BRITISH COLUMBIA GEOLOGICAL SURVEY

Province of British Columbia
Ministry of Energy Mines and Petroleum Resources

Mineral Resources Division
Geological Survey Branch
Applied Geochemistry

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Resource Geophysics and Geochemistry Division

1988
BRITISH COLUMBIA REGIONAL GEOCHEMICAL SURVEY

STREAM SEDIMENT AND WATER GEOCHEMICAL DATA

NTS 92E - NOOTKA SOUND

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

MEMPR BC RGS 21

GSC O.F. 2038

1988 Regional Geochemical Survey
92E - Nootka Sound

British Columbia Regional Geochemical Survey - RGS 21
Geological Survey of Canada Open File 2038

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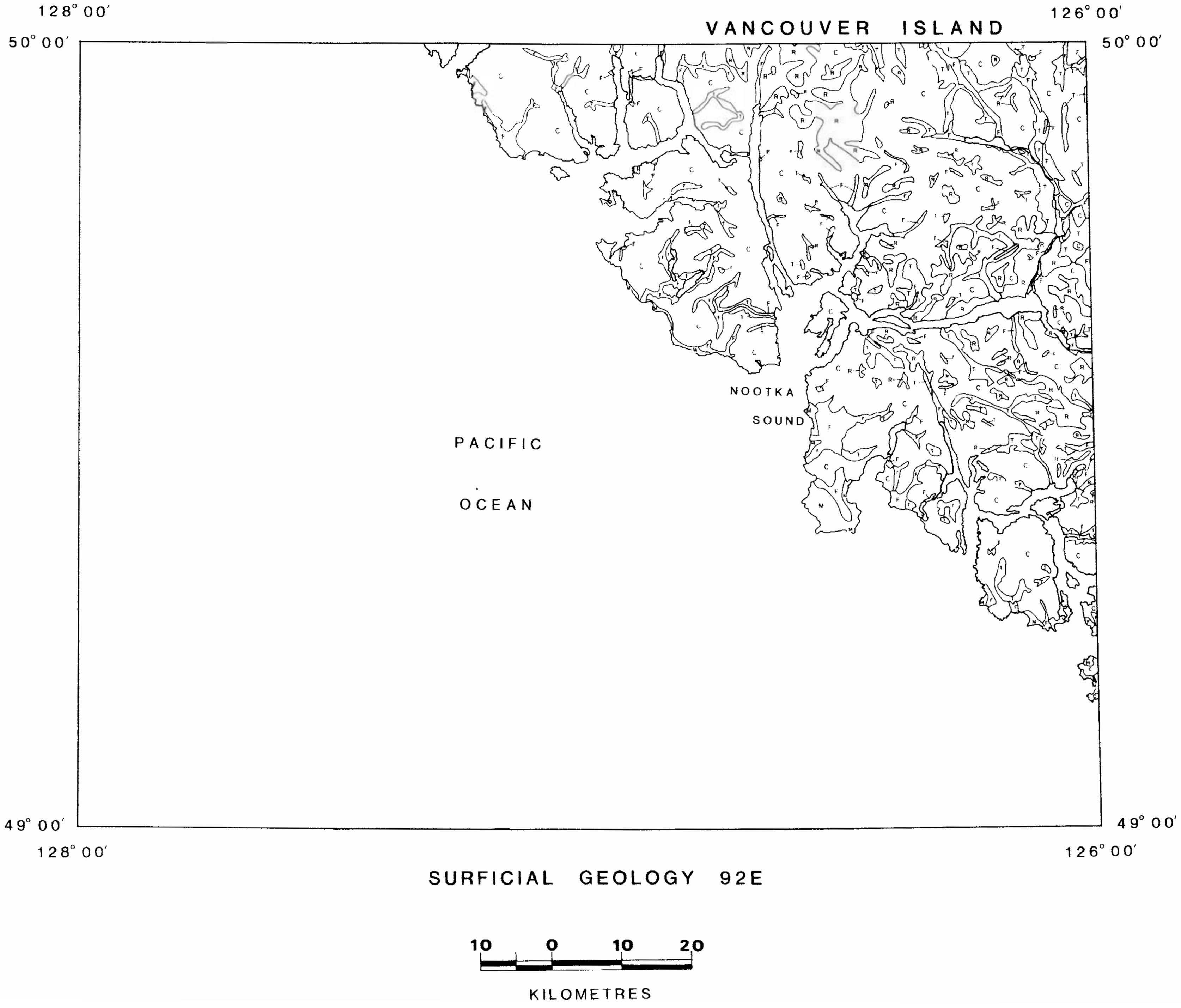

