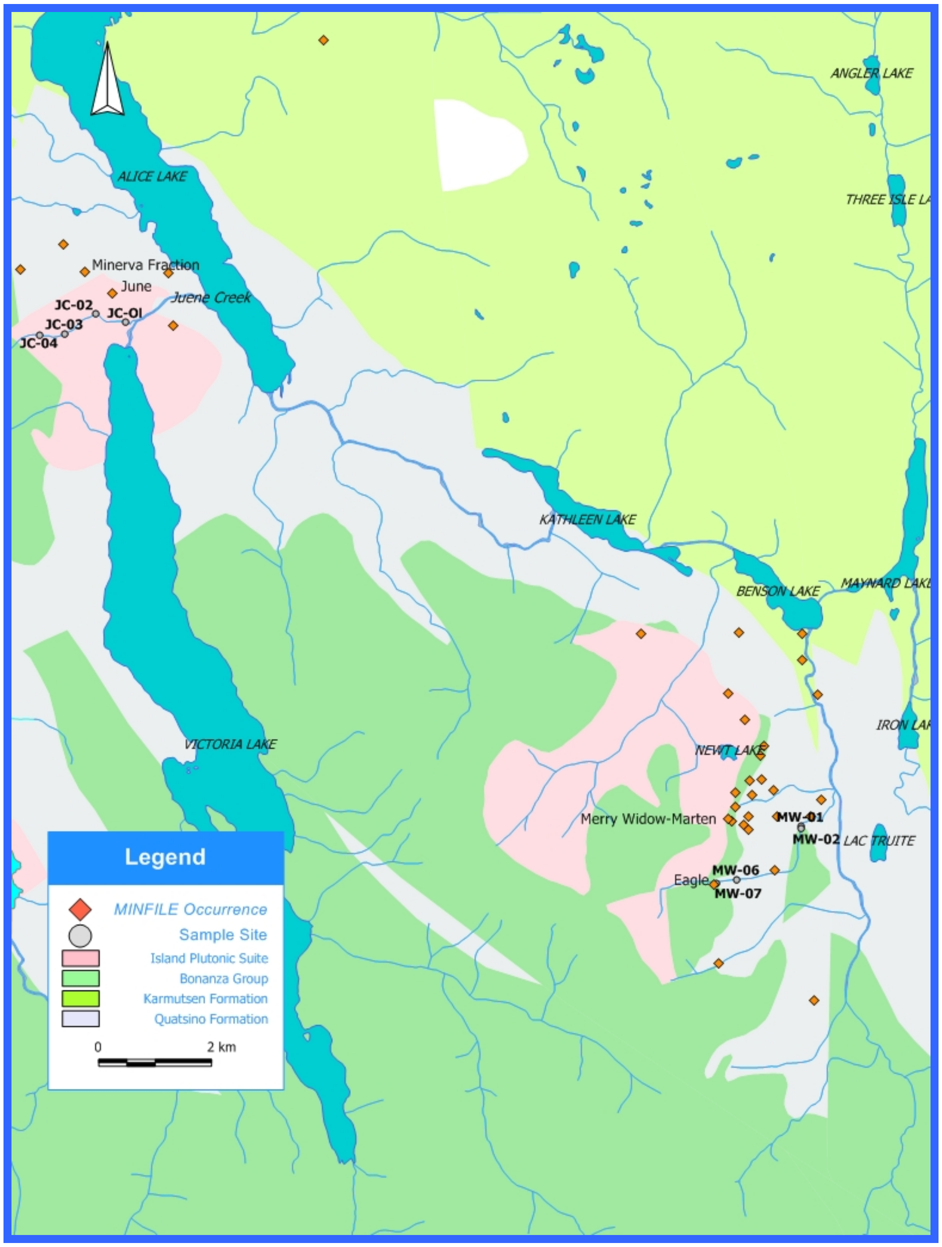


Figure A4-1- Jeune Creek (JC-) and Merry Widow (MW-) Creek Sample Sites

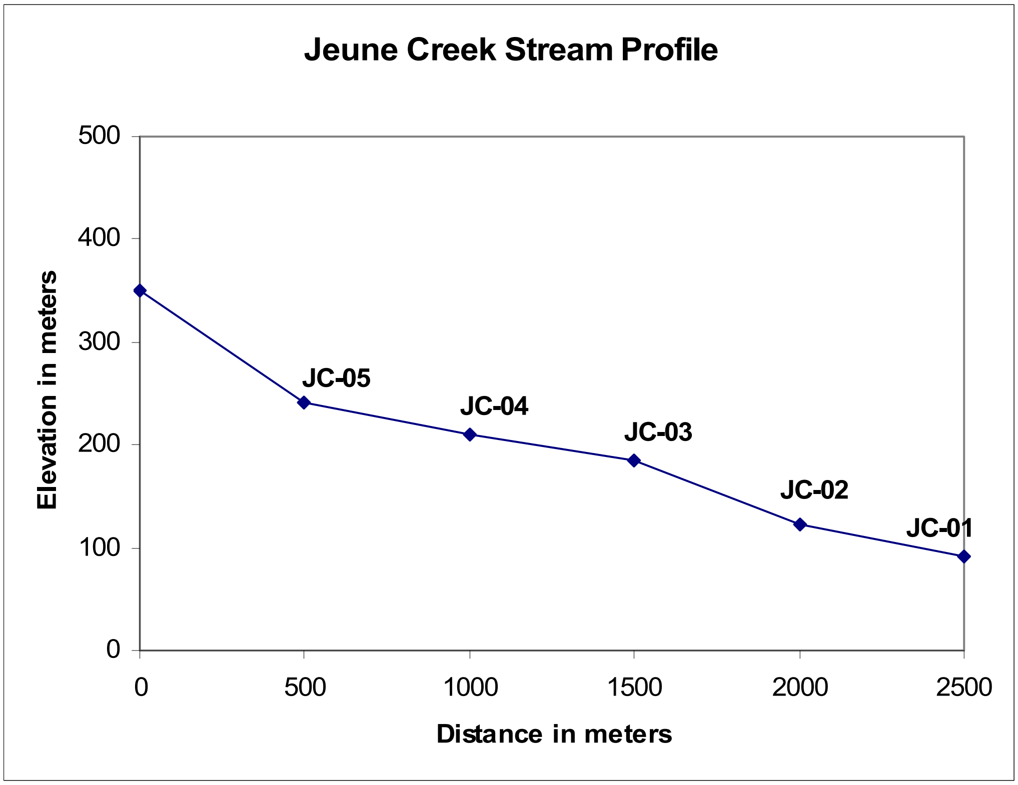


Figure A4-2. Jeune Creek stream profile.

JEUNE CREEK – BASE-METAL & IRON SKARNS

DEPOSIT #1 NAME: June *MINFILE #:* 092L 056

LOCATION: NTS – 92L06 LAT. - 50º26'06" LONG. - 127º24'12" UTM NORTH – 5587800 UTM EAST – 613000

STATUS: Prospect ***COMMODITIES:*** Iron, Copper, Gold, Silver, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite, Chalcopyrite, Boronite, Galena, Sphalerite, Arsenopyrite

DEPOSIT #2 NAME: Minerva Fraction *MINFILE #:*092L 112

LOCATION: NTS – 92L06 LAT. - 50º26'20" LONG. - 127º25'00" UTM NORTH – 5588409 UTM EAST – 612437

STATUS: Prospect ***Commodities:*** Zinc, Copper, Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Sphalerite, Magnetite, Pyrite, Pyrrhotite, Chalcopyrite

LOCAL GEOLOGY: Juene Creek drains a basin predominantly underlain by the June Stock of the Jurassic Island Intrusions (lower reach) and Bonanza Group volcanics (upper reach). To the north the June Stock is in intrusive contact-with Upper Triassic Quatsino Formation limestone. The multiphase June Stock ranges in composition from hornblende diorite to granodiorite to aplite (*Figure A4-1*).

ALTERATION AND MINERALIZATION: Skarn alteration marked by partial to total replacement of limestone by an epidote-chlorite-garnet-tremolite-actinolite assemblage is found at several locations along the contact between the Quatsino Formation and the Jeune Stock. At the Jeune and Minerva Fraction prospects, skarn alteration is accompanied by disseminated to massive magnetite, pyrite and pyrrhotite with lesser amounts of chalcopyrite, galena, sphalerite and arsenopyrite. The Jeune deposit is located on the north slope above the creek roughly 500 metres upstream of site JC-0l. The Minerva Fraction deposit lies 500 metres north of site JC-03. Sulphide bearing quartz veins were exposed in the creek bed above sites JC-02 and JC-04.

LOCAL ENVIRONMENT: Jeune Creek drains the eastern face of a ridge separating Neroutsos Inlet and Victoria Lake near the northern boundary of the Insular Mountains physiographic terrain. Local summits are rounded and range from 650 to 900 metres above sea level. The study area has moderately steep slopes and a topographic relief of 800 metres. Surficial cover consists of talus, thin till and colluvium in the steep upper basin of Jeune Creek and moderately thick till, colluvium and glaciofluvial deposits in the lower basin. Ice flow indicators define a north-northwest direction of travel during the last phase of glaciation. The above described deposits lie up ice of Jeune Creek. The present climate is cool and wet with annual precipitation in excess of 2500 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS: Jeune Creek undergoes a 150 metre vertical drop along the 2.0 km sampled course (*Figure A4-2*). In profile, Jeune Creek is seen to have a stepped pattern with a steep gradient (18 degrees) section above site JC-05, a moderate gradient section (5 degrees) between sites JC-05 and JC-03, a moderately steep section (11 degrees) between sites JC-03 and JC-02 and a moderate gradient section (6 degrees) below site JC-02. Waterfalls and Steep banks composed of till, colluvium or bedrock are common along the entire length of Jeune Creek. The channel pattern is mainly shoots-and-pools with the occasional braided section. Large boulders fill the creek bed.

SAMPLE PATTERN: Five sites were sampled for moss-mat sediment and conventional fine-grained stream sediment (*Figure A4-2*). Bulk fine-grained sediment was collected at every second site. Bulk sieved samples of coarse and fine-grained sediment from high and low energy sites was obtained from site JC-0l. Conventional fine-grained stream sediment was scarce to very scarce while moss mats were found in moderate to abundant amounts at each site.

RESULTS

Element Associations and Dispersion Curve Shapes

Three multi element dispersion patterns have been defined in both moss-mat sediment and in conventional fine-grained stream sediment.

The first pattern in moss-mat sediments, exhibited by As, Pb, Sb, Sr and Zn, describes concentrations which increase downstream with maximum concentrations at JC-02 or JC-01. In the second pattern, Al, Ba and Mn display a double peak pattern with elevated concentrations at JC-04 and JC-02 or JC-01. The third pattern, displayed by Ca, Fe, P, Ti and V defines low values at JC-04 and JC-02.

Similar dispersion trains are displayed As, Ag, Ba, Bi, Cu, Pb, Sb, Sr and Zn in conventional fine-grained stream sediment. Concentrations of these elements increase with distance downstream to maximum values at site JC-02. The second pattern in conventional stream sediments, defined by Al, Mn and organic matter, exhibits enhanced levels at JC-03 and JC-02. In the third pattern, Ca, Fe, P, Ti and V display a double peak profile with enhanced values at JC-04 and JC-02.

Concentrations of Mn, Fe, V, Ca, P, Cr, Ti, Sb and Bi are higher on average in moss-mats sediments relative to conventional fine-grained stream sediments, the inverse is true for the remaining elements.

Comparison to Background

Background and threshold concentrations were calculated for sediment derived dominantly from the Island

Intrusions (*Table A-4*). Elements which exceed threshold at one or more sites in either or both sample media are Au, Ag, As, Bi, Ba, Pb, Sb and Zn.

INTERPRETATION

Elements of the first group in moss-mat sediment and most elements in the first group of conventional stream sediment (with the possible exception of Cu and Sr) are interpreted as anomalous and related to the Minerva Fraction and the June deposits. Concentrations of As (*Figure A4-3a*), Pb (*Figure A4-3b*), Sb (*Figure A4-3c*) and Zn (*Figure A4-3d)* build to a maximum level in moss-mat and conventional stream sediment at site JC-02 which is closest to the June deposit. Copper bearing minerals are known to occur in the June and Minerva Fraction deposits, however Cu (*Figure A4-3e*) concentrations in moss mat and conventional fine-grained sediment are well below average background. Au (*Figure A4-3f*) concentrations are low in both media with average concentrations slightly higher in stream sediment. The patterns displayed by Mn and Al in both media (*Figure A4-3g*) correspond with elevated organic concentrations and may reflect organic scavenging or low-energy environments where light density minerals and organic matter may accumulate. Concentrations of Ca, Fe, P, Ti and V are within the background range and display an antipathetic relationship to the weight of the -80 mesh sediment (*Figure A4-3h*). Samples collected at these sites were particularly coarse due to high stream energy. The elevated concentrations of Ca, Fe, P, Ti and V are likely due to the winnowing of light minerals leaving an accumulation of heavier minerals including ferromagnesian silicates. Moss-mat samples collected at the same sites also produced low sample weights. Unlike the stream sediments, concentrations of Ca, Fe, P, Ti and V were low at these sites suggesting that these environments did not favour trapping heavy mineral grains in the mat.

The steep terrain and high average stream gradient should result in primarily mechanical dispersion of elements as primary and secondary minerals within the stream. The underlying lithology and locally derived surficial deposits are likely carbonate poor and therefore have a limited capacity to neutralize acids generated in the weathering environment. A potentially significant hydromorphic component of element dispersion may occur. The consistently higher concentrations in conventional stream sediments for element moderately to highly mobile under acidic environments (i.e. Ag, As, Zn) may be an indication of this process.

The June and Minerva Fraction deposits are best defined by As, Pb, Sb and Zn in one or both media. Potential pathfinders are Au, Ag, Ba and Bi which occasionally exceed background. Conventional fine-grained stream sediment is the optimal sample medium for all anomalous elements except Sb and Bi.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Pb	Stream	9 - 47 ppm	1	6	22.6	2.0 km
Zn	Stream	84 - 166 ppm	45	87	2.5	1.5 km
Sb	Moss	0.9 - 1.3 ppm	0.1	0.9	11	1.0 km
As	Stream	5.8 - 78.0 ppm	5	14	7.8	1.0 km
Bi	Moss	0.4 - 0.9 ppm	0.1	0.5	6.2	1.0 km
Ba	Stream	35 - 68 ppm	32	48	1.5	1.0 km
Au	Stream	1 - 14 ppb	2	10	2.3	1 site
Ag	Stream	0.1 - 0.4 ppm	0.1	0.5	1.8	?

Table A-4. Jeune Creek - Summary Table of Pathfinder Elements

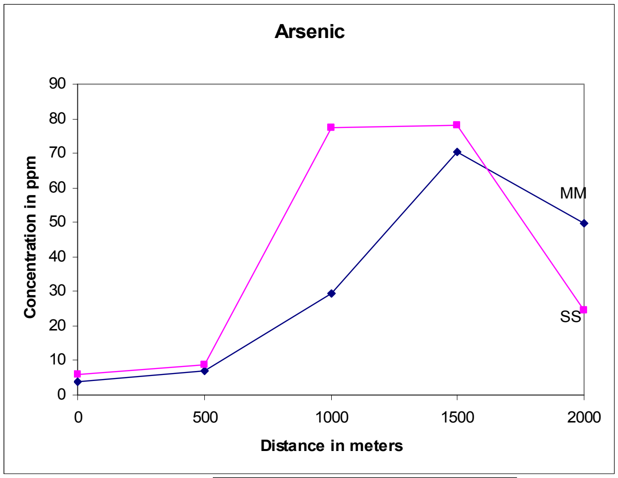


Figure A4-3a

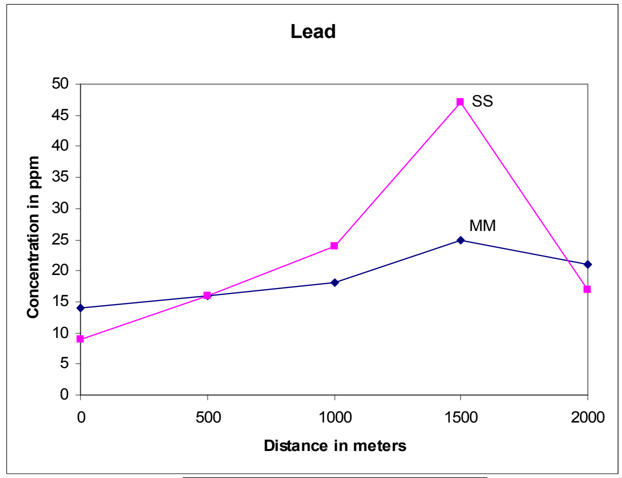


Figure A4-3b

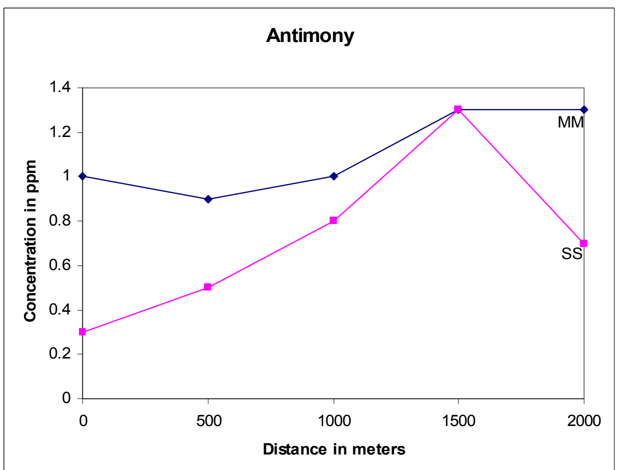


Figure A4-3c

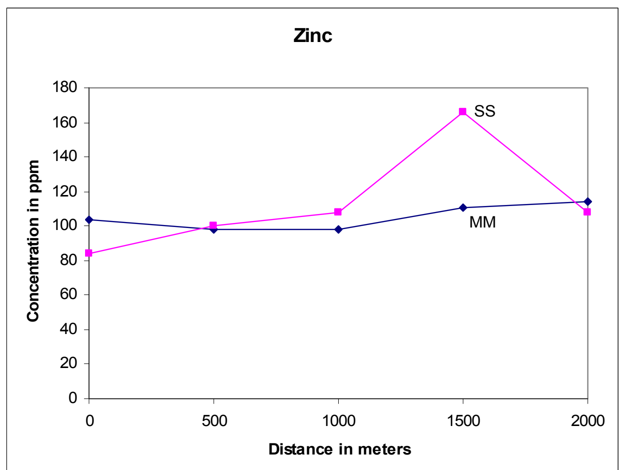


Figure A4-3d

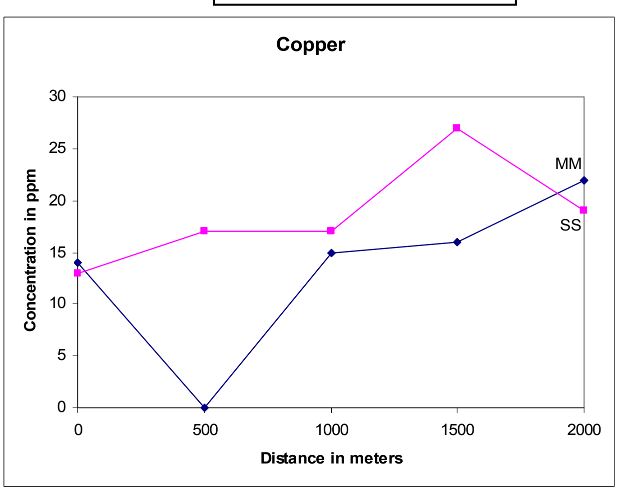


Figure A4-3e

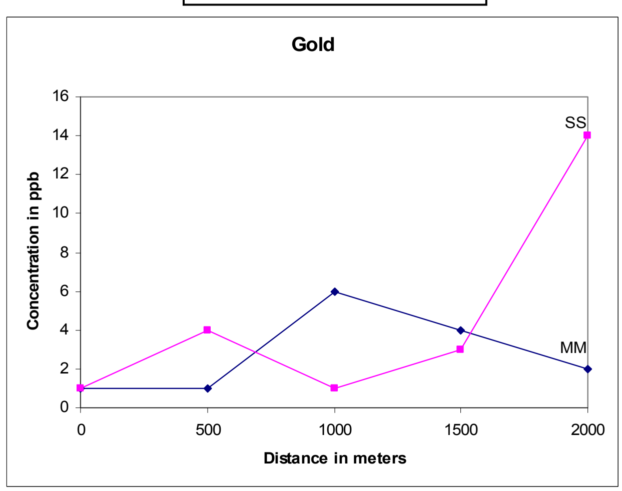
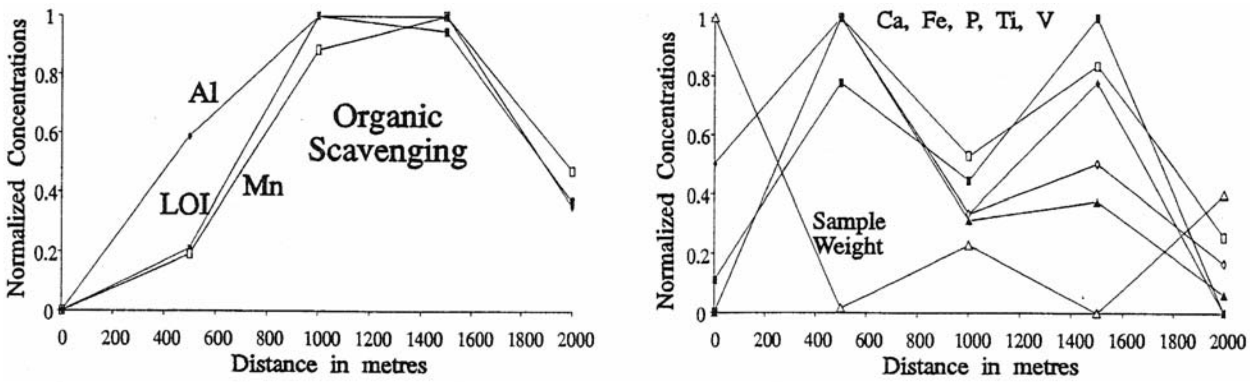


Figure A4-3f



Figures A4-3g & A4-3h. Geochemical profiles for Jeune Creek

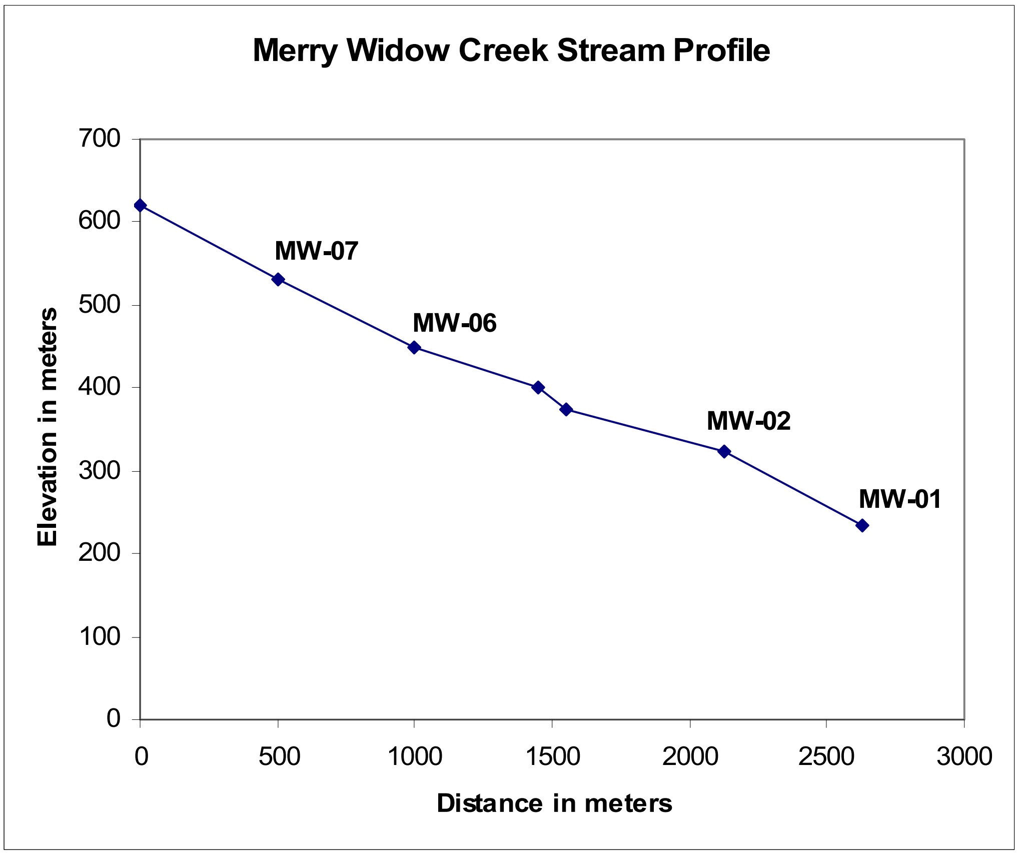


Figure A5-2. Merry Widdow Creek profile

MERRY WIDOW CREEK – IRON SKARN

DEPOSIT #1 NAME: Marten

MINFILE #: 092L 050

LOCATION: NTS – 92L06

LAT. - 50º21'10"
LONG. - 127º14'59"

UTM NORTH – 5579101
UTM EAST – 624517

STATUS: Showing

COMMODITIES: Iron, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite

DEPOSIT #2 NAME: Snowline

MINFILE #: 092L 051

LOCATION: NTS – 92L06 LAT. - 50º21'12" LONG. - 127º15'10" UTM NORTH – 5579157 UTM EAST – 624298

STATUS: Showing

COMMODITIES: Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite

DEPOSIT #3 NAME: Eagle

MINFILE #: 092L 114

LOCATION: NTS – 92L06 LAT. -50º20'35" LONG. - 127º15'25" UTM NORTH – 5578008 UTM EAST – 624029

STATUS: Showing

COMMODITIES: Copper, Cobalt

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Cobaltite

LOCAL GEOLOGY: Merry Widow Creek drains a basin predominantly underlain by Quatsino limestone of the Upper Triassic Vancouver Group in the lower reaches and Lower Jurassic Bonanza Group andesitic to rhyodacitic flows, tuffs and breccias in the upper reaches (*Figure A4-1*). The dioritic Benson Lake Stock, belonging to the Jurassic Island Intrusions, intrudes the Bonanza Group volcanics.

ALTERATION AND MINERALIZATION: At the Marten and Snowline showings, scattered magnetite rich skarn occurs along the contact between Bonanza volcanics and Quatsino limestone or between Bonanza volcanics and the Benson lake stock. The skarn alteration is usually marked by partial or total replacement of limestone or volcanics by an alteration assemblage comprising epidote, chlorite, garnet, tremolite and actinolite. At the Marten showing, chalcopyrite and pyrrhotite accompanies massive magnetite. At Snowline, only magnetite is identified. The development of skarn alteration was not described at the Eagle showing, however minor disseminated chalcopyrite and cobaltite occurs along the contact between the Quatsino limestone and Bonanza volcanics. The Marten and Snowline showings lay 1 kilometre north of site MW-06 and approximately 365 metres upslope of the creek bed. The Eagle showing lies 100 metres upstream of site MW-07. Minor (1 - 5 cm) lenses of magnetite were noted in exposed limestone adjacent to the creek at several locations. Considerable magnetite was present in sieved bulk samples collected at site MW-01.

LOCAL ENVIRONMENT: Merry Widow Creek drains the eastern flank of Merry Widow Mountain which forms part of the Vancouver Island Ranges in the Insular Mountains physiographic terrain. Local summits are jagged and range from 950 to 1 400 metres above sea level. The terrain of the study area is steep with local relief of 1 200 metres. Surficial cover is a veneer of talus, till and colluvium on middle to upper slopes which becomes a continuous till blanket along lower slopes. Bare rock is common in the headwaters of Merry Widow Creek. During the last glaciation, ice accumulating in the cirque above Merry Widow Creek, would have flowed along the upper stream basin prior to merging with a larger north-northwest flowing glacier occupying the Benson River valley. Merry Widow Creek lies up-ice of the major skarn deposits (Empire, Coast Copper) in the area and would not have been contaminated by these deposits. The present climate is moderately cool and wet with annual precipitation in excess of 2 500 millimetres. Soils are dominantly ferro-humic podzols.

STREAM CHARACTERISTICS: Merry Widow Creek undergoes a 296 metre vertical drop along the 2.1 km sampled course (*Figure A5-2*). In profile, Merry Widow Creek is seen to have a moderately steep gradient averaging 12.5 degrees. Below site MW-06, waterfalls in excess of 10 metres separated by low gradient stretches of stream channel were frequently encountered. Limestone walls enclosed the stream channel. Above site MW-06, the channel had a constant gradient with banks composed of bare rock, colluvium and till. Large boulders fill the creek bed.

SAMPLE PATTERN: Four sites were sampled for moss-mat sediment and conventional fine-grained stream sediment (*Figure A5-1*). Bulk fine-grained sediment was collected at sites MW-01 and MW-07. Bulk sieved samples of coarse and fine-grained sediment from high and low energy sites were obtained from site MW-01. Conventional fine-grained stream sediment was generally scarce while moss mats were found in moderate to abundant amounts at each site.

RESULTS

Element Associations and Dispersion Curve Shapes

Five dispersion patterns are identified in both moss-mat and conventional fine-grained stream sediment.

In both media, concentrations of Ca (*Figure A5-3a*), Sr and Mg increase significantly with distance downstream. All are enhanced in conventional fine-grained stream sediment relative to moss-mat sediment. Conversely, in the second pattern Al, Cr, K, Mn, Ni, P, (*Figure A5-3b*), Pb and Zn demonstrate a moderate to sharp decrease in concentrations with distance downstream with comparable concentrations in the two media. In the third pattern, common to both media, Fe and V (*Figure A5-3c*) display enrichment at site MW-06 and MW-01 with concentrations consistently higher in moss-mat sediment. The fourth pattern, best defined by the higher concentrations in moss-mat sediment, exhibits progressively higher values of Ag, As, Co, Cu and Sb with distance downstream and a positive concentration spike at site MW-01. The fifth pattern, unique to Au, describes concentrations which increase to a maximum value at site WM-02. Concentrations are consistently at least one order of magnitude higher in moss-mat sediment relative to conventional fine-grained stream sediment.

Comparison to Background

Background and threshold concentrations have been calculated for a lithology dominated by the Quatsino Formation (*Table A-5*). Elements which exceed threshold at one or more sites in either or both sample media are Au, Ag, As, Co, Cu, Fe, Sb and V.

INTERPRETATION

The first and second patterns reflect the change in lithology from Island Intrusions and Bonanza Group rocks in the upper basin to Quatsino limestone in the lower basin. Elements associated with carbonate minerals (Ca, Mg, Sr) demonstrate the increasing content of limestone derived sediment in the lower reaches. The lithophile and siderophile elements in the second pattern indicate the decrease in silicates (particularly ferro-magnesian silicates) with distance downstream. The substantially higher concentrations of Ca (*Figure A5-3b*), Sr and Mg in conventional stream sediment may be the result of hydromorphic enhancement. Hypothetically, carbonates dissolved in the upper basin (due to an acidic environment surrounding the Benson Lake Stock) may precipitate as sediment coating in the lower basin. Stream sediment, which is in continuous contact with carbonate enriched stream water, would develop thicker coatings relative to moss-mat sediment.

Concentrations of Fe and V (*Figure A5-3c*) are interpreted as anomalous and probably related to the magnetite bearing skarn showings intersected by the creek. The elements are moving primarily as heavy mineral grains which are preferentially concentrated in moss mats. The low concentrations of Fe and V in conventional fine-grained stream sediment at site WM-02 corresponds with a low sample weight and a high organic content. Sample notes described a low energy environment with considerable very-fine grained sediment.

The patterns described by Au (*Figure A5-3d*), Ag (*Figure A5-3e*), As (*Figure A5-3f*), Cu (*Figure A5-3g*), Sb and possibly Co (*Figure A5-3h*) are inferred to be anomalous and mineral deposit related. Elevated Au*,* As, Cu, Ag and Sb likely define the skarn deposits in the upper basin. The above elements, with the possible addition of Co, reflect the skarn deposits in the lower basin. The enhanced Cu concentration in moss-mat sediment, relative enrichment in the coarse fraction of the bulk sediment sample and variability between within-site duplicates in both media at WM-01 may be indicative of moderately coarse sulphide grains and a minor nugget effect. Enhanced Cu in conventional fine-grained stream sediment at MW-02 corresponds to a high organic content and may be the result of scavenging. Similar enhancements are seen for elements which are either scavenged (Ni, Sb, Zn, etc.), constituent to light density minerals such as the phyllosilicates (Al in *Figure A5-3a*) or are biophile (K).

The steep terrain and high average stream gradient should result in primarily mechanical dispersion of elements as primary and secondary minerals within the stream. The carbonate rich terrain may limit the break down of primary minerals and the mobilization of elements as aqueous phases.

