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Energy, Mines and  
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Geological Survey of Canada  
Commission géologique du Canada  
Resource Geophysics and Geochemistry Division

# 1988 BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY

## STREAM SEDIMENT AND WATER GEOCHEMICAL DATA

### NTS 92K - BUTE INLET

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Canada - British Columbia Mineral Development Agreement (1985 - 1989)

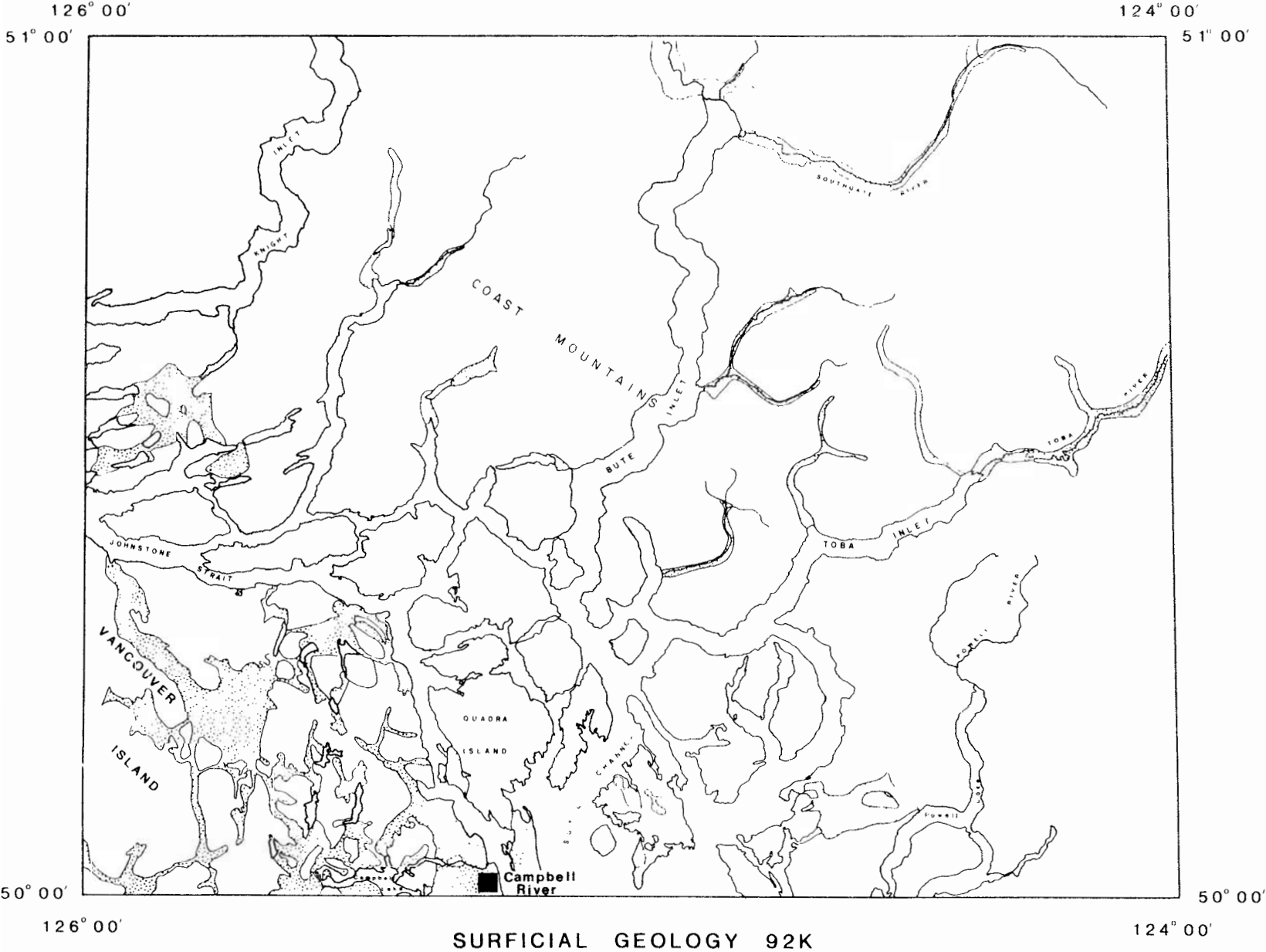
MEMPR BC RGS 22

GSC O.F. 2039

1988 Regional Geochemical Survey  
92K - Bute Inlet

British Columbia Regional Geochemical Survey - RGS 22  
Geological Survey of Canada Open File 2039

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LEGEND



**FLUVIAL SEDIMENTS:** Fluvial and/or fluvial glacial sediments usually consisting of mixtures of sand and gravel. Recent fluvial landforms include floodplains, deltas and alluvial fans. Fluvial glacial landforms consist of kames, eskers, kame terraces, and outwash plain and terraces.

Legend and map modified from Roddick (1977)

## Introduction

Open File package *BC RGS-22/GSC 2039* (Bute Inlet - NTS 92K) is one of three regional geochemical open files covering northern Vancouver Island and the adjacent mainland which were sampled in 1988. Open File *BC RGS 22* presents the results of moss-mat sediment, stream sediment and water analyses for 22 elements.

