GEOCHEMICAL ORIENTATION SURVEYS: NORTHERN VANCOUVER ISLAND, FIELDWORK AND PRELIMINARY RESULTS

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KEYWORDS: Applied geochemistry, northern Vancouver Island, orientation surveys, multi-element geochemistry, Goldvalley, Red Dog, stream sediments, moss-mat samples.

INTRODUCTION

Stream sediment Regional Geochemical Surveys (RGS) are planned by the Geological Survey Branch in 1988 to assess the mineral potential of northern Vancouver Island. However, very little is known about the geochemical responses of sediments to typical geological and environmental influences within the sampling area. Successful application of stream sediment techniques will be challenged by the unique surficial, physiographic and climatic conditions characteristic of Vancouver Island such as: (1) a thick and diverse blanket of glacial deposits; (2) intense mechanical weathering, due to high rainfall; (3) lack of fine sediments in granitic and carbonate terranes; and (4) widespread logging.

In order to assess the effectiveness of drainage geochemistry for reconnaissance multi-element surveys, a study was implemented to compare the relative merits of a variety of stream sediment sampling and sample preparation techniques. Orientation studies were conducted in a variety of geological and physiographic environments to determine the characteristics of stream sediment anomalies associated with five modes of mineralization on northern Vancouver Island.

Results from this study will be used to: (1) define background and threshold levels; (2) identify those factors that influence dispersion and are thus criteria for the interpretation of survey results; (3) recognize those features that must be noted and reported by the samplers; and (4) define optimum survey procedures.

This paper describes the sampling, sample preparation and analytical procedures and discusses some preliminary results from sampling in the Zeballos and Nahwitti Lake areas.

DESCRIPTION OF THE STUDY AREA

LOCATION

The study area is located on northern Vancouver Island from 126° to 128°50′ west longitude and 49°10′ to 50°57′ north latitude. It encompasses an area of 15 655 square kilometres, which is equivalent to about sixteen 1:50 000 map sheets.

PHYSIOGRAPHY

Northern Vancouver Island consists of two major physiographic units, the Nahwitti Lowland and Vancouver Island Mountains (Holland, 1964). The Nahwitti Lowland is composed of low mountains and coastal plains, while Vancouver Island Mountains are characterized by a more rugged terrain where elevations range between sea level in the deeply penetrating inlets, or 100 metres in several northerly trending finger lakes, to 2300 metres for the higher peaks. Howes (1981) further subdivided these units according to the underlying bedrock and its response to depositional and erosional processes. Descriptions and locations of these subunits are given in Table 5-3-1 and Figure 5-3-1.

CLIMATE

The survey area is characterized by cool, very wet winters and mild, wet summers. Mean annual precipitation varies from 1400 millimetres to greater than 4600 millimetres with 70 to 80 per cent occurring between October and March (Howes, 1981). Three distinct precipitation zones (Figure 5-3-1) have been suggested by Howes (1981): (1) Western Zone with mean annual precipitation increasing from about 2000 millimetres on the west coast to greater than 4600 millimetres along its eastern margin; (2) Southeastern Zone with mean annual precipitation (1550 to 3000 millimetres) considerably less than the Western Zone as result of the rain shadow effect of the western mountains; and (3) Northeastern Zone the driest of the three, with mean annual precipitation ranging from 1400 to 2000 millimetres.

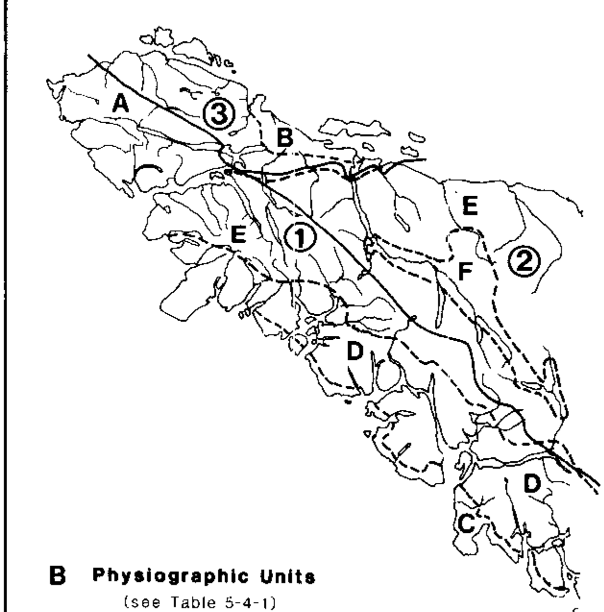

Figure 5-3-1. Physiographic and climatic regimes (*see* Table 5-3-1 and text, respectively), described by Howes (1981).

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1.

TABLE 5-3-1
ABRIDGED DESCRIPTIONS OF PHYSIOGRAPHIC UNITS AS DESCRIBED BY HOWES (1981).

Unit	Subunit	Location	Bedrock Geology	Quaternary Geology	Description
Nahwitti Lowland	(A) Nahwitti Plateau	Northern tip of Vancouver Island	Dominantly Karmutsen with some Island intrusives	Thin mantle of colluvium and till on hills, thick (glacio-)fluvial sediments and till in lowlands	Low relief, rounded hills, narrow valleys; broad lowlands and valleys
	(B) Suquash Basin	Eastern margin of the Nahwitti Lowland	Cretaceous sediments	As Nahwitti Plateau	Rolling to level topography below 300 m a.s.l.; scattered rounded hillocks and uplands
Vancouver Island Mountains	(C) Estevan Coastal Plain	Three-kilometre strip along west coast	Flat to gently dipping Tertiary clastic sedimentary rocks, scattered Island intrusives	Mantle of bedrock-derived colluvium (glacio-)fluvial, sediments, till and marine sediments on coast	Flat, featureless, rock cliffs and platforms, pocket beaches
	(D) Fiord-land	Islands and peninsulas along western coast	South of Esperanza Inlet, mostly granitic; north of inlet Bonanza volcanics, Brooks Peninsula is West Coast complex	Colluvial materials on steep valley walls and on summits; minor till on lower valley sides and slopes	Land rises abruptly to 600 to 900 m a.s.l.; rounded, timbered hill tops
	(E) Vancouver Island Range	Zones of NW/SE-oriented mountain ranges separated by the Nimpkish River Valley	Eastern zone underlain by Karmutsen volcanics, some Island intrusives; Karmutsen and Bonanza to west, with narrow belt of Quatsino and Parsons Bay	Very similar to fiord-land; fluvial and glacio-fluvial deposits in valley	Very rugged; U-shaped valleys, dissected Tertiary surface.
	(F) Nimpkish River Valley	Located in the south-central portion of the Vancouver Island Mountains	Predominantly underlain by Island intrusives	Dominantly till on valley sides and bottoms, mantling bedrock	Broad, U-shaped valleys; valley floor broken by a few peaks.