The iron skarn occurrences within the Merry Widow Creek drainage basin are best defined by Au, Ag, As, Cu, Fe, Sb and V in one or both media. A potential pathfinder is Co which has been documented in one local occurrence. Moss mats are the optimal sample medium for all anomalous elements.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	25 - 530 ppb	3	10	109.4	2.1 km
V	Moss	213 - 303 ppm	112	168	2.1	2.1 km
Ag	Moss	0.3 - 1.3 ppm	0.1	0.5	8	1.6 km
Cu	Moss	48 -716 ppm	46	118	7.1	1.6 km
Fe	Moss	7.27 - 11.57 %	5.3	7.2	1.9	1.6 km
As	Moss	11.4 - 164.3 ppm	10	27	7	0.4 km
Sb	Moss	0.6 - 1.2 ppm	0.1	0.8	9.3	0.4 km
Co	Moss	15 - 39 ppm	20	32	1.2	1 site

Table A-5. Merry Widdow Creek - Summary Table of Pathfinder Elements

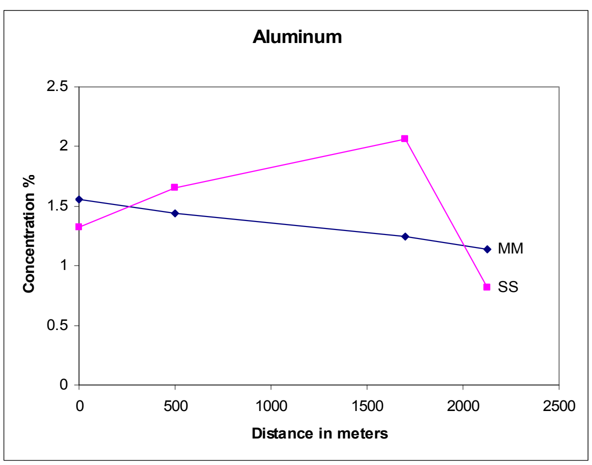


Figure A5-3a

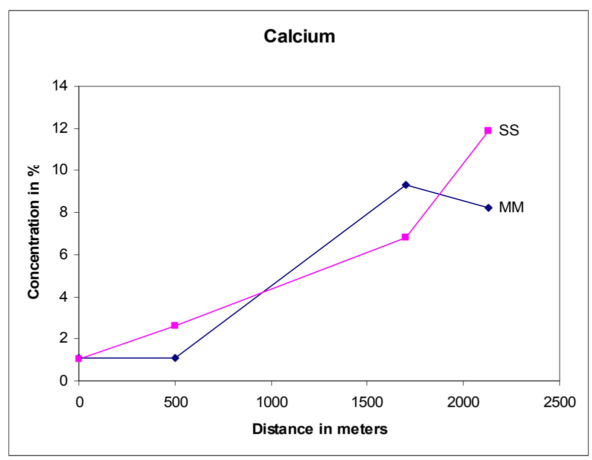


Figure A5-3b

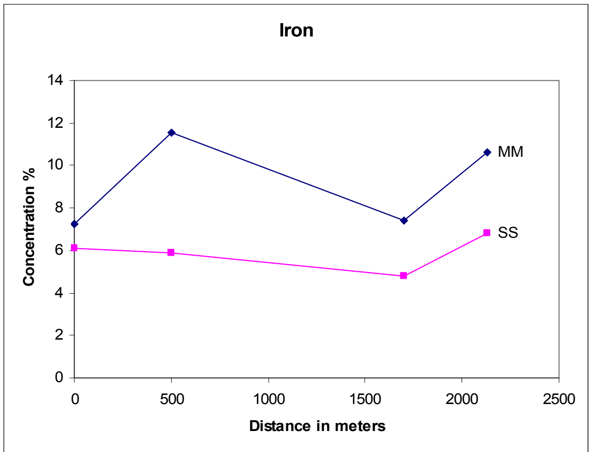


Figure A5-3c

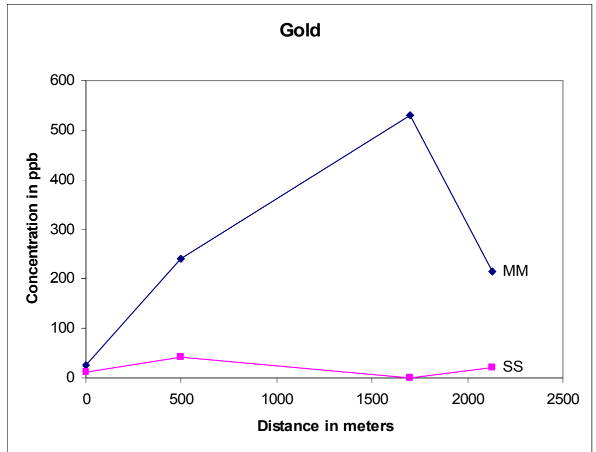


Figure A5-3d

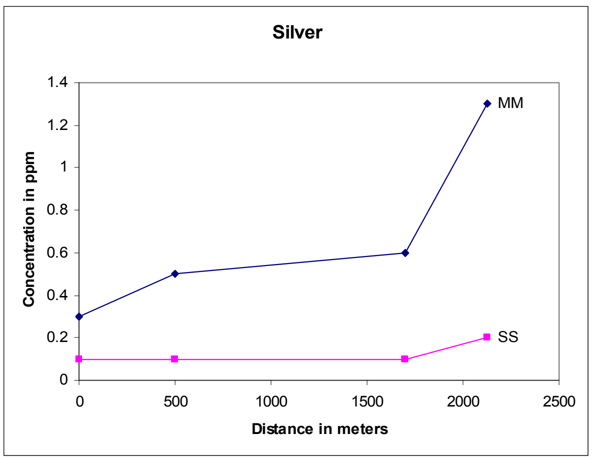


Figure A5-3e

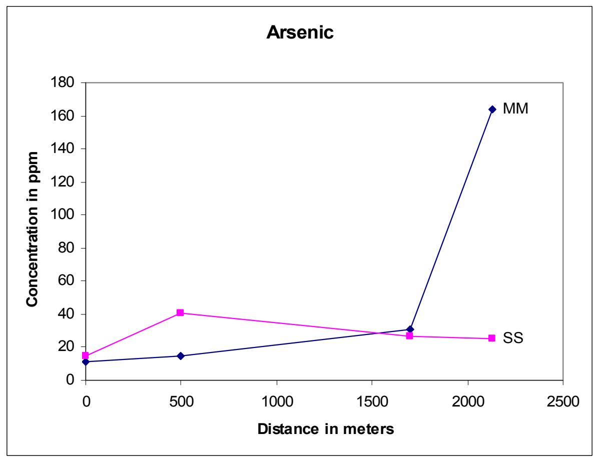


Figure A5-3f

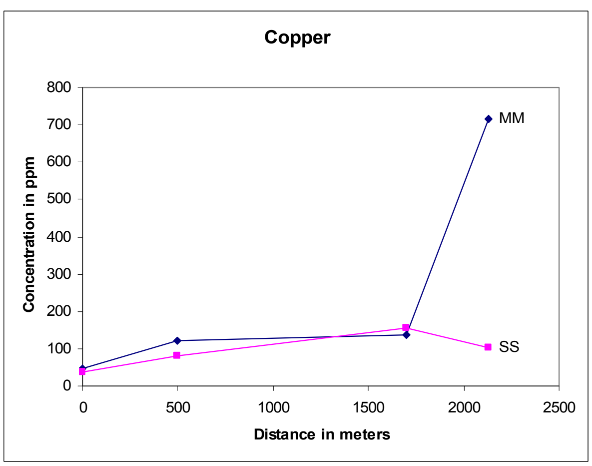


Figure A5-3g

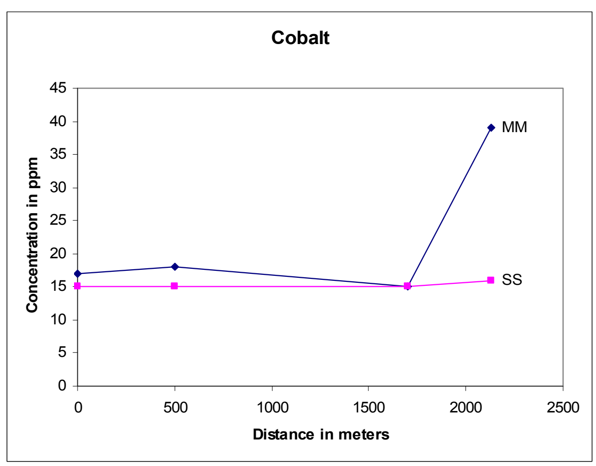


Figure A5-3h

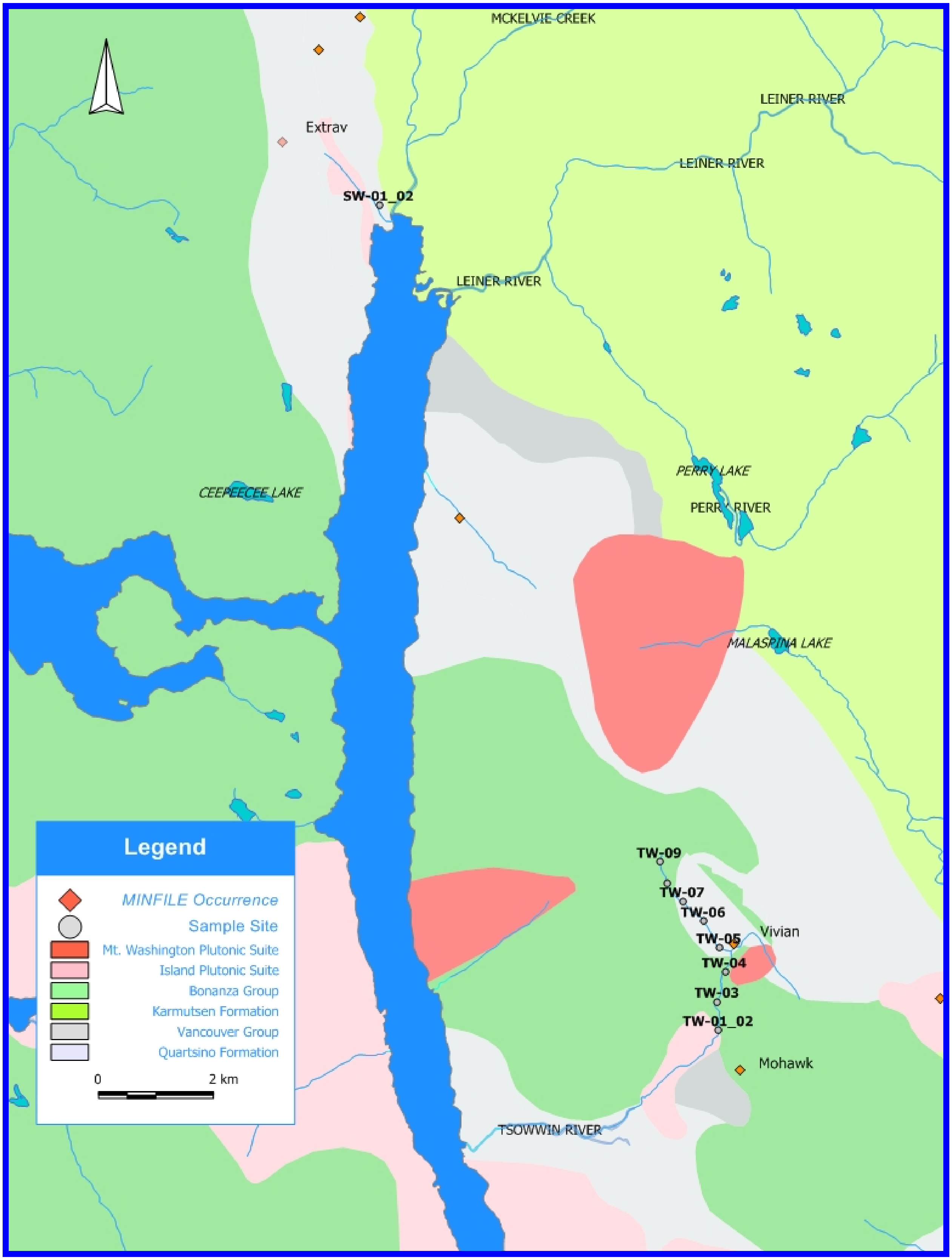


Figure A6-1 Storey Creek and Kinman Creek sample sites

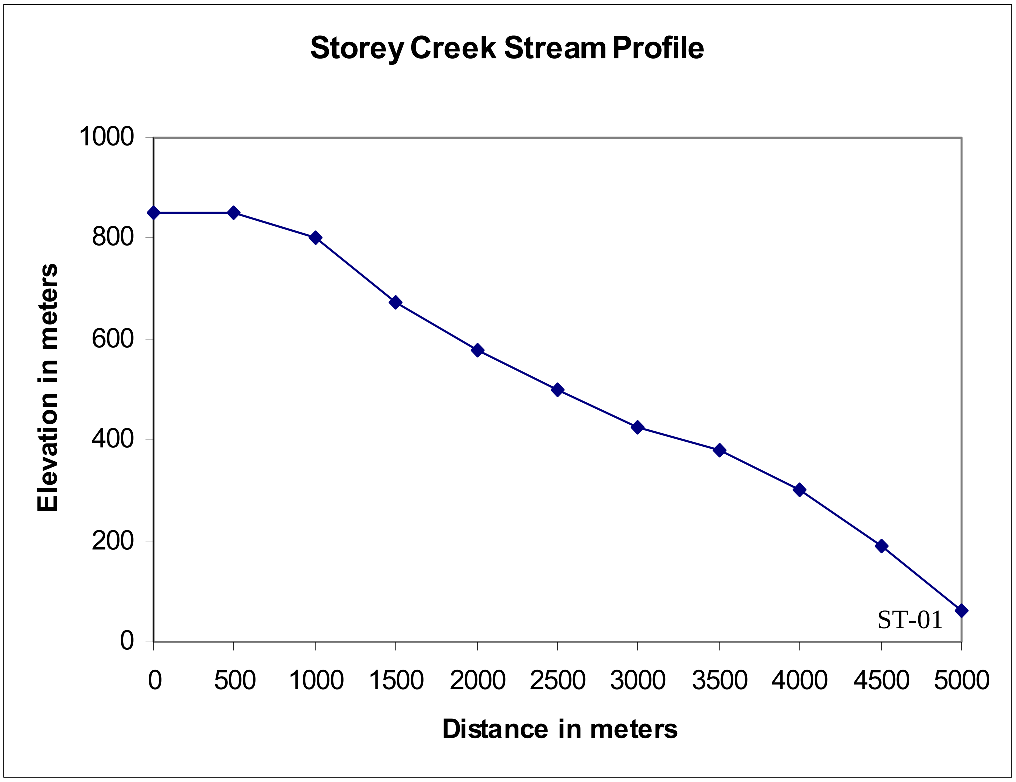


Figure A6-2. Storey Creek profile

STOREY CREEK – BASE METAL & IRON SKARN

DEPOSIT #1 NAME: Smith Copper

MINFILE #: 092L 037

LOCATION: NTS – 92L07

LAT. - 50º21'47"
LONG. - 126º54'37"

UTM NORTH – 5580867
UTM EAST – 648632

STATUS: Prospect

COMMODITIES: Iron, Copper, Zinc, Lead, Silver

***SIGNIFICANT AND ASSOCIATED MINERALS*:** Pyrrhotite, Magnetite, Chalcopyrite, Sphalerite, Pyrite

DEPOSIT #2 NAME: Wolf

MINFILE #: 092L 121

LOCATION: NTS – 92L07

LAT. - 50º22'10"
LONG. - 126º53'25"

UTM NORTH – 5581617
UTM EAST – 650034

STATUS: Showing

COMMODITIES: Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite

DEPOSIT #3 NAME: Martha 4

MINFILE #: 092L 133

LOCATION: NTS – 92L07 LAT. - 50º22’30” LONG. - 126º54’42” UTM NORTH – 5582192 UTM EAST – 648496

STATUS: Showing ***COMMODITIES:*** Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite

DEPOSIT #4 NAME: Smith Main *MINFILE #:* 092L 208

LOCATION: NTS – 92L07 LAT. - 50º21’52” LONG. - 126º55’00” UTM NORTH – 5581008 UTM EAST – 648173

STATUS: Prospect ***COMMODITIES:*** Zinc, Copper, Lead, Silver

SIGNIFICANT AND ASSOCIATED MINERALS: Sphalerite, Chalcopyrite, Galena, Pyrite, Pyrrhotite

LOCAL GEOLOGY: In the upper basin, Storey Creek (*Figure A6-1*) drains a region predominantly underlain by the Nimpkish Batholith, a granodioritic phase of the Lower Jurassic Island Intrusions. In the lower basin, Upper Triassic Vancouver Group rocks comprising limestones of the Quatsino Formation and tholeiitic basalt flows of the Karmutsen Formations together with felsic to intermediate flows, tuff and breccia of the Lower Jurassic Bonanza Group form the underlying lithology.

ALTERATION AND MINERALIZATION: Sporadic skarn alteration consisting of the assemblage garnet-epidote-diopside-actinolite-chlorite-calcite is seen to replace Quatsino limestone and/or Karmutsen volcanics near or along the contact between these formations and dykes or the main body of the Nimpkish Batholith. Base metal sulphides comprising chalcopyrite, sphalerite and galena accompany magnetite, pyrrhotite and pyrite in the Smith Main and Smith Copper deposits. These lay adjacent to Storey Creek approximately 1 kilometre upstream of site ST-01. The Martha 4 and Wolf deposits are described as magnetite bearing only, both lay in the upper basin over 3 kilometres upstream of site ST-01.

LOCAL ENVIRONMENT: Storey Creek lies in the Insular Mountains physiographic terrain. The study area is mountainous and steep with local relief of 1 400 metres. Surficial cover consists of talus, thin till and colluvium. Exposed bedrock is common in the headwaters of Storey Creek. During the last glaciation, ice flow was confined by the major north-northwest trending valley presently occupied by Nimpkish Lake. Storey Creek lies immediately down-ice of Smith Main and Smith Copper deposits. Glacial transport would aid mechanical dispersion of mineralized material into the creek. The climate is wet with annual precipitation in excess of 2 500 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (*Figure A6-2*), Storey Creek is seen to have a constant steep gradient averaging 18.5 degrees. Observations made from site ST-01 describe a narrow canyon with exposed bedrock walls.

SAMPLE PATTERN: One site (*Figure A6-1*) was sampled for moss-mat sediment, and conventional fine-grained stream sediment, bulk fine-grained sediment, and bulk sieved samples of coarse and fine-grained sediment from high and low energy sites. Waterfalls and near vertical canyon walls precluded a sampling traverse. Conventional fine-grained stream sediment was very scarce at ST-01.

RESULTS

Element Associations and Dispersion Curve Shapes

Comparison of element associations and dispersion curve shapes cannot be made due to only one site being sampled.

Comparison to Background

Background and threshold levels were calculated for a lithology comprised dominantly of the Island Intrusions. Elements which exceed their threshold in one at least one sample are Au, Ca, Cr, Cu, Ni, Pb, Sr and Zn (*Table A-6*). Elements which nearly exceed their thresholds include Ag and As.

INTERPRETATION

Background and threshold concentrations for Island Intrusions were employed in the Comparison to Background as this rock type underlies roughly 95 percent of the drainage basin and would be the main contributor to the sediment load. However an additional comparison was made with backgrounds for the Quatsino Formation which underlies the final 1.5 kilometres of the stream course and which would have some impact upon the geochemical signature of the sediment. Given the above, anomalous concentrations of Au, Cu, Pb and Zn are believed to be related to the mineralization at the Smith Main and Smith Copper deposits 1 kilometre upstream. The elevated concentrations of Ca, Ni and Sr exceed their thresholds for Island Intrusions but are well within the background range for Quatsino Formation. Cr approaches the threshold level for the Quatsino Formation and may be related to the mineralization.

The base metal skarns in the Storey Creek drainage basin are best defined by Pb and Zn which exceed their thresholds in every sample. Other pathfinders include Au and Cu which exceed their thresholds in at least one sample collected. Potential pathfinders are Ag, As and Cr which approach their thresholds.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Pb	Moss	12 - 15 ppm	1	6	13.5	1 site
Zn	Moss	143 - 180 ppm	45	87	3.6	1 site
Au	Moss	1 - 17 ppb	2	10	4.5	1 site
Cu	Stream	68 - 90 ppm	32	84	2.5	1 site
Ag	Moss	0.2 - 0.4 ppm	0.1	0.5	3	
As	Stream	12.2 - 12.4 ppm	5	14	2.5	
Cr	Stream	64 -70 ppm	18	27	3.7	?

Table A-6. Storey Creek - Summary Table of Pathfinder Elements

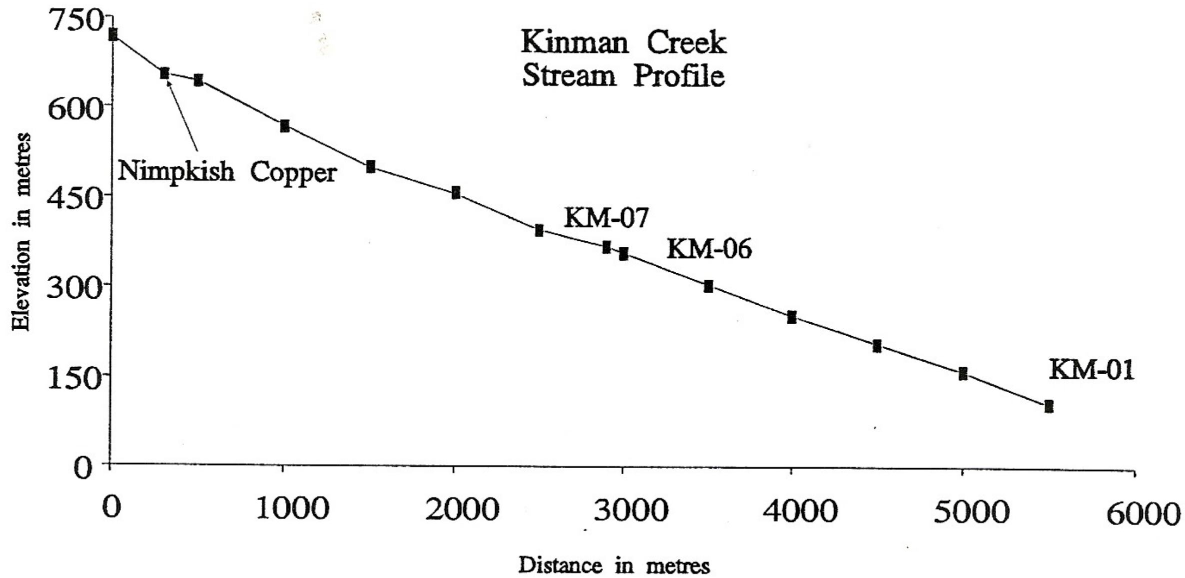


Figure A7-2 Kinman Creek Profile

KINMAN CREEK – BASE METAL SKARN AND MASSIVE SULPHIDE

DEPOSIT #1: NAME: Nimpkish Copper *MINFILE #:* 092L 036

LOCATION: NTS – 92L07 LAT. - 50º19'56" LONG. - 126º50'00" UTM NORTH – 5577567 UTM EAST – 652368

STATUS: Developed Prospect ***COMMODITIES:*** Copper, Gold, Zinc, Molybdenum, Cadmium, Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Sphalerite, Magnetite, Molybdenite, Bornite, Greenockite, Covellite

DEPOSIT #2 NAME: Hazel 7 *MINFILE #:* 092L 118

LOCATION: NTS – 92L07 LAT. - 50º19'53" LONG. - 126º51'33" UTM NORTH – 5577449 UTM EAST – 652368

STATUS: Developed Prospect ***COMMODITIES:*** Copper, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Sphalerite

DEPOSIT #3 NAME: Alpha 4 *MINFILE #:* 092L 132

LOCATION: NTS – 92L07 LAT. - 50º20'05 LONG. - 126º50'00" UTM NORTH – 5577876 UTM EAST – 654196

DEPOSIT #4 NAME: Mac LAT. -50º20'40" LONG. - 126º51'26" UTM NORTH – 5578905 UTM EAST – 652465

STATUS: Showing *COMMODITIES:* Iron

SIGNIFICANT AND ASSOCIATED MINERALS: Magnetite

LOCAL GEOLOGY: In the upper basin, above site KM-06, Kinman Creek (*Figure A6-1*) drains a region underlain equally by the Nimpkish Batholith, a granodioritic phase of the Lower Jurassic Island Intrusions, and Quatsino Formation limestone of the Upper Triassic Vancouver Group. In the lower basin, andesitic to rhyodacitic flows, tuff and breccia of the Lower Jurassic Bonanza Group form the underlying lithology. Strong regional north and northwest trending faults often define intrusive and lithological contacts in the area.

ALTERATION AND MINERALIZATION: Skarn development generally occurs along or adjacent to contact zones between the Quatsino limestone and the Nimpkish batholith. The limestone may be partially or totally replaced by a general assemblage of garnet-epidote-actinolite-chlorite-calcite-sericite. At the Nimpkish Copper deposit, skarn alteration envelops a massive chalcopyrite lens measuring 8 metres by 4 metres. Found in lesser amounts are sphalerite, magnetite, molybdenite, bornite, greenockite, covellite, pyrrhotite and pyrite. The deposit is exposed in Kinman Creek approximately 2.5 kilometres upstream of site KM-07. The Hazel 7, found 1 kilometre to the east of Nimpkish Copper, is a 23 by 11 by 1.2 metre massive chalcopyrite and sphalerite lens in a skarn zone. The Mac, found 1.5 kilometres northwest of Nimpkish Copper, comprises a few narrow magnetite seams in barren limestone. The Alpha 4 deposit, found roughly 1 kilometre east of Nimpkish Copper, is a massive sulphide lens comprising pyrrhotite, sphalerite and minor chalcopyrite lens which is hosted by the Nimpkish Batholith.

LOCAL ENVIRONMENT: Kinman Creek lies in the Insular Mountains physiographic terrain. The study area is mountainous with steep slopes and local relief of 1 290 metres. Surficial cover consists of talus, thin till and colluvium. Ice flow was confined by the major north-northwest trending valley presently occupied by Nimpkish Lake. The direction of glacial transport would have aided the deposition of mineralized material in Kinman Creek. The climate is wet with annual precipitation in excess of 2 500 millimetres. Soils are dominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (*Figure A7-2*), Kinman Creek is seen to have a constant moderately steep gradient of 10 degrees. Kinman Creek undergoes a 262 metre vertical drop along the 2.6 km sampled course. The stream channel is confined by bedrock canyon walls through most of it’s' course. Numerous waterfalls were encountered which shortened the sampling traverse. A shoots-and-pools channel pattern predominated.

SAMPLE PATTERN: Three sites (*Figure A6-1*) were sampled for moss-mat sediment, and conventional fine-grained stream sediment. Bulk fine-grained sediment samples were collected from sites KM-01 and KM-07. Duplicate moss-mat and conventional fine-grained stream sediment samples together with bulk sieved samples of coarse and fine-grained sediment from high and low-energy sites were obtained from site KM-01. Moderate to abundant amounts of conventional fine-grained stream sediment, found upstream of log jams, was available at every site. Moss mats were abundant throughout the stream traverse.

RESULTS

Element Associations and Dispersion Curve Shapes

The limited number of sample sites precludes an in-depth interpretation of dispersion curve shapes. Three general patterns are seen in moss-mat sediment and conventional fine-grained stream sediment.

Elements which describe generally decreasing concentrations in moss-mat and stream sediment with distance downstream are Bi, Ca, Ni and Sr. Elements which display generally increasing concentrations in both media are Al, As, B, Ba, Co, Fe, Mn, Pb, Se, Ti and V. Elements which show a generally flat dispersion curve are Ag, Cu, Cr, Mg, P, Sb and Te.

Moss-mat sediment has consistently higher concentrations of Cr, Fe, P, V and lower concentrations of Ca, Sr, Cu, Ni, Mg, Ba, Al, Bi. At site KM-01, Zn demonstrates a sharp enrichment in moss-mat sediment only.

Most of the elements show a sharp negative or positive spike at site KM-06. In general, elements believed to be transported mechanically as heavy minerals (Cr, Fe, Ti, V) display a negative spike in both moss-mat and stream sediment. Elements common to silicates (Al) or which may be incorporated as coatings on sediment grains (Mn) exhibit a positive spike.

Several elements (i.e. Cu, Pb, Fe, Cr, V, Te) display a large concentration variation (> 20 per cent) between within-site duplicates for both moss mat and conventional fine-grained stream sediment samples.

Comparison to Background

Background and threshold values were calculated for a mixed lithology comprising Quatsino Formation and Island Intrusions in equal parts (*Table A-7*). Elements which exceed their thresholds at one or more sites in either or both sample media are Au, B, Bi, Cu, Cr, Pb, Se, Sr, Te, W and Zn.

INTERPRETATION

The patterns and concentrations displayed by Ag, Al, As, Ba, Ca (*Figure A7-3c*), Co, Hg, Mg, Mn, P, Sr, Te and Ti are believed to reflect background and the change from a carbonate and granodiorite lithology in the upper basin to a dominantly volcanic lithology in the lower basin.

The patterns displayed by Au, B, Bi, Cu, Cr, Pb, Se, Te, W and Zn are interpreted as anomalous and related to the deposits based on the associations and concentrations displayed. The flat but elevated concentrations of Cu (*Figure A7-3a*), Zn (*Figure A7-3b*) and Bi (*Figure A7-3c*) in conventional stream sediment at site KM-06 may represent the distal portion of an anomalous dispersion train derived from the skarn deposits in the upper basin. These deposits could also be the source of the anomalous Au concentration in moss-mat sediment at this site.

The coincident and anomalous concentrations of Au (*Figure A7-3d*), B (*Figure A7-3e*), Cu, Cr, Fe, Pb (*Figure A7-3f*), Se, Te, W (*Figure A7-3g*) and Zn (*Figure A7-3h*) at site KM-01 suggests a lode source other than those discussed above. The concentration variations for within-site duplicates is likely due to variation in stream energy between duplicate sites. The generally higher concentrations of Zn in moss-mat sediment at KM-01 suggest mechanical dispersion of Zn as a heavy mineral.

The steep mountainous terrain and moderately steep stream gradient would promote mechanical dispersion of most elements within the stream environment. Dispersion in the surrounding terrain may vary from dominantly mechanical where carbonate rich rocks could neutralize acids generated in the weathering environment and thereby limit the mobilization of some elements (e.g. near site KM-01), to substantially hydromorphic in areas of low carbonate content.

The skarns in upper Kinman Creek are subtly defined by Cu, Zn and Bi in samples from the upper basin. A tentatively identified deposit (possibly skarn) in the lower basin is believed responsible for anomalous B, Cu, Cr, Fe, Pb, Se, Te, W and Zn at KM-01. Anomalous Au is associated with the skarn deposits in the upper basin and possibly with the deposit in the lower basin.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Cu	Stream	99 - 120 ppm	40	100	2.8	2.6 km
Zn	Stream	126 - 158 ppm	70	120	2	2.6 km
Au	Moss	6 - 185 ppb	3	10	22.2	2.0 km
Pb	Moss	4 - 18 ppm	1	7	8	2.0 km
Bi	Stream	0.2 - 0.9 ppm	0.1	0.5	2.5	0.6 km
Cr	Stream	50 - 63 ppm	40	55	3.7	2 sites
B	Stream	2 - 59 ppm	8	12	3	1 site
Te	Moss	0.3 - 0.7 ppm	0.2	0.5	2.2	1 site
W	Stream	1 - 5 ppm	1	5	1.8	1 site
Se	Moss	0.5 - 1.4 ppm	0.7	1.1	1.2	1 site

Table A-7. Kinman Creek - Summary Table of Pathfinder Elements

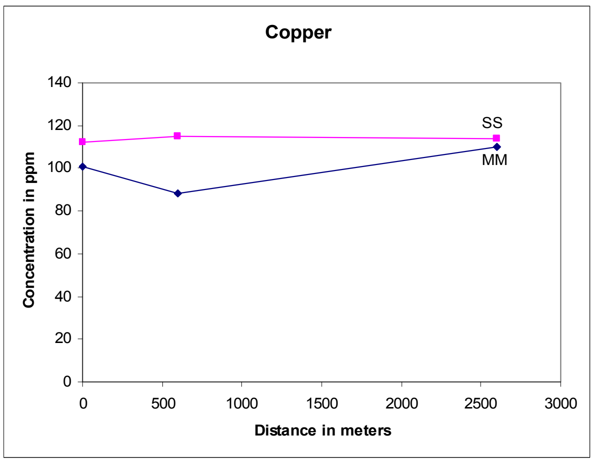


Figure A7-3a

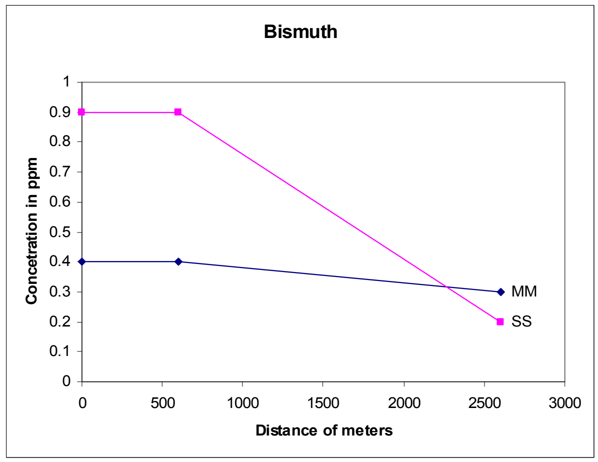


Figure A7-3b

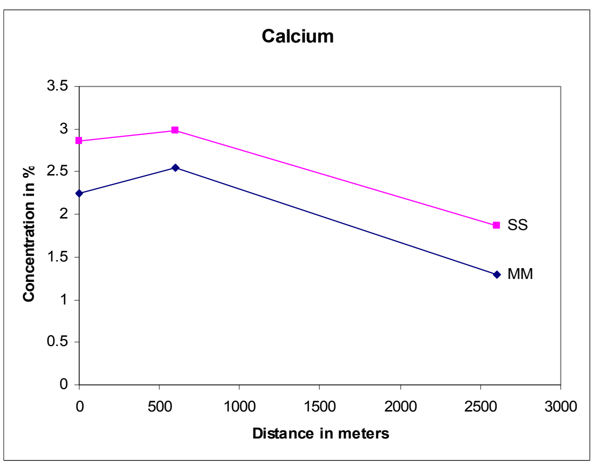


Figure A7-3c

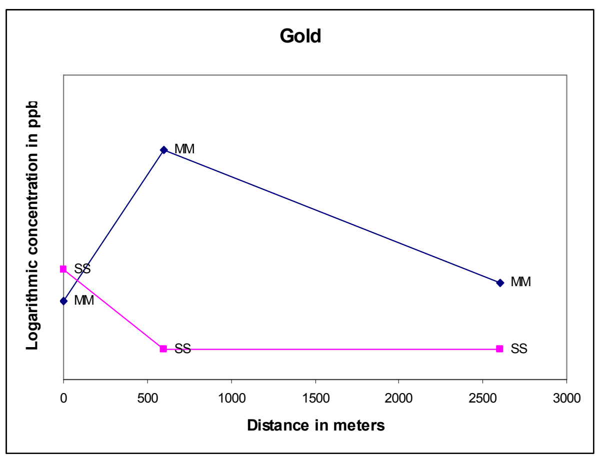


Figure A7-3d

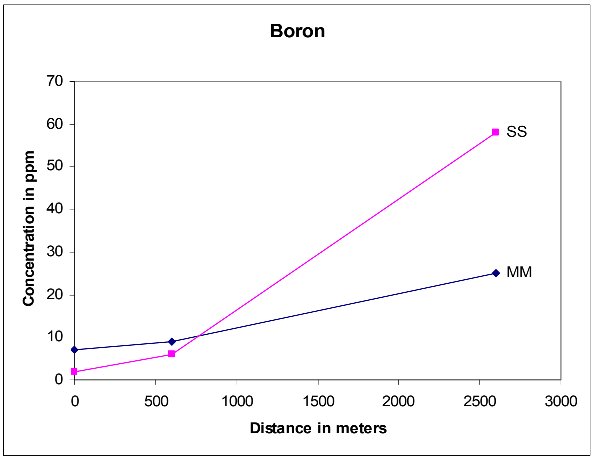


Figure A7-3e

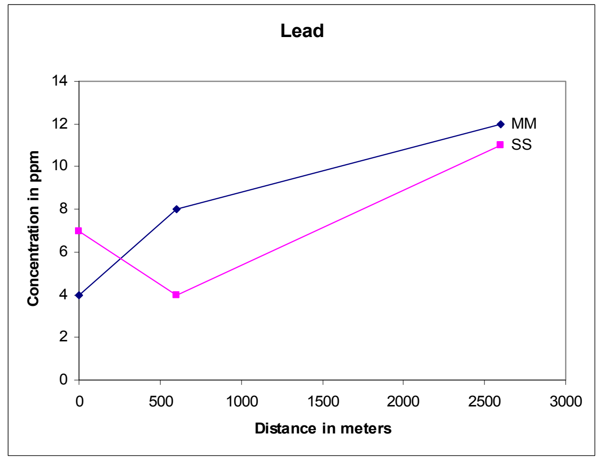


Figure A7-3f

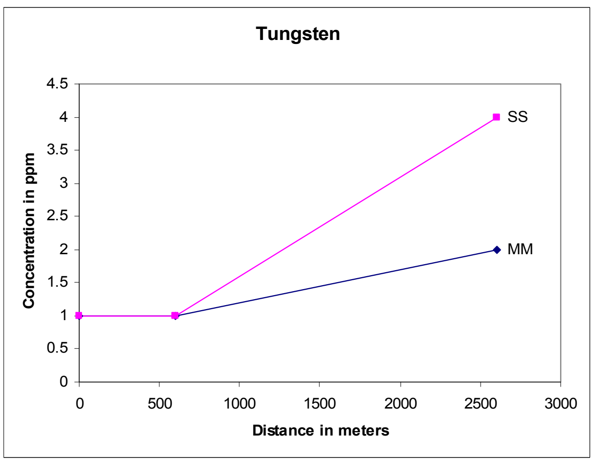


Figure A7-3g

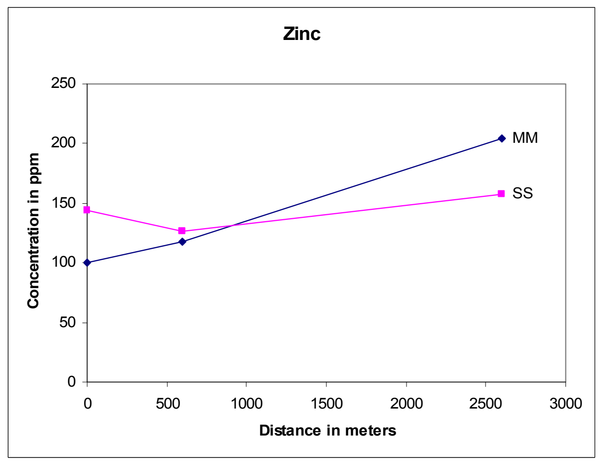


Figure A7-3h

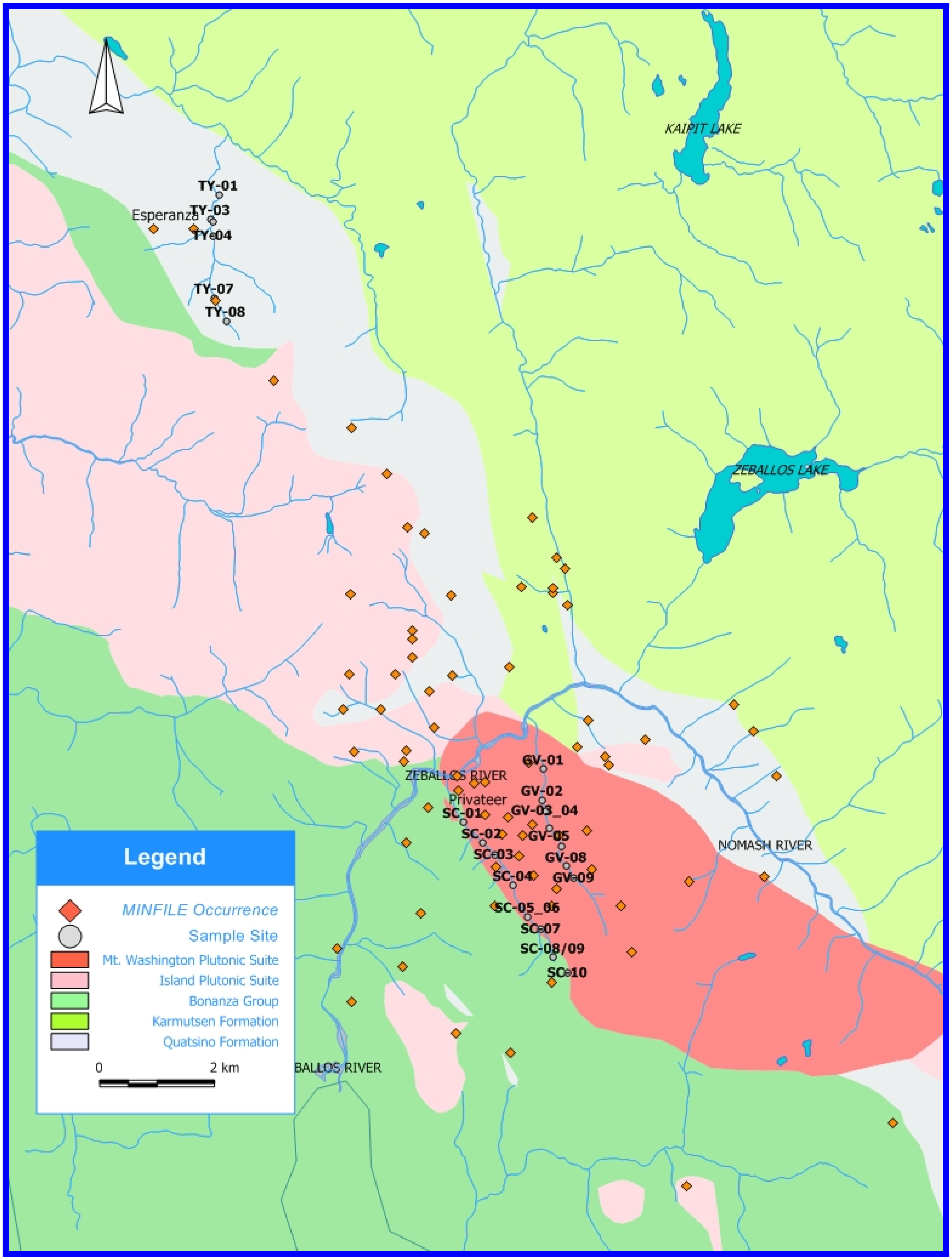


Figure A8-1 Tory Creek (TY-) Spud Creek (SC-) & Goldvalley Creek (GV) sample sites

