Applied Geochemistry

APPLIED GEOCHEMISTRY SUBSECTION: HIGHLIGHTS OF 1988 ACTIVITIES

By Paul F. Matysek, Stephen J. Day and John L. Gravel

KEYWORDS: British Columbia, applied geochemistry, Regional Geochemical Surveys, orientation surveys, sampling procedures, data analysis.

INTRODUCTION

The Applied Geochemistry Subsection of the British Columbia Geological Survey Branch was formed in 1986 to manage and provide Regional Geochemical Surveys (RGS), complimentary research and orientation surveys designed to promote the effective use of exploration geochemistry by industry. This paper highlights some of the subsection's 1988 investigations.

REGIONAL GEOCHEMICAL SURVEY PROGRAM (RGS)

To date, almost half of British Columbia (approximately 420 000 square kilometres) has been sampled at an average density of one sample every 12.5 square kilometres (33 500 samples). Results from these surveys are available in both open file and floppy diskette format. Complete reconnaissance coverage of the province is anticipated by 1997 at current sampling rates. Further details of the RGS program are described by Matysek (1987).

1988 RGS RELEASE — NORTHWESTERN BRITISH COLUMBIA

Data from the joint federal-provincial reconnaissance Regional Geochemical Survey completed in the summer of 1987 were simultaneously released on July 27 and July 29, 1988, in Stewart, Dease Lake and Vancouver (Figure 5-1-1). As expected, the release was well attended, benefiting from the high level of exploration activity in the survey area. The addition of the 1:100 000 sample-location maps and highly visible RGS aluminum site-identification tags proved helpful in claim staking. The availability of data on diskette enabled at least one company to process the data on site at the release and thus effect a rapid interpretation and target selection. A total of 205 Open File datasets and 47 floppy diskettes have been sold to November 15, 1988.

Survey results clearly outlined areas of known mineralization and identified several new regions of elevated precious and base metal concentrations, especially in the Sumdum map area (104°F). Simple sorting of the data on the basis of the age of underlying lithologies at the sample site indicates that 40 per cent (N = 85) of gold values greater than 50 ppb are associated with Triassic rocks. Similarily, close to 41 per cent (N = 48) of gold values greater than 100 ppb were collected from sites with a high volcanic component in the bedrock geology.

1988 RGS ENHANCEMENTS

In an ongoing effort to improve the quality of the RGS program, the Applied Geochemistry Subsection routinely conducts orientation surveys in areas selected for future surveys. These studies aid in the optimization of RGS parameters such as sample medium, sampling pattern, analytical procedures, interpretation and data presentation so that genuine regional geochemical and geological features and trends can be identified. As a result of the 1987 orientation studies (Matysek and Day, 1988), a number of new enhancements in sample collection procedures and data evaluation techniques were established.

NEW SAMPLE MEDIUM ON VANCOUVER ISLAND: MOSS-MAT SEDIMENTS

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 predicament, orientation studies were conducted (Matysek and Day, 1988) focusing on the applicability of fines-rich moss-mat sediments as an alternative sample medium. Assessment of field and analytical data obtained from detailed stream and moss-mat sediment sampling of 30 drainage basins on northern Vancouver Island indicated that moss mats are ubiquitous, easily sampled and yield up to 50 per cent more –80 mesh (fine sands, silts) material than stream sediments. In addition:

- Determinations of several elements are similar for both stream and moss-mat sediment samples.
- Elements dispersed as heavy minerals are concentrated up to 100-fold in moss mats.
- Background to anomaly contrast for gold is up to an order of magnitude greater in moss-mat sediments.

Based on these data, collection of moss-mat sediments on Vancouver Island was initiated for the 1988 RGS program. Details on results of this year's program are described in Gravel and Matysek (1989, this volume).

NEW RGS FIELD-DATA CARD

During collection of drainage sediments for Regional Geochemical Surveys, it has become customary to record categorical observations of characteristics of the drainage catchment (for example, drainage pattern), sample site (for example, site contamination) and sediment sample (for example, sediment colour). Despite their subjective character, categorical field observations can be related to significant variations in metal content of drainage sediments associated with a single rock unit (Matysek, 1985). New field-data cards were designed for the 1988 RGS program to improve data