BEDROCK GEOLOGY

Northern Vancouver Island is underlain mainly by Mesozoic volcanic and sedimentary rocks which were intruded, during Jurassic time, by granitic plutons. Details of the bedrock geology have been described by Muller *et al.*, (1974) and Muller (1977). The various bedrock formations have been grouped into six units according to their origin and lithology (Table 5-3-2 and Figure 5-3-2).

QUATERNARY AND SURFICIAL GEOLOGY

The landscape was extensively modified by glaciation during the Pleistocene. Most of the surficial materials were deposited either during the last glacial episode or as a result of nonglacial processes during the past 10 000 years.

Coast Mountain ice appears to have radiated across the Island, flowing in a southwesterly direction across the southern part of the study area and in a northwesterly direction across the Nahwitti Lowland. At the glacial maximum, about 15 000 years ago (Armstrong *et al.*, 1965), most of northern Vancouver Island was buried by ice.

Radiocarbon dates indicate that glacial recession commenced about 13 000 years ago. Two patterns of deglaciation have been distinguished (Howe, 1981). On the northern part of the Island, ice probably separated into discrete stagnant masses which occupied lowland sites. Meltwater flowed from these masses, depositing fluvioglacial materials in the valleys. In the Vancouver Island Mountains, an episode of valley glaciation produced U-shaped valleys, moraines and outwash deposits. During the last 10 000 years, post-glacial modification of slopes by intense weathering and mass wasting has resulted in the formation of talus and debris-avalanche deposits.

Studies of the distribution of surficial materials by Howes (1981) in the survey area indicated that colluvial (40 to 50 per cent) and morainal materials (30 to 35 per cent) account for the bulk of the total surface cover. The remainder of the region consists of bedrock outcrops (10 to 12 per cent), usually occurring in alpine areas and fluvial and fluvioglacial materials (8 to 10 per cent) which are principally distributed on the valley bottoms. Organic materials (1 per cent) and minor amounts of marine, glaciolacustrine and eolian deposits (less than 1 per cent) account for the remainder.

SAMPLING TECHNIQUES AND ANALYTICAL PROCEDURES

SAMPLE COLLECTION

Three hundred and twenty sediment samples were collected by the authors from 30 streams in northern Vancouver Island (92E and 92L). For the most part, sampling was restricted to single stations on secondary and tertiary streams draining basins averaging 8 to 15 square kilometres in area. Eleven of the sampled catchments are characterized by one of five types of mineralization (Table 5-3-3) and are undisturbed by large-scale placer or bedrock mining activity. Up to ten

TABLE 5-3-2
TABLE OF MAJOR BEDROCK UNITS ENCOUNTERED IN THE SURVEY AREA (MULLER *et al.*, 1973)

Name	Age	Characteristic Lithologies
7. Intrusives (e.g., Zeballos Stock)	Eocene	Quartz diorite
6. Sediments	Cretaceous	Conglomerate, greywacke, siltstone, shale, coal
5. Island Intrusions West Coast complex	Jurassic	Quartz diorite, granodiorite, quartz monzonite, quartz feldspar porphyry, gneiss, metaquartzite, marble, agmatite, amphibolite
4. Bonanza Group	Lower Jurassic	Andesitic to rhyodacitic lava, tuff breccia
Vancouver Group		
3. Parson Bay Formation	Upper Triassic	Calcareous siltstone, shale, limestone, greywacke, conglomerate, breccia
2. Quatsino Formation	Upper Triassic	Limestone, marble
1. Karmutsen Formation	Upper Triassic	Basaltic pillow lava, breccia, minor limestone

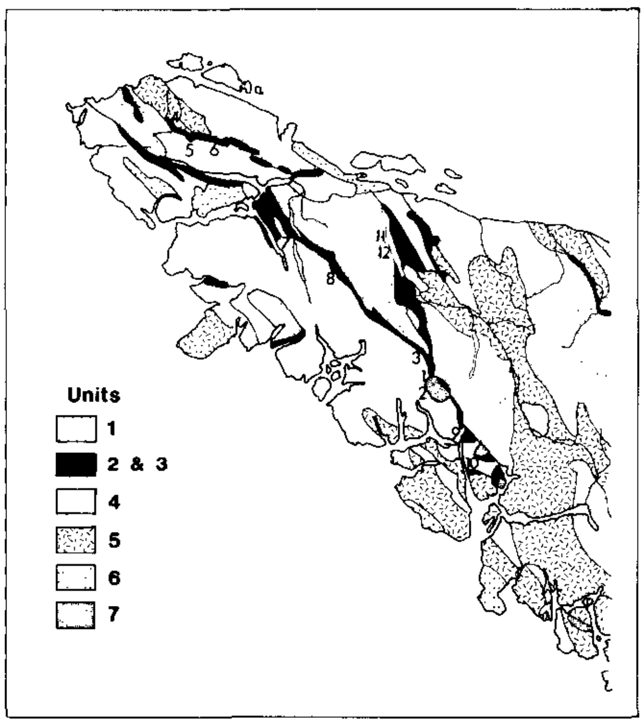

Figure 5-3-2. Simplified geology (after Muller *et al.*, 1974) and locations of anomalous streams. *See* Table 5-3-2 for descriptions of the geological units. Key to creeks: 1 = Goldvalley Creek; 2 = Spud Creek; 3 = Toray Creek; 4 = Red Dog Creek; 5 = Hepler Creek; 6 = HPH Creek; 7 = Jeune Creek; 8 = Merry Widow Creek; 9 = Extravagant Creek; 10 = Tsowwin River; 11 = Storey Creek; 12 = Kinman Creek.