SURFICIAL GEOLOGY 92E

LEGEND

M	**MARINE SEDIMENTS:** Includes raised off-shore deposits of clayey silt and littorial deposits of sands and gravel which may overlay off-shore sediments.
C	**COLLUVIAL SEDIMENTS:** Areas of colluvial sediments generally less than 5 m thick, includes colluvial blankets and talus deposits, mudflow fans, rockslide debris and avalanche fans. May include some rock outcrops.
F	**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.
T	**TILL:** Areas of till less than 5 m thick. May include till blankets and constructional landforms such as hummocky or gently rolling till plains and drumlins.
B	**BEDROCK:** Areas consisting of bedrock or bedrock covered by less than 10 cm of unconsolidated materials; includes pockets of shallow colluvium and/or till (<1 m).

Legend and map modified from Howes (1981)

Introduction

Open File package *BC RGS-21/GSC 2038* (Nootka Sound - NTS 92E) 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 21* presents the results of moss-mat 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 21* consists of a data booklet and a set of 28 maps. The maps include (1) 1:250 000 scale and (3) 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 GEOCHEMISTRY STAFF
■ P.F. Matysek : directed the survey
■ J.L. Gravel : coordinated staff and contract operations
■ 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 Nootka Sound map sheet covers approximately 4000 km^2 comprising fiord-land along the coast and the Vancouver Island Range mountains inland. Surficial geology (Fig. 1) comprises residual material on the highest mountain tops with till and colluvium on most slopes. Fluvial sediments occupy most river basins and a thin band of marine sediment lies along the coast (Howes, 1981). Underlying the area are volcanic and sedimentary rocks of Pennsylvanian to Jurassic age belonging to the Sicker, Vancouver and Bonanza Groups which are intruded by plutons of Jurassic to Tertiary age (Table. 2). Geological underlay for the open file maps used GSC map 1537A (Muller, 1981). Typical mineral occurrences are: mesothermal gold veins (Independence), copper skarns (Indian Chief) and iron skarns (Muller et al. 1981). Potential exists for the discovery of massive sulphides within the Sicker rocks. Assessment reports for the years 1981 to 1987 indicate the general level of activity is fairly low (Gravel and Matysek, 1989).

Sampling Program

A total of 385 sites were sampled for moss-mat sediment and stream water at a density averaging 1 site per 10.5 km^2 (Table 1). Fifty-seven percent of the samples were collected by truck and boat; the remaining samples (43%) 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. 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 50th, 75th, 90th and 95th percentile. Analytical determinations are listed adjacent to symbols for all samples exceeding the 75th 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 - 92E Nootka Sound

Map Sheet	Moss Mat	Strm Seds	Total Sites	Area km^2	Density km^2/Site
08	55	0	55	570	10.4
09	86	0	86	930	10.9
10	35	0	35	425	12.1
14	22	0	22	225	10.2
15	93	0	93	840	8.7
16	94	0	94	985	10.7
Total	385	0	385	3975	10.5

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 95th 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 < 50th percentile
+ 27.......... Single analysis > 75th 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 in 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^3 is weakly enriched. Gold, having a specific gravity of 15.5 to 19.4 gm/cm^3 is strongly enriched. Mercury, having a specific gravity of 8.2 gm/cm^3 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 Slope	Y intercept	Heavy Mineral	Spec. Grav. gm/cm^3
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.