The reconnaissance survey was undertaken by the Geological Survey Branch of the Ministry of Energy, Mines and Petroleum Resources with funding supplied in part under the Canada/British Columbia Mineral Development Agreement (1985-1989).

Open File package *BC RGS 22* consists of a data booklet and a set of 29 maps. The maps include (1) 1:250 000 scale and (4) 1:100 000 scale sample location maps plus (24) 1:250 000 scale symbol and value maps for analyzed elements, loss-on-ignition and pH of stream waters. The data is also available on floppy diskette.

This data booklet contains a description of the 1988 Regional Geochemical Survey (RGS) program, data listings, statistical summaries and sample evaluation charts. A full discussion of the RGS program is given by Gravel and Matysek (1989), descriptions on moss-mat sampling can be found in Matysek and Day (1988) and Matysek et al. (1989).

## Credits

Contracts were let to the following companies on a technically acceptable and competitive bid basis and were managed by the staff of the Applied Geochemistry Subsection:

COLLECTION: ■ McElhanney Engineering Services Ltd., Surrey, B.C.  
PROCESSING: ■ Kamloops Research and Assay Ltd., Kamloops, B.C.  
ANALYSIS: ■ Chemex Labs Ltd., North Vancouver, B.C. (sediment)  
■ Barringer Magenta Laboratories Ltd., Calgary, Alta. (water)  
DATA ENTRY: ■ Data Makers, Victoria, B.C.

APPLIED	■ P.F. Matysek : directed the survey
GEOCHEMISTRY	■ J.L. Gravel : coordinated staff and contract operations
STAFF	■ W. Jackaman : coordinated and edited open file production
	■ S. Pattenden : provided general assistance to the program

## 1988 RGS Program Modifications

1. Collection of **moss-mat sediments** on Vancouver Island and stream sediments on the mainland.
2. Precious metal pathfinder elements **chromium and bismuth were added** to RGS analytical suite.
3. **Sample evaluation charts** based on sample media, underlying lithologies and percentiles are provided in the data booklets.
4. **Addition of specific field observations** on stream channel characteristics and moss mat parameters such as position in stream, host, thickness and colour.
5. **Element histograms and surficial geology maps have been transferred** to the data booklet from the maps to facilitate use in the field.
6. **Statistics used for elemental maps and the statistical summary were calculated separately for the two sampling media.**
7. Symbol and value maps were not produced for those elements where greater than 98% of the samples had concentrations less than or equal to their respective detection limits.

## Geology and Mineral Potential

The Bute Inlet map sheet covers approximately 14,000 km<sup>2</sup> (Fig. 1). Thin till and colluvium cover the Insular Mountains of Vancouver Island. Till, fluvio-glacial deposits and marine sediments occupy the Coastal Trough along of the Strait of Georgia. On the mainland, thin till and talus cover steep slopes of the Coastal Mountains, thick outwash deposits occupy broad U-shaped valleys. Bonanza and Vancouver Island group rocks, intruded by Jurassic felsic plutons of the Island Intrusions, underlie Vancouver Island. The Coast Complex dominates the mainland (Table 2). Geological underlay for the open file maps used GSC Open File 480 (Roddick, 1977). Typical mineral occurrences are: copper-molybdenum porphyries (OK), massive sulphide (Menzies Bay) and vein and shear gold deposits (Dortha Morton). Potential exists for the discovery of massive sulphides and skarn deposits in the roof pendants of the Coast Complex. Assessment reports for the years 1981 to 1987 indicate the general level of activity has been very low (Gravel and Matysek, 1989).

### **Sampling Program**

In total 1214 sites were sampled for moss-mat sediment, stream sediment and stream water at a density averaging 1 site per 11.4 km<sup>2</sup> (Table 1). Sixty-one percent of the samples were collected by truck and boat; the remaining samples (39%) were collected by helicopter. Moss-mat sediment samples weighing 1-2 kg were scraped from boulders and logs found within the active stream channel and placed in large kraft-paper sample bags. To prevent contamination, moss mats growing on or near the banks and on decomposed logs and friable boulders were avoided. Stream sediment samples were collected from low energy sites and consisted of 2-4 kg of sand size and finer inorganic material. Water samples were collected in 250 ml nalgene bottles. Observations regarding sample material, sample site and the surrounding area were recorded (Table 3) in the field. Aluminum identification tags measuring 5 cm x 10 cm were inscribed with an RGS sample number and stapled to a nearby tree at each sample site. Numerous field checks were conducted by staff geochemists to monitor, control and assess sample collection procedures.

### **Field Processing and Sample Preparation Program**

Field processing of the sediment samples was completed at a central depot located in Campbell River. Samples were initially dried on open-air racks and then in a heated shed (<50°C). Moss-trapped sediment was liberated from plant fibres by pounding dried samples with a wooden mallet. All samples were then sieved to -18 mesh (-1 mm) to reduce sample weight and assess fines content. Sample quality checks were run by routinely sieving 1 sample in each block of 20 to -80 mesh (<177 microns), plus any samples suspected of low fines content. Samples containing less than 30 gm, the minimum amount needed for the RGS analytical determinations, were rejected and new samples collected. Only 12 samples sites were revisited due to poor sample quality from the 2746 total sites sampled during the 1988 RGS program

Field prepared samples were shipped to the contracted sample preparation laboratory for further sieving to -80 mesh. At this time, control reference samples and blind duplicate samples were inserted into each block of 20 sediment samples. For the water samples, only control reference samples were inserted into the block.