additional sampling stations were established at 500-metre intervals along each anomalous stream to examine downstream dispersion characteristics for a number of sampling

TABLE 5-3-3
MINERALIZATION TYPES ENCOUNTERED ON NORTHERN VANCOUVER ISLAND

Type	Deposit Examples (Sampled Creeks)	Commodities	Mineralogy
A. Tertiary Mesothermal Veins	Zeballos (Goldvalley, Spud Creek)	Au, Ag, Cu, Pb, Zn	Gold (coarse), chalcopyrite sphalerite, galena, pyrite, arsenopyrite, quartz, calcite
B. Epithermal	Hep (Hepler Creek)	Au, Ag	No data
C. Stockwork	Expo (Hepler Creek) Red Dog (Creek)	Cu, Mo	Chalcopyrite, molybdenite, pyrite
D. Base metal skarn	HPH (Creek)	Pb, Zn, Ag	Galena, sphalerite, chalcopyrite, tetrahedrite, pyrite, calcite
E. Iron skarn	Hiller (Toray Creek) Nimpkish Copper (Kinman Creek) Merry Widow area (Merry Widow Creek)	Fe, Cu, Pb, Zn, Cu, Ag, Au	Magnetite, chalcopyrite, bornite, arsenopyrite, pyrite, garnet, epidote, actinolite, calcite

methods. Locations (Figure 5-3-2) and the geology of the anomalous drainages are summarized in Table 5-3-4. The remaining sampled drainages (19) represent background concentrations of ore elements, based on the absence of reported occurrences of any economic minerals in a readily accessible, well-explored area.

At the lowermost sampling station on every stream, five types of samples were collected: (1) a coarse sample comprising 10 kilograms of wet-sieved, −20-mesh (1 millimetre) material collected from a high energy environment (sandy gravels); (2) a fine sample comprising 10 kilograms of wet-sieved, −20-mesh material collected from a low energy environment (sands); (3) a bulk sediment sample comprising 10 kilograms of nonsieved sand; (4) a moss sample comprising 1 to 2 kilograms of sediment-laden moss-mat scraped off logs, boulders or outcrop within the active stream channel; and (5) an RGS-style, 1 to 2-kilogram fine sand sample. On selected streams draining mineralized areas, conventional RGS and moss-mat sediment samples were collected at 500-metre intervals and unseived bulk sediment samples were collected at 1000-metre stations to determine dispersion characteristics 3 to 4 kilometres downstream from mineralization. Field site duplicates of moss-mat and conventional RGS samples were collected at one in five stations.

Moss-mat samples were collected because of their abundance and exceptional ability to scavenge fine sediment material in generally fines-poor Vancouver Island streams. Sieved and unseived bulk sediment samples were collected to compare elemental responses from various sizes and densities of sediment particles. Standard RGS samples were collected to be used as a baseline for interpreting results from other sampling and preparation methods.

Each site was photographed and a number of standard observations were recorded on RGS sediment field cards, as well as site specific observations on moss-mat samples such as host type and competency, position relative to the stream bank and active channel, estimated mat thickness, textural composition and moisture content. For heavy mineral samples, weight of material processed and elapsed time were recorded. Maps depicting sample media abundance, logging activity, bank materials, channel features and precipitates were prepared from traverses between sample stations on anomalous creeks.

PREPARATION

Preparation and analysis of unseived bulk, moss-mat and conventional stream sediment samples were carried out under contract by Acme Analytical Laboratories, Vancouver. Sieved bulk sediment samples were prepared under contract by C.F. Minerals and Research Laboratory, Kelowna.

Sample preparation for standard RGS and moss-mat samples involved standard RGS methods which consist of field drying, disaggregation and dry-seiving to obtain a −80-mesh (<177 microns) fraction. Bulk sediment samples were also field-dried, dissaggregated and dry-sieved into three size fractions: −60 to 100-mesh, −100 to 200-mesh and −200-mesh (ASTM units).

Field-sieved bulk samples were wet-sieved through a −60-mesh screen, followed by density separation by a two-stage heavy liquid treatment (tetrabromoethane, S.G. = 2.96 and methylene iodide, S.G. = 3.3) and then sized to prepare three intermediate and three heavy mineral concentrates (−60+100-mesh, −100+200-mesh and −200-mesh).

SAMPLE ANALYSES

Prepared density (heavy and intermediate) and size fractions were analysed by non-destructive instrumental neutron activation under contract to Nuclear Activation Services Ltd., Hamilton, Ontario.