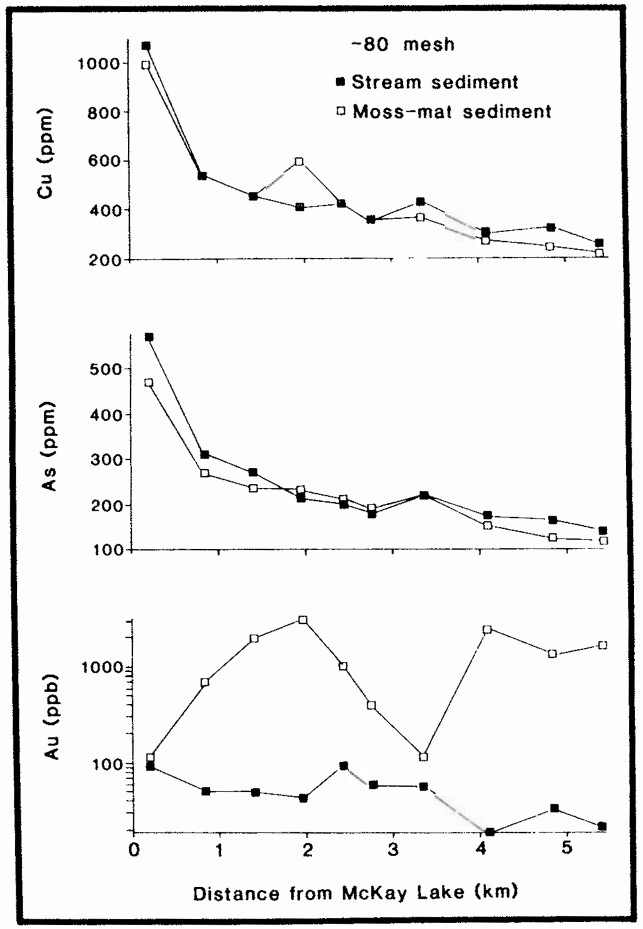

Figure 2. Down stream dispersion patterns for copper, arsenic and gold in moss-mat sediment and conventional stream sediment in McKay Creek, central Vancouver Island.