### **Analytical Program**

Sediment samples were sent to Chemex Labs Ltd. for analysis of antimony, arsenic, barium, bismuth, cadmium, chromium, cobalt, copper, fluorine, gold, iron, lead, manganese, mercury, molybdenum, nickel, silver, tin, tungsten, uranium, zinc and organic matter by loss on ignition. Prior to analysis for tin and tungsten, a 10 gm subsample was crushed to -150 mesh to reduce the rare particle effect. Water samples were shipped to Barringer Magenta Laboratories for determination of pH, fluorine ion and uranium content. The methods and specifications for analysis of each element are given in Table 4. Geological Survey of Canada quality control procedures were used to ensure that analytical data satisfy National Geochemical Reconnaissance standards.

### **Symbol and Value Map Presentation**

- Sample locations were digitized and verified from the sample collection contractor's field maps by Applied Geochemistry staff.
- On the sample location maps field duplicates are represented by the following system : first field duplicate sample number / second field duplicate sample number. Elemental concentrations for field duplicates are averaged on the value and symbol maps.
- Percentiles were calculated on the raw data for each sample medium. Symbol sizes on the map are based on the 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup> and 95<sup>th</sup> percentile. Analytical determinations are listed adjacent to symbols for all samples exceeding the 75<sup>th</sup> percentile.
- Symbol and value maps were not produced for those elements if less than 2% of the sample concentrations were above detection limit. Samples exhibiting elevated concentrations for these elements are highlighted separately in the data listing section.

Table 1. Sample Distribution - 92K Bute Inlet					
Map Sheet	Moss Mat	Strm Seds	Total Sites	Area km <sup>2</sup>	Density km <sup>2</sup> /Site
01	0	77	77	920	12.1
02	22	44	66	700	10.6
03	52	0	52	660	12.7
04	103	0	103	985	9.6
05	53	19	72	810	11.3
06	38	23	61	690	11.3
07	13	63	76	785	10.3
08	0	78	78	960	12.3
09	0	85	85	995	11.7
10	0	89	89	865	9.7
11	0	84	84	950	11.3
12	0	90	90	850	9.4
13	0	86	86	860	10.0
14	0	78	78	975	12.5
15	0	65	65	890	13.7
16	0	52	52	980	18.8
Total	281	933	1214	13875	11.4

#### Comments Regarding the Interpretation of Gold Results

The following discussion reviews the format used to present the gold geochemical data and outlines some important points to consider when interpreting the data. This discussion is included in recognition of the special geochemical behavior and mode of occurrence of gold in nature and the resultant difficulties in obtaining and analyzing samples which reflect the actual concentration level at a given site. Understanding gold geochemical data from regional stream sediments requires an appreciation of the unique chemical and physical characteristics of gold and its mobility in the surficial environment. Key properties that distinguish the geochemical behavior of gold from most other elements include:

- 1) Gold occurs most commonly in the native form. It is chemically and physically resistant and a high proportion of the metal is dispersed in Micron-sized particulate form. Gold's high specific gravity results in heterogeneous distributions, especially in stream sediments.
- 2) Gold typically occurs at low concentrations in the ppb range. Gold concentrations of a few ppm may represent economic deposits. Background levels encountered for stream and moss-mat sediments seldom exceed 10 ppb, and commonly are near the detection limit of 1 ppb.

The foregoing factors can result in a particle sparsity or "Nugget Effect", wherein very low concentrations of gold are heterogeneously distributed in the surficial environment. Hence, a major problem facing the explorationist is obtaining a representative sample. In general, the lower the concentration of gold, the larger the sample size required to reduce uncertainty over whether subsample analytical values truly represent actual values. Conversely, as gold concentrations increase, the number of gold particles to be shared in random subsamples increases and the variability of results decreases (Clifton et al., 1969; Harris, 1982).

The limited amount of material collected during the rapid, reconnaissance-style regional surveys and the need to analyze for a broad spectrum of elements, precludes the use of a significantly large sample weight for the gold analyses (usually 10 grams). Consequently, results from these analyses tend to be highly variable and qualitative rather than quantitative. To evaluate and monitor the sampling and analytical variability which are inherent in the analysis of gold in geochemical media, the following control methods are currently employed:

- 1) For each block of twenty samples:
  - a) random insertion of a standard reference sample to monitor and control analytical accuracy and long-term precision;
  - b) collection of a field duplicate (two samples collected separately from one site) to monitor sampling variance; and
  - c) analysis of a second subsample (blind duplicate) from one sample to monitor and control short-term precision.

## 2) Repeat analyses are performed on:

- a) samples exceeding the 95<sup>th</sup> percentile for gold;
- b) samples exhibiting low gold concentrations and anomalous concentrations in one or more pathfinder elements (As, Cu, Pb, Zn, Sb, Hg); and
- c) samples exhibiting a significant concentration difference between the first and repeat analysis.