TABLE 5-3-4. SUMMARY OF ALL STREAMS SAMPLED

Creek	NTS Sheet	UTM Coords		Physiography[1]	Lithology[2]						Deposit[3]					N	Samples[4]			
		East	North		1	2	3	4	5	6	A	B	C	D	E	N	H	B	S	M
Spud	92L/02	656100	5544100	D				x		x	x						2	4	9	10
Tsowwin	92E/15	672900	5517100	D		x	x	x			x						2	4	9	9
"Red Dog"	92L/12	570600	5618300	A		x		x	x				x				2	5	11	10
Goldvalley	92L/02	657600	5544800	D						x	x		x				2	4	8	9
Hepler	92L/12	579200	5617200	A		x		x	x			x	x				2	5	10	10
"HPH"	92L/12	584500	5516700	A	x	x	x							x			2	3	6	6
Toray	92L/02	651700	5555300	D		x	x	x	x						x		2	4	7	7
Merry Widow	92L/06	625700	5579200	E		x	x	x	x						x		2	2	4	4
Extravagant	92E/15	667800	5532700	D		x	x	x							x		2	1	2	2
Kinman	92L/07	648700	5578600	E		x	x	x	x				x		x		2	2	4	4
Jeune	92L/06	613200	5587500	E		x	x		x					x	x		2	3	5	5
Storey	92L/07	647100	5580400	E	x		x	x	x					x	x		2	1	2	2
Little Zeballos	92E/15	661200	5537700	D		x	x	x		x						A	2	1	2	1
"TB"	92E/15	660500	5538200	D				x		x						A	2	1	2	1
Nomash	92L/02	664700	5541100	D	x		x			x						A	2	1	2	1
Malaspina	92E/15	674300	5525700	E		x	x	x		x						A	2	1	2	2
"T3"	92E/15	673000	5516500	E		x		x								A	2	1	2	2
"T2"	92E/15	678000	5521600	E		x	x	x								A	2	1	2	2
Perry	92E/15	674700	5527100	E	x											A	2	1	2	1
Nahwitti	92L/12	588100	5616100	A	x	x	x									C	2	1	2	2
"N1"	92L/07	645700	5584900	E	x				x							CDE	2	1	1	1
"N9"	92L/07	645500	5592000	E	x	x	x	x								CDE	2	1	1	1
"N6"	92L/07	658400	5582600	E	x				x							CDE	2	1	1	1
"N7"	92L/07	650200	5592600	E		x		x								CDE	2	1	1	1
Mead	92L/12	584100	5616500	A	x	x	x									D	2	1	2	1
Rainier	92L/06	626200	5577500	E		x	x	x	x							E	2	1	1	1
"Akery"	92L/06	610400	5578600	E				x	x							E	2	1	2	2
"Vieux"	92L/06	611800	5585700	E		x			x							E	2	1	1	1
"Upper Toray"	92L/02	651700	5553700	D		x		x	x							E	2	1	1	1
Artlish	92L/02	654500	5552500	D		x	x		x							E	2	1	1	1
Craft	92L/06	622900	5581200	E				x	x							E	2	1	1	1
Yootook	92L/06	617000	5585400	E		x	x	x								E	2	1	1	1

[1] *See* Table 5-3-1.
[2] *See* Table 5-3-2.
[3] *See* Table 5-3-3, N = background to mineralization type indicated.
[4] Number of samples of each type.
H = sieved bulk samples.
B = nonsieved bulk samples.
M = moss-mat samples.
S = stream sediment samples.
Note: Creek names in quotations are informal designations made by the authors.

CONVENTIONAL RGS, MOSS-MAT AND BULK SEDIMENT SAMPLES

A 0.50-gram portion of each sample was digested with 3 millilitres of 3:1:2 $HCL:HNO_3:H_2O$ at 95°C for one hour and then diluted to 10 millilitres with water. Elemental concentrations of molybdenum, copper, lead, zinc, silver, nickel, cobalt, manganese, iron, strontium, vanadium, calcium, phosphorus, lanthanum, chromium, magnesium, barium, titanium, boron, aluminum, sodium, potassium and tungsten were determined by inductively coupled plasma emission spectroscopy (ICP-ES). This digestion is almost total for base metals, partial for rock-forming elements such as sodium, aluminum, calcium, phosphorus, magnesium and titanium, partial for iron, manganese and barium, and very weak for refractory elements such as chromium, boron and tungsten.

Arsenic, antimony, bismuth, germanium, selenium and tellurium in the above solution were reduced to their hydrides and determined by ICP-ES. Mercury was determined by cold vapour atomic absorption spectroscopy using an F and J Scientific mercury assembly after adding stannous chloride/hydrochloric acid solution to an aliquot of the digested sample solution.

Loss-on-ignition (LOI) was determined using a 500-milligram sample. The sample was weighed, placed in a furnace and heated to 500°C over a period of 2 to 3 hours. The sample was left at this temperature for 4 hours, then allowed to cool to room temperature for weighing.

For the majority of samples a 10-gram sample was ignited at 600°C, digested with hot aqua regia, extracted by methyl isobutylketone and analysed for gold by graphite furnace atomic absorption spectroscopy. The reported detection limit of this method is 1 ppb.

Background elemental values obtained from collected samples are generally well above the contracted laboratory's reported detection limits, except for determinations of molybdenum, silver, cadmium, germanium, bismuth and tungsten.

PRELIMINARY RESULTS AND DISCUSSION

The following discussions focus on comparing and contrasting analytical results obtained from the collection of 107 standard RGS stream sediment and 103 moss-mat sediment samples, and a detailed examination of their effectiveness in detecting and characterizing two mineral occurrences.

COMPARISON OF MOSS-MAT AND STREAM SEDIMENT DATA

Scarcity of easily collected conventional stream sediment (fine sands to silts) is a common problem in drainage sediment surveys on Vancouver Island. In response to this problem, collection of moss-mats was initiated because they are relatively ubiquitous in the survey area and can be quickly and easily sampled. More importantly, moss-mats contain large amounts of fine-grained particulate matter.