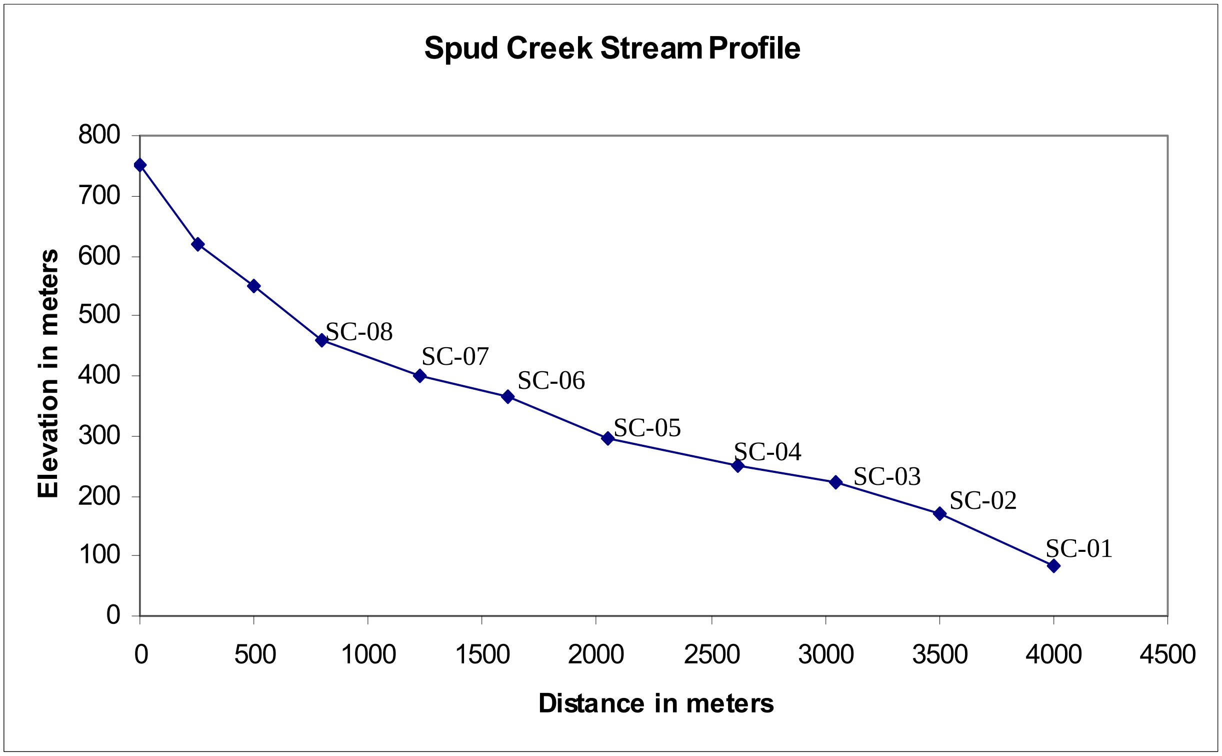


Figure A8-2. Spud Creek stream profile

SPUD CREEK – MESOTHERMAL VEINS

DEPOSIT #1 NAME: Privateer — *MINFILE #:* 092L 008

LOCATION: NTS – 92L02 — LAT. - 50º01'50" LONG. - 126º49'03" — UTM NORTH – 5544091 UTM EAST – 656312

STATUS: Past Producer — ***COMMODITIES:*** Gold, Silver, Copper, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Gold, Pyrite, Sphalerite, Galena, Chalcopyrite, Pyrrhotite, Arsenopyrite

DEPOSIT #2 NAME: Prident — *MINFILE #:* 092L 009

LOCATION: NTS – 92L02 — LAT. - 50º01'35" LONG. - 126º48'20" — UTM NORTH – 5543653 UTM EAST – 657181

STATUS*:** Past Producer — ***COMMODITIES: Gold, Silver, Zinc, Lead, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Gold, Pyrite, Arsenopyrite, Sphalerite, Galena

DEPOSIT #3 NAME: White Star *MINFILE #:* 092L 010

LOCATION: NTS – 92L02 LAT. - 50º01'25" UTM NORTH – 5543341
LONG. - 126º48'25" UTM EAST – 657091

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver, Copper, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Gold, Chalcopyrite, Galena, Sphalerite, Pyrite, Arsenopyrite

DEPOSIT #4 NAME: Golden Peak *MINFILE #:* 092L 011

LOCATION: NTS – 092L02 LAT. - 50º01'13" UTM NORTH – 5542979
LONG. - 126º48'10" UTM EAST – 657400

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Galena, Sphalerite

DEPOSIT #5 NAME: Mount Zeballos *MINFILE #:* 092L 012

LOCATION: NTS – 92L02 LAT. - 50º00'45" UTM NORTH – 5542103
LONG. - 126º48'30" UTM EAST – 657028

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver, Copper, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Galena, Sphalerite, Pyrite, Arsenopyrite

DEPOSIT #6 NAME: Brittania M *MINFILE #:* 092L 014

LOCATION: NTS – 92L02 LAT. - 50º00'45" UTM NORTH – 5542132
LONG. - 126º47'10" UTM EAST – 658023

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite

LOCAL GEOLOGY: Spud Creek (*Figure A8-1*) drains a region underlain equally by the Zeballos Stock, an Eocene quartz diorite phase of the Tertiary Catface Intrusions, and andesitic to rhyodacitic flows, tuff and breccia of the Lower Jurassic Bonanza Group. The creek roughly defines the contact the intrusion to the east and the volcanics to the west. Unconformably underlying Bonanza rocks and exposed on the northeast face of Mount Zeballos, are Quatsino Formation limestones of the Upper Triassic Vancouver Group. An east-west sinistral shear stress (Stevenson, 1950) has produced a multitude of shear planes and tension gashes across the north face of Mount Zeballos. Plane and gash orientations vary from 000 to 090 degrees, dips are steep to sub-vertical.

ALTERATION AND MINERALIZATION: Five past producing mines and one potential prospect lay within the Spud Creek drainage basin. Gold and silver, as free native metal or as sulphide inclusions, are found in mesothermal quartz veins which follow the shear zones. Varying amounts of arsenic, copper, lead and zinc sulphides accompany the gold mineralization. Four of the deposits (Britannia M, Golden Peak, Prident and White Star) are hosted by the Zeballos Stock. Mount Zeballos and Privateer are hosted by Bonanza Group rocks. At Privateer, volcanics in contact with the intrusion have been altered to a skarn assemblage comprising diopside, wollastinite, garnet, plagioclase, quartz and biotite. Combined recorded mine production for the above deposits is 380 000 tonnes from which was recovered 6.9 million grams of gold, 2.5 million grams of silver, 40 000 kilograms of lead and 8 000 kilograms of copper. The most productive deposits have an east-west vein orientation, a gold grade of 10 to 30 grams per tonne and a high Au to Cu ratio. The deposits are evenly spaced along the length of Spud Creek from Brittania M opposite site SC-06 to Privateer immediately adjacent to SC-01.

LOCAL ENVIRONMENT: Spud Creek lies in the Insular Mountains physiographic terrain. The study area is mountainous with steep slopes and a local relief of 1 100 metres. A veneer of talus, thin till and colluvium covers the flanks of Mount Zeballos. Alluvium in Spud Creek varies from thin to moderately thick (> 3 metres). Thick glaciofluvial deposits fill the Zeballos River basin. During the Fraser glaciation, ice accumulating in the upper reaches of Spud Creek likely flowed along the drainage basin prior to joining the east to west flowing main trunk glacier occupying the Zeballos River valley. The present climate is wet with annual precipitation in excess of 2 500 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (*Figure A8-2*), Spud Creek is seen to have a slightly stepped profile with moderately steep sections interspersed with moderate gradient sections. Overall, the sampled section of stream course has an average gradient of 10.5 degrees. The channel pattern alternates between shoots-and-pools and braided sections. Waterfalls and log jams are common. Banks are composed of till, talus or colluvium. Large boulders generally line the creek bed.

SAMPLE PATTERN: Eight sites (Figure A8-1) were sampled for moss-mat sediment, and conventional fine-grained stream sediment. Bulk fine-grained sediment samples were collected from every second site. Duplicate moss-mat samples were collected at sites SC-05 and SC-07. Duplicate conventional fine-grained stream sediment samples were collected from site SC-05. Bulk sieved samples of coarse and fine-grained sediment from high and low-energy sites were obtained from site SC-01. Moderate to abundant amounts of moss mat were available at every site. Conventional fine-grained stream sediment, while abundant at lower sites, became increasing scarce at higher sites.

RESULTS

Element Associations and Dispersion Curve Shapes

Six dispersion patterns in moss-mat sediment and five patterns in conventional fine-grained stream sediment have been defined.

The pattern displayed by Al, Ba, Mn, Mg and Ti in moss-mat sediment is essentially flat with enhanced concentrations at sites SC-07 and SC-01. The second moss-mat sediment pattern, defined by Cr, Fe and V, is similar to the above but with peak concentrations at SC-06 and SC-02. Both patterns display very low concentrations at site SC-08. The third pattern, shared by K and P in moss-mat sediments, defines decreasing concentrations with distance downstream. Peak concentrations are found at SC-08. Both elements display moderately increasing concentrations towards the lowest sample stations. Conversely Ca and Cu, which define the fourth pattern, exhibit increasing concentrations with distance downstream. Concentrations of Cu and Ca are enhanced at site SC-08. Moss-mat dispersion patterns for Ag, Pb and Zn display some similarity, the strongest feature is an enhancement at site SC-04. In the sixth and final dispersion pattern, Au, As and Sb exhibit increasing concentrations with distance downstream. Peak concentrations are seen at SC-04 and SC-02.

In stream sediments Al, Ba, K, Mg, Mn, P, Ti and Zn display similar dispersion pattern features, all decrease with distance downstream from peak concentrations at SC-08. The above elements also display, to varying extents, enhancement at site SC-05 with a slight to moderate concentration discrepancy between site duplicates. Concentrations of these elements are generally comparable between the two media. The second stream sediment pattern, exhibited by Cr, Fe, and V, mimics the first pattern but lacks enhancement at site SC-05. In addition, concentrations are consistently higher in moss-mat sediment. The third dispersion pattern, displayed by Ca and Cu, describes generally increasing concentrations with distance downstream. Enrichments are noted at SC-08, SC-05 and SC-03 to Sc-01. Concentrations of these elements are moderately higher in stream sediments. The dispersion pattern defined by As, Au and possibly Sb, exhibits increasing concentrations with distance downstream. These elements describe a marked enhancement between sites SC-05 and SC-04. Concentrations of all three are higher in moss-mat sediment.

Comparison to Background

Background and threshold values were calculated for a mixed lithology comprising Bonanza Group volcanics and Catface Intrusions (Table A-8). Elements which exceeded their thresholds at one or more sites in either or both sample media are Ag, As, Au, Ba, Bi, Cr, Fe, Hg, K, Mg, P, Pb, Sb, Ti and V.

INTERPRETATION

The numerous mineral deposits in the Spud Creek drainage basin prevents attributing anomalous results to any particular deposit, conclusions on anomalous associations are based on the mineralogy of the basin as a whole.

The dispersion trains displayed by Al (*Figure A8-3a*), Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, P, Ti, V and Zn are interpreted as background patterns. The change in basin geology from a region dominated by Bonanza Group volcanics (upper drainage) to a mixture of Bonanza Group and Catface Intrusions (middle and lower drainage) results in decreasing concentrations for Al, Ba, Cr, Fe, K, Mg , Mn, P, Ti, V and Zn. This geochemical trend is attributed to a lower proportion of ferro-magnesian silicates in the sediment. The extreme organic content (85 %) in moss-mat sediment at site SC-08 is the source of anomalous concentrations K and P (biophile elements) and corresponding low concentrations of the other elements. The increase in silicate related lithophile elements (e.g. Al, Ca, K,) at the base of the creek is due in part to an increase in the concentration of fine sediment (as seen in the bulk fine-grained sediment data) and possible inclusion of glacial debris from exposures of Quatsino Formation found up ice.

Anomalous Cr, Fe (*Figure A8-3b*) and V in moss-mat sediment at sites SC-06 and SC-02 may be an artefact of particularly effective trapping of heavy minerals by moss mats at these sites, however proximity of skarn alteration raises the possibility of iron-skarn deposits near these sites.

The increasing Ca and Cu (*Figure A8-3c*) concentrations in the lower and middle sections of the creek is attributed to the adjacent skarn alteration in the Bonanza Group rocks. In addition, provenance of drift covering the middle and lower basins is likely the carbonate rich terrain to the north and east.

The patterns and concentrations of Au (*Figure A8-3d*), As (*Figure A8-3e*), Ag (*Figure A8-3f*), Bi, Pb (*Figure A8-3g)* and Sb indicate an anomalous association which is clearly related to the various deposits within the drainage basin. The coincidence of anomalous Au*,* As, Ag, Pb and Sb in moss-mat at site SC-04 may indicate a nearby source. Although Zn (Figure A8-3h) is well below background at all sites, a moderate enrichment at site SC-04 indicates an association with the mineralized source. Subtly enhanced Hg is seen at sites SC-04 and SC-05 which partially coincides with the above anomalous trend and may be part of the association.

Steep terrain and abundant precipitation should promote mechanical dispersion within the stream, acidic soils and the lack of carbonate rich rocks to neutralize acids generated in the weathering environment should promote hydromorphic dispersion. Comparative enrichment of most elements in moss-mat sediment relative to conventional fine-grained stream sediment suggests mechanical transportation is the dominant dispersion mode in the creek and on the surrounding slopes.

The mesothermal veins in the Spud Creek drainage basin are readily defined by anomalous Au and As at nearly every site. Other pathfinders include Ag, Bi, Hg, Pb, Sb and possibly Zn which have very limited anomalous dispersion trains. Enhanced levels of Fe, Cr and V may be indicative of iron-skarn mineralization within the basin. The optimal sample media is moss-mat sediment for Au, Ag, As, Hg and Pb while conventional fine-grain stream sediments give better average contrasts for Bi and Zn.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	3 - 2630 ppb	2	10	305	1.9 km
As	Moss	1.9 - 112.9 ppm	11	21	4.7	1.9 km
Ag	Moss	0.1 - 1.1 ppm	0.1	0.5	2.6	1 site
Bi	Stream	0.1 - 1.3 ppm	0.1	0.5	3.1	1 site
Hg	Moss	50 - 200 ppb	80	200	1.5	1 site
Pb	Moss	4 - 23 ppm	6	12	1.5	1 site
Zn	Stream	27 -74 ppm	78	120	0.5	?

Table A-8. Spud Creek - Summary Table of Pathfinder Elements

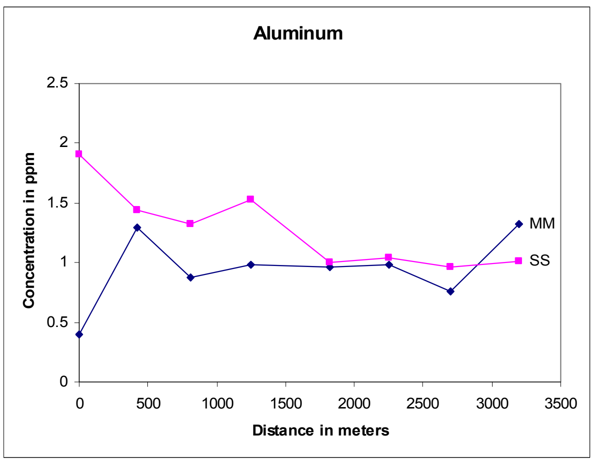


Figure A8-3a

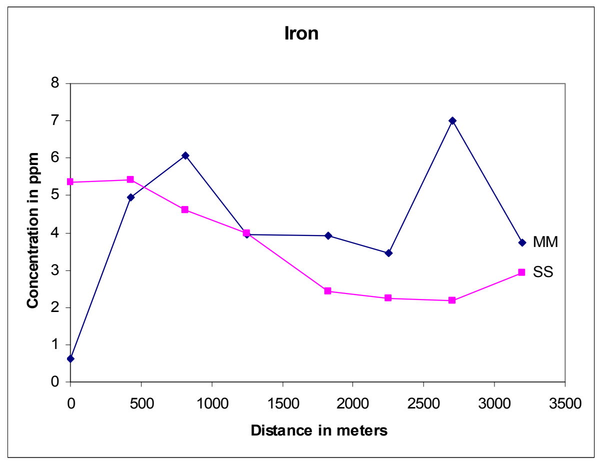


Figure A8-3b

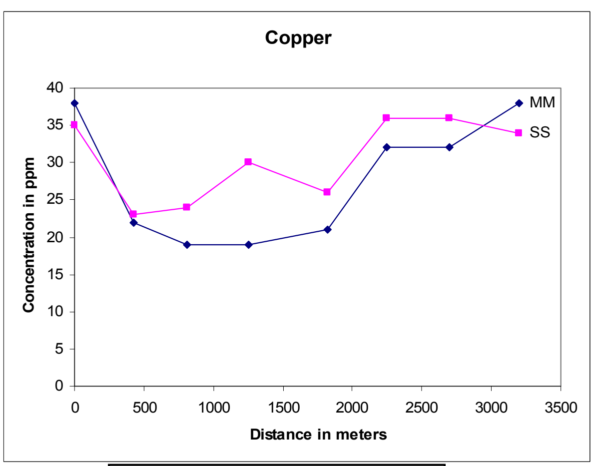


Figure A8-3c

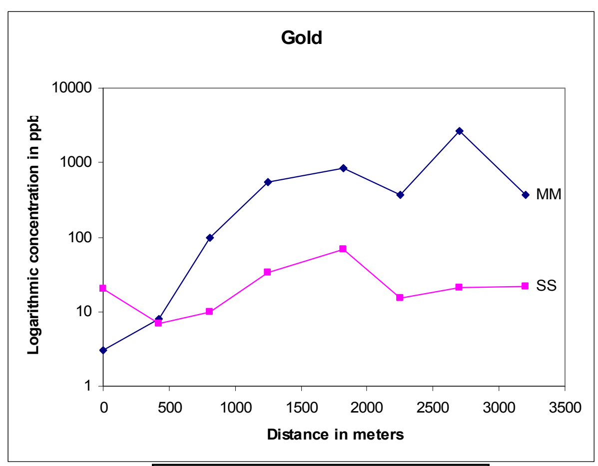


Figure A8-3d

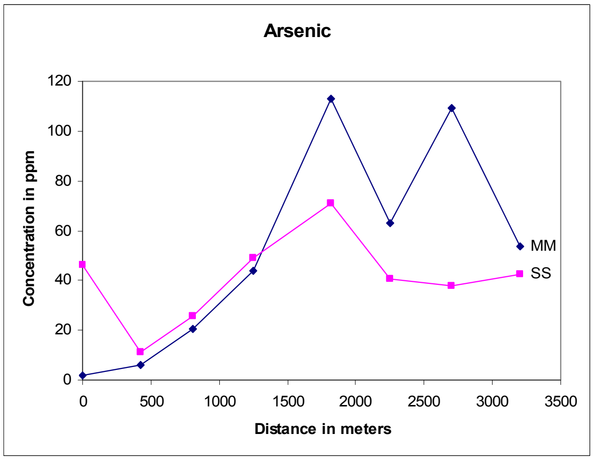


Figure A8-3e

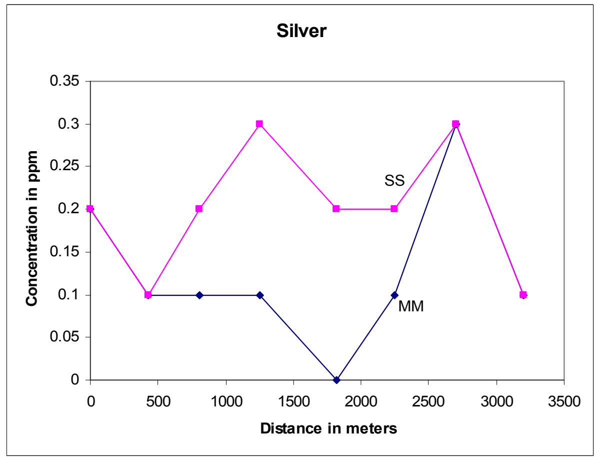


Figure A8-3f

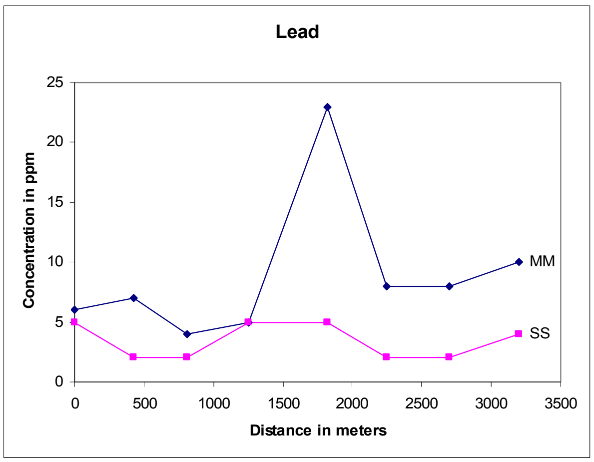


Figure A8-3g

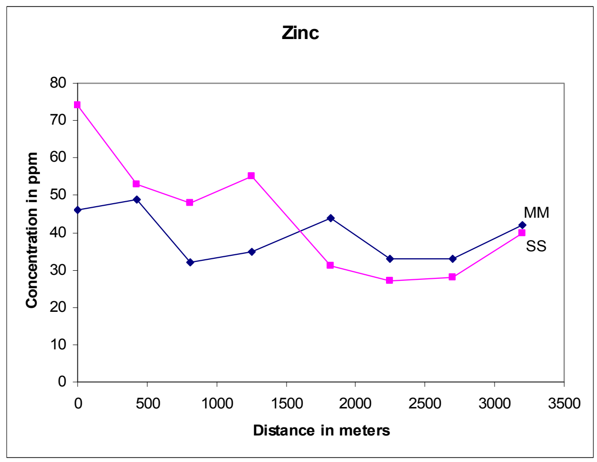


Figure A8-3h

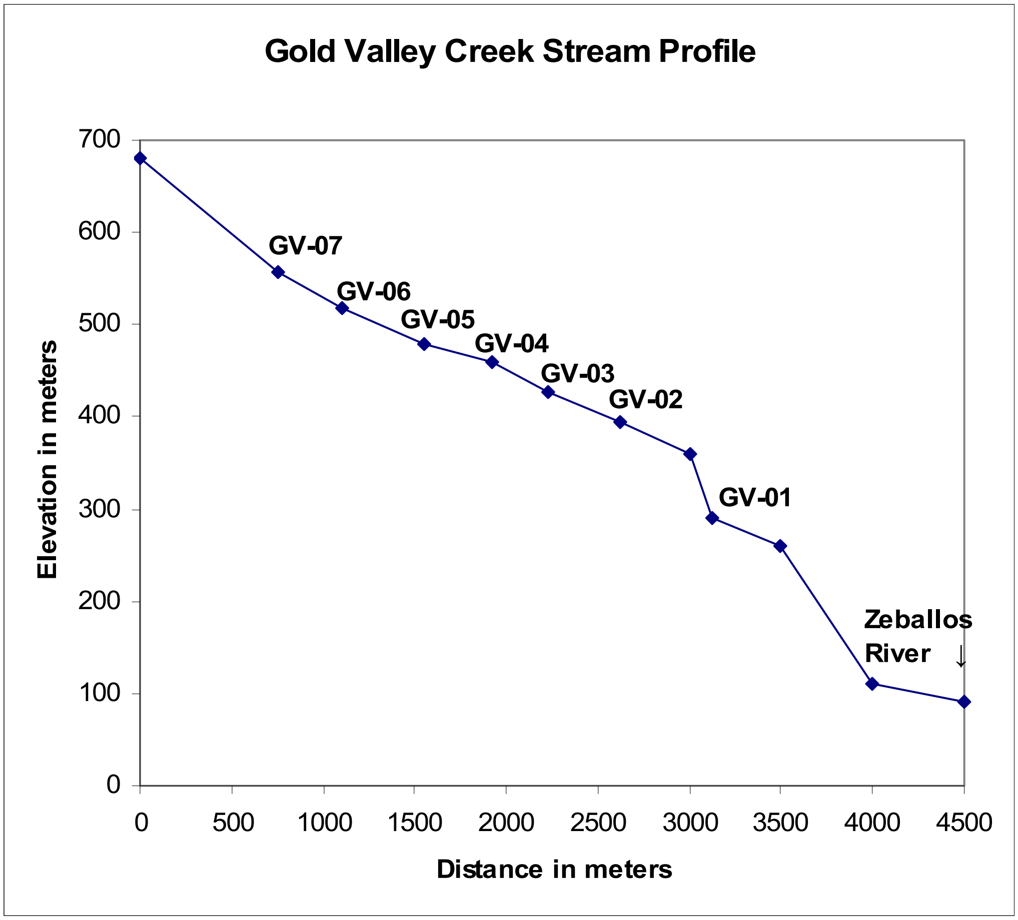


Figure A9-2. Gold Valley Creek stream profile

GOLDVALLEY CREEK – MESOTHERMAL VEINS

DEPOSIT #1 NAME: Roper, Spud Valley *MINFILE #:* 092L 013

LOCATION: NTS – 92L02 LAT. - 50º00'55" LONG. - 126º14'26" UTM NORTH – 5542443 UTM EAST – 658093

STATUS: Past Producer *COMMODITIES:* Gold, Silver, Lead, Zinc, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Sphalerite, Galena, Chalcopyrite

DEPOSIT #2 NAME: Lone Star *INFILE #:* 092L 015

LOCATION: NTS – 92L02 LAT. - 50º01'25" LONG. - 126º47'35" UTM NORTH – 5543370 UTM EAST – 658086

STATUS: Past Producer *COMMODITIES:* Gold, Silver, Lead, Zinc, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Sphalerite, Galena, Chalcopyrite

DEPOST #3 NAME: Rimy 1-8 *MINFILE #:* 092L 016

LOCATION: NTS – 92L02 LAT. - 50º01'28" UTM NORTH – 5543477
LONG. - 126º47'35" UTM EAST – 658580

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Galena, Sphalerite

DEPOSIT #4 NAME: North Star *MINFILE #:* 092L 017

LOCATION: NTS – 92L02 LAT. - 50º00'46" UTM NORTH – 5542198
LONG. - 126º46'40" UTM EAST – 659216

STATUS: Past Producer ***COMMODITIES:*** Gold, Lead, Zinc

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Sphalerite, Galena

DEPOSIT #5 NAME: IXL Fraction *MINFILE #:* 092L 084

LOCATION: NTS – 92L02 LAT. - 50º01'06" UTM NORTH – 5542800
LONG. - 126º47'06" UTM EAST – 658680

STATUS: Showing ***COMMODITIES:*** Gold

SIGNIFICANT AND ASSOCIATED MINERALS: unkown

DEPOSIT #6 NAME: Silver Queen *MINFILE #:* 092L 294

LOCATION: NTS – 92L02 LAT. - 50º00'18" UTM NORTH – 5541336
LONG. - 126º46'36" UTM EAST – 659321

STATUS: Showing ***COMMODITIES:*** Copper, Silver, Gold

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite

LOCAL GEOLOGY: Goldvalley Creek (*Figure A8-1*) drains a region entirely underlain by the Zeballos Stock, an Eocene quartz diorite phase of the Tertiary Catface Intrusions. To the east and north of the watershed, the Zeballos Stock is in contact with andesitic to rhyodacitic flows, tuff and breccia of the Lower Jurassic Bonanza Group. Unconformably underlying Bonanza rocks and exposed on the northeast face of Mount Zeballos, are Quatsino Formation limestones of the Upper Triassic Vancouver Group. An east-west sinistral shear stress (Stevenson, 1950) has produced a multitude of shear planes and tension gashes across the north face of Mount Zeballos. Plane and gash orientations vary from 000 to 090 degrees, dips are steep to sub-vertical.

ALTERATION AND MINERALIZATION: Four past producing mines and two showings lay within the Goldvalley Creek drainage basin. Gold and silver, as sulphide inclusions, are found in mesothermal quartz-calcite veins which follow shear zones. Varying amounts of arsenic, copper, lead and zinc sulphides accompany gold mineralization. All of the deposits are hosted by the Zeballos Stock. Chloritic, argillic and sericitic alteration surround the shear zones. Combined recorded mine production for the above deposits is 211 000 tonnes from which was recovered 1.9 million grams of gold, 0.6 million grams of silver, 11 075 kilograms of lead and 9 700 kilograms of copper. The most productive deposits have an east-west vein orientation, a gold grade of 10 to 30 grams per tonne and a high Au to Cu ratio. The deposits lay in the upper basin above site GV-03 along the eastern and western slopes.

LOCAL ENVIRONMENT: Goldvalley Creek lies in the Insular Mountains physiographic terrain. The study area is mountainous with steep slopes and a local relief of 1 070 metres. A veneer of talus, thin till and colluvium cover the flanks of Mount Zeballos. Alluvium in Goldvalley Creek is generally thin (< 3 metres). Thick glaciofluvial deposits fill the Zeballos River basin. During Fraser glaciation, ice accumulating in the upper reaches of Goldvalley Creek likely flowed along the basin prior to joining an east to west flowing trunk glacier occupying the Zeballos River valley. Glacial debris derived from the Quatsino Formation to the east, may have been deposited within the Goldvalley Creek basin. The present climate is wet with annual precipitation in excess of 2 500 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (*Figure A9-2*), Goldvalley Creek is seen to have a moderate gradient (7.7 degrees) in its' middle and upper basins and a steep gradient (18 degrees) in its' lower basin. Between sites GV -07 to GV -04, the stream varies between moderately high and low energy sections, only moderate and high energy reaches are found below site GV -04. The lower energy sections have alluvial banks, a meandering channel pattern and a bed composed of fine sand to gravel. The moderately high and high energy sections have steep banks composed of till, colluvium or bare rock, a shoots-and-pools channel pattern, a channel bed filled with large bounders and numerous waterfalls.

SAMPLE PATTERN: Seven sites (*Figure A8-1*) were sampled for moss-mat sediment, and conventional fine-grained stream sediment. Site duplicate samples of moss-mat sediment were collected at sites GV-03 and GV-05. Duplicate conventional find-grained sediment samples were collected at site GV-03. Bulk fine-grained sediment samples were collected from every second site. Sieved coarse and fine-grained sediment samples were obtained from site GV-01. Moderate to abundant amounts of conventional fine-grained stream sediment was found above site GV-04, below this point stream sediment was scarce. Moss mats were scarce in the low-energy sections due to a lack of appropriate sites (e.g. large boulders or logs), otherwise moderate to abundant amounts were present.

RESULTS

Element Associations and Dispersion Curve Shapes

Five dispersion patterns have been defined in moss-mat sediment and three patterns in conventional fine-grained stream sediment.

The first pattern, displayed by Al, Ba, Bi, Ca, Cu, Mg, Sr and Zn in moss-mat sediment, describes generally increasing concentrations with distance downstream. A sharp increase in concentrations is seen at site GV-05. In the second moss-mat sediment pattern, Mn and P display increasing concentrations with distance downstream with a positive spike at site GV-04. Moderate to high concentrations of Mn and P are seen at site GV-07. The pattern displayed by Cr, Fe and Ti define a jagged pattern with positive concentration spikes at sites GV-07, GV-04 and GV-02. Concentrations for these elements define a flat or slightly decreasing trend. The fourth dispersion train pattern in moss-mat sediment, displayed by As and Pb, defines sharply increasing concentrations downstream of site GV-04 with peak concentrations at site GV-02. The fifth and final pattern shared by Ag, Au and Hg, describes a triple peaked dispersion pattern with positive concentration spikes at GV-07, GV-04 and GV-02. Unique patterns are displayed by Sb and W. Limited concentration ranges are seen in Co, K, Ni and Se.

The dominant pattern, displayed by Al, Ba, Ca, Co, Cu, Cr, Fe, Hg, K, Mg, Mn, Ni, P, Sb, Se, Sr, Ti, V and Zn in conventional fine-grained stream sediment, describes a jagged dispersion train with positive concentration peaks at sites GV-06, GV-04 and GV-02. Subtle variations in the pattern depict increasing (Al, Ba, Ca, Cu, Hg, K, Mg, Ni, Sr, Ti, V and Zn), decreasing (Mn) and flat (Co, Cr, Fe, P, Sb, Se) trends. The jagged pattern is less pronounced in As and Pb, maximum concentrations in both elements are seen at site GV-02. The jagged pattern is muted in Ag and Au, both elements display maximum concentrations at site GV-02, lesser Au enrichments are present at GV-04 and GV-07. Limited concentration ranges are seen for Bi and W.

Elements enriched in moss-mat sediments comprise Ag, Au, Bi, Ca, Cr, Fe, Hg, P, Sb and V, the remaining elements have either comparable concentrations (Co, W) or are relatively enriched in conventional fine-grained stream sediment.

Comparison to Background

Background and threshold values (*Table A-9*) were calculated for the dominant lithology (Catface Intrusions) based on the few creeks sampled in this study and in the RGS programs covering NTS 92L and 92E. Elements which exceeded their thresholds at one or more sites in either or both sample media are Ag, As, Au, Bi, Cr, Fe, Hg, Pb, Sb, V and W.

INTERPRETATION

The numerous mineral occurrences in the Goldvalley Creek makes assigning anomaly features to specific deposits rather dubious, the most influential deposits based on size would be the Spud Valley (190 000 tonnes), Lone Star (6 800 tonnes) and North Star (13 600 tonnes) which are lay upslope of sites GV-03, GV-05 and GV-07 respectively.

The jagged dispersion train seen for nearly all elements in conventional fine-grained stream sediment may be attributed in part to varying stream energy between sites. The variations correlate moderately well with organic concentration at each site (*Figure A9-3a*). However, unlike the previous case studies, segregation is not seen between elements normally associated with silicates and elements common to heavy minerals. In addition, a review of the field notes failed to uncover any correlation between the dispersion pattern and observed stream characteristics. Coincidence with high Au concentrations (an element determined separately) in the first set of sub samples should rule out an instrumental artifact. Mineralization as the source for all enhancements at every second site is equally unlikely. Second and third analyses of sample pulps for Au (*Table A-9*) produced substantially different dispersion patterns thus raising the possibility of sub-sampling errors. Uncertainty in the source of the patterns prevents interpretation.

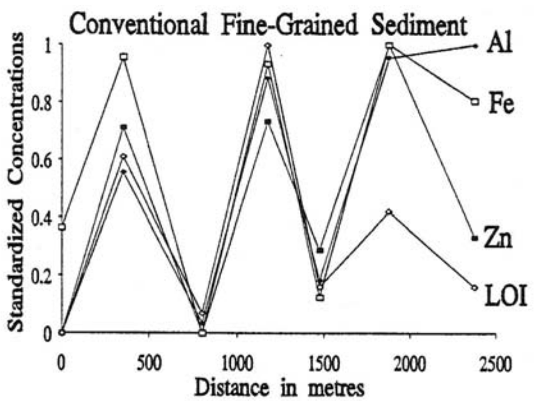
The patterns displayed in moss-mat sediment may be more indicative of background and anomalous relationships. The generally increasing concentrations seen for most lithophile and some chalcophile (*Figure A9-3b*) elements (elements of dispersion pattern 1) is probably due to comminution of mineral grains and an increasing proportion of drift derived from carbonate and mafic rocks to the east. The spike at site GV-05 correlates to higher LOI and sample weight suggesting a higher proportion of the light density, fine-fraction sediment. Enhanced to anomalous levels of Cr, Fe and V (*Figure A9-3c*) at sites GV-07, GV-04 and GV-02 may be related to mineralization or may be an artifact of more effective moss mat trapping of heavy minerals at these sites. The anomalous concentrations of Ag (*Figure A9-3d*), As (*Figure A9-3e*), Au (*Figure A9-3f*), Hg (*Figure A9-3g*) and Pb (*Figure A9-3h*) reflect mineralization within the drainage basin. Moderately enhanced concentrations of these elements at site GV-07 suggests a source lying in the upstream basin. Enrichment of As and Pb at site GV-03 coincides with the observed position of mine tailings upslope of GV-03. Highly anomalous concentrations of Ag, As, Au with elevated Hg and Pb at site GV-02, with near identical As values in moss mat and stream sediment, suggests a source in the immediate vicinity.