Presentation of gold data within the booklet and on the symbol and value map differ from other elements as follows:

## 1) Summary Statistics

- a) Only the initial gold value was used.
- b) Gold values less than the variable detection limit were set to 1 ppb.

## 2) Symbol and Value Gold Map

- a) Repeat analyses are listed in brackets following the initial determination.
- b) Symbol size represents an average of the initial and repeat analyses.
- c) Second repeat analyses are not included.
- d) Possible variations in map format presentation:
  - + ..... Data < 50<sup>th</sup> percentile
  - + 27..... Single analysis > 75<sup>th</sup> percentile
  - + 27(42).... Initial and first repeat analysis

In summary, geochemical follow-up investigations should be based on a careful consideration of all geological and geochemical information, and especially a thorough appraisal of gold geochemical data and its variability. In some cases, prospective follow-up areas may be indirectly identified by pathfinder element associations in favorable geology, although an anomalous gold response due to natural variability may be lacking. Once an anomalous area has been identified, field investigations should be designed to include detailed geochemical follow-up surveys and collection of large representative samples. Subsequent repeat subsample analyses will increase the reliability of results and permit a better understanding of natural variability which can then be used to improve sampling methodology and interpretation.

**Interpretation of Moss-Mat Sediment Results****Orientation Surveys**

Conventional stream sediment sampling in cool humid mountainous environments is severely hampered in high-energy streams by the lack of fine sediment. The problem is magnified in west-coast rainforests where stream drainage is highly efficient. In these environments, more than 4 kilograms of coarse-grained sediment must often be collected to provide enough sample material to satisfy RGS analytical requirements.

Orientation surveys (Matysek and Day, 1988) were conducted on northern Vancouver Island prior to the 1988 RGS program. Several sample media types were evaluated to determine the sampling method which would optimize logistical parameters such as time taken to collect a sample, without compromising geochemical parameters such as contrast and dispersion length. Initial results suggested that moss-mat sediments offered the best balance between cost effectiveness and ability to identify real geochemical trends.

Further studies were undertaken along several streams draining both mineralized and background areas on northern Vancouver Island to compare geochemical dispersion characteristics for moss-mat versus conventional stream sediments (Matysek et al., 1989). At McKay Creek, which drains the Mt. Washington copper-gold deposit, paired moss-mat sediment and stream sediment samples were collected at 500 metre intervals along a 5½ kilometre reach of the stream (Fig. 2). Both media produced similar concentrations and dispersion patterns for copper, arsenic and other base metals. In contrast, gold displayed a marked enrichment in moss-mat samples. At the lower-most sample station located furthest from the mineral occurrence, gold concentration in moss-mat sediment is up to 3 orders of magnitude greater than the matching stream sediment. Similar trends were obtained from other creeks draining fine-grained gold deposits. Relative to stream sediment results, moss-mat sediments are characterized by improved contrast and longer dispersion trains. Given these results, moss-mat sediments were collected exclusively on northern Vancouver Island for the 1988 RGS program.

## 1988 RGS Check Samples

A framework of reference was needed by which to compare the results of moss-mat sediments collected in the 1988 RGS program with conventional stream sediments. Stream sediment "check" samples were therefore collected at one in every twenty moss-mat sample sites (96 in total).

On average, moss-mat sediments yielded 4-5 times the amount of -80 mesh material relative to stream sediment check samples. A 1-2 kg moss-mat sample would produce a minimum of 100 gm of sieved material.

Comparison of concentrations for those elements which are typically hydromorphically dispersed such as copper, zinc, nickel, cobalt, arsenic and manganese show excellent correlation between sample types (Fig. 2). The correlation coefficient value  $r$  varies from a low of 0.79 for arsenic to a high of 0.96 for copper (Table 5). Relative elemental concentrations are also similar for both sample media types as evidenced by clustering of points around the unity line on the scatter diagrams.

Elements dispersed as heavy minerals (chromium, uranium, iron, vanadium, mercury and gold) exhibit enrichment in moss-mat sediment (Fig. 3). Regression lines were plotted as dashed lines for these elements. The degree of enrichment can be measured by the decreasing slope of the regression line. In general, correlation is seen between the specific gravity of the most commonly occurring mineral form for each element and the degree of enrichment (Table 5). Chromite with a specific gravity of 3.5 to 4.1 gm/cm<sup>3</sup> is weakly enriched. Gold, having a specific gravity of 15.5 to 19.4 gm/cm<sup>3</sup> is strongly enriched. Mercury, having a specific gravity of 8.2 gm/cm<sup>3</sup> in the form of cinnabar, is only moderately enriched.