PHYSICAL DIFFERENCES

Comparison of weights of −80-mesh sediment obtained from moss-mat samples and conventional sediment samples shows that a high proportion (44 per cent) of standard RGS sediment samples do not yield enough sediment for both an ICP-ES analysis and a 10-gram gold analysis, despite collecting close to 2 kilograms of sandy material in the field. Sixteen per cent of samples yielded less than 5 grams of the material needed for analysis. In sharp contrast, only 5 per cent of moss-mat samples yielded insufficient material for an ICP-ES analysis and the two 10-gram gold analyses which would normally be required for the purpose of quality control. All moss-mat samples yielded at least 22 grams of −80-mesh sediment with the average sample yielding more than 60 grams. Consequently, if gold is to be determined with appropriate duplicates, samples up to 10 kilograms of fine sediment maybe required, alternatively samples should be field-sieved. Moss-mat samples may be an attractive alternative provided that the chemical differences are not overwhelming.

CHEMICAL DIFFERENCES

Direct comparison of analyses of moss-mat sediments and stream sediments shows some significant differences. For example, stream sediments returned consistently higher values of zinc, nickel, manganese, strontium, calcium, magnesium, barium, aluminum and sodium, whereas moss-mat sediments have higher values for vanadium, phosphorus, lanthanum, potassium and antimony. There are no significant differences for molybdenum, copper, lead, cobalt, iron, arsenic, chromium, titanium, boron, mercury and selenium or loss-on-ignition. Figure 5-3-3 illustrates some of the above relationships. At present, there is insufficient data to classify gold. At this early stage of the project, it is not clear what factors may be important in determining differences, but possible mechanisms are.

- Uptake of mobile elements by the moss, that is transfer of metals from the particulate phase (analysed) to the organic phase (not analysed).
- Incorporation of particulate material from the moss-mat host.
- Different size and/or density distributions of sediment in moss-mat sediments and stream sediments, resulting from morphological characteristics of moss-mats and their location in the stream flow.

These factors will be resolved as the study progresses, with chemical analyses of the organic fraction, detailed site-specific studies and textural analyses of moss-mat and stream sediments.

RED DOG COPPER-MOLYBDENUM STOCKWORK

The Red Dog copper-molybdenum stockwork deposit is located approximately 8 kilometres north of Holberg in till-blanketed, rolling hills of the Nahwitti Plateau physiographic region. Chalcopyrite and molybdenite mineralization is hosted in lapilli tuff and brecciated tuff of the Bonanza Group and Parsons Bay Formation (Muller *et al.*, 1974) adjacent to a Jurassic diorite stock. The deposit crops out on a low hill in the headwaters of Red Dog Creek (name coined by authors),

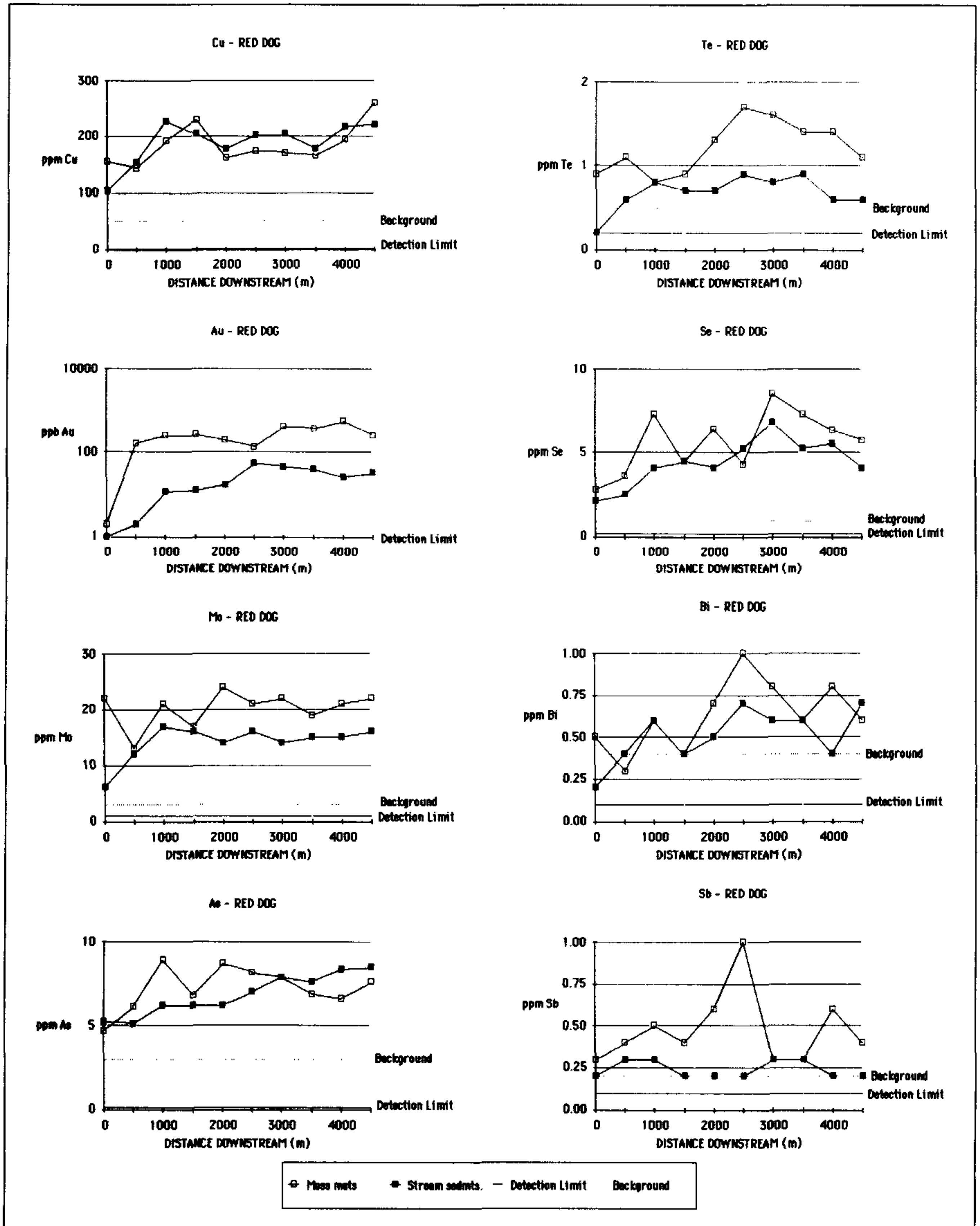

Figure 5-3-5. Downstream dispersion patterns for Au, Mo, Cu, As, Sb, Bi, Se and Te in Red Dog Creek moss-mat and stream sediment samples. Detection limits are from the analytical company's brochure, regional background level determined as described in the text. *See* Figure 5-3-4 for sample locations.

however alteration and quartz veining were observed up to 2 kilometres downstream from the main mineralized zone.