The mesothermal veins in Goldvalley Creek likely contain medium to coarse-grained Au. Highest average concentrations were detected in the -100 +200 mesh size fraction. Repeat analyses showed severe nugget effects. Three separate determinations for gold in stream sediment at site GV-02 gave values of 1 660 ppb, 12 480 ppb and 32 950 ppb.

The mesothermal veins in the Goldvalley Creek drainage basin are readily defined by anomalous Au and As which exceed threshold at most sites. Potential nugget effect problems associated with coarse Au promotes As as the better pathfinder. Other pathfinders include Ag, Hg and Pb which are anomalous only in the immediate vicinity of the mineral deposits. Potential pathfinders may include Sb and Bi which display enhanced concentrations near mineralization. Enhanced levels of Fe, Cr and V may be indicative of mineralization but are likely due to slightly more efficient trapping of magnetite and chromite in moss-mat at some sites. Moss mat sediment is the optimal sample medium for Au, Ag, Bi, Hg and Sb while conventional stream sediment give higher average contrasts for As and Pb.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	220 - 35700 ppb	4	15	1594	2.4 km
As	Stream	17.1 - 113.3 ppm	14	22	4.3	1.2 km
Pb	Stream	4 - 28 ppm	5	10	2.3	1.2 km
Ag	Moss	0.1 - 13.9 ppm	0.1	0.5	16.8	0.5 km
Hg	Moss	10 - 290 ppb	60	140	1.3	1 site
Bi	Moss	0.1 - 0.6 ppm	0.1	0.5	3	1 site
Sb	Moss	0.2 - 0.8 ppm	0.3	0.7	1.2	1 site

Table A-9 Gold Valley Creek - Summary Table of Pathfinder Elements



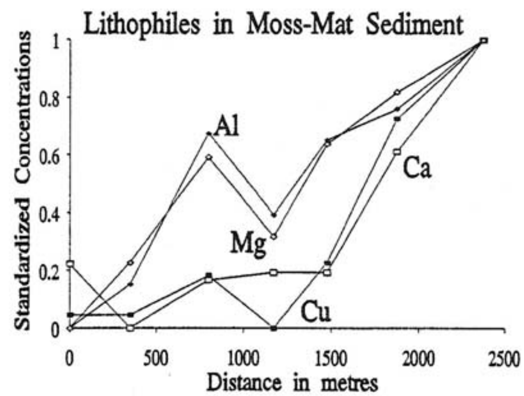
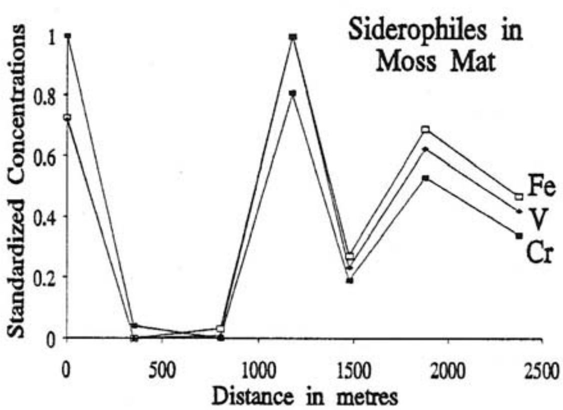


Figure A9-3a and 3b



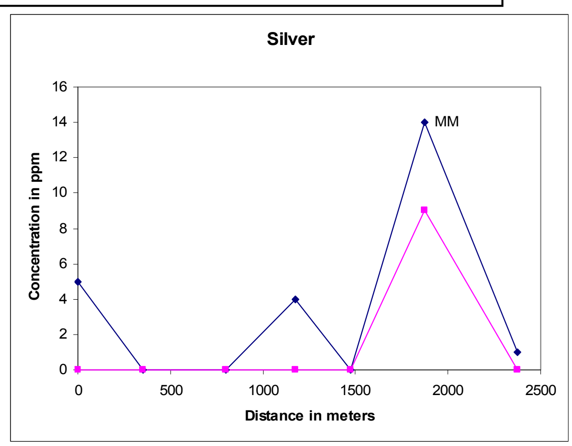


Figure A9-3c

Figure A9-3d

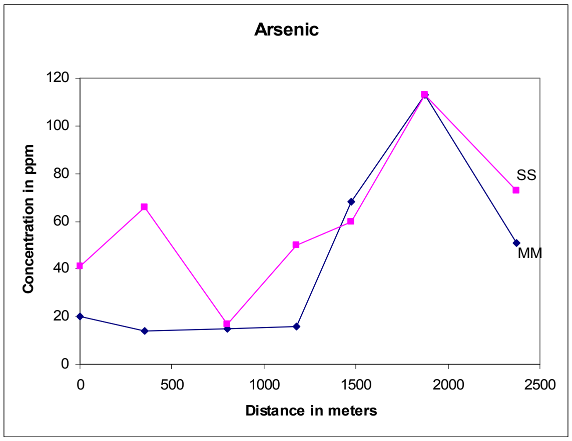


Figure A9-3e

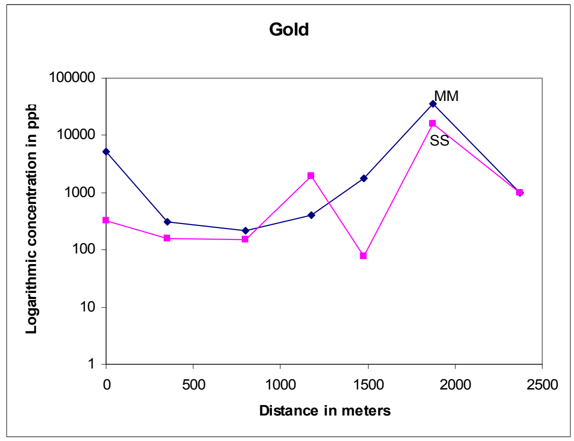


Figure A9-3f

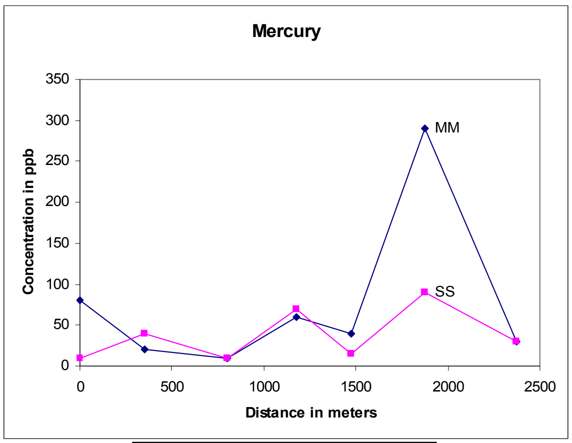


Figure A9-3g

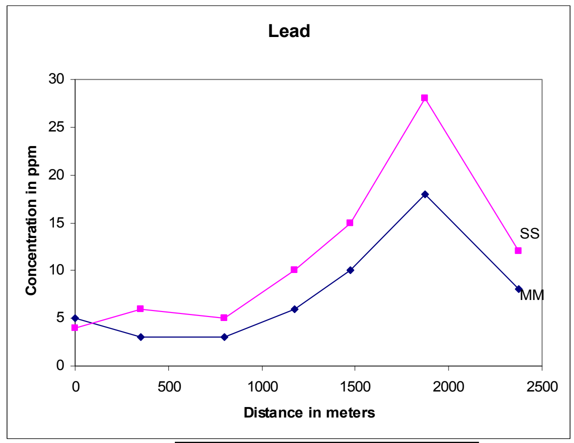
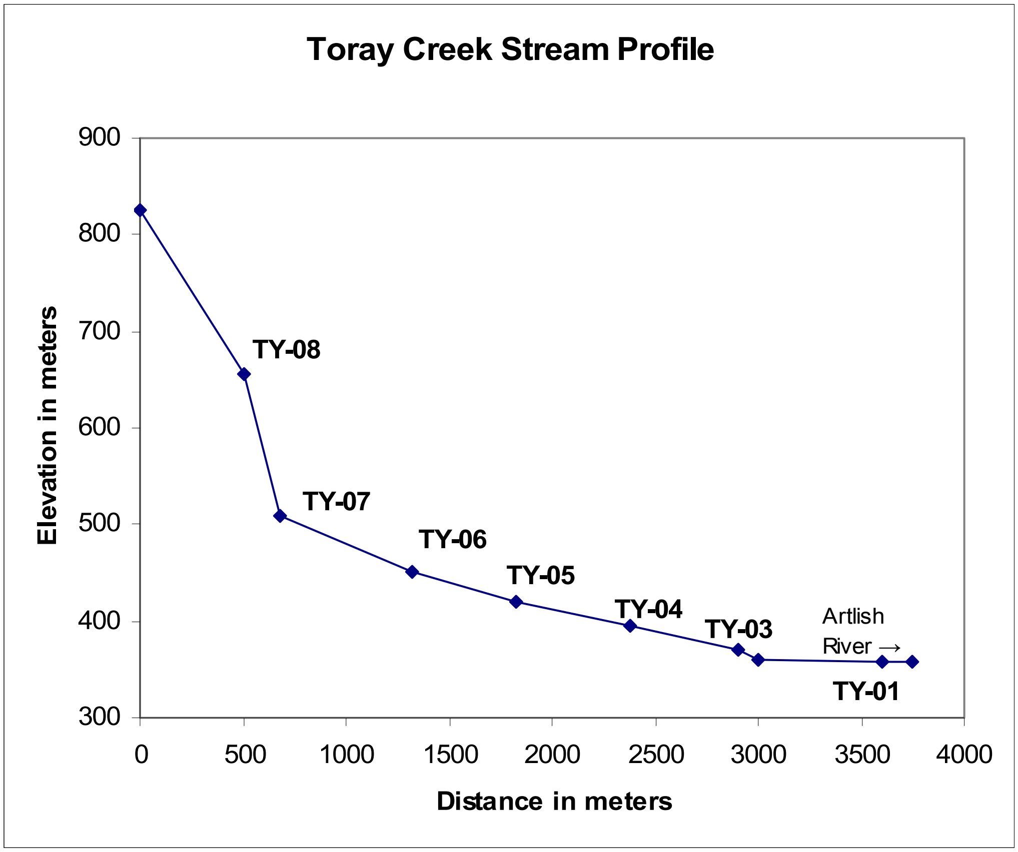


Figure A9-3h



TORAY CREEK – IRON SKARN

DEPOSIT #1 NAME: Esperanza *MINFILE #:* 092L 299

LOCATION: NTS – 92L02 LAT. - 50º07'05" LONG. - 126º53'00" UTM NORTH – 5553683 UTM EAST – 651322

STATUS: Showing ***COMMODITIES:*** Gold, Silver

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Pyrrhotite, Magnetite, Arsenopyrite

DEPOSIT #2 NAME: Hiller 12, A25 *MINFILE #:* 092L 302

LOCATION: NTS – 92L02 LAT. - 50º07'05" LONG. - 50º07'05" UTM NORTH – 5553663 UTM EAST – 650627

STATUS: Prospect ***COMMODITIES:*** Gold, Copper, Iron, Tellurium, Bismuth

SIGNIFICANT AND ASSOCIATED MINERALS: Gold, Chalcopyrite, Magnetite, Pyrrhotite, Tellurobismuthite

LOCAL GEOLOGY: Toray Creek (*Figure A10-1*) drains a region of northwest trending sediments and volcanics of the Middle to Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group. The lower Toray Creek basin, below site TY-06, contains limestones of the Quatsino Formation, the upper basin is underlain by Parson Bay Formation calcareous sediments and, in the headwaters, andesitic pyroclastics and limy argillites of the Bonanza Group. Locally intruding the above sequence are numerous dacitic to rhyolitic dykes, likely related to the Jurassic Island Intrusions found immediately to the south and east.

ALTERATION AND MINERALIZATION: The Hiller 12 occurrence comprises one of a series of iron skarn deposits found along an 8 kilometre zone following the contact between Bonanza Group and Parson Bay Formation rocks. Massive magnetite accompanied by pyrrhotite, native gold, chalcopyrite and tellurobismuthite is hosted by skarn altered calcareous sediments adjacent to a dacitic dyke. A two metre drill intersection of the Hiller 12 deposit gave a gold grade of 310 grams per tonne. The Hiller 12 occurrence is exposed in Toray Creek immediately upstream of TY-07. The Esperanza deposit comprises conformable pyritic beds hosted by intercalated siltstone and calcareous sediments along the transition zone between the Quatsino and Parson Bay formations. The pyritic zone also contains pyrrhotite, magnetite and massive arsenopyrite. Trench sampling produced an average grade of 5.9 grams per tonne gold over a one metre width. The occurrence is intersected by Toray Creek in the vicinity of TY-06. Skarn mineralization was noted in boulders and bedrock near site TY-04.

LOCAL ENVIRONMENT: Toray Creek lies in the Insular Mountains physiographic terrain. The study area is mountainous and moderately steep with local relief of 770 metres. A veneer of thin till, colluvium and talus covering most slopes becomes a continuous, moderately-thick blanket of till and alluvium within the main basin of Toray Creek. Thick outwash fills the Artlish River basin. During glaciation, ice accumulating above Toray Creek would have flowed north along the drainage then joined with a large lobe flowing northwest along the Artlish River. Drift in the lower basin likely comprises a mixture of Parson Bay and Quatsino formation erosional material. The present climate is wet with annual precipitation in excess of 2 500 millimetres. Soils are dominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (*Figure A10-2*), Toray Creek is seen to have a very steep gradient (25 degrees) above site TY-06. Below this point, the stream flattens dramatically averaging 3.5 degrees. Channel features in the high-energy upper basin include channel banks composed dominantly of exposed bedrock, numerous waterfalls, large bounders lining the creek bed and a shoots-and-pools channel pattern. In the lower basin, the creek is confined in several places by narrow limestone canyon walls where it develops a shoots-and-pools channel pattern which is occasionally interrupted by small waterfalls. Elsewhere the stream has alluvial banks, a braided or point bar channel pattern and a bed comprising gravels or cobbles.

SAMPLE PATTERN: Seven sites (*Figure A10-1*) were sampled for conventional fine-grained stream sediment and six for moss-mat sediment. Bulk fine-grained sediment samples were collected from every second site. Sieved coarse and fine-grained sediment samples were obtained from site TY-01. Fine-grained stream sediment was generally scarce in the high energy stream sections above site TY-06 and moderate to abundant below this point. Moderate to abundant moss mats were observed at most sites except for a logged clearing surrounding TY-06 where the creek had redefined its' course and only recent alluvium could be found. Moss-mat and conventional fine-grained stream sediment was collected from site TY-02 on a large tributary to Toray Creek to help establish background.

RESULTS

Element Associations and Dispersion Curve Shapes

Four dispersion patterns have been defined in the moss-mat sediment data while upwards of eight patterns are seen in may exist in the conventional fine-grained stream sediment data.

The first pattern in moss-mat sediment, defined by Al, Ba, Cr, Fe, Mg, Ni, Ti and V, displays flat to slightly decreasing concentrations with distance downstream. The most pronounced feature is a sharp negative concentration spike at site TY-08. The second pattern in moss-mat sediment, shared by B, Ca, K, Mn, P and Sr, also defines a flat to decreasing concentration curve with distance downstream, however a sharp positive concentration spike is seen at TY-08. An exponential decay curve is depicted by Bi, Cu and Se in moss-mat sediment. Concentrations steadily decrease from a peak value at TY-08.

A similar pattern is defined by As, Au, Co and Sb; however the maximum concentration is seen at TY-07. A weak, secondary peak is displayed by Au at site TY-04. In the final group, Mo and Pb display dispersion trains with two concentration peaks. Maximum concentrations coincide with site TY-07 and TY-04 or TY-03. The dispersion train for Zn in moss-mat sediment is flat except for a weak enhancement at TY-05.

Similar dispersion patterns are defined by Al, Mg and Ni in conventional fine-grained stream sediment. These elements collectively display a negative concentration spike at TY-08, a well defined decrease in concentrations between sites TY-06 and TY-05, and increasing concentrations downstream of site TY-04. The second dispersion train pattern, shared by K, Na and Sr, depicts decreasing concentrations with distance downstream from maximum concentrations at site TY-08. Slight increases in Na and Sr concentrations are noted at the most downstream stations. A unique dispersion pattern is defined by Ca which displays a jagged curve above TY-05 and a flat curve below this site. The patterns exhibited by Mn and Zn also exhibit widely varying concentrations above site TY-05 however, maximum concentrations in these elements coincide with minimum concentrations in Ca. Both B and P display a sharp increase in average concentrations between site TY-06 and TY-05. Common dispersion train features of Ba, Cr, Ti and V are a negative concentration spike at TY-08, and weak positive enrichments at TY-06 and TY-04. Generally decreasing concentrations with distance downstream from site TY-08 is noted in the dispersion trains for As, Bi, Co, Cu, Fe, Mo, Pb and Se. Weak to well defined enrichments are noted for some of the elements at TY-06 (As, Fe, Se) and TY-04 (Bi, Co, Fe, Pb). Both Au and Sb exhibit concentrations increasing from TY-08 to TY-06 and generally flat dispersion trains downstream from TY-05. Only Au, B, Hg and Sb have consistently higher concentrations in moss-mat sediment relative to stream sediment.

Comparison to Background

Table A-10 gives background and threshold values for the Parson Bay and Quatsino formations for comparison purposes. Anomaly definition is based on the Parson Bay Formation values. Elements which exceeded their thresholds at one or more sites in either or both sample media are As, Au, B, Bi, Ca, Co, Cu, Fe, Hg, K, Mo, P, Pb, Sb, and Se.

INTERPRETATION

Lithology controlled background patterns are displayed by most of the lithophile and siderophile elements. The rapid change in base level concentrations between TY-06 and TY-05 in stream sediment coincides with the inferred contact between the Parson Bay (upper basin) and Quatsino (lower basin) formations. Elements displaying increasing concentrations in stream sediment below TY-05, a region of low stream gradient and abundant fine-grained sediment, are those associated with light density and/or easily comminuted minerals. The coincident Mn-Zn pattern and the antipathetic Ca pattern in stream sediment above TY-06, may be the result of local weathering of sulphides. Restricted acid generating environments at these sites could cause dissolution of Ca-carbonate while Mn and Zn, mobilized in reducing groundwater, could precipitate upon encountering the oxygenated stream environment. Enhanced Cr, Ti and V in stream sediment at TY-06 and TY-04 may be attributable to magnetite associated with the pyritic beds at the Esperanza showing and the iron skarns above site TY-04. Elevated B downstream of TY-06 suggests a higher background in Quatsino limestone, a maximum concentration at TY-04 suggests enrichment associated with the iron skarn at this site. The iron skarn in Parson Bay rocks at TY-07 lacks anomalous boron.

The negative anomaly in heavy mineral forming elements and positive anomaly in biophile elements at TY-08 in moss-mat sediment is due to the high organic content of this sample (63.5%).

The patterns displayed by As, Au, Bi, Cu, Co, Mo, Pb, Sb and Se are interpreted as anomalous and related to the deposits based on their association and concentration. As noted above with B, dissimilarities are seen in element associations between occurrences. Hiller 12 and Esperanza are enriched with As while the iron skarn at TY-04 is not. Enhanced Co defines the Hiller 12 and TY-04 skarns but not the Esperanza pyritic beds. Several elements display maximum concentrations in conventional fine-grained stream and moss-mat sediment upstream of the Hiller 12 deposit indicating either a separate occurrence upstream or an extension of existing deposit. The patterns for Band Zn are predominantly lithology related however individual concentration peaks may be due to the deposits. Peak concentrations roughly coincide with the positions of exposed mineral occurrences.

Hypothetically, a proportionally greater content of the finest size fraction in conventional stream sediment relative to moss-mat sediment could the source of that medium's higher concentrations of both mobile and immobile lithophile elements.

The highest Au concentrations in bulk fine-grained sediment samples were encountered in the medium size fraction (-100 +200 mesh) potentially indicating the modal grain size.

The optimal pathfinders for the various skarn related deposits in Toray Creek are Au (*Figure A10-3a*), Cu (*Figure A10-3b*) and Fe (*Figure A10-3c*) which give the longest dispersion trains. Arguably, the dispersion train for Cu may be shorter if the higher Cu threshold for the Quatsino Formation is employed as the discriminator between background and anomalous values. Supporting this argument is a generally flat dispersion curve downstream of TY-05. Other pathfinders include Bi (Figure A10-3d), As (*Figure A10-3e*), Se (*Figure A10-3f*), Co (*Figure A10-3g*), Sb (*Figure A10-3h*), Mo and Pb which display anomalous levels in the immediate vicinity of the mineral deposits. Potential pathfinders include B and Zn which display enhanced concentrations near mineralization. Moss-mat sediment is the best medium for the detection of Au, As, Bi and Sb while conventional fine-grained stream sediment is optimal for the remaining chalcophile and siderophile elements.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Cu	Stream	110 - 243 ppm	40	80	3.7	3.1 km
Au	Moss	4 - 2370 ppb	2	10	237.6	1.9 km
Fe	Stream	6.35 - 9.22 ppm	5.7	7.6	1.4	1.9 km
Bi	Stream	0.2 - 1.0 ppm	0.1	0.5	6.1	0.8 km
As	Moss	42.0 - 132.3 ppm	14	65	5.9	0.8km
Se	Stream	1.1 - 2.9 ppm	0.7	2	2.5	0.8 km
Co	Stream	27 - 54 ppm	21	32	1.7	0.8km
Sb	Moss	0.4 - 5.8 ppm	0.2	1.6	8.6	0.5 km
Mo	Stream	2 - 8 ppm	1	4	3.6	0.5 km
Pb	Stream	6 - 18 ppm	8	12	1.3	1 site
B	Moss	9 - 31 ppm	6	12	3.7	?
Zn	Stream	79 - 93 ppm	100	150	0.8	?

Table A-10 Toray Creek - Summary Table of Pathfinder Elements

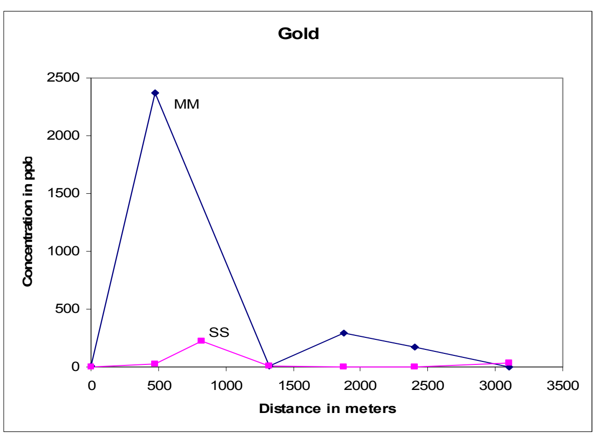


Figure A10-3a

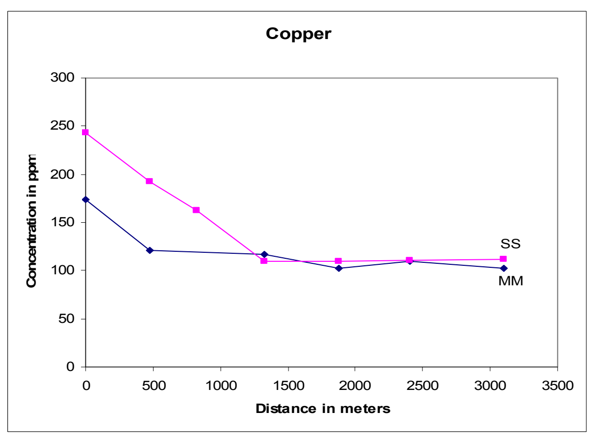


Figure A10-3b

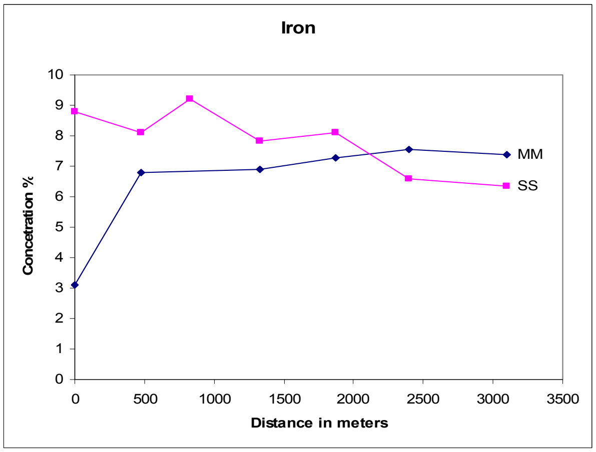


Figure A10-3c

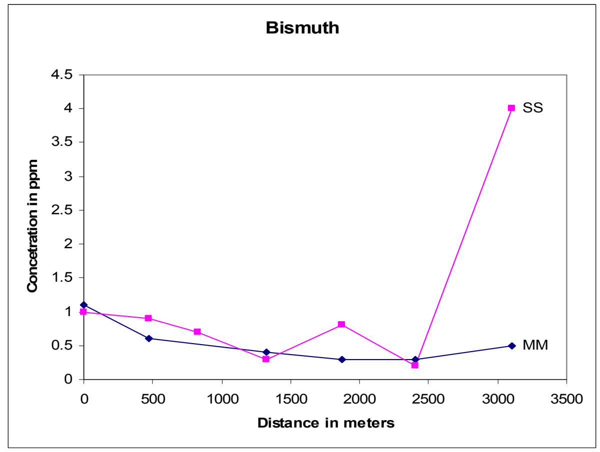
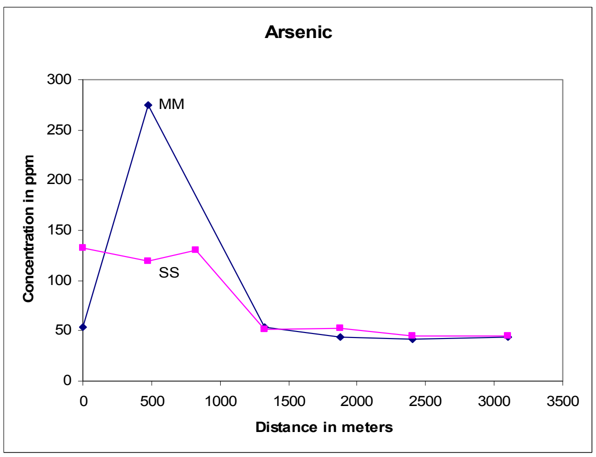


Figure A10-3d



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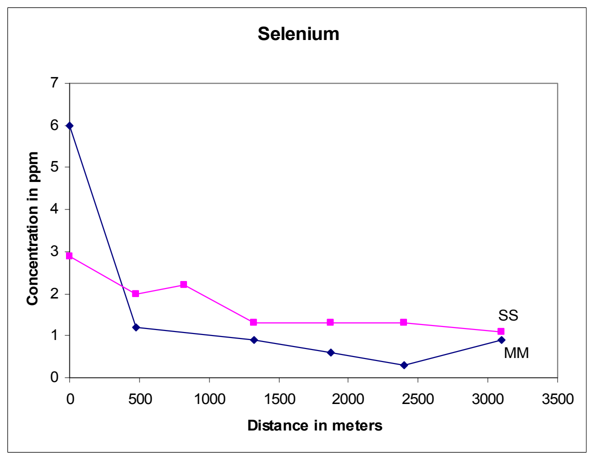


Figure A10-3f

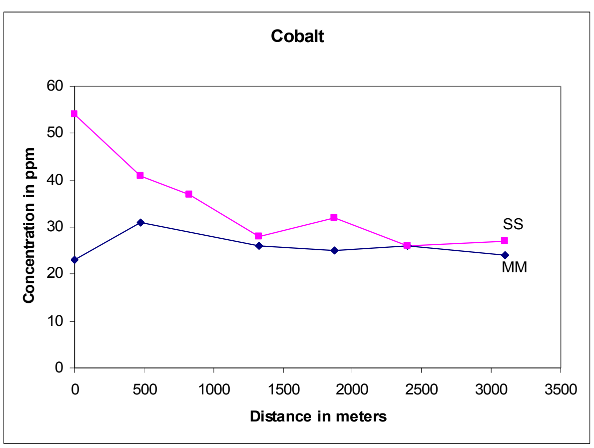


Figure A10-g

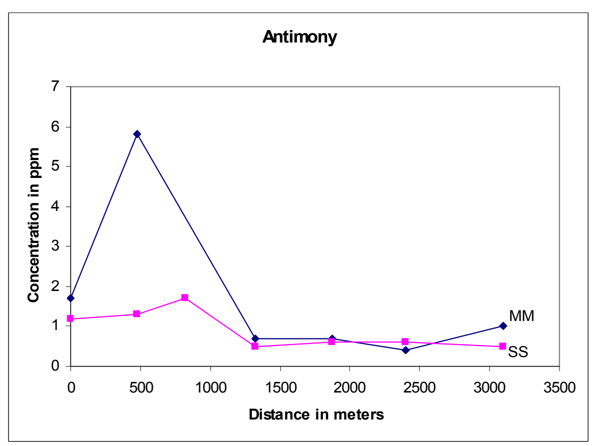


Figure A10-3h

EXTRAVAGANT CREEK – IRON SKARN

DEPOSIT NAME Geo, Star of the West *MINFILE #:* 092E 010

LOCATION: NTS – 92E15 LAT. - 49º55'05" UTM NORTH – 5531914
LONG. - 126º39'55" UTM EAST – 667604

STATUS: Prospect

COMMODITIES*:* Gold, Silver, Copper, Lead, Zinc, Iron, Arsenic

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Galena, Sphalerite, Magnetite, Arsenopyrite, Bornite, Pyrite, Pyrrhotite

LOCAL GEOLOGY: Extravagant Creek (*Figure A12-1*) drains a region of north-northwest trending sediments and volcanics of the Middle to Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group. The middle to lower Extravagant Creek basin, contains limestones of the Quatsino Formation, the upper basin is underlain by Parson Bay Formation calcareous sediments and volcanics of the Bonanza Group. Locally intruding the above sequence is a granodiorite plug presumably belonging to the Jurassic Island Intrusions.

ALTERATION AND MINERALIZATION: The Geo occurrence consists of garnet-epidote altered limestone of the Quatsino Formation in contact with the granodiorite plug. Mineralization comprising lenses of chalcopyrite, magnetite, pyrite, pyrrhotite and arsenopyrite with minor galena, sphalerite, bomite and azurite replaces skarn. Analysis of skarn samples gave grades upwards of 51.4 grams per tonne silver, 5.2 grams per tonne gold, 16 per cent copper and 14 per cent zinc. The deposit location may be in question, the Ministry of Energy, Mines and Petroleum Resources Assessment Report 12354 locates the deposit adjacent to Extravagant Creek approximately 1.5 kilometres upstream of its' mouth, however the Minister of Mines Annual Report for 1926 places the deposit on Ubedam Creek approximately 2 kilometres to the south.

LOCAL ENVIRONMENT: Extravagant Creek lies in the Insular Mountains physiographic terrain. The area is mountainous with steep slopes and a local relief of 1 100 metres. Thin till, colluvium and talus covers the local slopes. During the last glaciation, ice accumulating in the upper basin would have flowed along Extravagant Creek prior to joining the main ice mass flowing southwards through Tahsis Inlet. The present climate is cool and wet with annual precipitation in excess of 2 500 millimetres. Soils are predominantly ferro-humic podzols.

STREAM CHARACTERISTICS: In profile (Figure A11-2), Extravagant Creek is seen to have a very steep gradient averaging 32 degrees. Observations at site SW-01 described coarse sediment found amongst large boulders in a creek confined by narrow limestone canyon walls.

SAMPLE PATTERN: One site (*Figure A12-1*) was sampled for moss-mat sediment, and conventional fine-grained stream sediment, bulk fine-grained sediment and sieved bulk samples of coarse and fine-grained sediment from high and low-energy sites. Waterfalls and near vertical canyon walls precluded a sampling traverse. Conventional fine-grained stream sediment was very scarce.

RESULTS

Element Associations and Dispersion Curve Shapes

Comparison of element associations and dispersion curve shapes can not be made owing to only one site being sampled.

Comparison to Background

Table A-11 gives background and threshold values for the Quatsino Formation. Elements which exceed their thresholds in either or both sample media are Au, As, Ba, P, Pb, and Se.

INTERPRETATION

Of the elements which exceed threshold, only Au, As, Pb and possibly Se are tentatively defined as anomalous and accredited to the Geo deposit 1.2 kilometres upslope. Although each of these elements exceed their thresholds by a minimal margin. Elements which form part of the deposit mineralogy and are found in near threshold concentrations in sediment are Cu, Zn and Ag. Slightly higher concentrations of Cu and As in moss-mat sediment implies that mechanical transportation of detrital grains from the mineralization may be occurring. Progressively higher concentrations of these elements in progressively finer size fractions indicates either finely comminuted mineral grains or potential hydromorphic enrichment.

The Geo iron skarn is tentatively identified by Au, As, Pb and possibly Se. Other potential pathfinders include Cu, Zn and Ag. The lack of additional samples to define associations and dispersion patterns and the doubtful location of the mineral deposit, precludes identifying these elements as truly anomalous.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Pb	Moss	7 - 12 ppm	1	7	9.5	1.2 km
Au	Stream	16 - 18 ppb	3	10	5.7	1.2 km
As	Moss	28.6 - 32.3 ppm	10	27	3	1.2 km
Se	Moss	1.1 - 2.2 ppm	0.7	1.1	2.4	1.2 km
Cu	Moss	66 - 84 ppm	46	118	1.8	?
Zn	Stream	113 - 123 ppm	88	146	1.4	?
Ag	Stream	0.2 - 0.4 ppm	0.1	0.5	3.5	?