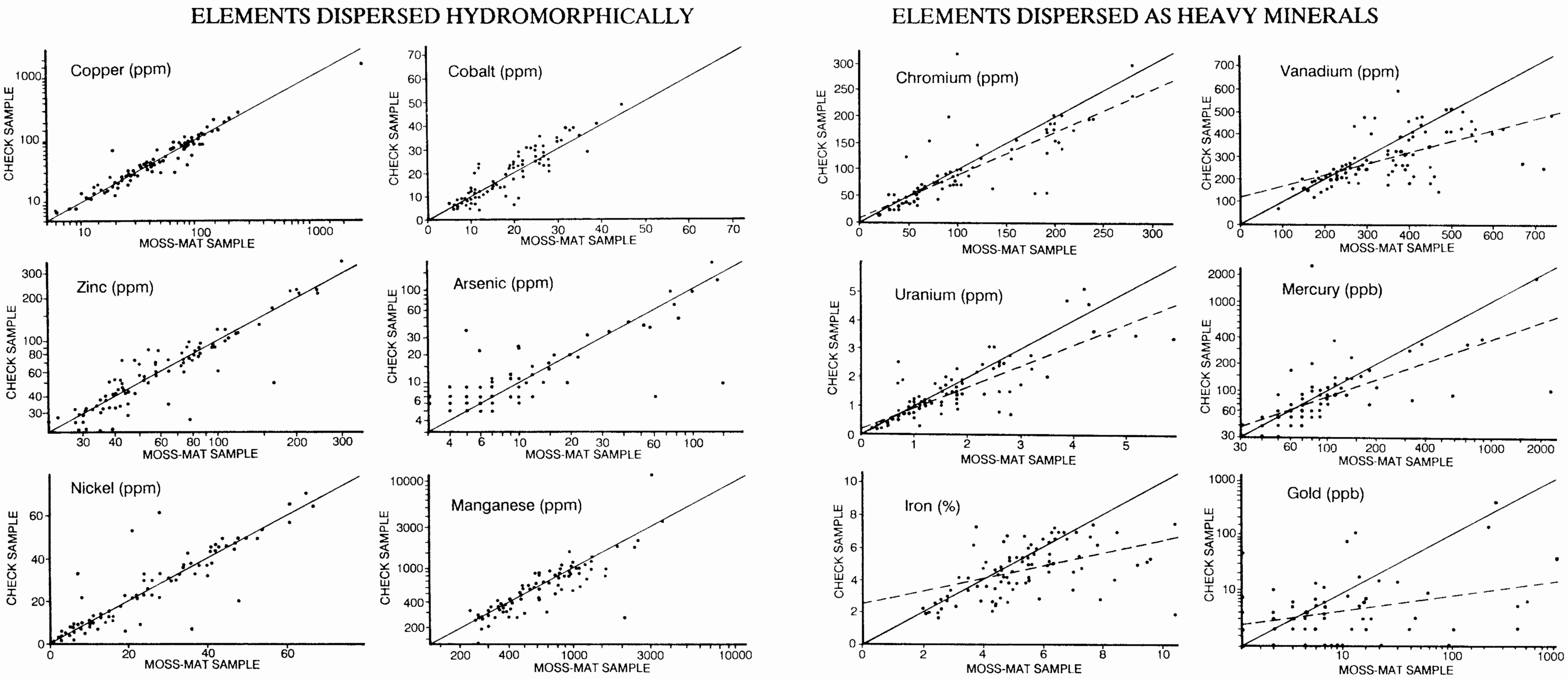

Figure 3. Scatter diagrams comparing concentrations of elements dispersed hydromorphically (copper, zinc, nickel, cobalt, arsenic and manganese) and elements dispersed as heavy minerals (chromium, uranium, iron, vanadium, mercury and gold) in 96 paired stream sediment check samples and moss-mat sediment 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 Nootka Sound Map Sheet - NTS 92E

FORMATION	ROCK TYPE	AGE	DESCRIPTION
			STRATIFIED ROCKS
TERTIARY			
			Oligocene and/or Miocene
			Carmanah Group
Ts	CGLM	60	Sooke Formation: conglomerate sandstone
			Eocene and Oligocene
lTH	SLSN	59	Hesquiat Formation: siltstone shale,sandstone,conglomerate
lTE	SNDS	59	Escalante Formation:sandstone conglomerate
JURASSIC AND CRETACEOUS			
JKP	GRCK	51	Pacific Rim Complex:greywacke siltstone, conglomerate, ribbon chert, pillow lava
			Lower Cretaceous
			Kyuquot Group
lKOT	SLSN	53	One Tree Formation: siltstone calcareous grit, sandstone
			Middle and Upper Jurassic
muJK	SLSN	49	Kapoose Formation: siltstone, shale, greywacke,conglomerate
JURASSIC			
			Lower Jurassic
			Bonanza Group
lJB	BTRT	48	Basaltic to rhyodacitic lava, tuff, breccia, greywacke
			Middle and Upper Triassic
			Vancouver Group
uTPB	SLSN	44	Parson Bay Formation: calcareous siltstone, shale, limestone
uTQ	LMSN	44	Quatsino Formation: limestone
uTK	BSLT	44	Karmutsen Formation: Layered and pillowed basalt, aquagene tuff, breccia
PENNSYLVANIAN			
			Sicker Group
CPs	GRCK	33	Greywacke, argillite, limestone, meta-diabase sills
			PLUTONIC ROCKS
EOCENE			
Tg	TNLT	59	Catface Intrusions: tonalite, granodiorite, hornblende-plagioclase porphyry
JURASSIC			
Jg	GRDR	47	Island Intrusions: quartz-diorite, granodiorite, granite
			METAMORPHIC ROCKS
PALEOZOIC AND MESOZOIC			
			Westcoast Complex
PMsv	SCST	40	Actinolite schist, amphibolite, metasediments
PMdn	QRZD	40	Quartz diorite, tonalite, magmatite, gneiss, amphibolite