Red Dog Creek rises at an elevation of some 500 metres, falling 300 metres over a distance of 4500 metres, with a drainage basin area of approximately 13 square kilometres (Figure 5-3-4). In the upper reaches, the stream flows through logjams producing localized sand and gravel deposits. Toward the lowest sampling location, near the confluence with the Goodspeed River, the stream meanders between point bars occasionally reaching bedrock below till up to 10 metres thick. Moss mats, typically growing on logs, and stream sediments were sampled from 10 stations at 500-metre intervals. The highest sampling location is several hundred metres upstream from the surface expression of mineralization.

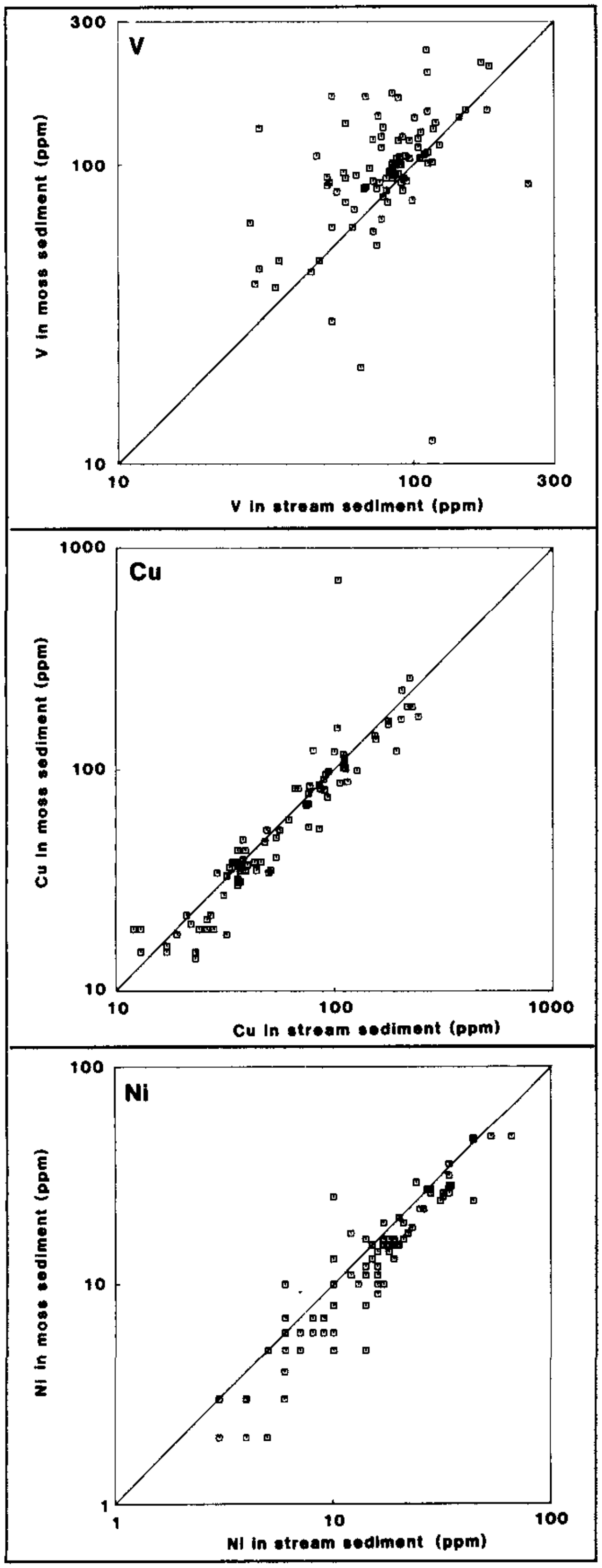

Figure 5-3-3. Some examples of results for moss-mat and standard RGS stream sediment samples taken at the same sampling station. The diagonal line represents the case where both media return the same value.

RESULTS

Geochemical Background

Locally, copper-molybdenum mineralization is commonly associated with Jurassic diorite stocks, thus definition of geochemical background is difficult. Other samples collected from streams draining Jurassic diorite intrusions (creeks N1 and N6, Table 5-3-4) in the Nimpkish Lake area provide a preliminary indication of regional trace element background values, though weathering and lithological characteristics are likely to be different in the Vancouver Island Ranges. In addition, the uppermost sampling point probably represents local background. Assuming these samples represent background levels, copper, molybdenum, silver, gold, arsenic, antimony, bismuth, selenium and tellurium show anomalous values in both moss-mat sediments and stream sediment samples (Figure 5-3-5).

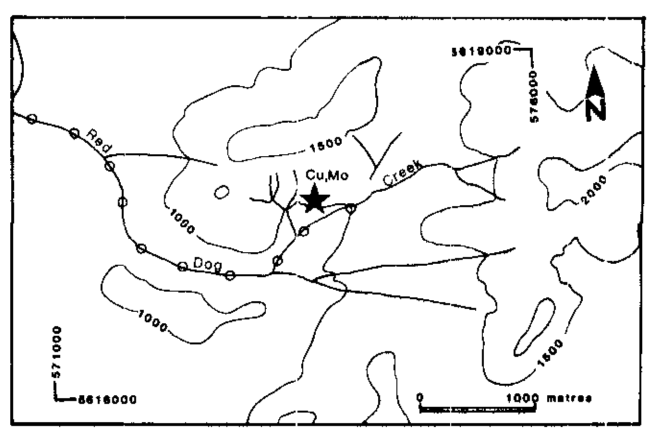

Figure 5-3-4. Sample locations (circles) on Red Dog Creek draining Red Dog copper-molybdenum deposit (star). The contour interval is 500 feet.