Table A-11 Extravagant Creek - Summary Table of Pathfinder Elements

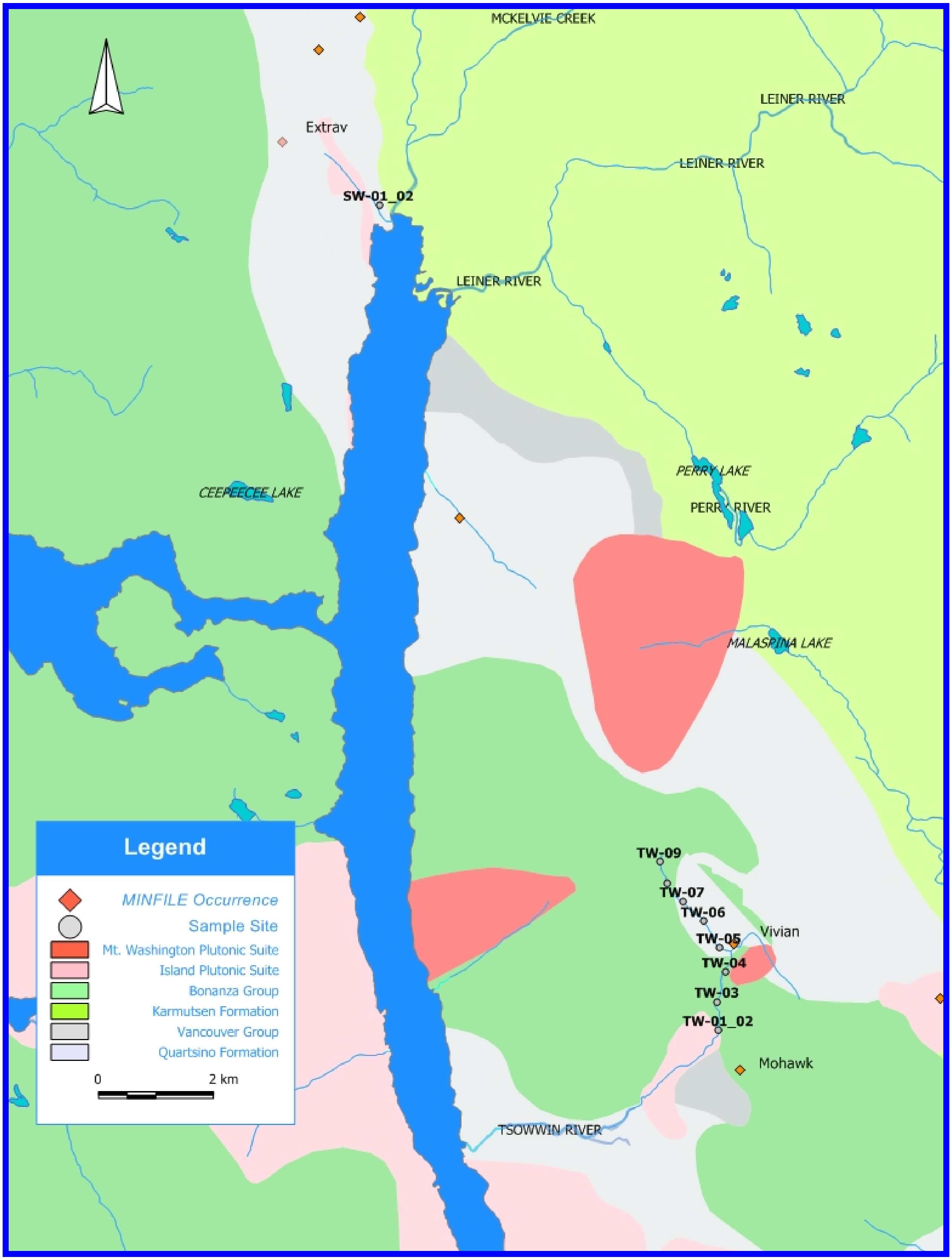


Figure A12-1 Tsowwin River (TW-) and Extravagant Creek (SW-)sample sites

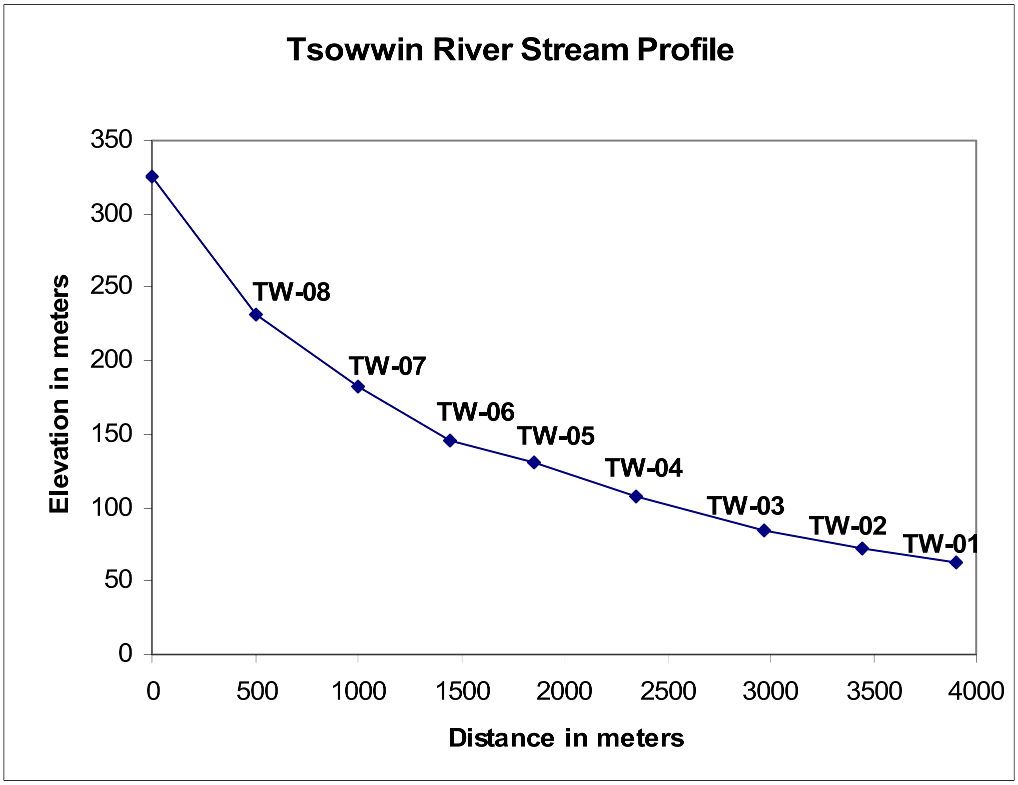


Figure A12-2 Tsowwin River stream profile

TSOWWIN RIVER – HYDROTHERMAL VEINS

DEPOSIT #1 NAME: Mohawk — *MINFILE #:* 092E 005

LOCATION: NTS – 92E15 — LAT. - 49º47'26" LONG. - 126º34'15" — UTM NORTH – 5517950 UTM EAST – 674850

STATUS: Showing — ***COMMODITIES:*** Gold

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite

DEPOSIT #2 NAME: Vivian — *MINFILE #:* 092E 006

LOCATION: NTS – 92E02 — LAT. - 49º48'37" LONG. - 126º34'21" — UTM NORTH – 5520150 UTM EAST – 674650

STATUS: Prospect — ***COMMODITIES*:** Gold, Silver

SIGNIFICANT AND ASSOCIATED MINERALS: Unknown

SAMPLE PATTERN: Eight sites (*Figure A12-1*) were sampled for conventional fine-grained stream sediment and moss-mat sediment. Bulk fine-grained sediment samples were collected from every second site. Within-site duplicate samples of moss-mat and conventional fine-grained stream sediment, in addition to bulk sieved samples of fine and coarse-grained sediment from low and high-energy sites, were collected at site TW-01.

RESULTS

Element Associations and Dispersion Curve Shapes

Five basic dispersion patterns have been defined for both moss-mat sediment and conventional fine-grained stream sediment.

In the first pattern, Co, Cr, Cu, Fe, Ni and V in moss-mat sediment display flat to slightly increasing concentrations with distance downstream. Common features are maximum concentrations at sites TW-05 and TW-02. The second pattern in moss-mat sediment, shared by Al, Mg, Mn and Zn, also defines flat to slightly increasing concentrations with distance down stream, however sites TW-05 and TW-02 are marked by low concentration spikes. The common pattern in moss-mat sediment displayed by Ba, K, LOI and Sr describes decreasing concentrations with distance downstream with low concentration spikes at TW-06 and TW-03. The fourth group, comprising Ca and P, exhibits some similar features relative to the previous group between TW-08 to TW-06, further downstream the patterns diverge wherein Ca and P increase in concentration. The final pattern in moss-mat sediment includes As, Au, Hg and Pb wherein As, Au and Pb display simultaneous enrichments at TW-08 and TW-06, while Au and Hg are enriched at TW-03.

Element associations, similar to the above groupings, are present in the conventional fine-grained stream sediment data. The first group, comprising siderophile and chalcophile elements, display flat to slightly increasing concentrations with coincident high and low concentration spikes. Concentrations of Co, Cu, Cr and Ni are compatible between the two media while Fe and V are enhanced in moss-mat sediment. The pattern produced by the second association, containing Al, Mg, Mn and Zn, is less coherent relative to the moss-mat sediment pattern with considerable discord displayed by Zn. These elements are relatively enhanced in fine-grained stream sediment. The alkali elements, Ca, K and Sr exhibit nearly identical patterns in stream sediment with concentrations decreasing downstream from TW-08. All three elements exhibit a low concentration spike at TW-03. Decreasing concentrations with distance downstream is also characteristic of the dispersion patterns demonstrated by Ba, LOI and Sb while P, after an initial decrease, depicts increasing concentrations. Of these elements, Ba, Ca and Sr are relatively enriched in conventional fine-grained stream sediment while K and Sb display compatible concentrations between the two media types. Moss-mat sediment is comparatively enriched in P. The fifth dispersion pattern in stream sediment is shared by As, Ag, Au, Hg and Pb, coincident high concentrations are seen at TW-08, TW-04 and TW-02. Moss-mat sediments are enhanced in Au, As and Hg while Ag and Pb are comparatively enriched in conventional fine-grained stream sediments.

Comparison to Background

Table A-12 gives background and threshold values for the Bonanza Group and Quatsino Formation for comparison purposes. Definition of anomalous concentrations is based on the Quatsino Formation values. Elements which exceeded their thresholds at one or more sites in either or both sample media are As, Au, Pb and Sb.

INTERPRETATION

The decreasing concentration trends displayed by the alkali elements Ca, K and Sr (*Figure A12-3a*) correspond to a change in the underlying lithology from Quatsino limestone to Bonanza volcanics. Organic content (LOI) exceeding 10 per cent introduces noise in the dispersion patterns for these elements in both media and may be the dominant source of between-site variation for Ba and Sr in conventional fine-grained stream sediment. Site energy and the relative ability of individual moss mats to trap heavy minerals is interpreted as the source of most variation in concentrations for elements in the first (Figure *A12-3b*) and second (*Figure A12-3c*) groups. Concentrations of lithophile elements typically associated with silicates corresponds well with field observations on the abundance of "silt" trapped in the various moss-mat samples. Site energy also strongly influences the concentration of heavy mineral related elements in conventional fine-grained stream sediments as indicated by the similarity of dispersion patterns (*Figure A12-3d*). However, the patterns in conventional fine-grained stream sediment are less cohesive (likely due to a greater influence of the underlying geochemical trends) than seen in moss-mat sediment, attesting to the control or selectivity moss mats exert on the nature of sediment trapped.

The patterns displayed by As (*Figure A12-3e*), Au (*Figure A12-3f*) and possibly Pb (*Figure A12-3g*) are interpreted as anomalous and mineralization related. Although Ag and Hg (*Figure A12-3h*) do not exceed threshold, their dispersion patterns correlate to some extent with the anomalous elements. The positions of the anomalous concentrations at TW-08 and TW-03 to TW-02 roughly coincide with the known positions of the Vivian and Mohawk deposits. The source of anomalous concentrations at TW-06 to TW-05 is unknown.

Bulk fine-grained samples produced background to low anomalous levels of Au in all size fractions except for a single, moderately anomalous concentration in the coarse fraction from site TW-01.

Optimal pathfinders for the hydrothermal quartz veins along the Tsowwin River are Au, As and Pb which give the longest dispersion trains and best contrast to background. Potential pathfinders include Ag and Hg which exceed or approach their thresholds coincident with the anomalous elements.

Anomalous Element	**Optimum Media**	**Range**	**Background**	**Threshold**	**Average Contrast**	**Anomaly Length**
Au	Moss	21 - 3420 ppb	3	10	311.3	3.4 km
As	Moss	45.5 - 134.0 ppm	10	27	8.8	3.4 km
Pb	Stream	5 - 14 ppm	1	7	9.3	2.0 km
Hg	Moss	40 - 280 ppb	100	270	0.9	1 site
Ag	Stream	0.1 - 0.3 ppm	0.1	0.5	1.8	?

Table A-12 Toswwin River - Summary Table of Pathfinder Elements

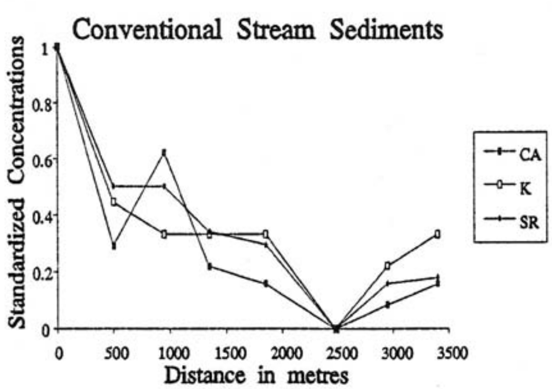


Figure A12-3a

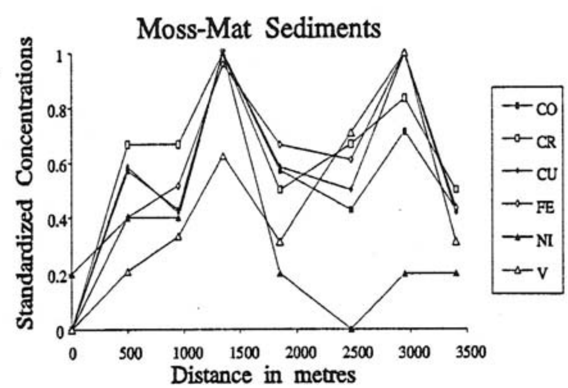


Figure A12-3b

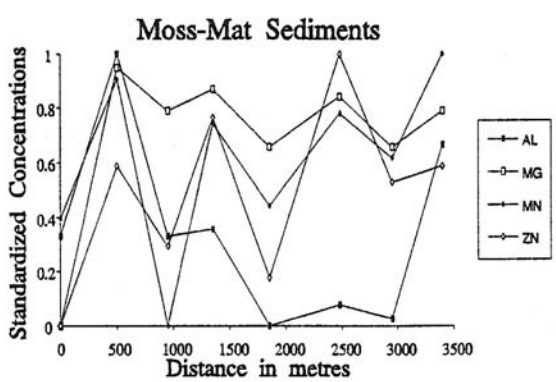


Figure A12-3c

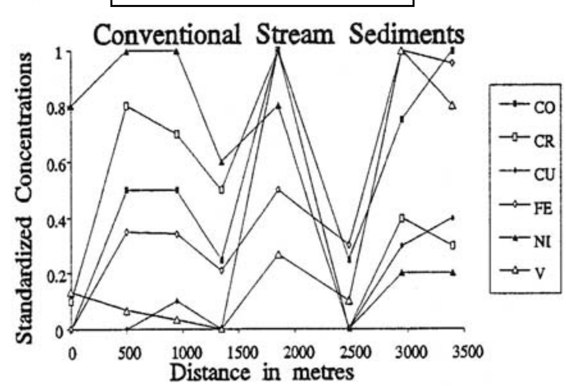


Figure A12-3d

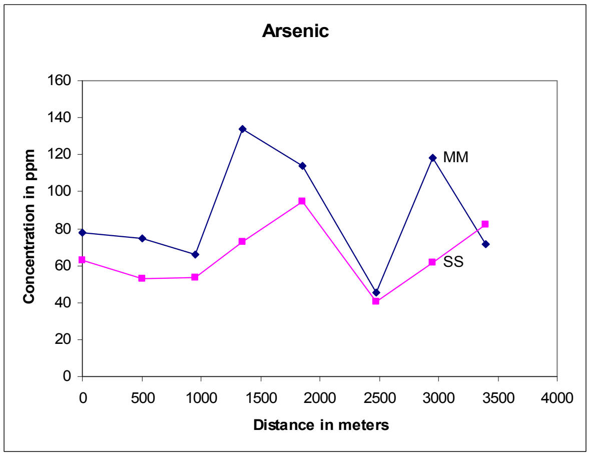


Figure A12-3e

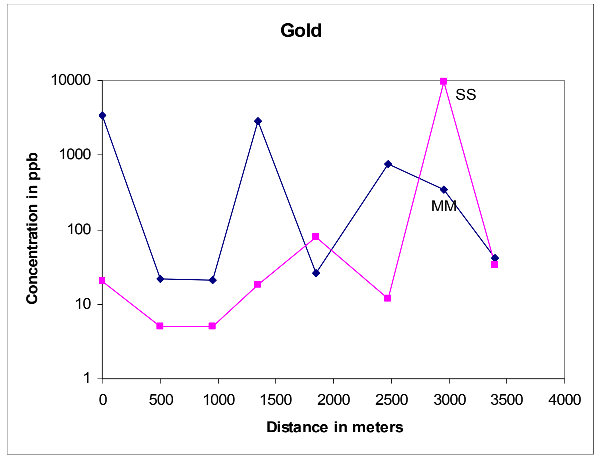


Figure A12-3f

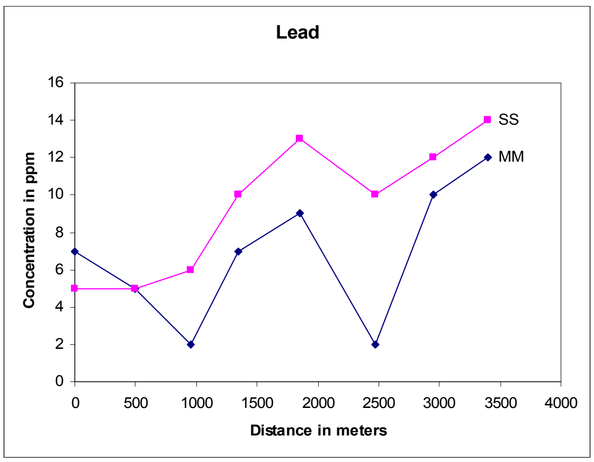


Figure A12-3g

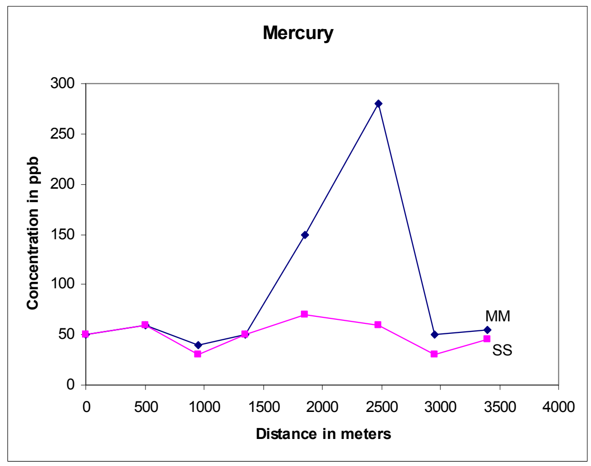


Figure A12-3h

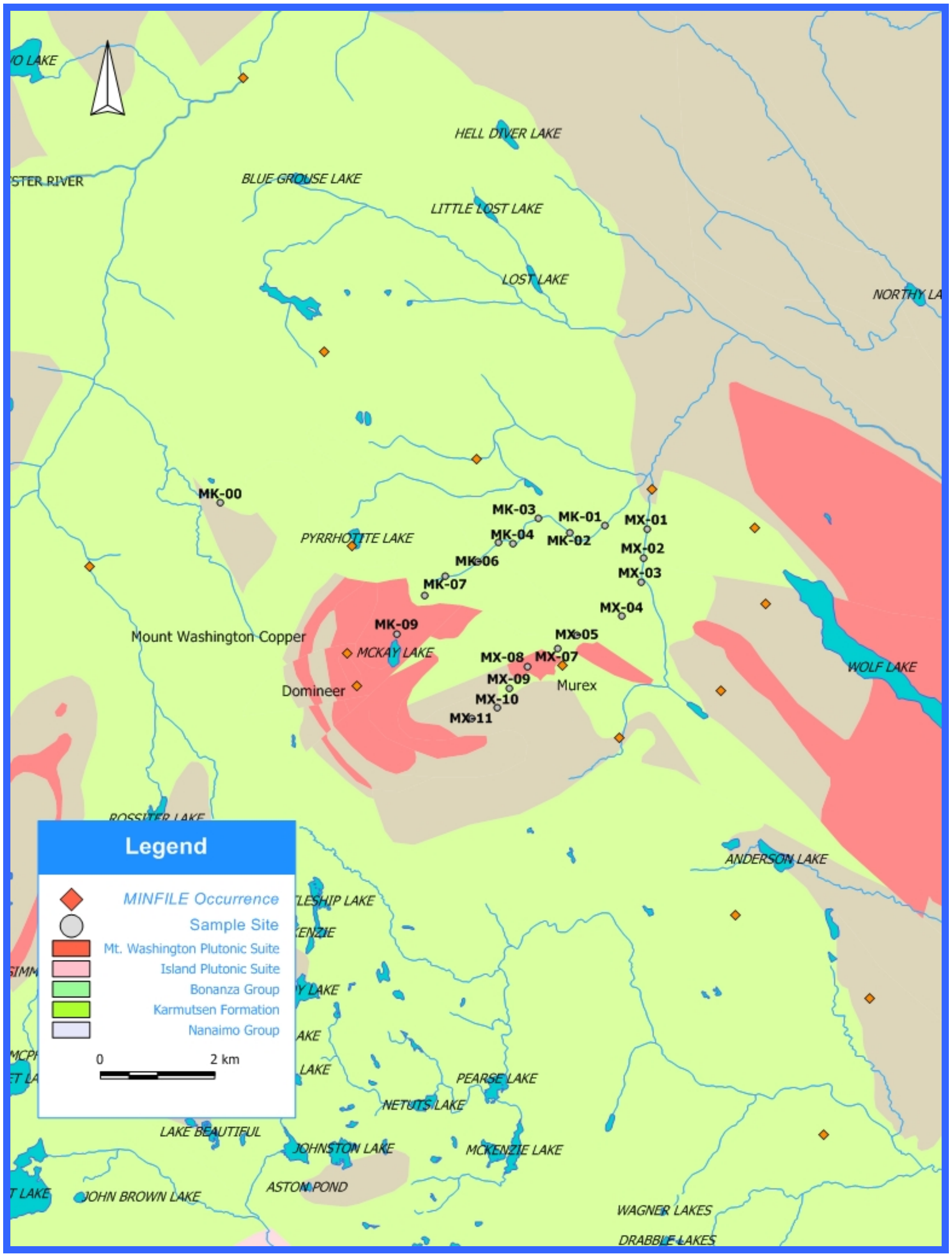


Figure A13-1 Murex Creek (MX-) and McKay Creek (MK-)sample sites

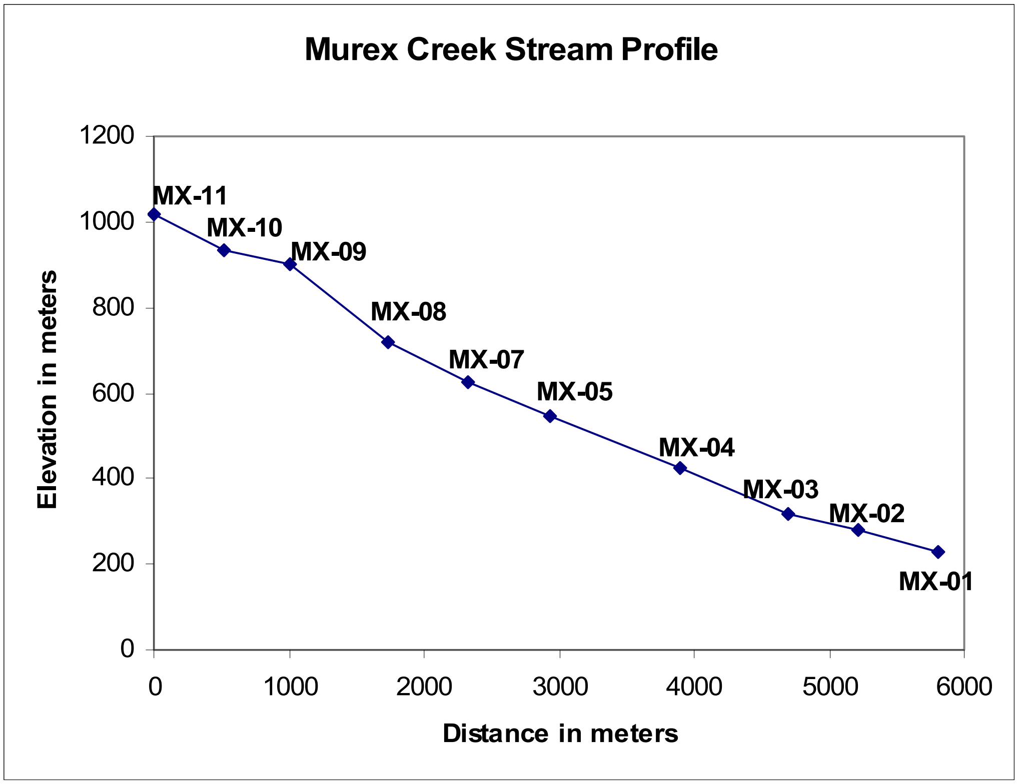


Figure A13-2 Murex Creek stream profile

MUREX CREEK – STOCKWORK & EPITHERMAL VEINS

DEPOSIT #1 NAME: Mount Washington Copper

MINFILE #: 092F 117

LOCATION: NTS – 92F14 LAT. - 49º45'49" LONG. - 125º18'03" UTM NORTH – 5514669 UTM EAST – 334300

STATUS: Past Producer

COMMODITIES: Copper, Gold, Silver, Arsenic, Molybdenum, Zinc, Lead

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Pyrite, Bornite, Covellite, Realgar, Orpiment, Molybdenite, Sphalerite, Galena, Pyrrhotite, Arsenopyrite

DEPOSIT #2 NAME: Murex Creek

MINFILE #: 092F 206

LOCATION: NTS – 92F14 LAT. - 49º45'41" LONG. - 125º14'55" UTM NORTH – 5514300 UTM EAST – 338050

STATUS: Prospect

COMMODITIES: Copper, Gold, Silver

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Pyrite, Pyrrhotite, Magnetite

LOCAL GEOLOGY: Murex Creek drainage basin is underlain predominantly by basaltic flows and pillow lavas of the upper Triassic Vancouver Group Karmutsen Formation (*Figure A13-1*). Near the headwaters, interbedded fine-grained sandstone and siltstone belonging to the Cretaceous Nanaimo Group Comox Formation unconformably overlie Karmutsen rocks. Tertiary (35 ± 6 m.a.) Catface porphyry stocks of quartz-felspar to quartz-diorite composition intrude both formations near the summit of Mt. Washington. Flat lying satellite breccias found proximal to the intrusions and along Murex creek have been interpreted as diatremes and collapse breccias.

ALTERATION AND MINERALIZATION: Mount Washington Copper has been interpreted as a porphyry style deposit superimposed by a younger epithermal system. Mineralization is a stockwork of chalcopyrite-pyrite-quartz veins in a subhorizontal tabular zone near the contact between the overlying Nanaimo sediments and the underlying "Pit" diorite. Production between 1964 and 1967 recovered 131 kilograms of gold, 7 235 kilograms of silver and 3 548 tonnes of copper from 381 773 tonnes of ore. Porphyry intrusions have been potassically altered with a kaolinization overprint. Mineralization in the Murex Creek showing comprises sulphides (< 1 to 10 per cent) disseminated in the matrix of a collapse breccia associated with the Mt. Washington intrusions. Mineralization post dates brecciation, low angle faults which bound the deposits are interpreted to have acted as conduits for hydrothermal fluids. Chlorite and epidote within the breccia matrix indicates propylitic alteration. The porphyry intrusions have been potassically altered with a kaolinization overprint. Sulphide bearing quartz veins are exposed in the creek bed at MX-08 and MX-07. A clay-rich bank containing abundant pyrite is exposed at MX-08.

LOCAL ENVIRONMENT: Mount Washington lies along the divide between Vancouver Island Ranges of the Insular Mountains and the Nanaimo Lowlands. The terrain is mountainous with local relief of 1 400 metres. A veneer (< 1 metre) of till and colluvium mantles upper slopes becoming a continuous till blanket exceeding 10 metres in thickness along the lower course of Murex Creek. Glacial indicators suggest a southeast direction of flow across the study area. The present climate is mild and moderately wet with annual precipitation of 1 800 millimetres. Soils are dominantly humo-ferric podzols.

STREAM CHARACTERISTICS: Murex Creek (*Figure A13-2*) has a moderately steep gradient (12 degrees) undergoing an 800 metre vertical drop over the 5.9 kilometre sample traverse. The profile is slightly stepped, a short, low-energy upper course is marked by alluvium banks, sandy bed load and a meandering channel. A steep, high-energy middle section results in waterfalls, bedrock banks, and a bouldery channel bed. The gradient decreases slightly along the lower section characterized by alluvium banks, a shoot-and-pools channel pattern and a channel bed composed of gravels or boulders. Sections of exposed bedrock are found along the entire surveyed length of Murex Creek.

SAMPLE PATTERN: Ten sites (*Figure A13-1*) were sampled for conventional fine-grained stream and moss-mat sediment. Bulk fine-grained sediment samples were collected from every second site. A sieved bulk sample of coarse sediment from a high-energy environment was obtained from site MX-01. Within-site duplicate samples of moss-mat and conventional fine-grained stream sediment were collected at MX-01 and MX-03. Fine-grained stream sediment was generally scarce through out the sample traverse. Moderate to abundant quantities of moss mats were available at each sample site. Moss-mat and conventional fine-grained stream sediment was collected from site MX-12 on a large tributary to Murex Creek to help establish background.

RESULTS

Element Associations and Dispersion Curve Shapes

Four dispersion patterns in both moss-mat sediment and conventional fine-grained stream sediment have been defined.

The patterns described by Al, Ba, K and Mg (pattern 1) and those of Cr, Fe, Ti and V (pattern 2) in moss-mat sediment display many similar features with corresponding concentration crests and troughs. The general trend of the first pattern is of decreasing concentration with distance downstream, while the second pattern exhibits generally increasing concentrations. A sharp concentration spike is noted in both patterns at site MX-08. The third pattern, shared by Ca, Co, Mn, Ni and Sr depicts flat to slightly increasing concentrations with distance down stream. Each element exhibits a sharp low concentration spike at site MX-08. In the fourth and final pattern, elevated concentrations of Au, Ag, As, Bi, Cu, Mo, P, Pb, Sb, Se, W and Zn occur, to varying degrees, at MX-11, MX-08 to MX-04 and MX-01. Enrichment at MX-08 is most pronounced in Au, Ag, Cu, Mo, Sb and Se.

Similar dispersion train patterns are displayed by Ca, Co, Cr, Fe, Mg, Mn, Ni, Ti and V in conventional stream sediment. Most of the elements exhibit a sharp decrease in concentrations between MX-11 to MX-09 with a subsequent steady increase downstream of this point. Several of the elements display a sharp increase downstream of the western tributary which enters above site MX-03. The patterns defined by Al, Ba and Sr have many similar features compared to the above elements but with a general decreasing concentration trend. Moderately well defined exponential dilution curves are exhibited by As, Bi, P, Se and Zn. Maximum concentrations are found at MX-11 with minor enhancements seen at MX-08 to MX-05. Notable enrichment of Zn is seen at MX-02. The fourth pattern, defined by Cu, K, Mo, Pb and Sb, exhibits strong enrichments between MX-08 and MX-04. A characteristic step pattern is seen in the dilution curves for Cu, K and Mo at MX-04 which coincides with similar though more subtle steps in As, Bi and P. In addition MX-04 has enriched levels of Au and W.

Comparison to Background

Table A-13 gives background and threshold values for sediment derived from the Karmutsen Formation. The following elements exceed their thresholds in either or both media at one or more sites; Au, As, Ag, Ba, Bi, Cr, Cu, Fe, K, Mg, Mo, P, Pb, Sb, Se, Te, W and Zn.

INTERPRETATION

The patterns displayed by the lithophile and siderophile elements; Al, Ba, Ca, Co, Cr, Fe, Mg, Mn, Ni, Sr, Ti, V (*Figures A13-3a and A13-3b*) are interpreted as the product of lithology with variations introduced by site and sample attributes. The peak concentration seen in several of the above elements (Al, Ba, Cr, Fe, Mg, Ti, V) in moss-mat sediment at site MX-08 is due to the sample being collected from the pyritic, clay-rich bank. The anomalously low concentrations displayed by elements which are moderately to highly mobile under acidic-oxidizing conditions (Ca, Co, Mn, Ni, Sr) is likely the product of sulphide weathering causing mobilization and depletion. Similar though subtler patterns are seen in stream sediment at this site. Very likely the geochemical impact of the pyrite and clay-rich bank is muted by sediment derived from upstream.

The patterns displayed by Au (*Figure A13-3c*), Ag, As (*Figure A13-3d*), Bi, Cu (*Figure A13-3e*), K, Mo (*Figure A13-3f*), P, Pb, Sb (*Figure A13-3g*), Se, W (*Figure A13-3h*) and Zn are believed to be anomalous. Concentrations are well above threshold, exponential dilution curves are displayed by some elements and the element associations match the mineralogy of the deposits. Differences in the mineralogy of the Murex Creek and Mount Washington deposits are reflected in location of maximum concentrations. Spiked concentrations at MX-08 in moss-mat and stream sediment are attributed to the pyritic clay bank. The step seen in the dispersion trains of several anomalous elements including Au and W at MX-04 may be the result of an unknown anomalous source which has enhanced levels of W in association with Au. The anomalous levels of Au, Bi, Sb and Te at MX-01 may be the product of placer formation due to a flattening of the stream gradient.

Concentrations of As, Bi, Cu, P, Pb and Se in stream sediment which exceed moss-mat sediment at MX-11 to MX-09 may indicate a fair degree of hydromorphic dispersion from the Mount Washington Copper deposit. In contrast, preferential concentration of these and other elements in moss-mat sediment downstream of the Murex Creek deposit may be indicating mechanical dispersion of sulphide grains from exposed sulphide veins.

Medium to coarse gold is apparently associated with the Murex Creek deposit based on a maximum concentration in the coarse fraction of a bulk fine-grained sediment sample taken downstream of the deposit.