## Possible Mechanism of Heavy Mineral Entrapment

Moss mats are commonly found on the top and downstream faces of boulders and logs. The mats are submerged during floods caused by heavy precipitation or spring runoff. During these events fine-grained heavy minerals will be carried in suspension and trapped by perched moss mats. Sediment is likely deposited in two manners; a) gravity deposition by reduction of water turbulence over the mat much like the grid in a sluice box and b) filter deposition as sediment-laden waters pass through the dense growth of moss fronds much like a coffee filter. Enrichment in heavy minerals appears to be a dynamic process between gravity deposition and flushing of the mat. At high flood stages, water

velocity over the mat may allow deposition of only high density minerals. As the flood wanes, decrease in flow velocity allows progressive trapping of lighter minerals. During the next flood, some of these lighter minerals may be flushed from the mat resulting in a concentration of high density minerals such as gold, magnetite and chromite.

## Conclusions

In humid mountainous environments, the collection of moss-mat sediments offers several advantages over conventional stream sediments:

1. Moss-mats are easily located and sampled.
2. Moss-mats provide 4 - 5 times more -80 mesh sediment for RGS analyses.
3. Elements transported hydromorphically exhibit similar concentrations and dispersion characteristics to stream sediments.
4. High density minerals are enriched relative to stream sediments, with the degree of enhancement apparently related to the specific gravity of the mineral.

Overall, the detection of gold or other heavy mineral deposits within drainage systems will be improved due to higher concentrations and longer dispersion trains.

## Acknowledgements

The authors wish to recognize the Geological Survey of Canada for their continued cooperation in the RGS program. Their work on GSC Open File 1649 has been a valuable source of ideas which we have used in the development of our new format. The authors also wish to thank Pamap Graphics Ltd. of Victoria for the speedy development of software required to produce the statistics in this booklet.



TABLE 5 Correlation Coefficients and Regression Line Values for Paired Moss-mat and Stream Sediment Check Samples					
ELEMENT	Corr. Coef.	Regression Line		Heavy Mineral	Spec. Grav. gm/cm <sup>3</sup>
		Slope	Y intercept		
COPPER*	0.96	0.96	0.06	nil	nil
ZINC*	0.91	0.96	0.06	nil	nil
NICKEL	0.83	0.93	3.02	nil	nil
COBALT	0.88	0.91	2.16	nil	nil
ARSENIC*	0.81	0.69	0.35	nil	nil
MANGANESE*	0.85	0.95	0.09	nil	nil
CHROMIUM	0.81	0.80	11.28	chromite	3.5 - 4.1
URANIUM	0.84	0.75	0.22	zircon	4.7
IRON	0.51	0.44	2.29	magnetite	5.1 - 5.2
VANADIUM	0.64	0.52	112.54	magnetite	5.1 - 5.2
MERCURY*	0.65	0.65	0.63	cinnabar	8.2
GOLD*	0.32	0.26	0.37	gold	15.5-19.4
* Corr. Coef. and Regression calculated using log values.					