Gold

Gold analyses on 10 pairs of 5-gram splits of stream sediments are reasonably consistent (Table 5-3-5) suggesting that gold is present as numerous small inclusions rather than one or two coarse particles. Highly erratic results related to the nugget effect are typical of the latter case.

Five hundred metres downstream from the highest sampling location, gold concentrations in moss-mat sediments increase from 2 ppb to over 100 ppb. This level is maintained even to the lowest sampling location 4 kilometres downstream (Figure 5-3-5). In comparison, anomaly contrast is lower for stream sediments with concentrations never rising above 50 ppb, though values are greater than 10 ppb for most of the section. Dilution of the anomaly is not apparent in either moss-mat sediments or stream sediments despite erosion of till in the banks. This is perhaps due to gold input from quartz veins and alteration observed in the stream bed, or anomalous gold concentrations in the till derived from the deposit.

Other Anomalous Elements (Molybdenum, Copper, Silver, Arsenic, Antimony, Bismuth, Selenium, Tellurium)

There are marked similarities between results for molybdenum, copper, arsenic, selenium and tellurium, and gold results. After initially rising to anomalous levels, concentrations of these elements do not decay downstream (Figure 5-3-5). Concentrations of antimony and silver are anomalous in both moss-mat sediments and stream sediments though levels are very close to the detection limit. However, concentrations in moss-mat sediments are greater than in stream sediments resulting in slightly greater anomaly contrast. Results show that for this particular geological and physiographic setting, a standard RGS sediment sample collected up to at least 4 kilometres from known mineralization would detect the anomaly. Because anomaly contrast is greater in moss-mat samples, these may represent an improvement over the conventional samples.

GOLDVALLEY CREEK, ZEBALLOS CAMP

The Zeballos gold camp is located in the fiord-land physiographic region of the west coast of Vancouver Island. Gold mineralization is demonstrably associated with the granitic Tertiary Zeballos stock (Hansen and Sinclair, 1984) intruded into Bonanza Group, Karmutsen Formation, Quatsino Formation and a Jurassic Island Intrusions pluton. Mesothermal gold and silver-bearing veins with minor lead and copper have been mined at two locations in Goldvalley (Spud Valley mine, CD mine).

Elevations in the camp vary from sea level to 1300 metres at the summits of very rugged peaks. Goldvalley Creek rises in a logged cirque and initially meanders over a very gently sloping area that was possibly the site of a tarn. The stream gradually steepens, flowing over bedrock and then, toward the confluence with the Zeballos River, becomes choked by

TABLE 5-3-5
GOLD CONCENTRATIONS OBTAINED FROM 5-GRAM SPLITS OF GOLDVALLEY AND RED DOG STREAM SEDIMENTS

	Gold concentrations (ppb)	
Sample Number	Split 1	Split 2
RED DOG SAMPLES		
RD-SS-01	13	50
RD-SS-02	18	31
RD-SS-03	26	52
RD-SS-04	45	NSS[1]
RD-SS-05	35	30
RD-SS-06	85	60
RD-SS-07	24	9
RD-SS-08	13	10
RD-SS-09	7	15
RD-SS-10	2	2
RD-SS-11	1	1
GOLDVALLEY SAMPLES		
GV-SS-01	1950	NSS[1]
GV-SS-02	12480	32950
GV-SS-03	26	30
GV-SS-04	30	245
GV-SS-05	640	2580
GV-SS-06	12	420
GV-SS-07	25	290
GV-SS-08	27	905

[1] Not sufficient sample for analysis.

very large granite boulders. In addition to known mineralization, chalcopyrite and molybdenite stringers were found 2250 metres downstream from the uppermost sampling station. Moss-mat samples from boulders and stream sediment samples were collected at seven stations 500 metres apart (Figure 5-3-6). Drainage basin area to the lowest sampling station is approximately 8 square kilometres.

Results

Geochemical Background

Background levels were determined for moss-mat and standard RGS stream sediment samples collected from three streams (Table 5-3-4) assumed to be draining unmineralized portions of the Zeballos stock. However, concentrations of gold (69 ppb in a moss-mat sediment sample), and several other trace elements (molybdenum, copper, zinc, nickel, cobalt, arsenic and antimony) obtained from Little Zeballos

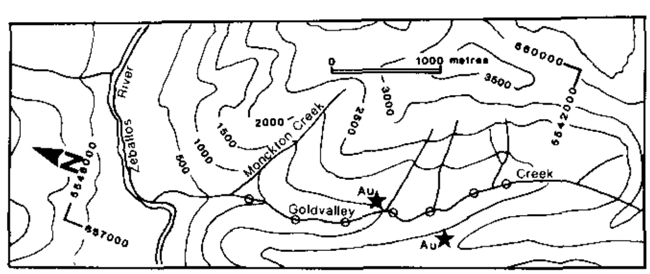

Figure 5-3-6. Sample locations (circles) on Goldvalley Creek in the Zeballos camp. Gold occurrences are indicated by stars. The contour interval is 500 feet.

River moss-mat and stream sediments, were considerably higher than the other two basins assumed to be barren (TB Creek and Nomash River). This is perhaps due to undiscovered mineralization upstream from the sampling location or the result of this stream also draining Bonanza volcanics, which typically have high background base metal values. Based on background levels obtained from samples collected from Nomash River and TB Creek, gold, silver, arsenic and lead concentrations are anomalous in Goldvalley sediments. As was the case for the Red Dog example, anomalous concentrations are reflected in both moss-mat and standard RGS sediment samples. Conspicuously, copper, which has been produced in the camp and molybdenum, which was observed in streambed outcrops, are characterized by background concentrations for both sample media.