Mineralization associated with the Mount Washington deposits is best defined (longest dispersion train and best average contrast) in Murex Creek by Au, As, Sb, Bi. Other pathfinders which are locally anomalous are Mo, K, Cu, Pb, Se and Ag. Potential pathfinders which are anomalous only adjacent to mineralization comprise W, Zn and P. Based on average contrast, moss-mat sediment is the optimal sample medium for Au, Ag, As, Bi, Cu, K, Mo, Sb and W while conventional stream sediments are best for P, Pb, Se and Zn based on average contrast.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
As	Moss	73.5 - 251.4 ppm	4	15	31.9	5.8 km
Sb	Moss	2.7 - 9.4 ppm	0.3	1	17.3	5.8km
Bi	Moss	0.2 - 1.8 ppm	0.1	0.5	7.5	5.2km
Au	Moss	16 - 1260 ppb	6	25	68.2	4.9 km
Mo	Moss	1 - 14 ppm	2	4	2.3	4.2 km
K	Moss	0.05 - 1.93 ppm	0.04	0.09	6.7	3.7 km
Cu	Moss	109 - 594 ppm	115	178	2.1	3.7 km
Pb	Stream	8 - 26 ppm	2	11	6.4	2.9 km
Se	Stream	0.2 - 1.3 ppm	0.2	0.5	2.4	1.9 km
Ag	Moss	0.1 - 0.6 ppm	0.1	0.5	3.3	1.2 km
W	Moss	1 - 10 ppm	1	5	2.9	1 site
Zn	Stream	59 - 190 ppm	76	107	1.1	1 site
P	Stream	0.019 - 0.051 ppm	0.032	0.048	0.8	1 site

Table A-13 Murex Creek - Summary Table of Pathfinder Elements

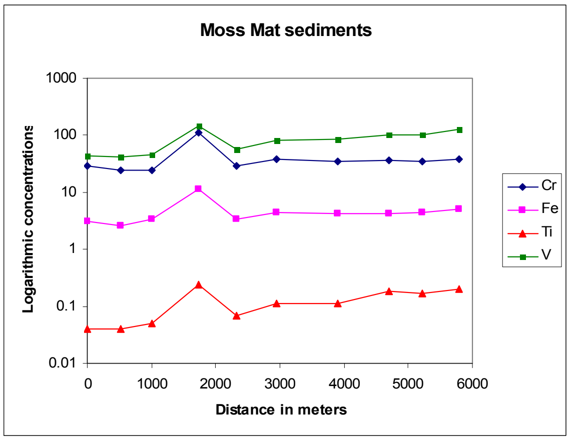


Figure A13-3a

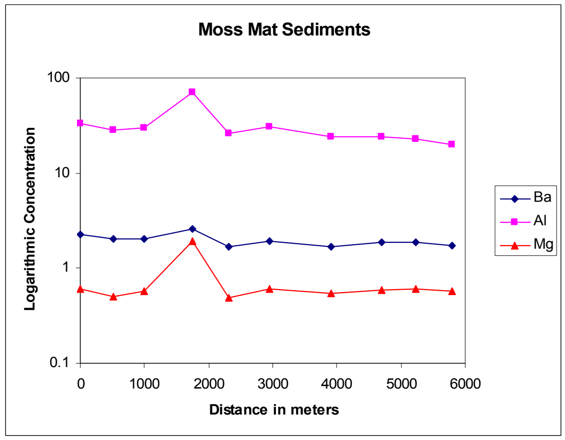


Figure A13-3b

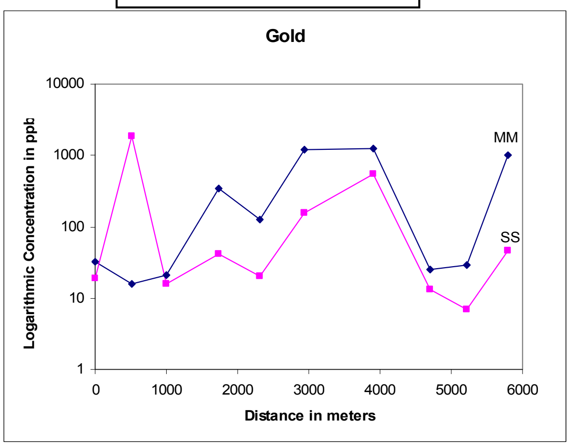


Figure A13-3c

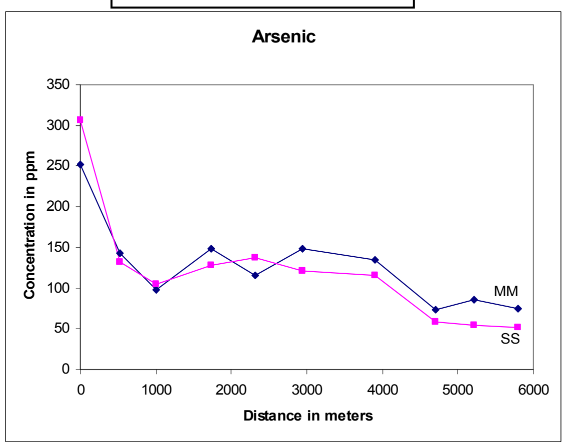
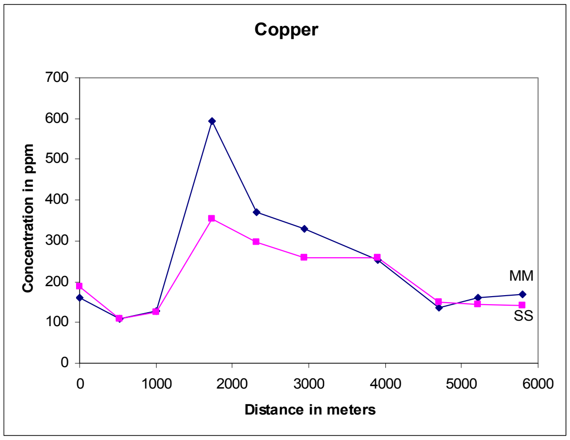


Figure A13-3d



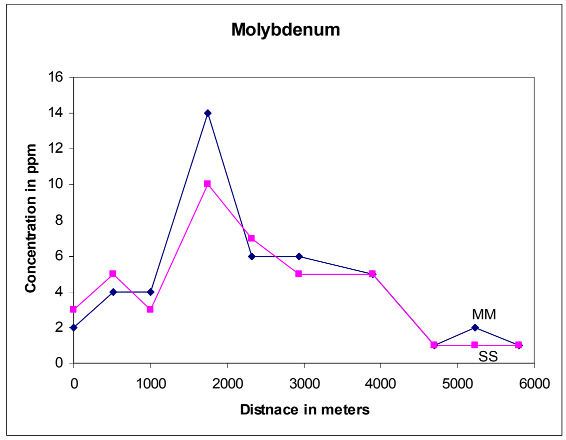
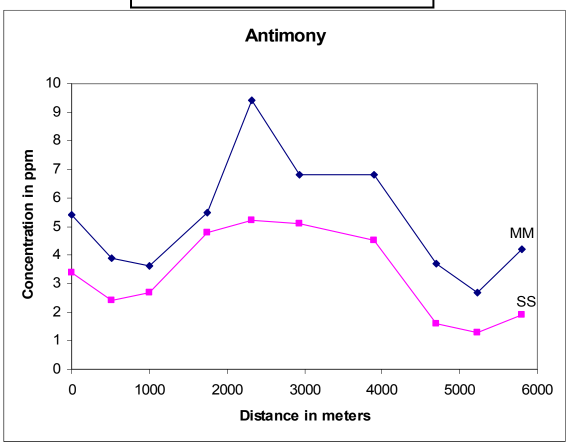


Figure A13-3e

Figure A13-3f



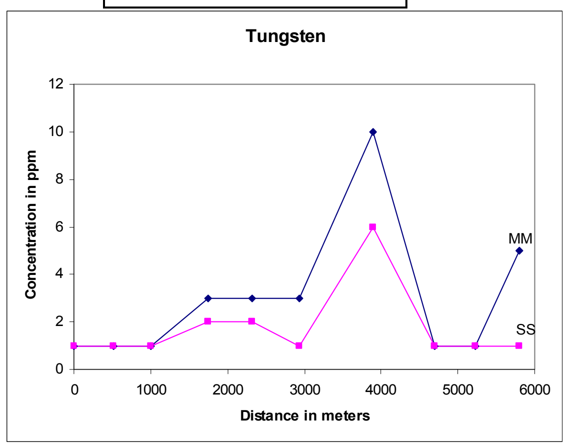


Figure A13-3g

Figure A13-3h

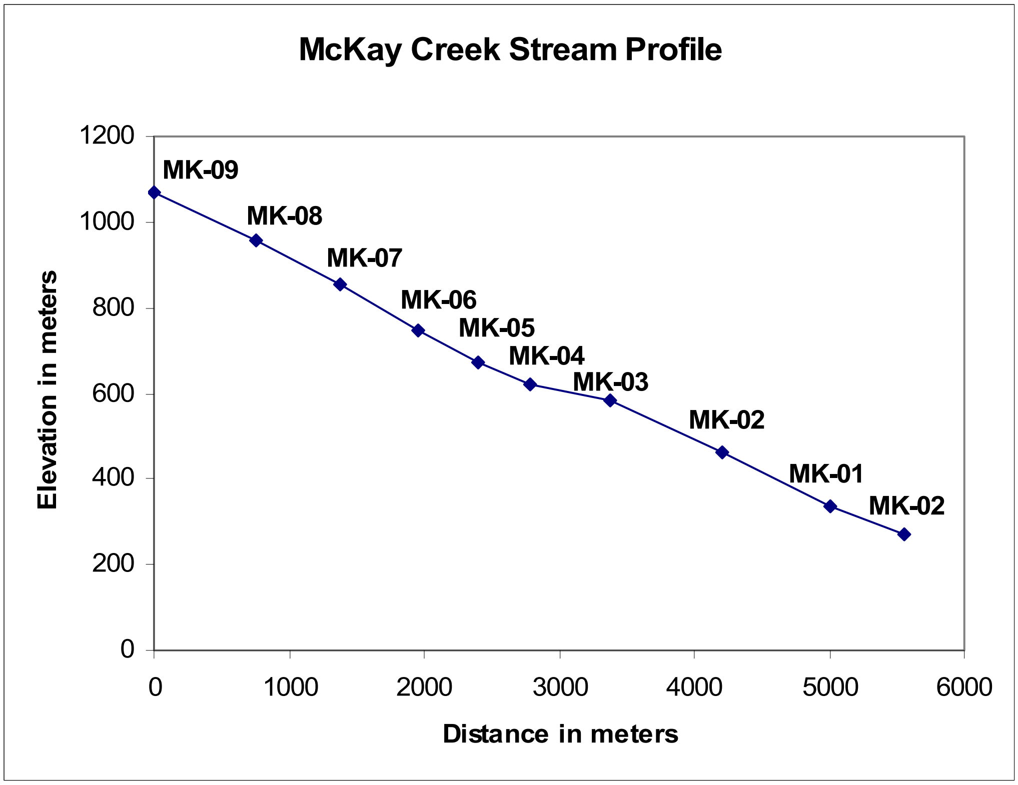


Figure A14-1 McKay Creek stream profile

MCKAY CREEK – STOCKWORK & EPITHERMAL VEINS

DEPOSIT #1 NAME: Domineer *MINFILE #:* 092F 116

LOCATION: NTS – 92F14 LAT. - 49º45'42" UTM NORTH – 5514455
LONG. - 125º18'06" UTM EAST – 334234

STATUS: Prospect ***COMMODITIES***: Copper, Molybdenum, Gold, Silver, Arsenic, Zinc, Lead, Antimony

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Arsenopyrite, Chalcopyrite, Covellite, Sphalerite, Galena, Tennantite, Bornite

DEPOSITE #2 NAME: Mount Washington Copper
MINFILE #: 092F 117

LOCATION: NTS – 92F14 LAT. - 49º45'49" UTM NORTH – 5514669
LONG. - 125º18'03" UTM EAST – 334300

STATUS: Past Producer ***COMMODITIES:*** Copper, Gold, Silver, Arsenic, Molybdenum, Zinc, Lead

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite, Pyrite, Bornite, Covellite, Realgar, Orpiment, Molybdenite, Sphalerite, Galena, Pyrrhotite, Arsenopyrite

LOCAL GEOLOGY: McKay Creek is predominantly underlain by massive basaltic flows and pillow lavas of the upper Triassic Karmutsen Formation of the Vancouver Group (*Figure A13-1*). Tertiary (35 ± 6 Ma) Catface quartz diorite and quartz diorite porphyry intrusions are observed at the summit of Mt. Washington and surrounding McKay Lake at the head of McKay Creek. Flat lying satellite breccias found proximal to the intrusions and along Murex creek have been interpreted as diatremes and collapse breccias.

ALTERATION AND MINERALIZATION: Mount Washington Copper has been interpreted as a porphyry style deposit superimposed by a younger epithermal system. Mineralization is a stockwork of chalcopyrite-pyrite-quartz veins in a subhorizontal tabular zone near the contact between the overlying Nanaimo sediments and the underlying "Pit" diorite. Production between 1964 and 1967 recovered 131 kilograms of gold, 7 235 kilograms of silver and 3 548 tonnes of copper from 381 773 tonnes of ore. Porphyry intrusions have been potassically altered with a kaolinization overprint.

LOCAL ENVIRONMENT: Mount Washington lies along the divide between the Vancouver Island Ranges of the Insular Mountains and the Nanaimo Lowlands. The terrain is mountainous with local relief of 1 400 metres. A veneer (< 1 metre) of till and colluvium mantles upper slopes becoming a continuous till blanket exceeding 10 metres in thickness along the lower course of Murex Creek. Glacial indicators suggest a southeast direction of flow across the study area. The present climate is mild and moderately wet with annual precipitation of 1 800 millimetres. Soils are dominantly humo-ferric podzols.

STREAM CHARACTERISTICS: McKay Creek (*Figure A14-2*) undergoes an 800 metre vertical drop over the 5.5 kilometre sample traverse resulting in an average stream gradient of 13 degrees. The profile is slightly stepped containing short moderate gradient sections in an overall moderately high gradient stream. Channel pattern varies between braided and shoots-and-pools, gravels and boulders line the creek bed. Banks are composed almost exclusively of till and/or alluvium.

SAMPLE PATTERN: Ten sites (*Figure A14-1*) were sampled for conventional fine-grained stream and moss-mat sediment. Bulk fine-grained sediment samples were collected from every second site. A sieved sample of coarse sediment from a high-energy environment, in addition to within-site duplicate samples of moss-mat and conventional stream sediment, was obtained from site MK-00. Fine-grained stream sediment was generally scarce through out the sample traverse. Moss mats were scarce in the upper basin (above site MK-04) where logging had removed most of the vegetation shading the creek, moderate to abundant quantities were available in the lower basin.

RESULTS

Element Associations and Dispersion Curve Shapes

Three dispersion patterns are displayed by moss-mat sediment and conventional fine-grained stream sediment.

Generally increasing concentrations with distance downstream are exhibited by Ca, Cr, Fe, Mg, Ni, Ti and V in moss-mat sediment. Several of the elements display a single or double concentration spike between sites MK-07 to MK-05. In the second pattern, dispersion trains for Al, Ba, Co, Mn and Zn describe a rapid decrease in concentrations from MK-09 to MK-08 followed by a flattening of the concentration curve. Enhanced concentrations are also noted at MK-06 and MK-03, these spikes are most pronounced in Al. In the third pattern, exponential dilution curves are displayed by Ag, As, Bi, Cu, K, Mo, P, Pb, Sb, Se and Te, from maximum concentrations at MK-09 or MK-08. Several elements in this group also show enhancements at MK-06 and MK-03.

The pattern defined by Ca, Cr, Fe, Mg, Ni, Ti and V describes generally increasing concentrations with distance downstream from a minimum value at MK-09 to MK-07. A minor enhancement in Cr, Fe, Mg, Ti and V is seen at MK-06. Rapidly decreasing concentrations between MK-09 to MK-07 are seen in the patterns for Al, Ba, Co, Mn and Zn. Downstream of MK-07, these elements describe flat, slightly decreasing or increasing concentrations. Exponential dilution curves are displayed by Ag, As, Bi, Cu, K, Mo. P, Pb, Sb, Se and Te. The smooth trend of the exponential dilution curve for some of the elements is interrupted by minor enhancements at MK-01, MK-03 and MK-05.

A unique pattern is displayed by Au in both media. In moss-mat sediment, Au displays a double peak with maximum enrichments at MK-06 and MK-02. Enhancements of Au in stream sediment is seen at MK-09, MK-05, MK-03 and MK-00.

Elements which are enhanced in stream sediment relative to moss-mat sediment include: Al, As, Ba, Co, Cu, Mg, Mn, Ni, Pb, Sr and Zn.

Comparison to Background

Table A-14 gives background and threshold values for sediment derived from the Karmutsen Formation. The following elements exceed their thresholds in either or both media at one or more sites; Au, As, Ag, Ba, Bi, Co, Cu, K, Mo, P, Pb, Sb, Se, Te, and Zn.

INTERPRETATION

The moss-mat and stream sediment patterns displayed by the lithophile and siderophile elements; Ca, Cr, Fe, Mg, Ni, Ti and V are attributed to the underlying lithology. Downstream increases correspond to the transition from quartz diorite of the Catface Intrusion to the basaltic volcanics of the Karmutsen Formation. Individual concentration spikes which correlate between element dispersion pattern are the result of site and sample attributes such as quantity of fine sediment, organic content, efficiency of heavy mineral trapping (moss mats) or degree of hydraulic sorting at the sample site (conventional fine-grained stream sediments).

High concentrations of Al, Ba, Co, K, Mn and Zn at MK-09 are due in part to the mineralization and the surrounding alteration zone. Beyond MK-09, these elements are quickly diluted to background levels and dispersion train features are the product of site and sample induced variations. Strong similarities in the Co, Zn and Mn (*Figure A14-3a*) patterns suggests Mn scavenging.

The Domineer and Mount Washington Copper deposits are clearly the source for anomalous levels of Au (*Figure A14-3b*), As (*Figure A14-3c*), Ag, Bi, Cu (*Figure A14-3d*), K (*Figure A14-3e*), Mo (*Figure A14-3f*), P (*Figure A14-3g*), Pb, Sb (*Figure A14-3h*), Se and Te given the characteristic dilution curves and an element association matching the known mineralogy of the deposits. Minor enhancements at MK-05, MK-03 and MK-01 correspond with site observations of higher fine-grained sediment content of samples.

The unique pattern expressed by Au may be the product of placer formations downstream of the lode source. The enhanced levels of Au in moss-mat sediment relative to stream sediment (consistently one to two orders of magnitude higher) in Mckay Creek, is the most pronounced example of preferential trapping of heavy minerals in moss mat of all case studies examined. Consistently higher Au concentrations in the finest size fraction of bulk sediment samples suggests a predominance of fine-grained gold associated with the deposits.

The significantly higher concentrations in conventional fine-grained stream sediments of numerous chalcophile elements which are mobile in acidic-oxidizing environments and evidence of Mn scavenging suggests hydromorphic dispersion occurs adjacent to the deposits.

The stockwork deposits on Mount Washington are best defined by Au, As, Sb, Pb, Cu and Mo which produce the longest dispersion trains and highest average contrast with background. Other pathfinders which are locally anomalous include Ag, K, Bi, Se and Te. Potential pathfinders which are anomalous only adjacent mineralization include Zn, P and Co. Moss-mat sediments give higher average contrasts for Au, Ag, Bi, P, Sb and Se while conventional fine-grained streams sediments are better for As, Co, Cu, K, Mo, Pb, Te and Zn.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	116 - 3110 ppb	6	25	208.1	5.5 km
As	Stream	144.8 - 613.6 ppm	4	15	64.3	5.5 km
Sb	Moss	4.2 - 14.9 ppm	0.3	1	27	5.5 km
Pb	Stream	14 - 42 ppm	2	11	11.6	5.5 km
Cu	Stream	261 - 1071 ppm	115	178	4	5.5 km
Mo	Stream	3 - 18 ppm	2	4	3.2	5.0 km
Ag	Moss	0.3 - 1.4 ppm	0.1	0.5	6.3	4.2 km
K	Stream	0.06 - 0.13 ppm	0.04	0.09	2.3	4.2 km
Bi	Moss	0.2 - 3.0 ppm	0.1	0.5	8.5	2.8 km
Se	Moss	0.2 - 1.2 ppm	0.2	0.5	2.4	2.7 km
Te	Stream	0.3 - 0.8 ppm	0.3	0.6	1.5	2.2 km
Zn	Stream	53 - 147 ppm	76	107	1	1 site
P	Moss	0.025 - 0.049 ppm	0.032	0.048	1.1	1 site
Co	Stream	12 - 39 ppm	24	32	0.7	1 site

Table A-14 McKay Creek - Summary Table of Pathfinder Elements

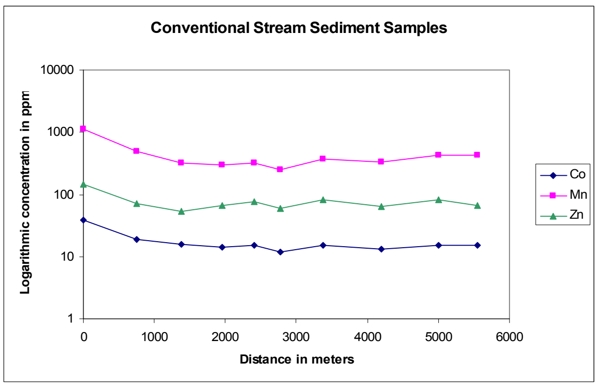


Figure A14-3a

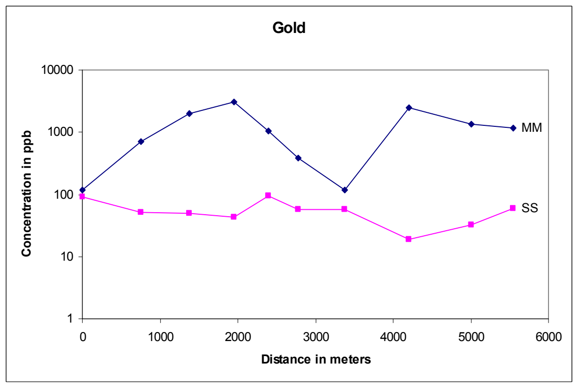


Figure A14-3b

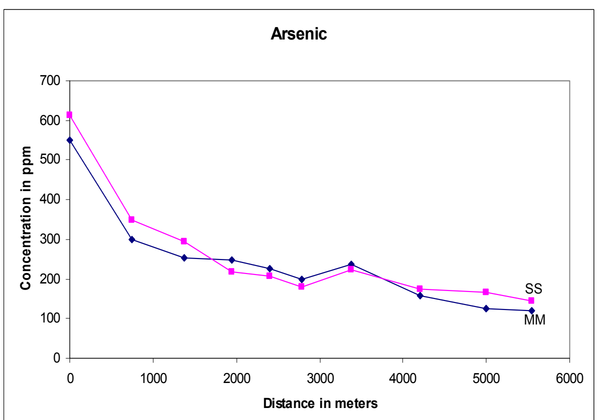


Figure A14-3c

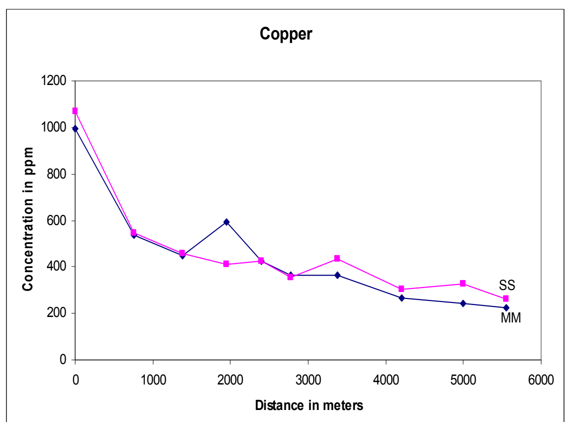


Figure A14-3d

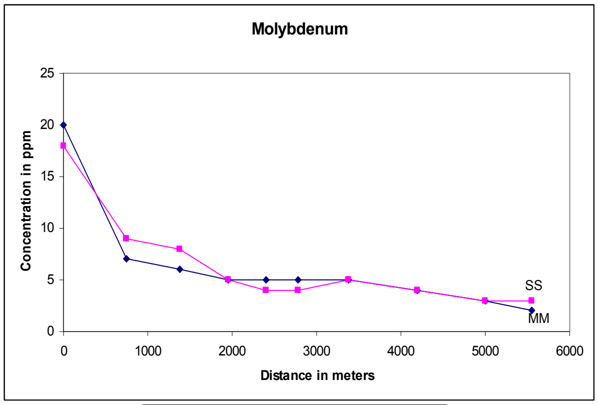
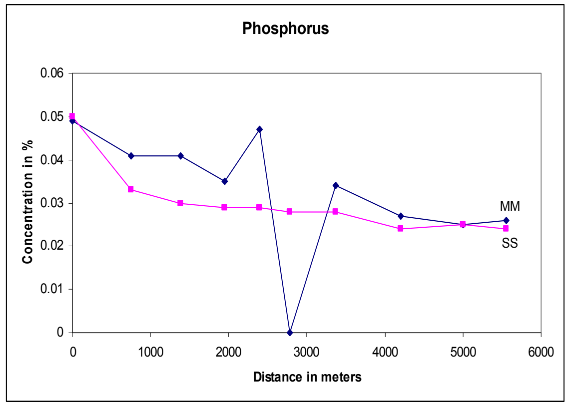


Figure A14-3e



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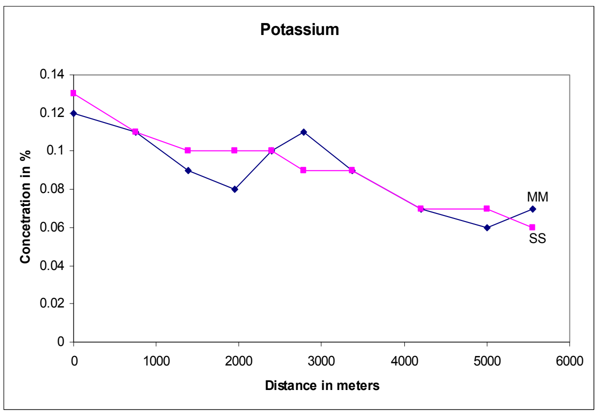


Figure A14-3g

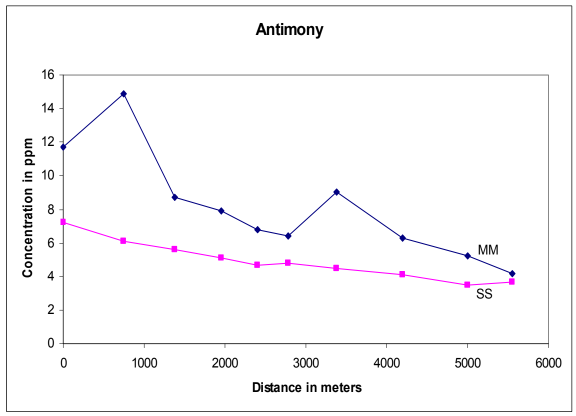


Figure A14-3h

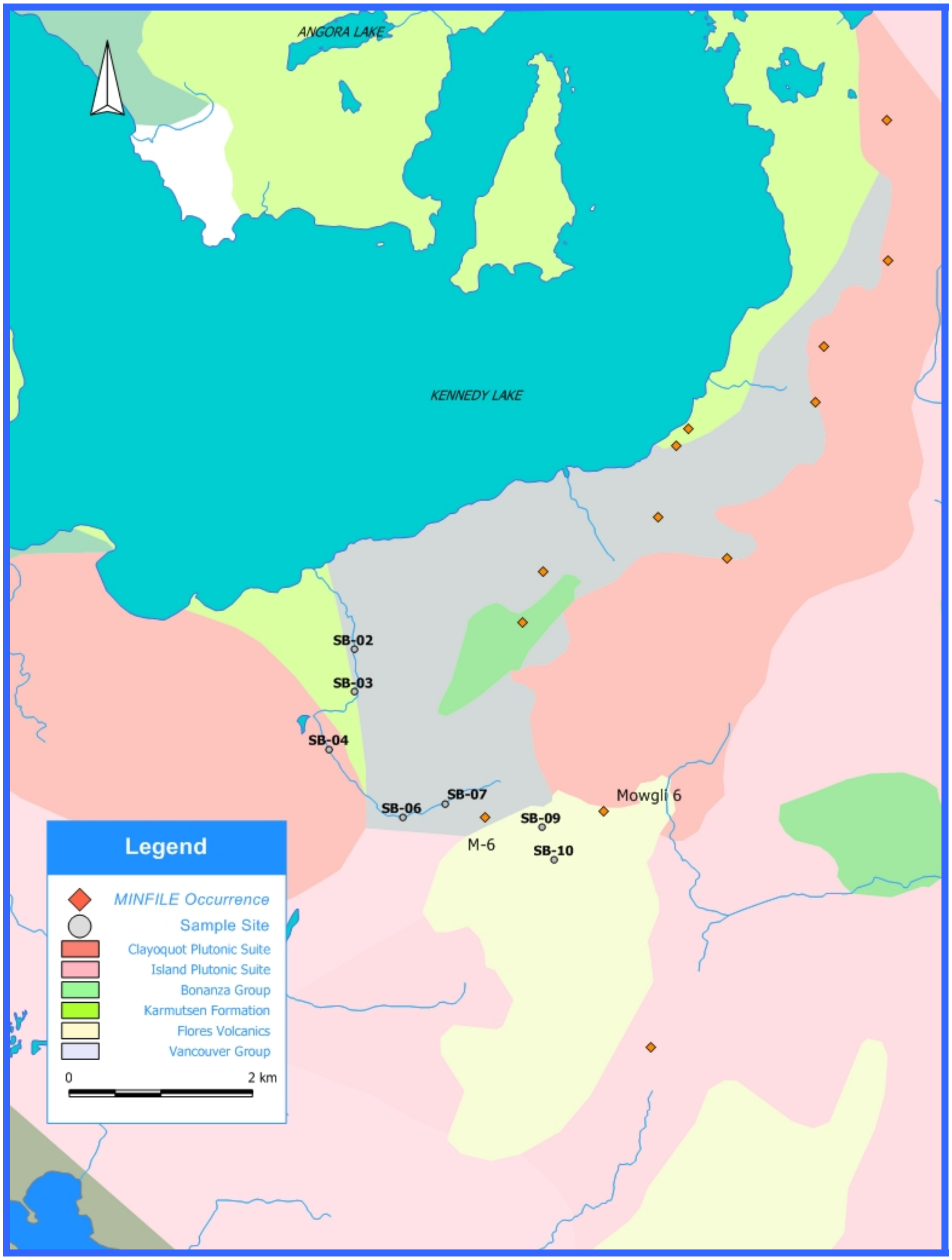


Figure A15-1 Salmonberry Creek (SB-) sample sites

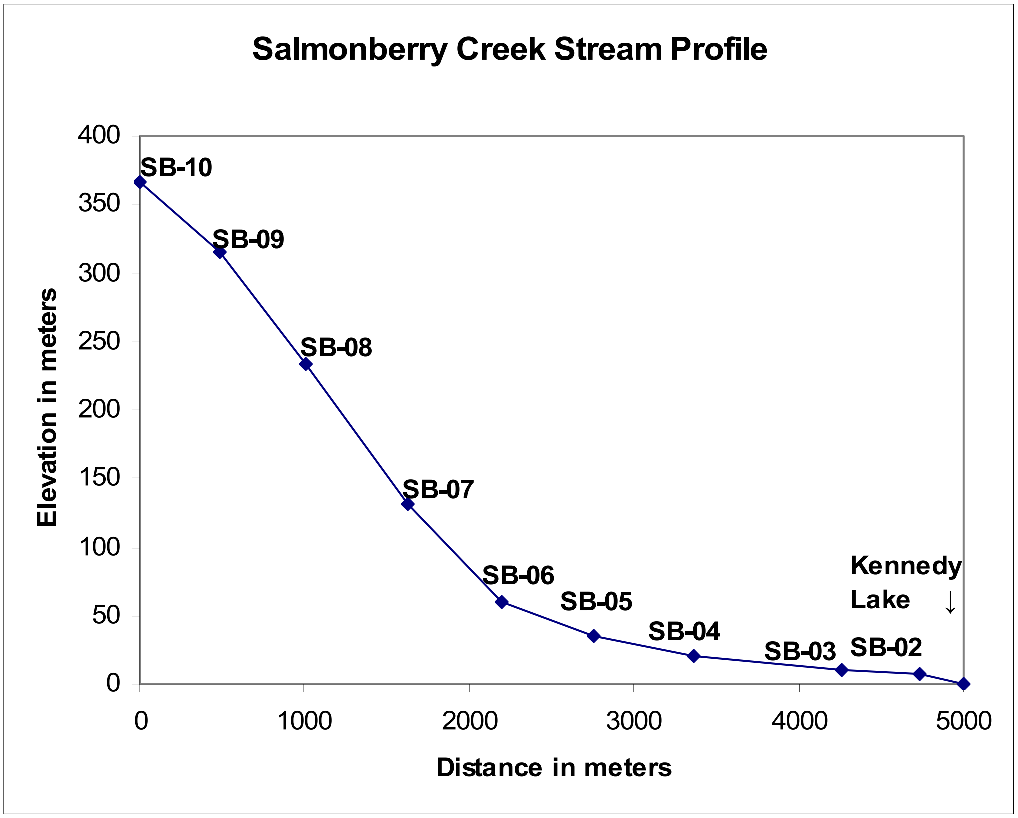


Figure A15-2 Salmonberry Creek stream profile

SALMONBERRY CREEK – EPITHERMAL VEINS

DEPOSIT #1 NAME: Mowgli 6 *MINFILE #:* 092F 013

LOCATION: NTS – 92F03 LAT. 49º00'51" LONG. - 125º29'40" UTM NORTH – 5431800 UTM EAST – 317600

STATUS: Showing ***COMMODITIES:*** Gold, Silver, Copper, Zinc, Lead, Arsenic

SIGNIFICANT AND ASSOCIATED MINERALS: Arsenopyrite, Pyrite, Chalcopyrite, Sphalerite, Galena

LOCAL GEOLOGY: Paleozoic Westcoast Complex diorite to quartz diorite rocks are the oldest assemblage in the area and underlie the lowest section of Salmonberry Creek (*Figure A15-1*). These are unconformably overlain by siliceous carbonates and limestones of the Triassic Vancouver Groups' Parson Bay and Quatsino formations. These assemblages underlie the lower middle section of Salmonberry Creek. Intruding the above are stocks of the early Tertiary Tofino Suite ranging in composition from hornblende quartz diorite to quartz felspar porphyry. These intrusions form the upper half of the Salmonberry Creek drainage basin.

MINERALIZATION AND ALTERATION: The Salmonberry Creek mineral showings are classified as epithermal systems in shear zones. Gold together with sulphides of arsenic, iron, copper, zinc and lead are found along a regional fault / shear zone referred to as the "Switchback Shear Zone" which cuts the intrusions. The zone is characterized by intense brecciation and abundant clay, limonite and sericite. The Main or Mowgli showing lies roughly 900 metres upslope of site SB-09. The M-6 showing is exposed along a minor tributary upstream of site SB-08. A zone of altered bedrock was noted above site SB-07. The trace of the shear zone in Salmonberry Creek would lie near SB-10.

LOCAL ENVIRONMENT: Salmonberry Mountain, part of the MacKenzie Range, lies on the border between the Vancouver Island Ranges and the Estavan Coastal Plain within the Insular Mountains physiographic terrain. The immediate area is mountainous with a local relief of 670 metres. A veneer (< 1 meter) of till and colluvium mantles most of Salmonberry Mountain. Thick marine sediments cover the flat plain immediately west of the mountain. Direction of ice flow during the last phase of glaciation was from northeast to southwest. The present climate is mild and very wet with annual precipitation of 4 000 millimetres. Dominant soil type is a ferro-humic podzol.

STREAM CHARACTERISTICS: Salmonberry Creek seen in profile (*Figure A15-2*) has a moderately steep (12 degrees), high-energy upper course which drops 300 metres vertically over a 2 kilometre horizontal distance, followed by a gentle low-energy section which drops 50 metres vertically over the final 3.5 kilometres. The division between these regimes is marked by an alluvial fan. Banks in the upper course consist of coarse alluvium, till and exposed bedrock. Coarse gravels and boulders line the creek bed. The channel pattern is primarily shoots-and-pools. The decrease in gradient below the alluvial fan is reflected in a meandering channel pattern with channel bed and banks composed of fine-grained alluvium. Organic content of the sediment is higher along the lower course.

SAMPLE PATTERN: Nine sites (*Figure A15-1*) were sampled for conventional fine-grained stream and moss-mat sediment. Bulk fine-grained sediment samples were collected from every second site. A sieved bulk sample of coarse grained sediment from a high-energy site, in addition to site duplicate samples of moss-mat and conventional stream sediment, were obtained from SB-02. Upstream of SB-06 conventional fine-grained stream sediment varied from scarce to abundant, downstream of this site, fine-grained stream sediment was abundant and occasionally organic-rich. Moss-mat sediment was available at every site in moderate to abundant amounts.

RESULTS

Element Associations and Dispersion Curve Shapes

Three dispersion train patterns are evident in both moss-mat and conventional fine-grained stream sediment.

Dispersion trains for Al, Ba, Bi, Co, Cr, Cu, Fe, K, La, Mn, Ni, P, Th, Ti, V and Zn, describe concentrations which increase downstream in both media. Several elements display a distinctive jump in concentrations between sites SB-07 to SB-05. The second pattern (both media), defined by Ca, Mg and Sr, is characterized by decreasing concentrations with distance downstream subsequent to a sharp increase between sites SB-10 and SB-09. The final pattern (both media), depicted by Au, As, Pb and Sb, defines varying degrees of enhanced concentrations at sites SB-10 and SB-07 from which concentrations decay downstream.

Comparison to Background

Background and threshold values were calculated for the Catface Intrusions which hosts the mineral deposits. Elements which exceeded their thresholds at one or more sites in either or both sample media are As, Au, Bi, Ca, La, Pb, Sb and Th (*Table A-15*).

INTERPRETATION

The elements which describe the first dispersion pattern in both media types are a product of the underlying lithology, topography and the mineralized Switchback Shear Zone. Elevated concentrations of clay (*Al, Ba, La, Th in Figure A15-3a*), sericite (*K in Figure A15-3a*), limonite (*Figure A15-3b*), and sulphide (*Figure A15-3c*) associated elements are seen at SB-10 which lies near the trace of this zone. Immediately downstream these elements display patterns related to the changing lithology and the flattening stream gradient (general increase due to a greater abundance of very fine-grained sediment).

The distinctively lower values for Ca, Mg and Sr (*Figure A15-3d*) may be the result of these elements being mobilized from the highly acidic environment near the shear (upwards of 15 % sulphides).

The pattern defined by As, Au, Pb, Sb is believed to be anomalous based on the association of elements and their concentrations. The shear zone near SB-10 is the likely source. The alteration zone seen adjacent to SB-07 is a potential source for minor enrichments at this site. Local mapping places a splay of the shear zone in this area.

Concentrations of Au are consistently higher in the finest fraction of bulk samples, suggesting to the presence of fine gold. Erratic results in the coarser size fraction suggests that some medium to coarse gold is also present.

The higher concentrations of mineralization associated elements in moss-mat sediments is likely due to the mineralization being exposed in the creek and eroding mechanically.

The epithermal quartz shears in Salmonberry Creek are best defined by Au (*Figure A15-3e*), As (*Figure A15-3f*) and Sb (*Figure A15-3g*) which produce the longest anomalous dispersion trains. Other potential pathfinders include Bi, Pb (*Figure A15-3h*) and Zn may be locally anomalous. Moss-mat sediment is the optimal medium for Au, As, Pb, Sb and Zn. Bismuth is marginally higher in stream sediments.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Sb	Moss	0.4 - 1.2 ppm	0.3	0.7	2.8	3.7km
As	Moss	18.7 - 96.7 ppm	14	22	2.5	3.4 km
Au	Moss	4 - 400 ppb	4	15	23.4	2.9 km
Pb	Moss	7 - 24 ppm	5	10	2.8	1.2 km
Bi	Stream	0.2 - 0.8 ppm	0.1	0.5	4.7	1.1 km
Zn	Moss	37 - 73 ppm	60	80	0.9	?