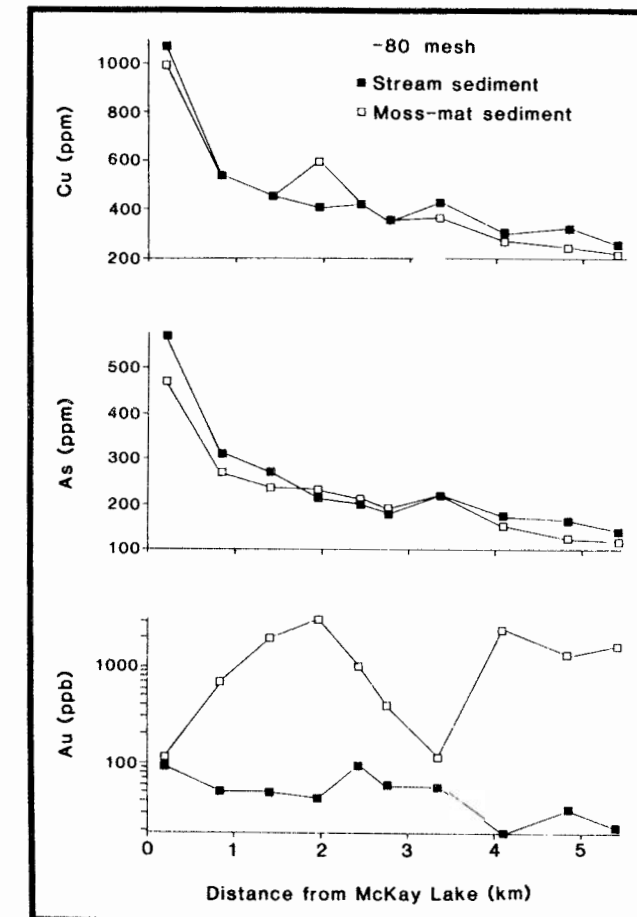
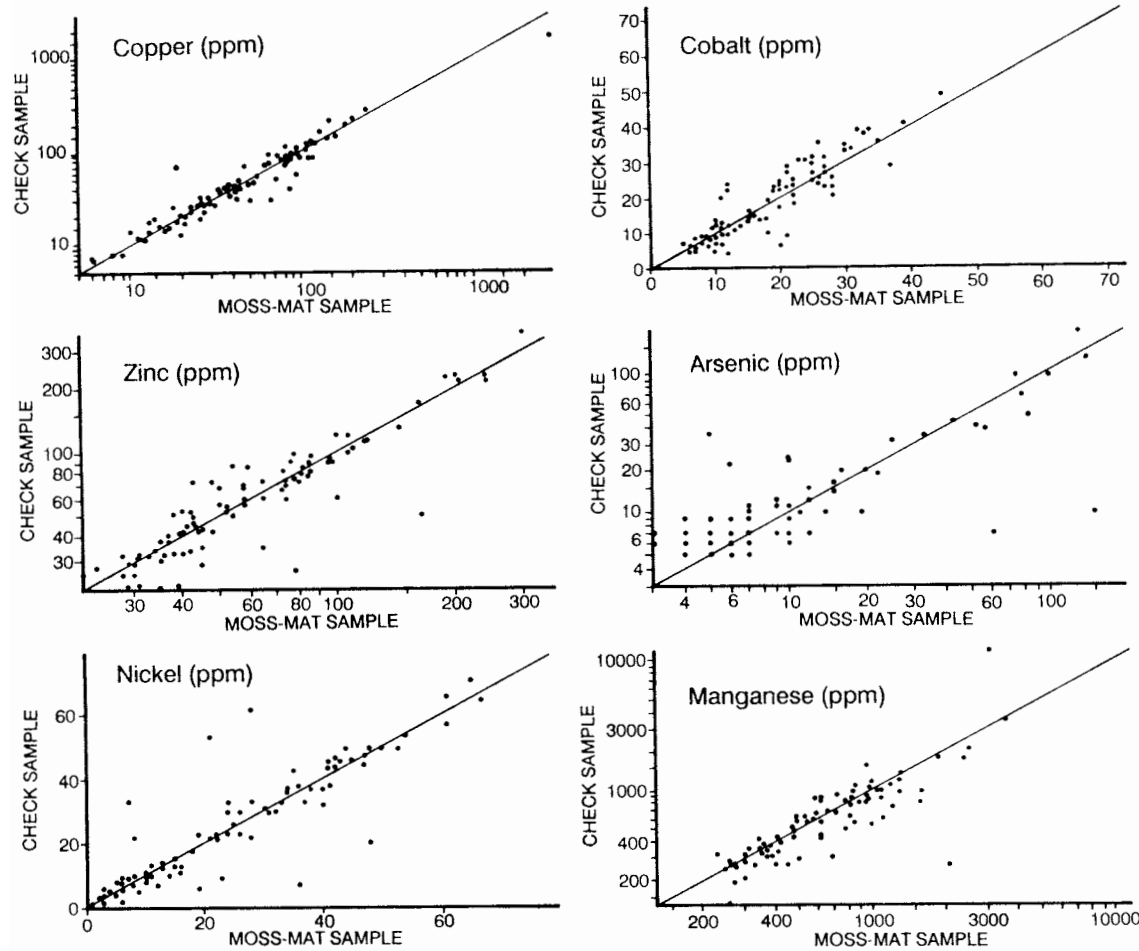


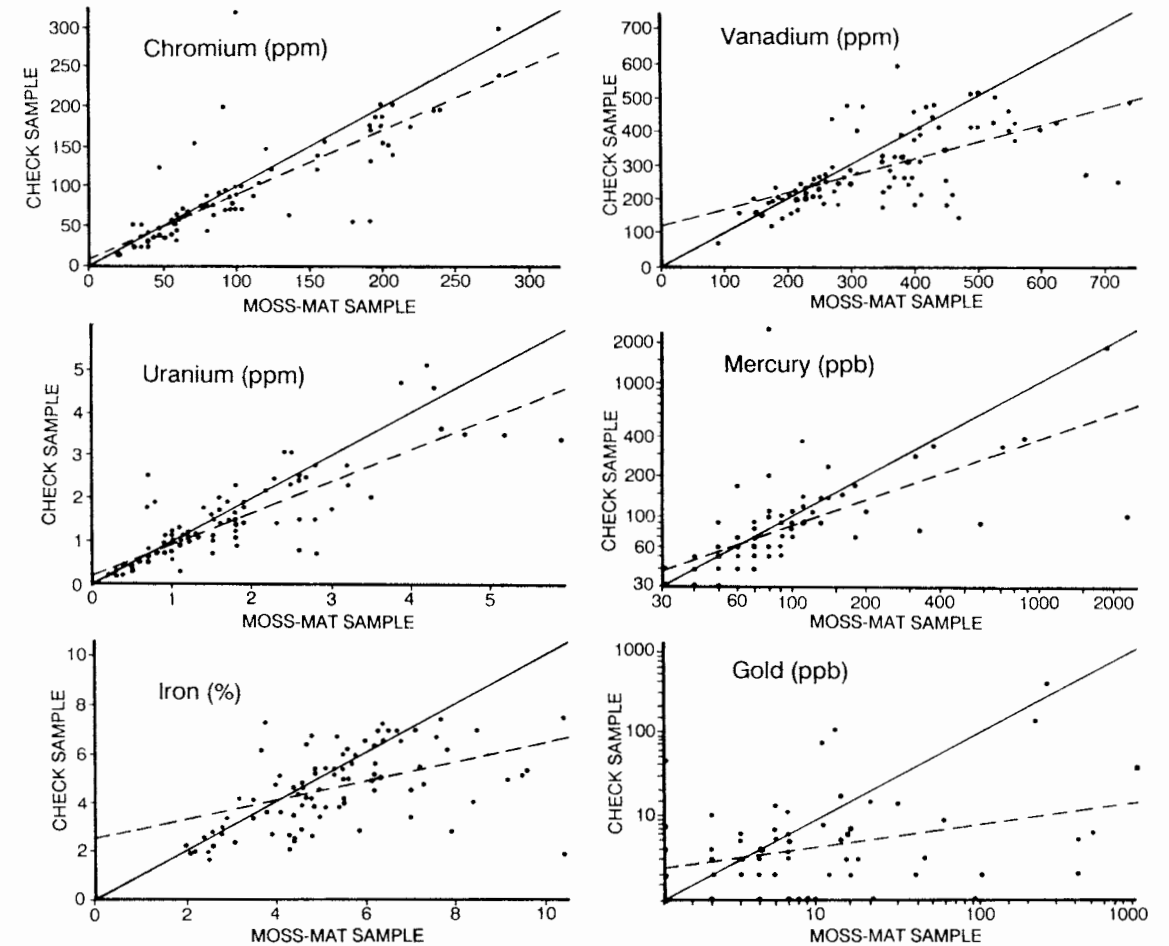
Figure 2.