Gold

In contrast to Red Dog Creek results, gold concentrations in stream sediment duplicate splits are high (up to 33 ppm) but very erratic (Table 5-3-5) indicating that gold is present as coarse free particles which are not partitioned evenly between splits. Nonetheless, downstream dispersion patterns for moss-mat sediments and stream sediment samples are comparable (Figure 5-3-7), both showing very high values 2500 metres downstream and a distinctive low at 500 to 1000 metres.

Other Anomalous Elements (Silver, Arsenic and Lead)

Silver concentrations are well correlated with gold concentrations and consequently are very erratic. Moss-mat sediment silver concentrations vary from the detection limit (two samples) to greater than 10 ppm, whereas only one stream sediment sample is above the estimated background for the region. Arsenic concentrations show very similar trends with peaks at 0 metre and 2500 metres and a low point at 500 to 1000 metres (Figure 5-3-7). Trends in lead concentration are above background in the area of small-scale mining near 1500 metres and increase to the same peak as observed for gold, silver and arsenic at 2500 metres (Figure 5-3-6). As in Red Dog Creek, the gold anomaly would be detected at the lowest sampling location using a conventional stream sediment sample, though of the three other elements that characterize the deposit, only arsenic shows clearly anomalous values.

SUMMARY

Preliminary results indicate that the lack of fine sediment in northern Vancouver Island streams is likely to be a severe problem in regional drainage sediment projects. Much larger samples must be collected to satisfy the analytical requirements for gold. Moss-mat sediments may be a satisfactory alternative for many important elements (molybdenum, copper, lead, cobalt, iron, arsenic, mercury) because the fine-sediment yield is very high. However, questions remain about significant differences for other elements, in particular, zinc, nickel, manganese, antimony, vanadium and phosphate. Further research will be initiated.

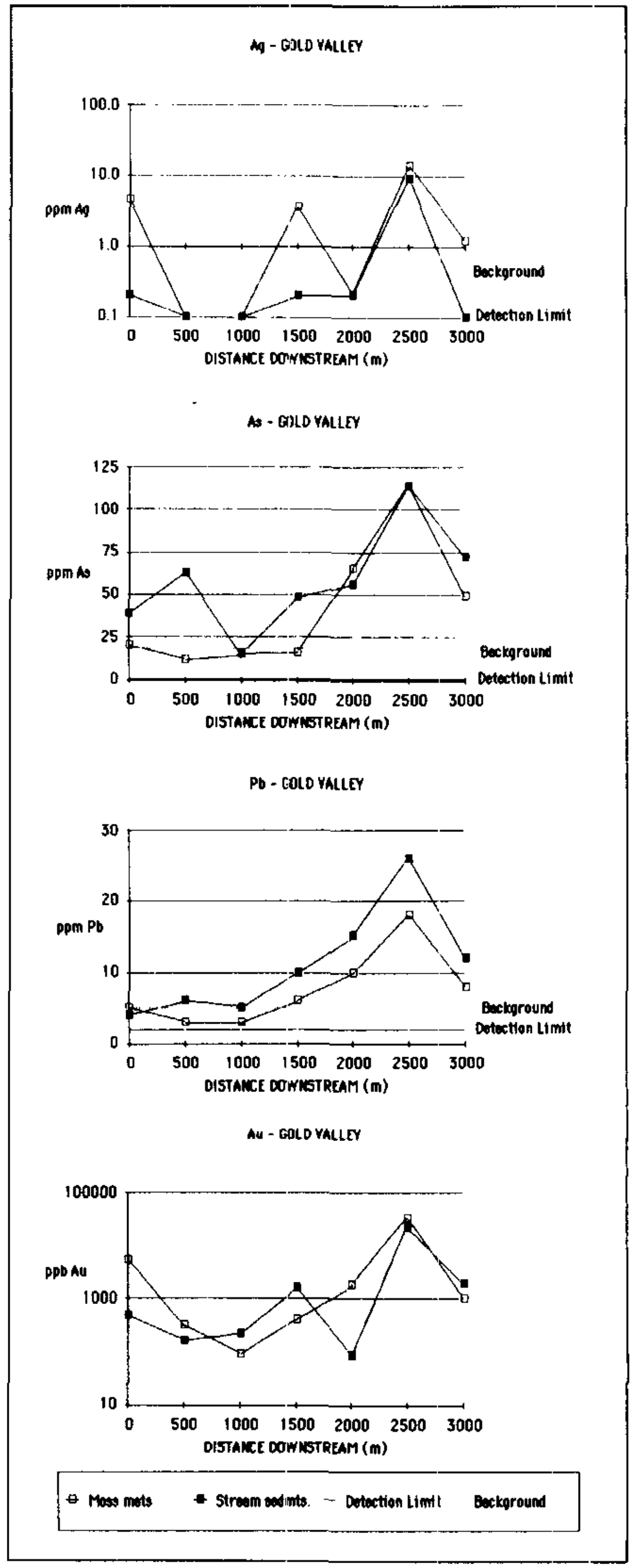

Figure 5-3-7. Downstream dispersion patterns for Au, Ag, As and Pb in Goldvalley Creek moss-mat and stream sediment samples. Detection limits are from the analtyical company's brochure, regional background level determined as described in the text *See* Figure 5-3-6 for sample locations.

Results from contrasting streams in the Nahwitti Lowlands and the coastal mountains show that anomalous gold and base metal concentrations can be determined satisfactorily at regional scale sampling density in conventional stream sediments. Moss-mat samples reflect similar results and often provide better contrast. Additional information on the effectiveness of conventional stream sediment samples will be available as soon as results from bulk nonsieved and sieved samples become available.

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