Table A-15 Salmonberry Creek - Summary Table of Pathfinder Elements

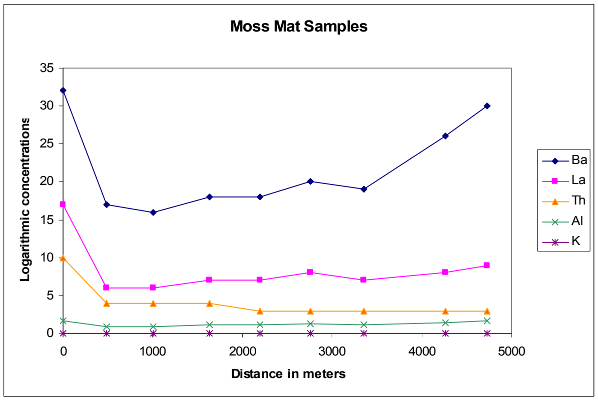


Figure A15-3a

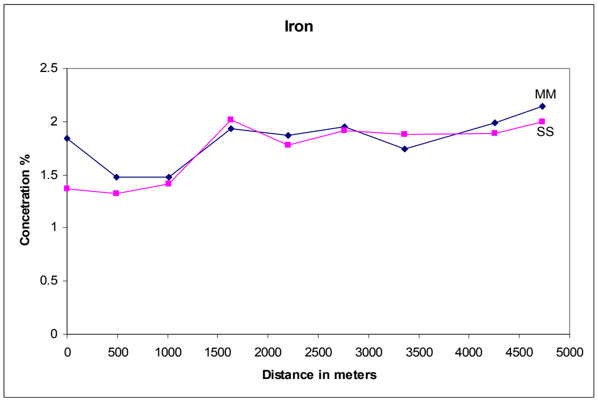


Figure A15-3a

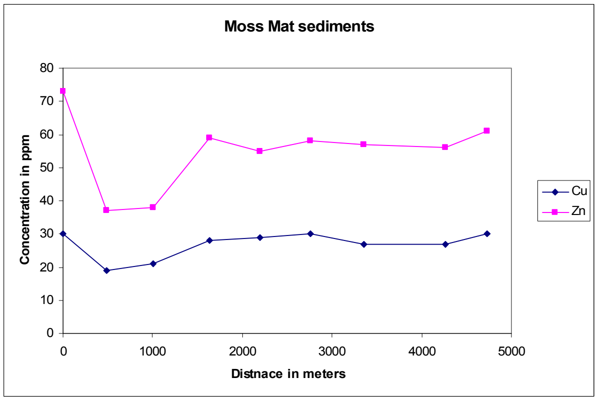


Figure A15-3a

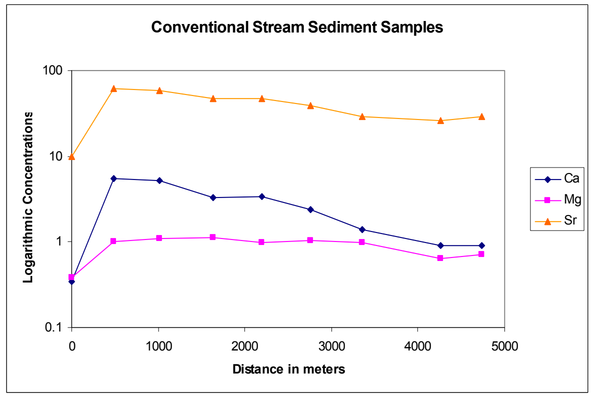


Figure A15-3a

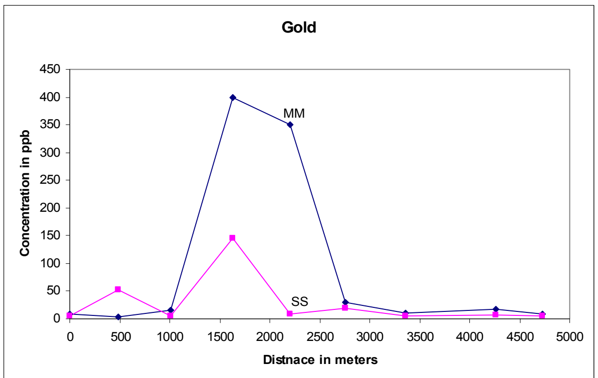


Figure A15-3a

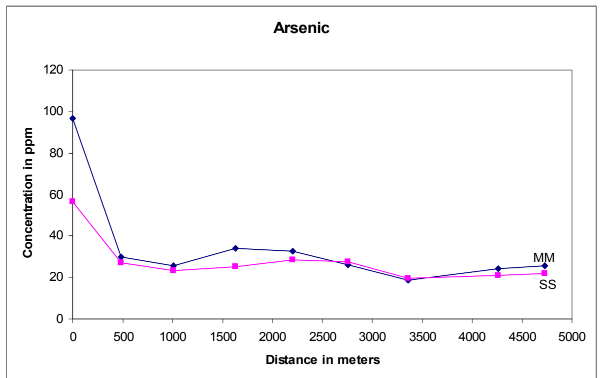
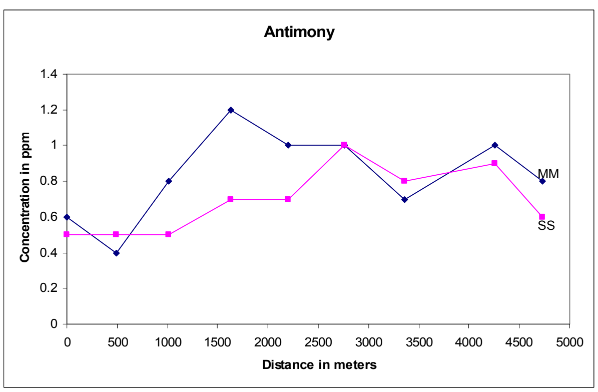


Figure A15-3a



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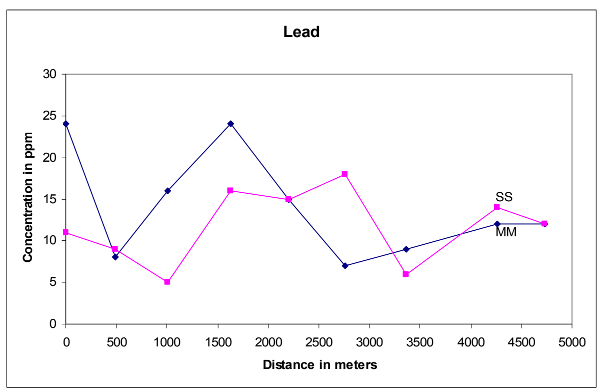

Figure A15-3a

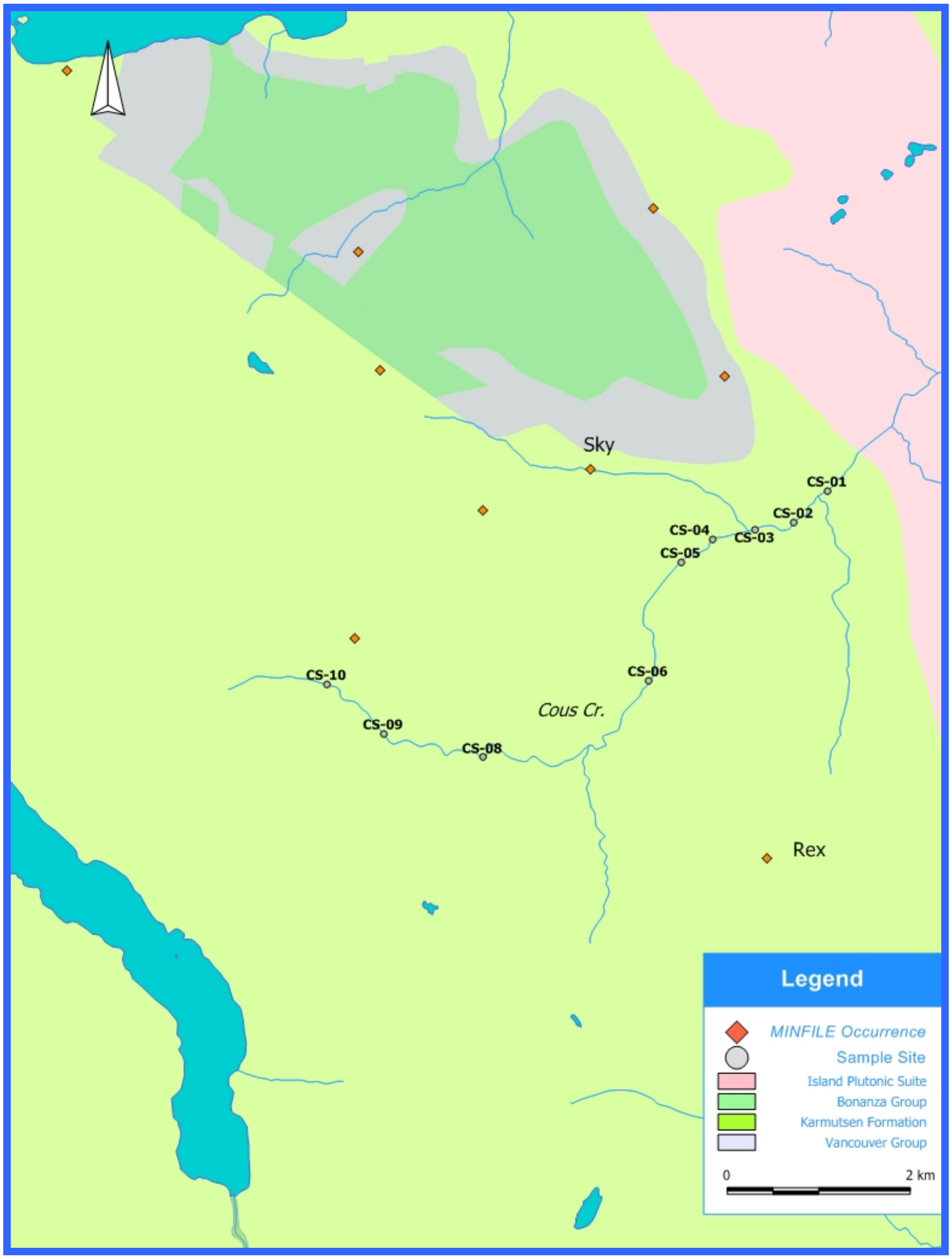

Figure A16-1 Cous Creek (CS -) sample sites

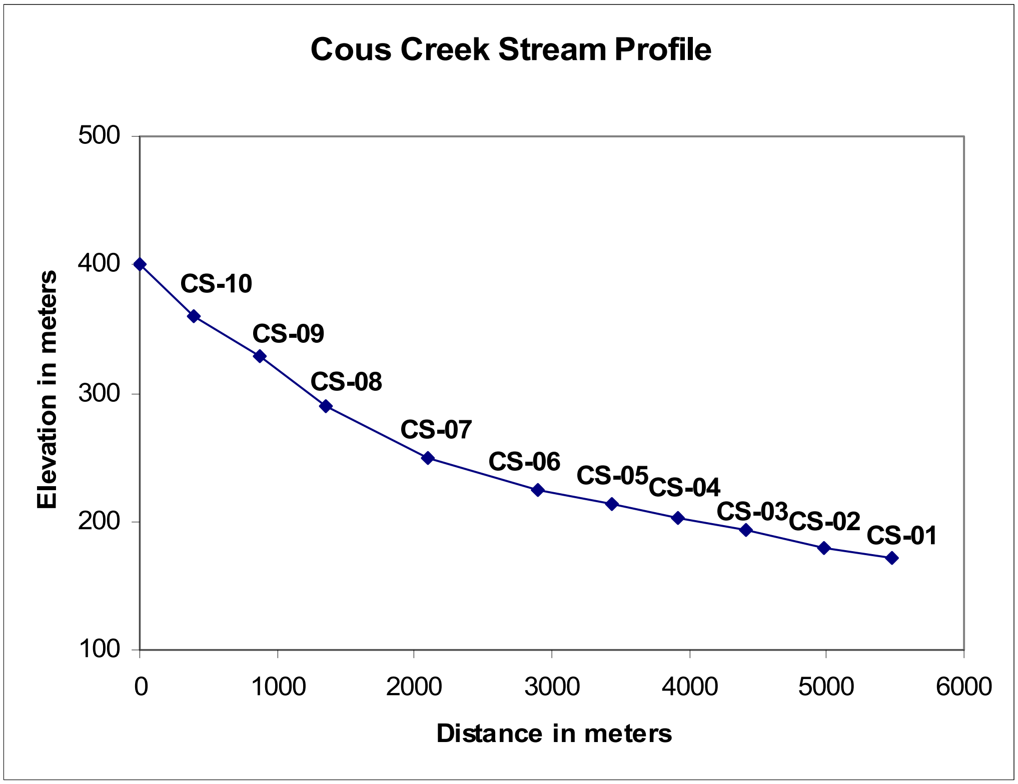

Figure A16-2 Cous Creek stream profile

COUS CREEK – STOCKWORK VEINS

DEPOSIT NAME: Rex *MINFILE #:* 092F 22

LOCATION: NTS – 92F02 LAT. - 49º09'27" LONG. - 124º54'35" UTM NORTH – 5446500 UTM EAST – 360750

STATUS: Showing ***COMMODITIES:*** Molybdenum, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Molybdenite, Chalcopyrite

LOCAL GEOLOGY: The Cous Creek drainage basin is entirely underlain by basaltic flows of the upper Triassic Karmutsen Formation (*Figure A16-1*). Swarms of quartz-feldspar porphyry dykes and several outcrops of hornblende diorite belonging to the Jurassic Island Intrusions occur locally.

MINERALIZATION AND ALTERATION: Early government reports initially used in this study placed the REX occurrence in the upper Cous Creek drainage basin, recent MINFILE updates correctly place the showing in the drainage basin immediately east of Cous Creek. In that basin, an area along the creek is composed of intensively pyritized and altered quartz-feldspar porphyry dykes and mafic volcanics. Molybdenite occurs as rosettes and bands within quartz stringers. Scattered showings of chalcopyrite have been located throughout the area and are considered minor. The Trout showing in the lower reaches of Cous Creek and immediately upstream of site CS-01, comprises minor pyrite and chalcopyrite in a quartz vein.

LOCAL ENVIRONMENT: Cous Creek lies in the Insular Mountain physiographic terrain. Local summits of the

Vancouver Island Ranges are well rounded and range from 1 000 to 1 200 metres above sea level. Topographic relief in the immediate area is 500 metres. The summits were likely overridden by the southwest flowing ice sheet during the Fraser glacial maximum. A continuous till and colluvium blanket covers the surrounding mountains. During the final stages of the Fraser glaciation ablating ice may have resumed a northeasterly flow following the creek basin. Surficial deposit exposures along Cous Creek indicate till and fluvial deposits in excess of 10 metres. The present climate is mild and moderately wet with annual precipitation of 1 500 to 2 500 millimetres. Soils are predominantly humo-ferric podzols.

STREAM CHARACTERISTICS: Cous Creek drops approximately 190 metres over the 5.0 kilometre sample traverse (*Figure A16-2*). The upper course (southern tributary) has a moderate gradient averaging 7 degrees prior to merging with the lower (western) tributary. Banks composed of bedrock, boulder lined beds and numerous waterfalls are noted in the upper section. Below the western tributary, the stream gradient decreases to less than 2 degrees. In this lower energy environment, banks are generally composed of alluvium with few outcrops. The channel pattern varies between braided and meandering sections.

SAMPLE PATTERN: Ten sites along Cous Creek and one background site on the western tributary were sampled for moss-mat and conventional fine-grained stream sediment (*Figure A16-1*). However, samples from site CS-07 were lost. Bulk fine-grained sediment samples were collected from every second site. A bulk sieved coarse-grained sample from a high-energy environment and a within-site duplicate sample of moss-mat sediment, was obtained from site CS-01. Availability of fine-grained sediment varied from scarce to vary scarce along the upper stream course. Well sorted fine-grained stream sediment, lacking the very fine-grained fraction, was found along the lower course. Moss-mat sediment was available at every site in moderate to abundant amounts.

RESULTS

Element Associations and Dispersion Curve Shapes

One basic pattern is displayed in both moss-mat and conventional stream sediment however various associations of elements display slight variants of the central pattern.

All of the elements display a jagged pattern in both media, with good correlation between concentration crests and troughs. The most pronounced feature in moss-mat sediment is a minimum concentration at site CS-05 seen in every element except As. In general, samples collected in the upper basin exhibit negligible variation in concentrations for all elements except Au and Cu. Concentrations of Al, Cu, Mn and Zn are notably higher in the upper basin compared to the lower basin. The reverse is seen for Ca and Sr. The remaining elements give comparable concentrations.

Gold in moss-mat sediment exhibits elevated levels in the southern tributary and along the lower section of Cous Creek. The maximum concentration was detected at the lowest sampling site (CS-01). Gold in stream sediment is generally low upstream of site CS-05, elevated levels are encountered downstream of this site.

Comparison to Background

Table A-16 gives background and threshold values for stream sediment derived from the Karmutsen Formation. The following elements exceed their thresholds in either or both media at one or more sites; Au, Al, Ca, Cr, Cu, Fe, Mg, P, Pb, Sb, Ti and V.

INTERPRETATION

All elements except Cu and Au are believed to reflect background variation introduced by sampling and site dynamics. The exceptionally low concentrations at site CS-05 in moss-mat sediment is likely to product of well sorted sands containing very little fine-grained material trapped in the mat. Concentrations for most elements are limited, some elements (e.g. As, Co, Sr) fall within the background ranges for Karrnutsen volcanics, others (Al, Cr, Fe, Mg, P, Ti and V) which are uniformly high, might reflect a slightly more mafic phase (*Figure A16-3a*).

Elevated Au and Cu concentrations in the southern tributary could be indicative of a minor copper showing although evidence of mineralization was not noted during the sample traverse.

Anomalous Au (*Figure A16-3b*) and elevated Cu (*Figure A16-3c*), Pb (*Figure A16-3d*), Sb (*Figure A16-3e*) and Zn in moss-mat sediment at site CS-01 might be attributed to nearby Trout Showing.

The existence of a mineralized occurrence in the Cous Creek drainage basin other than the Trout showing is uncertain, local elevated levels of Cu, Au and possibly Ag in moss-mat sediment in the upper basin suggests some potential.

Anomalous Element	**Optimum Media**	**Range**	**Background**	**Threshold**	**Average Contrast**	**Anomaly Length**
Au	Moss	7 - 307 ppb	6	25	12.5	?
Cu	Moss	81 - 179 ppm	115	178	1.1	?
Pb	Moss	4 - 17 ppm	2	11	5.1	?
Sb	Moss	0.6 - 1.2 ppm	0.3	1	3.1	?
Zn	Moss	59 - 89 ppm	76	107	1	?

Table A-16 Cous Creek - Summary Table of Pathfinder Elements

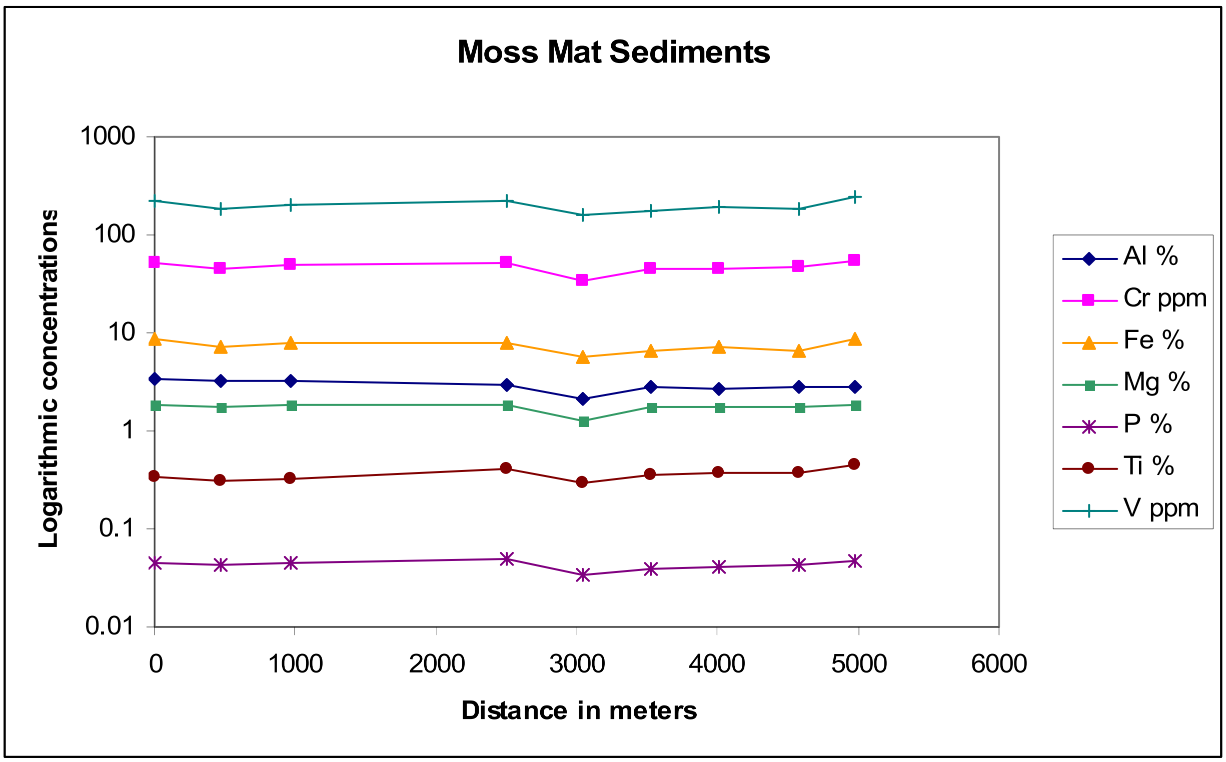

Figure A16-3a

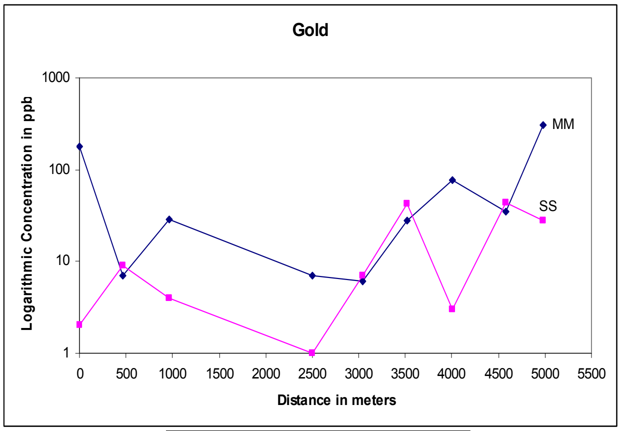

Figure A16-3b

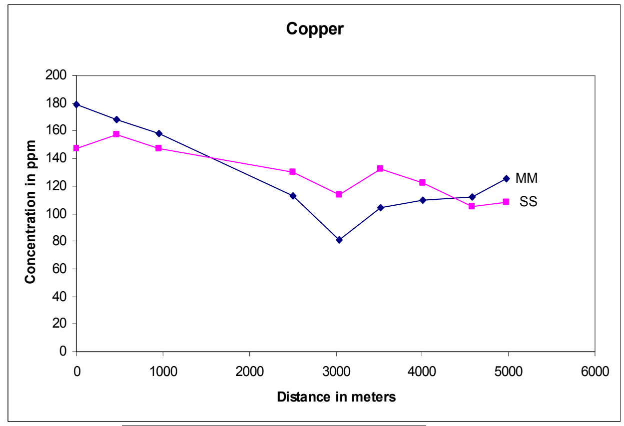

Figure A16-3c

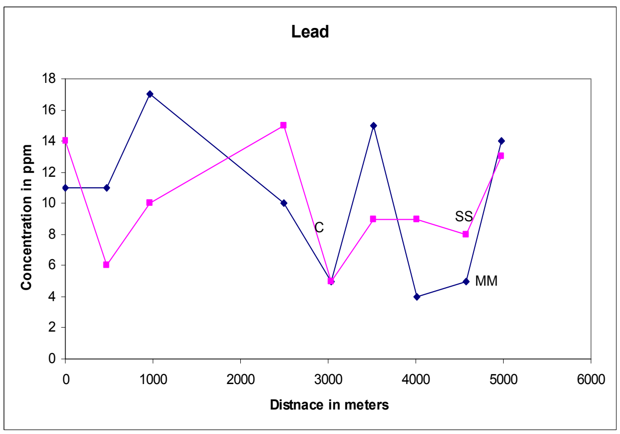

Figure A16-3d

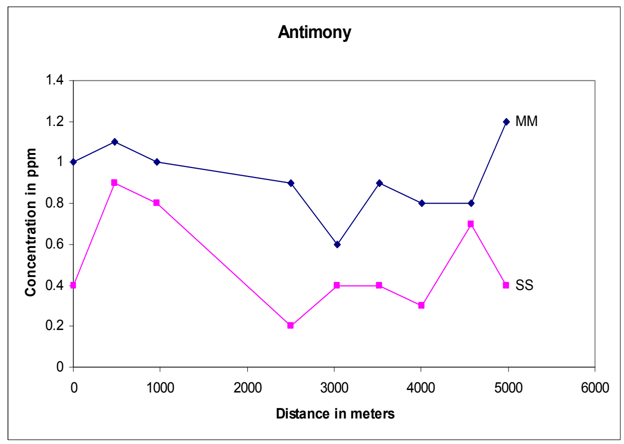

Figure A16-3e

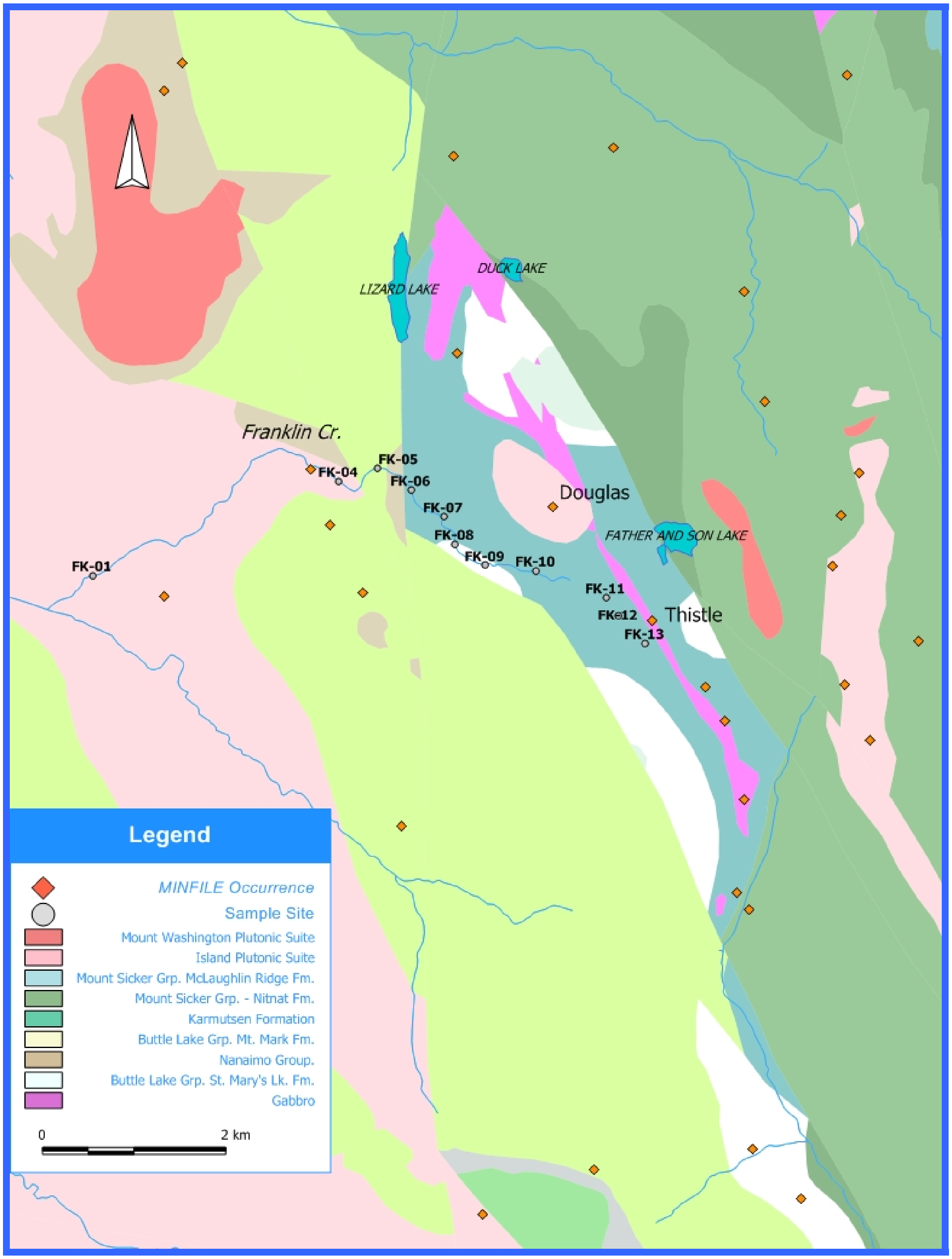

Figure A17-1 Franklin Creek (FK-) sample sites

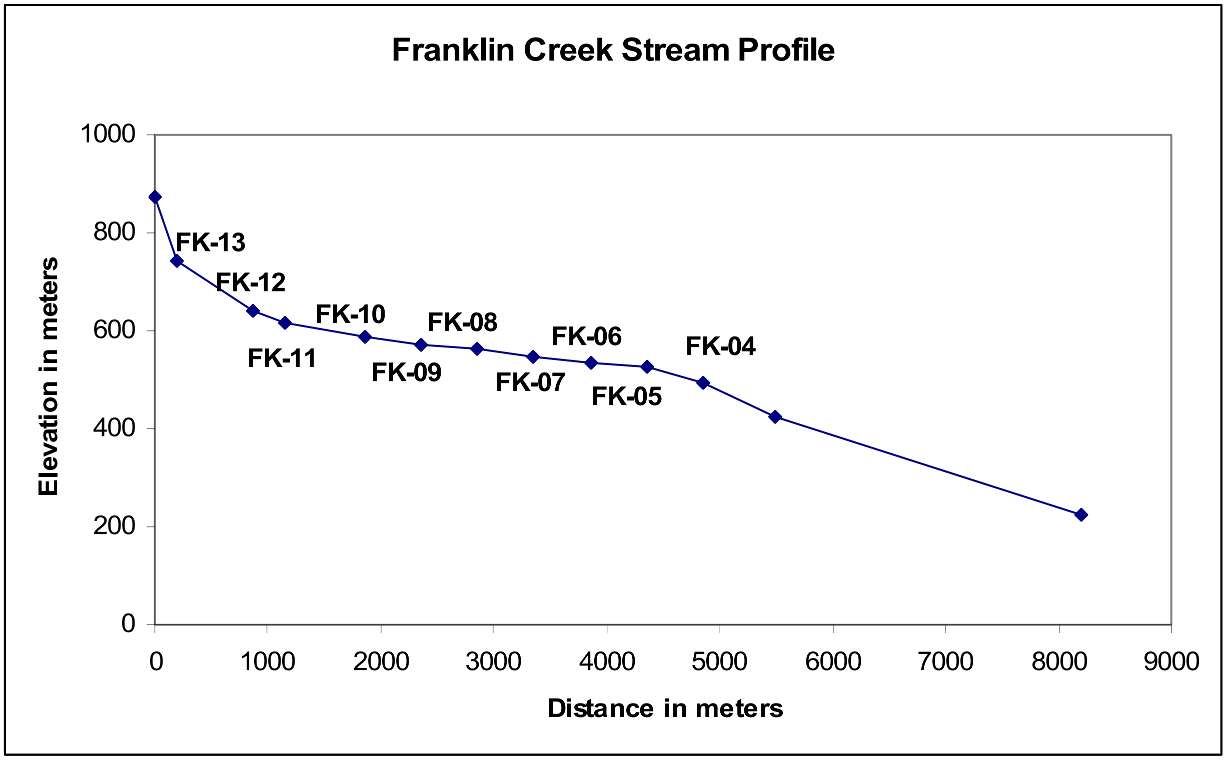

Figure A17-2 Franklin Creek stream profile

FRANKLIN CREEK – SHEAR ZONE HYDROTHERMAL VEINS

DEPOSIT #1 NAME: Thistle

*MINFILE #:*092F 083

LOCATION: NTS – 92F02 LAT. - 49º06'24" LONG. - 124º38'08" UTM NORTH – 5440382 UTM EAST – 380625

STATUS: Past Producer ***COMMODITIES:*** Gold, Silver, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Chalcopyrite, Magnetite, Pyrrhotite

DEPOSIT #2 NAME: Museum

MINFILE #: 092F 386

LOCATION: NTS – 92F02 LAT. - 49º06'36" LONG. - 124º40'43" UTM NORTH – 5440825 UTM EAST – 377500

STATUS: Showing ***COMMODITIES:*** Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Pyrrhotite, Chalcopyrite

DEPOSIT #3 NAME: Douglas

MINFILE #: 092F 443

LOCATION: NTS – 92F02 LAT. - 49º07'05" LONG. - 124º39'00" UTM NORTH – 5441570 UTM EAST – 379598

STATUS: Showing *COMMODITIES:* Gold, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Pyrrhotite, Chalcopyrite

DEPOSIT #4 NAME: Upper Franklin *MINFILE #:* 092F 456

LOCATION: NTS – 92F02 LAT. 49º07'00" LONG. - 124º41'00" UTM NORTH – 5441570 UTM EAST – 377163

STATUS: Showing *COMMODITIES:* Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite

DEPOSIT #5 NAME: Pat 1 *MINFILE #:* 092F 457

LOCATION: NTS – 92F02 LAT. - 49º07'20" LONG. - 124º41'10" UTM NORTH – 5442192 UTM EAST – 376974

STATUS: Showing *COMMODITIES:* Copper, Silver, Gold

SIGNIFICANT AND ASSOCIATED MINERALS: Chalcopyrite

LOCAL GEOLOGY: A layered succession of volcanics (McLaughlin Ridge) and carbonate sediments (Mount Mark Formation) of the Paleozoic Sicker Group and basaltic flows and pillows of the Upper Triassic Vancouver Group (Karmutsen Formation) underlay the upper basin of the Franklin River (*Figure A17-1*). Granodiorite to quartz diorite of the Jurassic Island Intrusions underlies the lower Franklin River drainage basin. Several large northwest trending reverse faults, including the southern extension of the Mineral Creek Fault, cross the survey area.

MINERALIZATION AND ALTERATION: Several mineral occurrences lie in the upper Franklin River catchment area. Prominent amongst these, is the abandoned Thistle Mine in the headwaters of Franklin River. Disseminated to massive sulphide mineralization in quartz-carbonate veins occurs in sheared pyritic quartz-sericite schist and chloritized mafic volcanic flows and tuffs. Mineralization has been variously interpreted as volcanogenic, mesothermal and skarn related. Several other Cu-Au mineral prospects are known within the catchment area. They are invariably hosted by Karmutsen rocks and interpreted as hydrothermal veins.

LOCAL ENVIRONMENT: Franklin Creek lies in the Insular Mountain physiographic terrain. Local summits of the Vancouver Island Ranges are jagged and range from 1 200 to 1 500 metres above sea level. Topographic relief in the immediate area is 1 100 metres. Thin till and bedrock derived colluvium mantle most upper slopes, bedrock is exposed on cirque walls in the headwaters of the river. Lower slopes and valley floors are covered by a progressively thickening sequence of till and fluvial sediments. Direction of ice movement during the final stage of glaciation was likely from east to west down the Franklin River. The present climate is mild and moderately wet with annual precipitation of between 1 500 to 2 500 millimetres. Soils are predominantly humo-ferric podzols.

STREAM CHARACTERISTICS: The sampled section of Franklin River drops 510 metres over an 8 kilometre course (*Figure A17-2*). The upper course, above site FK-10, is moderately steep with an average gradient of 8.5 degrees. This section is marked by bedrock banks, numerous logjams and a shoots-and-pools channel pattern with few gravel bars. Between FK-10 and FK-04, the stream gradient flattens to 3 degrees. The channel pattern varies from shoots-and-pools to braided, banks are composed of alluvium. Several tributaries form the headwaters of Franklin River, the northeastern tributary flows from Father and Son Lake.

SAMPLE PATTERN: Eleven sites along Franklin River and 2 tributary sites were sampled for moss-mat sediment (*Figure A17-1*). Conventional fine-grained stream sediment was obtained from 9 sites on the river and 1 tributary site. Bulk fine-grained sediment samples were collected from every second site. Sieved coarse and fine-grained sediment samples, in addition a duplicate sample of moss-mat sediment, were obtained from site FK-01. Abundant quantities of moss mat were available at every site. Stream sediment at most sites was coarse to very coarse. The lack of fine-grained sediment prevented the collection of this medium at three sites.

RESULTS

Element Associations and Dispersion Curve Shapes

Visual comparison of element dispersion trains defines five basic patterns in moss-mat sediment and three patterns in conventional fine-grained stream sediment.

Generally increasing concentrations with distance downstream characterizes Co, Cr, Fe, Mg, Ni, Ti and V in moss-mat sediments. Several elements display two concentration tiers with the lower tier between FK-13 to FK-9 and the upper tier between FK-09 to FK-01. Concentration crests and troughs correlate well between elements with minimum concentrations at FK-13, FK-09 and FK-05, and maximums at FK-12, FK-08 and FK-06. Dispersion trains depicted by Al, Ba, Ca, Mn, P, Se, Sr and Zn define a trend of decreasing concentrations with distance. Maximum concentrations are seen at FK -13, FK -10 or FK-09 and FK-07 or FK-06. Minimums for these elements are seen at FK-12 to FK-11 and FK-08. The pattern displayed by Al exhibits some resemblance to this group but with a flat trend. Good correlation is noted between As, Au and Pb with pronounced enrichments at FK-09. A unique dispersion pattern is displayed by Cu which decreases exponentially between FK-13 to FK-08, increases between FK-07 and FK-06 then decays again from FK-06 to FK-01.
Concentrations of Co, Cr, Cu, Fe, Ni, Ti and V increase with distance downstream in conventional fine-grained stream sediment. As in moss-mat sediment, there are lower and upper concentration tiers which are separated by site FK-09. Coincident concentration crests (sites FK-10, FK-08, FK-06) and troughs (sites FK-09, FK-07) are displayed by Al, As, Ba, Ca, Mn, Se, and Zn although the general trends vary from slightly increasing (Al, Ca), to slightly decreasing (Ba, Se), to essentially flat (As, Mn, Zn). The inverse of this pattern is displayed by Mg, Pb and Sr which have enhanced concentrations at FK-12, FK-09 and FK-07 with minimum concentrations at FK-10 and FK-08. The dispersion pattern of Au in stream sediment is unique with enrichment seen at FK-11 and FK-08 to FK-07.