Table 3. Reference Guide for Field Observations

Column	Definition and Descriptions
MAP	1:50 000 NTS map sheet number
SAMPLE ID	Sample number
UTM ZONE	UTM Zone Number
UTM EAST	UTM East Coordinate
UTM NORTH	UTM North Coordinate
STA	Replicate Sample Status: **0** = Routine Sample **1** = 1st Field Duplicate **2** = 2nd Field Duplicate **8** = Blind Duplicate **9** = Control Reference
MED	Sample Media Collected: **1** = Stream Sediment only **6** = Stream Sediment & Water **7** = Moss-Mat Sediment only **8** = Moss-Mat Sediment & Water
FORMATION **ROCK TYPE** **AGE**	( ) (see Table 2) ( )
WAT COL	Water Colour: **0** = Colourless **2** = White Cloudy **1** = Brown Clear **3** = Brown Cloudy
FLW	Water Flow Rate: **0** = Stagnant **3** = Fast **1** = Slow **4** = Torrent **2** = Moderate
SED COL	Sediment Colour: **B** = Black **R** = Red **G** = Grey-Blue **T** = Tan-Brown **O** = Olive-Green **W** = White-Buff **P** = Pink **Y** = Yellow
SED PPT	Sediment Precipitate: N = None (otherwise same as SED COL)
CON	Contamination: **N** = None **D** = Domestic **P** = Possible **F** = Forestry **A** = Agricultural **M** = Mining
SED COMP	Sediment Composition: estimate of Sand-Fines-Organic content **0** = Absent **1** = Minor (<1/3 of total) **2** = Moderate (>1/3 but <2/3) **3** = Major (>2/3 of total)
STRM WDTH	Stream Width: in metres
STRM DPTH	Stream Depth: in centimetres
BNK	Bank Composition: **A** = Alluvium **R** = Rock **C** = Colluvium **S** = Talus **G** = Outwash **T** = Till **O** = Organic **U** = Unknown
BNK PPT	Bank Precipitate: **N** = None (otherwise same as SED COL)
CHL BED	Channel Bed: **B** = Boulders **S** = Gravel-Sand **F** = Silt-Clay **O** = Organics
CHL PTN	Channel Pattern: **S**=Shoots-Pools **M**=Meandering **B**=Braided **D**=Disturbed
ELEV	Elevation: in metres
PHY	Physiography: **H**=Hilly **P**=Plateau **L**=Lowland **S**=Swamp **M**=Mature mountains **Y**=Youthful
DRN	Drainage Pattern: **D**=Dendritic **H**=Herringbone **G**=Glacially deranged **I**=Interrupted **R**=Rectangular
TYP	Stream Type: **P**=Permanent **S**=Seasonal
ODR	Stream Order: **1**=Primary **3**=Tertiary **2**=Secondary **4**=Quaternary
SRC	Stream Source: **G**=Groundwater **S**=Spring runoff **M**=Melt water **U**=Unknown
MOSS **HGHT**	Height: above stream in metres
COLR	Colour: **L**=light green **D** =Dark green **B** =Brown-black
HLTH	Health: **A** = Alive **D** = Dead
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	10 gm	Fire Assay fusion	**FA-NA**	Neutron Activation on dore bead: detection limit doubles each time sample weight is halved
		2 ppb	5 gm			
		4 ppb	2.5 gm			
Cadmium	ppm	0.2 ppm	1 gm	3 ml HNO_3 let sit over-night, add 1 ml HCl in 90°C water bath for 2 hrs cool add 2 ml H_2O wait 2	**AAS**	Atomic Absorption Spectrophotometer using air-acetylene burner and standard solutions for calibration, background corrections made for Pb, Ni, Co, Ag, Cd.
Cobalt	ppm	2 ppm				
Copper	ppm	2 ppm				
Iron	%	0.02 %				
Lead	ppm	2 ppm				
Manganese	ppm	5 ppm				
Nickel	ppm	2 ppm				
Silver	ppm	0.2 ppm				
Zinc	ppm	2 ppm				
Molybdenum	ppm	1 ppm	0.5 gm	Al solution added to above		
Barium	ppm	10 ppm	1 gm	HNO_3-HCl-HF taken to dryness, hot HCl added to leach residue		
Vanadium	ppm	5 ppm				
Chromium	ppm	5 ppm				
Bismuth	ppm	0.2 ppm	2 gm	HCl - $KClO_2$ digestion, KI added to reduce Fe, MIBK and TOPO for extraction	**AAS**	Organic layer analyzed by Atomic Absorption Spectrophotometry with background correction
Antimony	ppm	0.2 ppm				
Tin	ppm	1 ppm	1 gm	sintered with NH_4I, HCl & ascorbic acid leach	**AAS**	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_3 - .2M HCl	**AAS-H**	2 ml borohydride solution is added to produce AsH_3 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_3 & 1 ml HCl	**AAS-F**	10% stannous sulphate added to evolve mercury vapour Atomic Absorption Spectrometer determination (after Jonasson et al., 1973)
Tungsten	ppm	1 ppm	0.5 gm	$K2SO_4$ fusion HCl leach	**COLOR**	colorimetric: reduced tungsten complexed with toluene 3,4 dithiol
Fluorine	ppm	40 ppm	0.25 gm	$NaCO_3$-KNO_3 fusion H_2O H_2O leach	**ION**	Citric acid added and diluted with water, Fluorine determined with specific ion electrode (after Ficklin, 1970)
Uranium	ppm	0.5 ppm	1 gm	nil	**NADNC**	Neutron Activation with delayed neutron counting (after Boulanger et al., 1975)
LOI	%	0.1 %	0.5 gm	nil	**GRAV**	Sample ashed (500°C), weight difference measured
pH - water	pH unit	0.1	25 ml	nil	**GCE**	Glass-calomel electrode system
U - water	ppb	0.05 ppb	5 ml	nil	**LIF**	add .5 ml Fluran place in Scintrex UA-3 analyzer
F - water	ppb	20 ppb	25 ml	nil	**ION**	Fluorine measured by ion specific electrode