Down stream dispersion patterns for copper, arsenic and gold in moss-mat sediment and conventional stream sediment in McKay Creek, central Vancouver Island.

### ELEMENTS DISPERSED HYDROMORPHICALLY



### ELEMENTS DISPERSED AS HEAVY MINERALS



**Figure 3.** Scatter diagrams comparing concentrations of elements dispersed hydromorphically (copper, zinc, nickel, cobalt, arsenic and manganese) and elements dispersed as heavy minerals (chromium, uranium, iron, vanadium, mercury and gold) in 96 paired stream sediment check samples and moss-mat sediment samples. Solid sloped lines are the unity lines, points plotting along these lines are sample pairs having equal elemental concentrations. Sloped dashed lines are least squares regression lines.

Table 2. Geology of Bute Inlet Map Sheet - NTS 92K

FORM- ATION	ROCK TYPE	AGE	DESCRIPTION	FORM- ATION	ROCK TYPE	AGE	DESCRIPTION	FORM- ATION	ROCK TYPE	AGE	DESCRIPTION
<u>STRATIFIED ROCKS</u>								<u>PLUTONIC ROCKS</u>			
<b>QUATERNARY</b>				<b>TRIASSIC</b>				<b>JURASSIC</b>			
Q	TILL	64	Alluvial and glacial deposits	Upper Triassic				qm	QTMZ	51	Quartz monzonite
<b>CRETACEOUS</b>				<u>Vancouver Group</u>				gd	GRDR	51	Granodiorite
Lower Cretaceous				Karmutsen Formation:				qd	QRZD	51	Quartz diorite
1KG	GRNS	53	Greenstone, volcanic breccia, argillite, minor conglomerate limestone and schist	uTK	BSLT	45	Upper: Basalt flows, minor limestone, shale, pillow lava and pillow breccia	di	DORT	51	Diorite
				uTKm	VLBX	45	Middle: Pillow Breccia and aquagene tuff	gb	GBBR	51	Gabbro
<b>JURASSIC</b>				uTKl	BSLT	45	Lower: Closely packed pillow lava				
Lower Jurassic								<u>HYPABYSSAL ROCKS</u>			
1JB	ANDS	48	Andesite flows, pyroclastics	<b>PALEOZOIC AND/OR TRIASSIC</b>				<b>JURASSIC</b>			
1JH	ARGL	48	Harbledown Formation: feldspathic wacke, siliceous argillite, phyllite, minor limestone and quartzite	PT	AMPH	9	Amphibolite, schist, quartzite, minor crystalline limestone, greenstone	f	FLSP	51	Felsite
<b>TRIASSIC</b>				<b>PALEOZOIC OR OLDER</b>							
Upper Triassic				gn	GNSS	9	Granitoid gneiss, amphibolite and schist				
<u>Vancouver Group</u>											
uTPB	SHLE	45	Parson Bay Formation: limy shale, calcarenite, wacke								
uTQ	LMSN	45	Quatsino Formation: limestone								
								(after Roddick, 1977)			