Comparison to Background

Table A-17 gives background and threshold values for sediments derived from the Karmutsen Formation and the Sicker Group. Average contrast values for moss-mat and stream sediment were calculated on a theoretical homogeneously mixed sediment derived equally from the above rocks. Background and threshold levels given in the dispersion charts are based on this mixed sediment, elements which exceed their thresholds at one or more sites are: Al, As, Au, Ba, Ca, Cr, Mn, P, Pb, Sb, Se, Sr and Ti.

INTERPRETATION

The combination of contrasting lithologies on opposing sides of the basin, several mineral deposits and variable degrees of sediment sorting at various sites produces highly complicated dispersion patterns. Most of the inflections seen in the patterns for lithophile and siderophile elements can be interpreted as due to the influence of nearby tributaries injecting sediment derived entirely from either of the dominant rock types. These patterns appear to be best developed in moss-mat sediment which reflects predominantly mechanical dispersion. For example, Ba (*Figure A17-3a*) displays a dispersion pattern in moss-mat sediment in which highs coincide with tributaries draining the carbonate-rich formations of the Sicker Group while lows correlate with tributaries draining Karmutsen rocks or the volcanic formations of the Sicker Group. Element associations and concentrations at sites above FK-09 indicate sediment derived principally from Sicker Group rocks, between FK-09 and FK-05 considerably greater concentrations of Karmutsen derived sediment is present. Below FK-05 and increasing proportion of the sediment will be derived from the Island Intrusions.

The pattern displayed by Au (*Figure A17-3b*) and potentially that of Cu (*Figure A17-3c*) and Pb (*Figure A17-3e*) can be related to mineralization. Although Cu concentrations are well below the regionally calculated threshold, the dispersion pattern suggests exponential dilution from the Thistle and Museum deposits. The broader anomaly and higher concentrations of Cu and Pb in stream sediment associated with the Museum deposit, suggests hydromorphic transport from this source.

The source(s) of Au is less well defined in moss-mat and conventional fine-grained stream sediment due to noise from variable site energy, effectiveness of heavy mineral trapping (moss mats) and possible nugget effects. As indicated by Fletcher (1990), the finest size fraction from bulk fine-grained stream sediment decreases geochemical noise, the resulting pattern (*Figure A17-3d*) clearly portrays the dispersion of fine Au from the Thistle and Museum deposits. Predominantly fine grained-gold is indicated by the consistently higher concentrations in the finest size fraction. Lower concentrations but a similar dispersion pattern in the coarse (relative to the fine fraction) may be due to dry sieving ineffectively removing fine gold from the coarse fraction or uniform distribution of fine gold in an encapsulating mineral. Anomalous concentrations of Au, Ag, Pb and Sb in moss-mat sediment at site FK-01 are either due to effective trapping of mineralized particles from the known deposits or may represent a closer, unknown source. The various size fractions for the bulk sample from this site contain only background levels of all four elements. The 3.0 kilometre sampling gap between FK-04 and FK-01 precludes further interpretation.

Individual peaks from other elements may correlate with the various deposits, however no clear trends are defined. Anomalous As (*Figure A17-3f*), Pb and Se (*Figure A17-3g*) in both media and Au in moss-mat sediment at site FK-09 may reflect the Douglas deposit at the head of the small tributary above this site.

The mineral deposits in the Franklin River drainage basin are best defined by Au which gives the highest contrast and longest dispersion train. The characteristic dilution pattern for Cu in moss-mats from FK-13 to FK-08 suggests it is anomalous with respect to the unique background levels of this basin. On a regional scale however, the concentrations are well below threshold. Other potential pathfinders produce single site anomalies at best.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	36 - 450 ppb	6	25	20.9	8.0 km
Cu	Stream	92 - 136 ppm	94	163	1.2	?

Table A-17 Frankin Creek - Summary Table of Pathfinder Elements

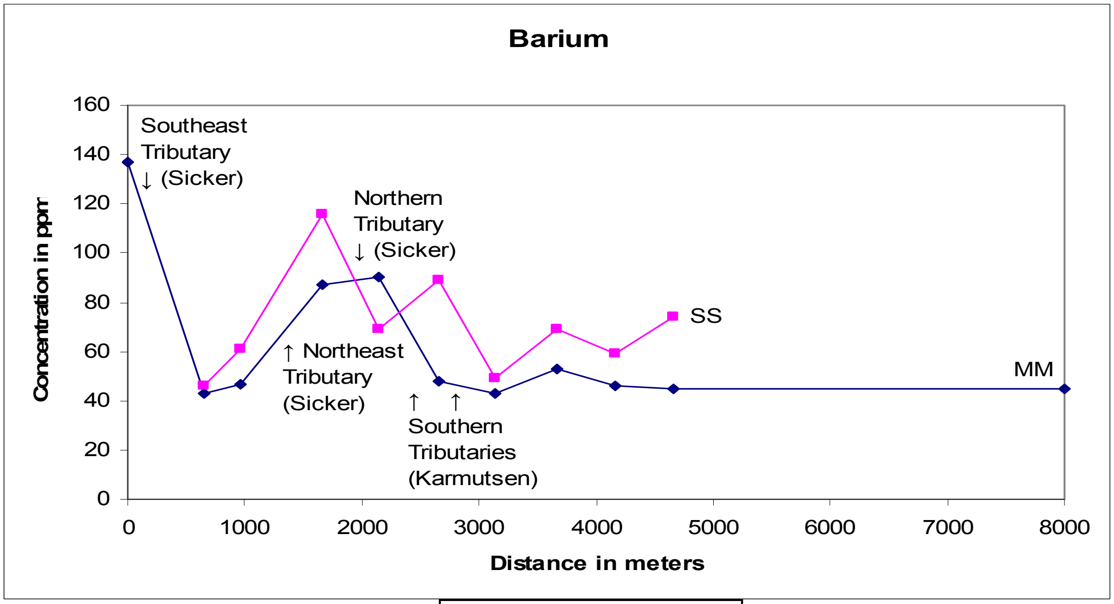

Figure A17-3a

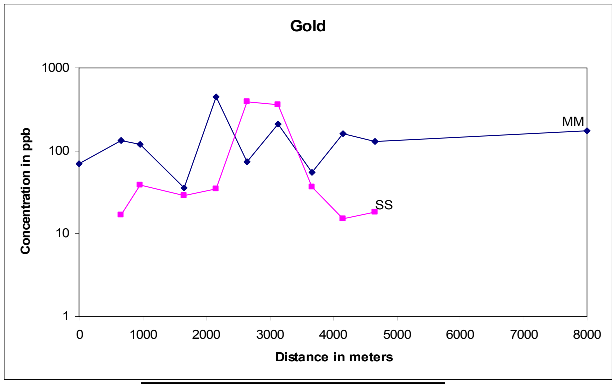

Figure A17-3b

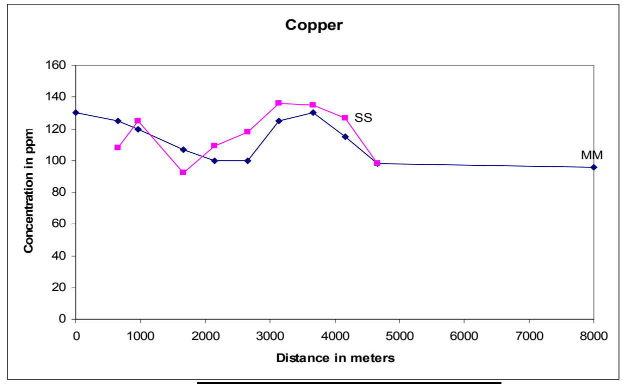

Figure A17-3c

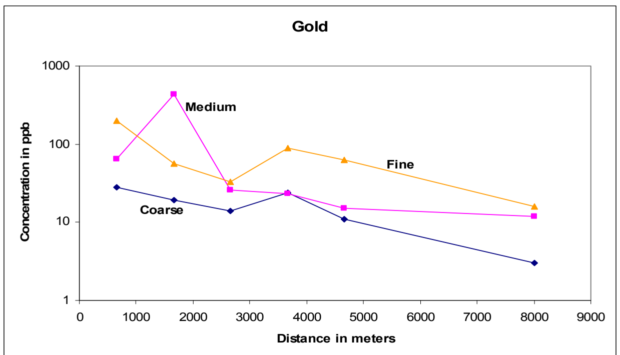

Figure A17-3d

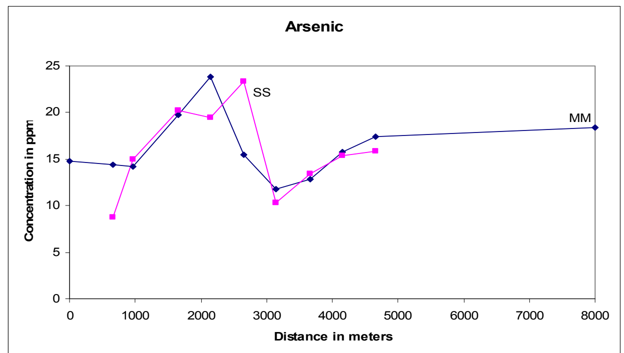

Figure A17-3e

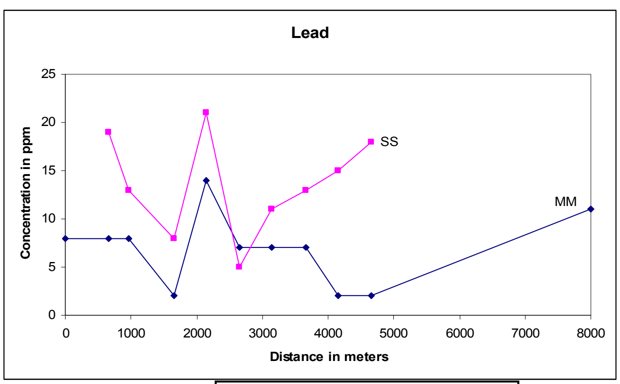

Figure A17-3f

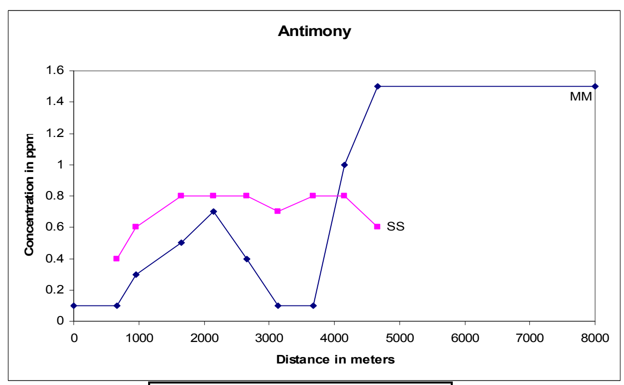

Figure A17-3g

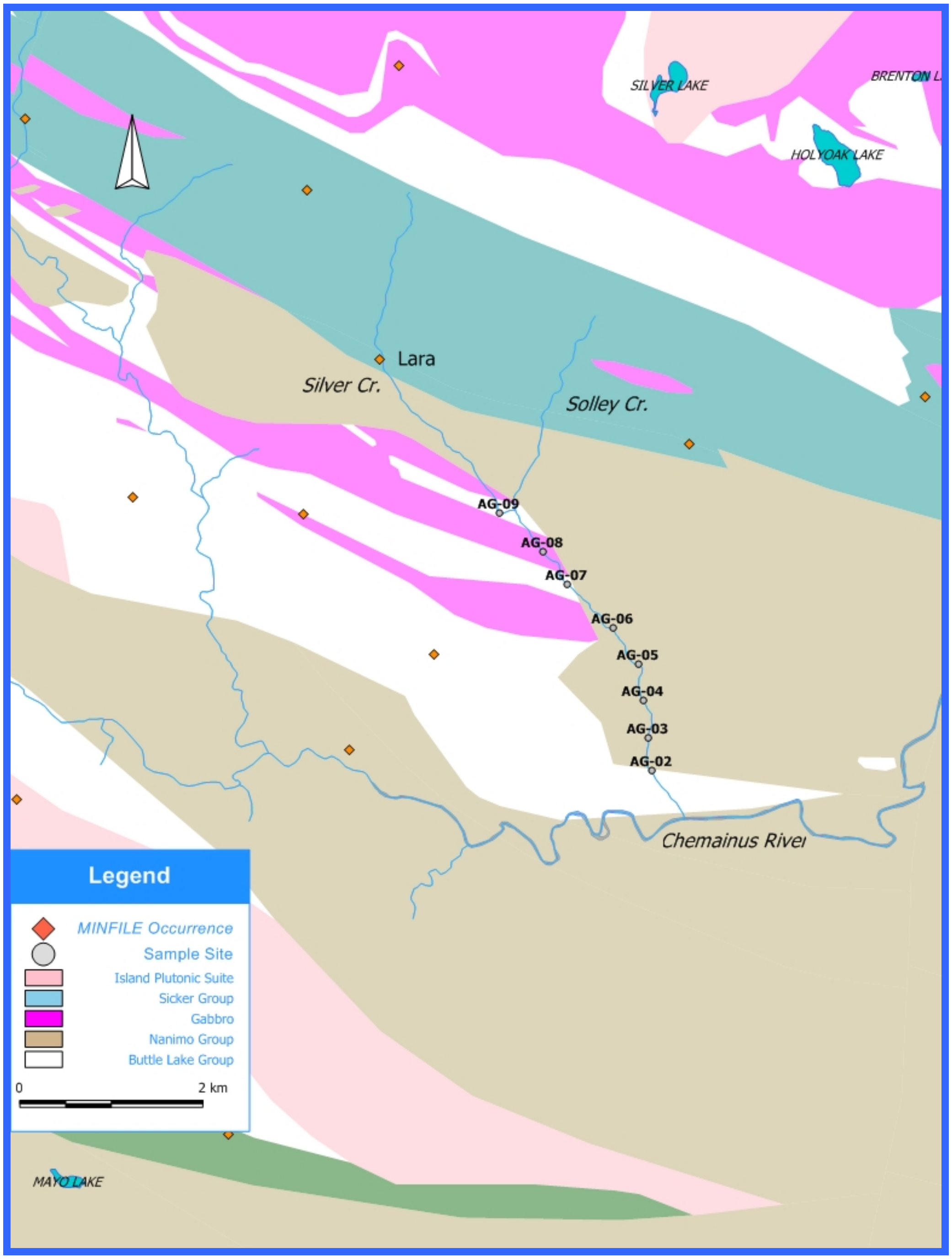

Figure A18-1 Silver-Solley Creeks (AG-) sample sites

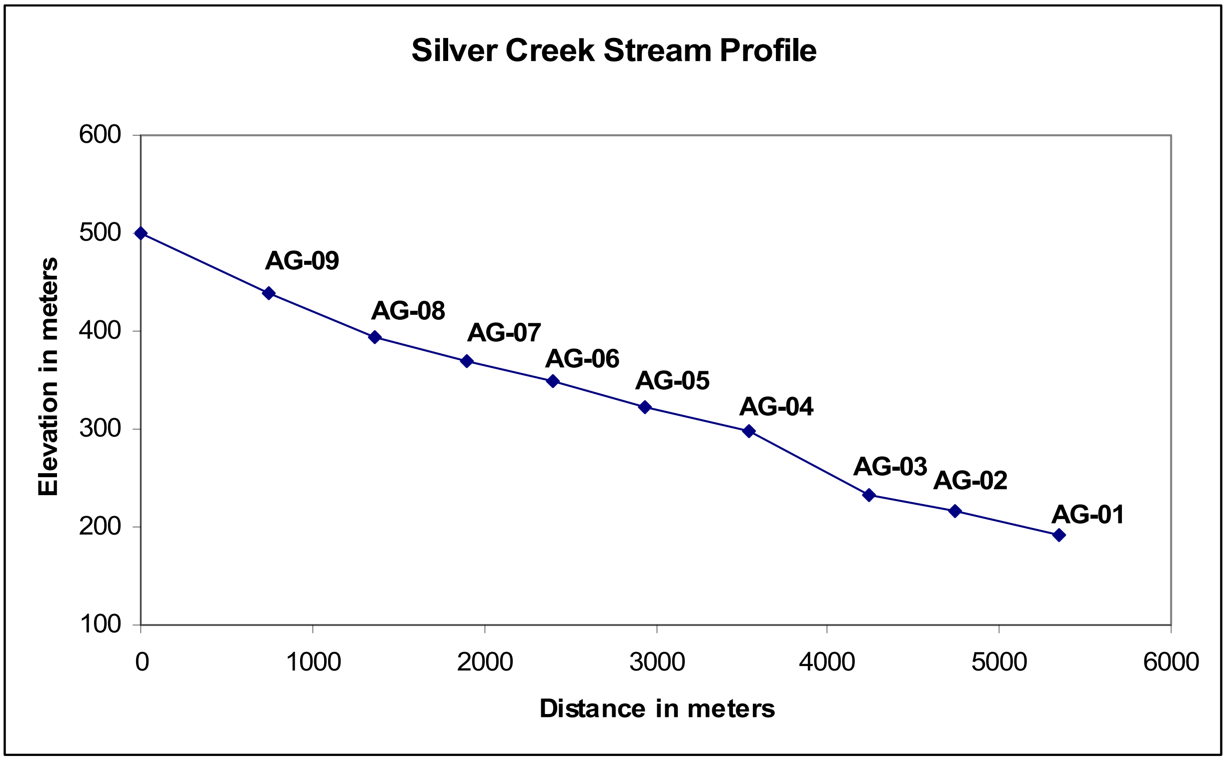

Figure A18-2 Silver Creek stream profile

SILVER CREEK – VOLCANOGENIC MASSIVE SULPHIDE

DEPOSIT #1 NAME: Hope *MINFILE #:* 092B 110

LOCATION: NTS – 92B13 LAT. - 48º52'25" UTM NORTH – 5413550
LONG. - 123º54'13" UTM EAST – 437100

STATUS: Showing ***COMMODITIES:*** Gold, Silver, Zinc, Copper, Lead

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Sphalerite, Pyrrhotite, Chalcopyrite

DEPOSIT #2 NAME: Lara *MINFILE #:* 092B 129

LOCATION: NTS – 92B13 LAT. - 48º52'58" UTM NORTH – 5414600
LONG. - 123º54'13" UTM EAST – 433750

STATUS: Developed Prospect ***COMMODITIES:*** Gold. Silver, Zinc, Lead, Copper

SIGNIFICANT AND ASSOCIATED MINERALS: Pyrite, Sphalerite, Galena, Chalcopyrite, Tetrahedrite, Tennantite, Rutile, Bornite, Electrum, Pearceite, Arsenopyrite, Barite

LOCAL GEOLOGY: The Silver Creek drainage basin (*Figure A18-1*) is underlain by a northwest trending sequence comprising (from oldest to youngest): intermediate volcanic flows and tuffs of the Sicker Group McLaughlin Ridge Formation (upper Devonian), clastic and carbonate sediments of the Buttle Lake Group Fourth Lake Formation (Pennsylvanian), gabbro sills and dykes interpreted as the intrusive equivalent of the Triassic Karmutsen Formation and clastic sediments of the lower Cretaceous Nanaimo Group. Several deep seated west-northwest trending high angle reverse faults cut the units and have thrusted older rocks over younger rocks. Geology and mineralization of the Cowichan Lake Uplift which contains the study area has been mapped and described by Massey *et al.* (1987)

MINERALIZATION AND ALTERATION: The Lara deposits, comprising three polymetallic bodies known as the Coronation Zone, the Coronation Extension Zone and the Hanging Wall Zone, are Kuroko type volcanogenic massive sulphides. The deposits form massive, laminated and stringer sulphide zones hosted by a 75 metre thick sequence of strongly silicified rhyolite, ash tuff and argillaceous interbeds (Rhyolite Sequence). The Coronation and Coronation Extension Zones lie along the same stratigraphic horizon immediately adjacent to the Fulford fault. Solly Creek, the western tributary of Silver Creek, intersects the horizon between these zones. Sphalerite, chalcopyrite, galena, pyrite and trace amounts of rutile, bornite, electrum, pearceite, arsenopyrite and barite are found in a gangue consisting mainly of quartz, calcite, muscovite and barium-rich feldspar. Probable reserves are 529 000 tonnes grading 4.7 grams per tonne gold, 100.1 grams per tonne silver, 5.9 percent zinc, 1.2 percent lead and 1.0 percent copper. Deposit thickness is variable but averages 6 metres.

LOCAL ENVIRONMENT: Silver Creek lies in the Insular Mountains physiographic terrain. Local summits of the Vancouver Island Ranges are moderately well rounded and range from 1 100 to 1 300 metres above sea level. Topographic relief in the immediate area is 1 100 metres. A continuous 1 to 2 metre thick till blanket covers the Lara deposits and mantles most slopes. The adjacent Chemainus river valley contains thick (> 10 metres) fluvioglacial deposits. During the Fraser maximum, overriding ice flowed from east to west. During ablation ice may have resumed a mountain glaciation flow pattern. The study area lies near the margin of the east coast dry zone. Annual precipitation ranges from 1 000 to 1 500 millimetres which is received mainly during the mild winter months. Soils would consist of dystric brunisols or poorly developed humo-ferric podzols.

STREAM CHARACTERISTICS: Silver/Solly Creek undergoes a 246 metre vertical drop along the 4.6 km sampled course (*Figure A18-2*). In profile, the creek is seen to have a moderately low gradient averaging 4.8 degrees. The creek flows within a deeply incised channel, the upper reaches are noted for abundant bedrock exposure and waterfalls. The middle and lower sections have banks composed of till and alluvium, bank collapse was noted at several sites. The channel bed consists mainly of large boulders and gravel. A shoots-and-pools channel pattern dominated throughout.

SAMPLE PATTERN: Silver Creek was sampled from the Solly Creek tributary to the Chemainus River junction (*Figure A18-1*). Nine sites were selected along Silver Creek and one site on Solly. AG-09, on Solly Creek, lies 2.5 kilometres downstream of the Lara deposits. AG-12, on upper Silver Creek, lies 1.3 kilometres downstream of the deposit bearing horizon. Moss-mat and conventional fine-grained stream sediments were collected at each site, bulk fine-grained stream sediment was obtained at every second site. Site duplicates of moss-mat and conventional stream sediment and a sieved coarse-grained sample from a high-energy environment were collected at site AG-01. Abundant moss-mats and coarse stream sediment were present throughout the traverse.

RESULTS

Element Associations and Dispersion Curve Shapes

Three dispersion trains have been defined in both moss-mat and conventional fine-grained stream sediment.

Similar dispersion features are defined by Au, Co, Cr, Fe, Ni, Pb, Ti and V in moss-mat sediment with enhanced concentrations at AG-09 or AG-08 and AG-04, separated by low concentrations at AG-06 and AG-02. The pattern displayed by Ca is a variant of the above, concentrations decay from enhanced levels at sites AG-08 and AG-03. The general concentration trend varies from decreasing with distance downstream (Au, Ca, Co, Cr, Ni, Ti), to flat (Fe, V), to increasing (Pb). The common pattern displayed by Al, Ba, Mg, Mn and Zn defines decreasing concentrations with distance downstream from maximums at AG-07. A region of low concentrations is seen between AG-06 and AG-03. Elevated Cu is also seen at AG-07, however downstream of this point the dispersion pattern matches that of the Fe group. The third dispersion pattern, shared by As, Bi and Sb, displays a prominent enrichment at AG-06. The general concentration trend of these elements is flat. Elements whose dispersion patterns do not fit the above patterns and have restricted concentration ranges include Ag, B, P, Se and Sr.

In conventional fine-grained stream sediment, Au, Cr, Fe, Ti and V exhibit coincident concentration crests and troughs, the most prominent feature is a concentration low at AG-04. The general concentration trend varies from decreasing with distance downstream (Au, Cr), to flat (Ti), to increasing downstream (Fe, V). The second dispersion pattern, defined by Al, Ba, Co, Cu, Mg, Mn, Ni, Pb and Zn, exhibits strong enhancement at AG-08 followed by a concentration low between AG-07 and AG-06. A second, lesser enrichment is seen at AG-02. A similar pattern is defined by Ca however its' maximum concentration occurs at AG-07. Decreasing concentrations are displayed by As, Bi and Sb in conventional fine-grained stream sediment. Maximum concentrations for As and Bi are seen at AG-09 while Sb has a peak concentration at AG-08.

Concentrations are consistently higher in moss-mat sediments relative to conventional stream sediments for all elements except As, Ba and Mn.

Comparison to Background

Table A-18 gives background and threshold values for stream sediment derived from Nanaimo and Sicker Group rocks. Average contrast values for moss-mat and stream sediment were calculated on a theoretical, homogeneously mixed sediment derived equally from these rocks. Background and threshold levels given in the dispersion charts are based on this mixed sediment, elements which exceed their thresholds at one or more sites are: Au, Ba, Bi, Fe, Pb, Se, and V.

INTERPRETATION

Dispersion trains for all elements (excluding Au, Ba and Pb) in the first (*Figure A18-3a*) and second (*Figure A18-3b*) groups of both media are interpreted as background patterns based on element associations, lack of definitive anomalous dispersion train shapes and generally background concentration ranges. Elements of the first group are commonly associated with heavy detrital minerals while elements of the second group are constituent to silicates. Site dynamics (energy level) and sample attributes (proportion of very fine-grained sediment) are the likely source of variation for these elements. Within-site variability exhibited by field duplicates (AG-01) may account for up to 50% of the total variability for some elements.

Elements such as Co, Ni and Pb display media dependence in their association. In moss-mat sediment, they correlate with potential heavy mineral forming elements, while in conventional fine-grained stream sediment they occur with silicate forming elements. A fraction of element speciation may be as heavy minerals (or trace constituents thereof), source of which may be the deposits. Their concentrations are low, therefore site and sample induced variation could easily mask any anomalous dispersion trends.

The anomalous concentrations of Au (*Figure A18-3c*) and Ba (*Figure A18-3d*) are potentially mineralization related. Resemblance of their dispersion trains to other background elements is due to modestly enhanced concentrations, selective moss mat trapping of heavy minerals (Au) and the presence of Ba in feldspars which are hydraulically indistinguishable from other light minerals.

Concentrations of As (*Figure A18-3e*), Bi and Sb in stream sediment are well below their regionally calculated thresholds, their dispersion patterns apparently define anomaly dilution trends. Hydromorphic enrichment of As may be indicated by the higher concentrations in conventional stream sediment (relative to moss-mat sediment) and successively higher concentrations in the finer fractions of bulk fine-grained sediment samples. Excluding Au, Sb and Bi, all other elements exhibit similar lower concentrations in the fine fraction.

Consistently higher Au concentrations in the finest size fraction of bulk samples (*Table A-18*) indicates predominantly fine grains with some medium grains present as suggested by poor within-site reproducibility in moss-mat sediment at AG-01 (220 ppb versus 1 ppb).

Anomalous concentrations of Au, Ba, Bi and Pb and the dilution patterns displayed by As and Sb are attributed to the Lara deposit. This is not conclusive due to a 2.5 kilometre sampling gap between the deposit and the first downstream sample. Dispersion train lengths are not given in the summary table due to this gap. Surprisingly, the main commodity elements Cu (Figure A18-3f), Pb (Figure A18-3g) and Zn (Figure A18-3h) portray background patterns and concentrations, indicating that their anomaly dispersion lengths (if present) are less than 2.5 kilometres in the local environment.

Anomalous Element	Optimum Media	Range	Background	Threshold	Average Contrast	Anomaly Length
Au	Moss	36 - 450 ppb	6	22	20.7	
As	Stream	11.3 - 18.5 ppm	5	26	3.2	
Ba	Stream	92 - 135 ppm	71	111	1.6	
Bi	Moss	0.1-1.3 ppm	0.1	0.5	4	
Pb	Moss	3 - 15 ppm	3	10	3.3	
Sb	Moss	0.4 - 1.0 ppm	0.4	1.4	2	

Table A-18 Silver Creek - Summary Table of Pathfinder Elements

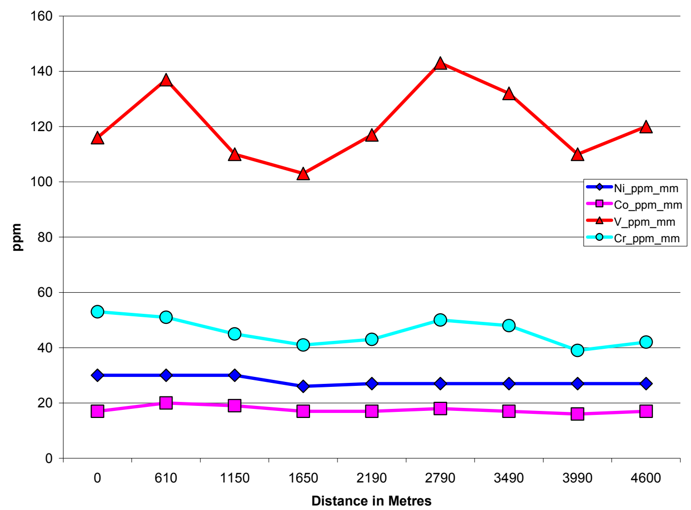

Figure A18-3a

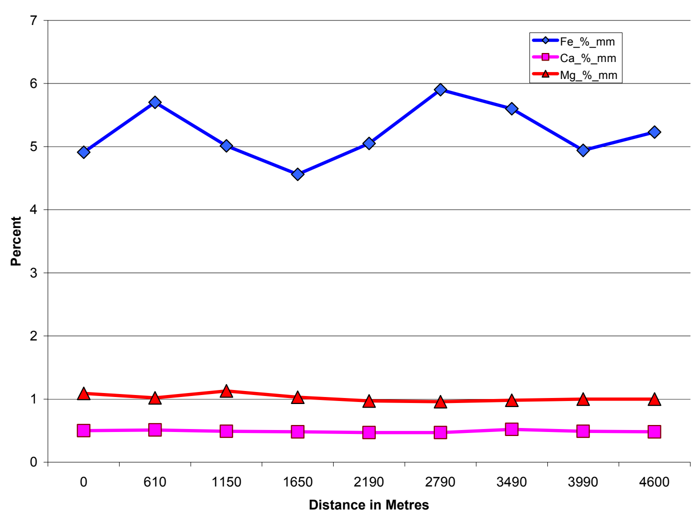

Figure A18-3b

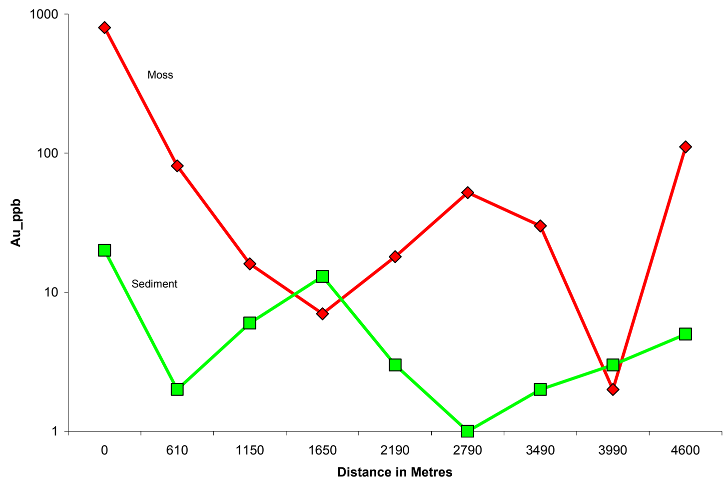

Figure A18-3c

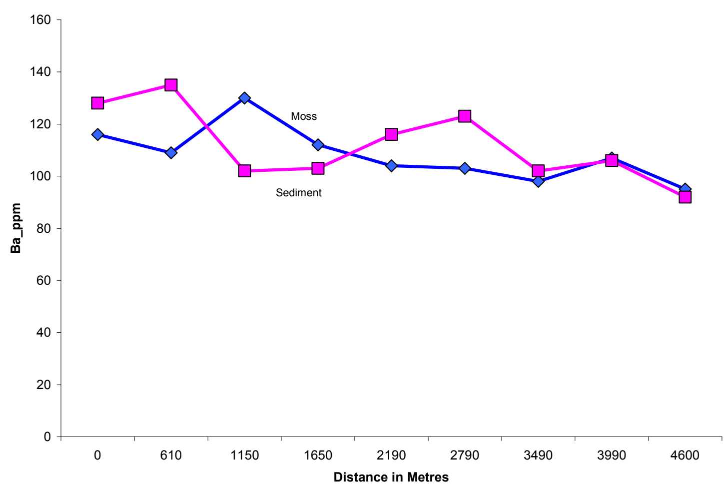

Figure A18-3d

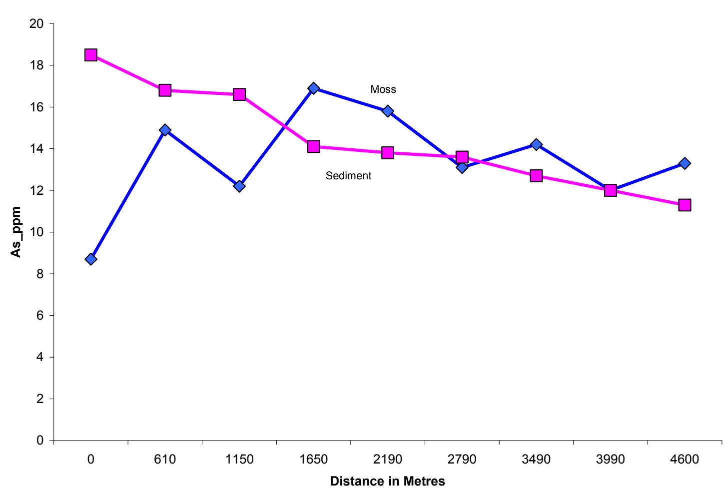

Figure A18-3e

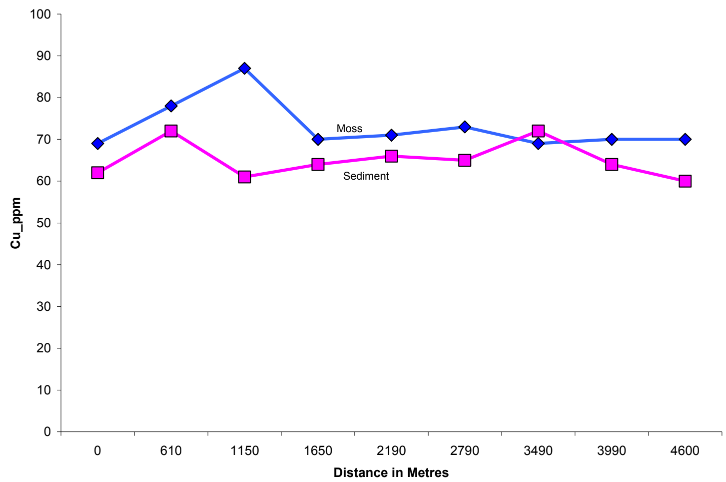

Figure A18-3f

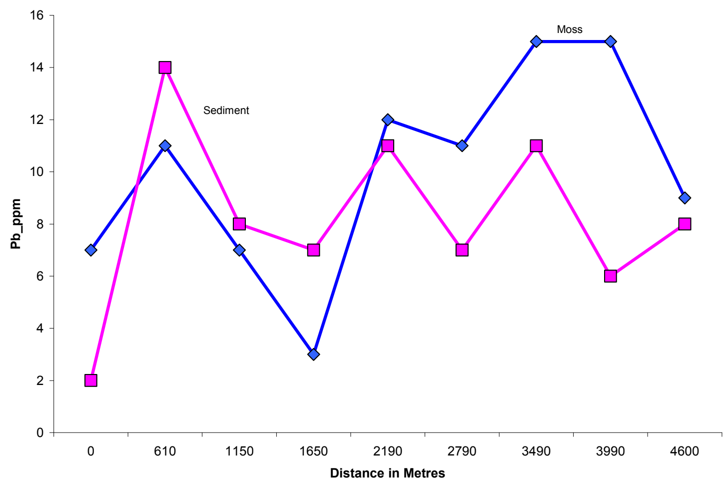

Figure A18-3g

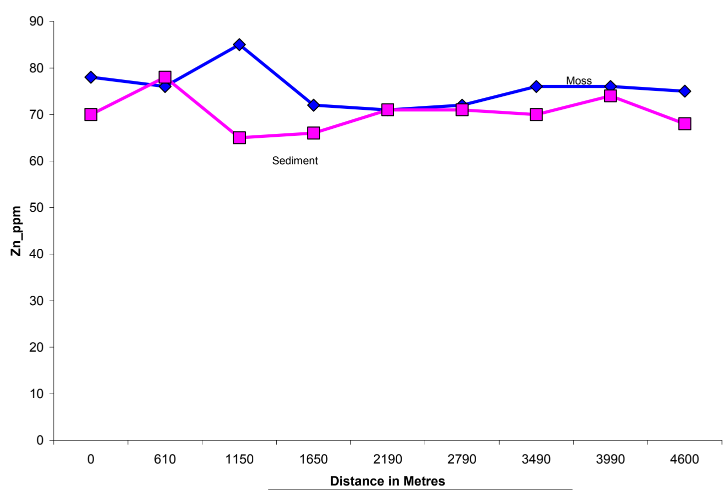

Figure A18-3h