References

Aslin, G.E.M. (1976) The Determination of Arsenic and Antimony in Geological Materials by Flameless Atomic Absorption Spectrophotometer: Journal of Geochemical Exploration, Vol. 6, pp. 321- 330.

Boulanger, A., Evans, D.J.R. and Raby, B.F. (1975) Uranium Analysis by Neutron Activation Delayed Neutron Counting: Proceedings of the 7th Annual Symposium of Canadian Mineral Analysts. Thunder Bay, Ontario, Sept. 22-23, 1975.

Clifton, H.E., Hunter, R.E., Swanson, F.J. and Phillips, R.L. (1969) Sample Size and Meaningful Gold Analysis. U.S. Geological Survey, Professional Paper, 625-C

Ficklin, W.H. (1970) A Rapid Method for the Determination of Fluorine in Rocks and Soils, Using an Ion Selective Electrode. U.S. Geological Survey, Paper 700C, pp. C186-188.

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

Harris, J.F. (1982) Sampling and Analytical Requirements for Effective use of Geochemistry in Exploration for Gold. In Levinson, A.A., editor; Precious Metals in the Northern Cordillera, Proceedings of a symposium sponsored by the Association of Exploration Geochemists and the Cordilleran Section of the Geological Association of Canada, pp. 53-67.

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

Jonasson, I.R., Lynch, J.J. and Trip, L.J. (1973) Field and Laboratory Methods used by the Geological Survey of Canada in Geochemical Surveys: No. 12, Mercury in Ores, Rocks, Soils, Sediments and Water: Geological Survey of Canada, Paper 73-21.

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 Geochemistry Subsection: Highlights of 1988 Activities, B.C. Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork 1988, Paper 1989-1, pp. 579-583.

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.