Table 3. Reference Guide for Field Observations

Column	Definition and Descriptions	Column	Definition and Descriptions	Column	Definition and Descriptions	
MAP	1:50 000 NTS map sheet number	SED COL	Sediment Colour: B = Black                      R = Red G = Grey-Blue                T = Tan-Brown O = Olive-Green              W = White-Buff P = Pink                        Y = Yellow	CHL PTN	Channel Pattern: S=Shoots-Pools    M=Meandering B=Braided            D=Disturbed	
SAMPLE ID	Sample number			ELEV	Elevation: in metres	
UTM ZONE	UTM Zone Number			PHY	Physiography: H=Hilly                      P=Plateau L=Lowland                  S=Swamp M=Mature                   Y=Youthful mountains	
UTM EAST	UTM East Coordinate	CON	Contamination: N = None                      D = Domestic P = Possible                  F = Forestry A = Agricultural              M = Mining			
UTM NORTH	UTM North Coordinate					SED COMP
STA	Replicate Sample Status: 0 = Routine Sample 1 = 1st Field Duplicate 2 = 2nd Field Duplicate 8 = Blind Duplicate 9 = Control Reference			STRM WPTH	Stream Width: in metres	
MED	Sample Media Collected: 1 = Stream Sediment only 6 = Stream Sediment & Water 7 = Moss-Mat Sediment only 8 = Moss-Mat Sediment & Water	STRM DPTH	Stream Depth: in centimetres			
FORMATION	(                      ) Formation					BNK
ROCK TYPE	(see Table 2) underlying			M	HGHT	
AGE	(                      ) sample site	COLR	Colour: L=light green D =Dark green    B =Brown-black			
WAT COL	Water Colour: 0 = Colourless    2 = White Cloudy 1 = Brown Clear 3 = Brown Cloudy					HLTH
FLW	Water Flow Rate: 0 = Stagnant            3 = Fast 1 = Slow                4 = Torrent 2 = Moderate			HOST	Host: 1=Rock    2=Friable Rock 3=Log        4=Decomposed Log	
		THCK	Thickness of Mat: centimetres			

**Table 4. Methods and Specifications for Sample Analysis**

Element	Units	Detection Limits	Sample Weight	Digestion Technique	Determination Method	
Gold	ppb	1 ppb 2 ppb 4 ppb	10 gm 5 gm 2.5 gm	Fire Assay fusion	<b>FA-NA</b>	Neutron Activation on dore bead: detection limit doubles each time sample weight is halved
Cadmium Cobalt Copper Iron Lead Manganese Nickel Silver Zinc	ppm ppm ppm % ppm ppm ppm ppm ppm	0.2 ppm 2 ppm 2 ppm 0.02 % 2 ppm 5 ppm 2 ppm 0.2 ppm 2 ppm	1 gm	3 ml HNO <sub>3</sub> let sit over-night, add 1 ml HCl in 90°C water bath for 2 hrs cool add 2 ml H <sub>2</sub> O wait 2	<b>AAS</b>	Atomic Absorption Spectrophotometer using air-acetylene burner and standard solutions for calibration, background corrections made for Pb, Ni, Co, Ag, Cd.
Molybdenum	ppm	1 ppm	0.5 gm	Al solution added to above		
Barium Vanadium Chromium	ppm ppm ppm	10 ppm 5 ppm 5 ppm	1 gm	HNO <sub>3</sub> -HCl-HF taken to dryness, hot HCl added to leach residue		
Bismuth Antimony	ppm ppm	0.2 ppm 0.2 ppm	2 gm	HCl - KClO <sub>2</sub> digestion, KI added to reduce Fe, MIBK and TOPO for extraction	<b>AAS</b>	Organic layer analyzed by Atomic Absorption Spectrophotometry with background correction
Tin	ppm	1 ppm	1 gm	sintered with NH <sub>4</sub> I, HCl & ascorbic acid leach	<b>AAS</b>	Atomic Absorption Spectrophotometry

**Table 4. (Continued) Methods and Specifications for Sample Analysis**

Element	Units	Detection Limits	Sample Weight	Digestion	Determination Method	
Arsenic	ppm	1 ppm	0.5 gm	add 2 ml KI & dil. HCl to .8M HNO <sub>3</sub> - .2M HCl	<b>AAS-H</b>	2 ml borohydride solution is added to produce AsH <sub>3</sub> gas which is passed through heated quartz tube in the light path of Atomic Absorption Spectrophotometer (after Aslin, 1976)
Mercury	ppb	10 ppb	0.5 gm	20 ml HNO <sub>3</sub> & 1 ml HCl	<b>AAS-F</b>	10% stannous sulphate added to evolve mercury vapour Atomic Absorption Spectrometer determination (after Jonasson et al., 1973)
Tungsten	ppm	1 ppm	0.5 gm	K <sub>2</sub> SO <sub>4</sub> fusion HCl leach	<b>COLOR</b>	colorimetric: reduced tungsten complexed with toluene 3,4 dithiol
Fluorine	ppm	40 ppm	0.25 gm	NaCO <sub>3</sub> -KNO <sub>3</sub> fusion H <sub>2</sub> O H <sub>2</sub> O leach	<b>ION</b>	Citric acid added and diluted with water, Fluorine determined with specific ion electrode (after Ficklin, 1970)
Uranium	ppm	0.5 ppm	1 gm	nil	<b>NADNC</b>	Neutron Activation with delayed neutron counting (after Boulanger et al., 1975)
LOI	%	0.1 %	0.5 gm	nil	<b>GRAV</b>	Sample ashed (500°C), weight difference measured
pH - water	pH unit	0.1	25 ml	nil	<b>GCE</b>	Glass-calomel electrode system
U - water	ppb	0.05 ppb	5 ml	nil	<b>LIF</b>	add .5 ml Fluran place in Scintrex UA-3 analyzer
F - water	ppb	20 ppb	25 ml	nil	<b>ION</b>	Fluorine measured by ion specific electrode

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