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

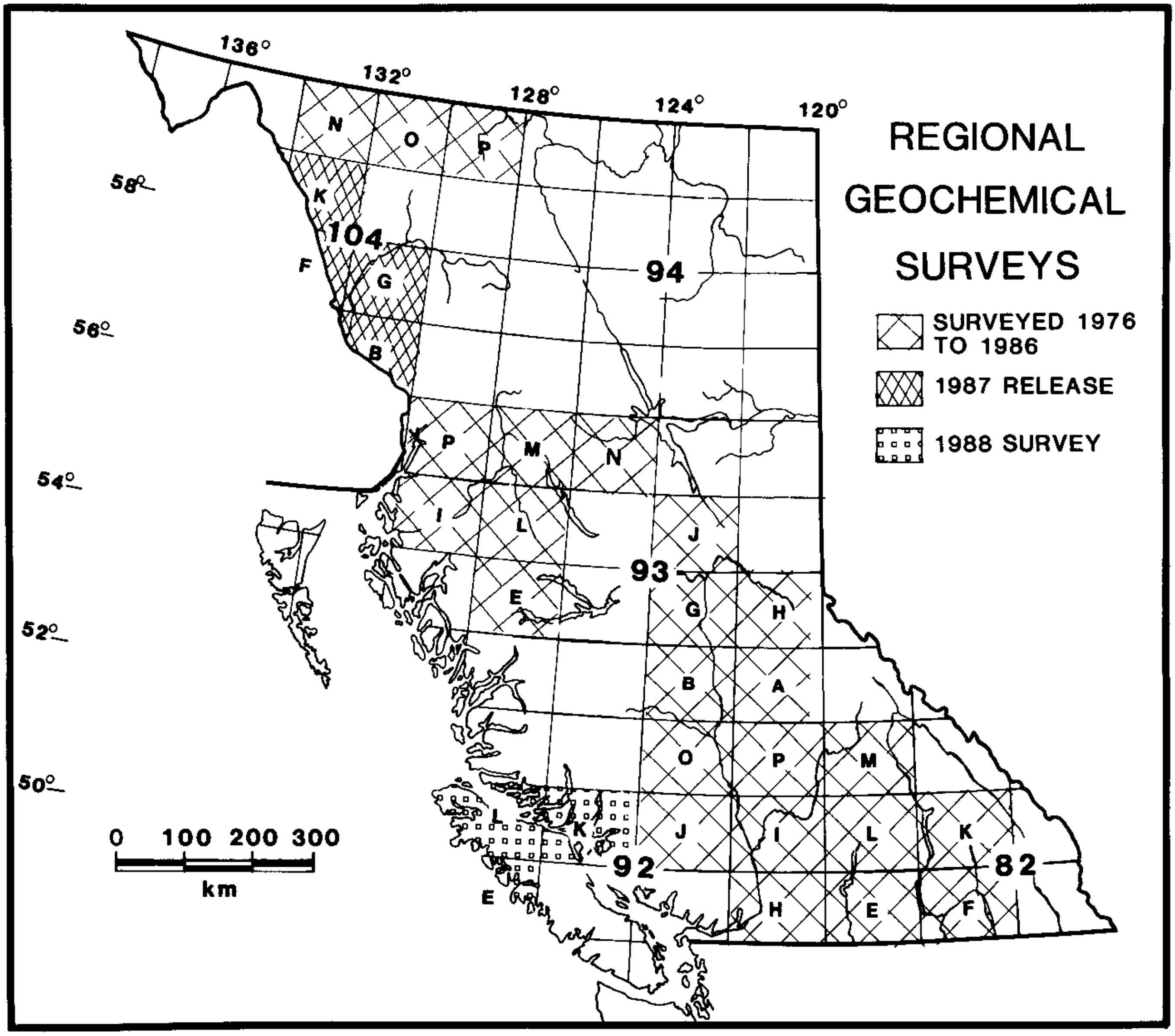

Figure 5-1-1 Areal distribution of Regional Geochemical Surveys.

capture and quality control on sampling and sample processing. Improvements included:

- Eliminating redundant field observations.
- Alphabetical recording of categorical field observations.
- Recording of field observations that aid in the interpretation of moss-mat sediment data.

DATA EVALUATION

The ability to discriminate real trends related to geological and geochemical causes from those that result from spurious factors such as sampling and analytical errors is of paramount importance in the success of geochemical interpretation. In the case of the RGS, analytical duplicates and control reference samples are randomly inserted in every batch of 20 samples in order to control and monitor short and long-term precision as well as accuracy (Matysek, 1985). To ensure strict adherence to national standard accuracy, tolerance and precision guidelines, the Applied Geochemistry Subsection has developed a microcomputer quality control program – CONTROL. Features include rapid identification of bad analytical batches, recognition of temporal drift, and estimation of detection limits and precision levels using Thompson and Howarth (1978) plots. The program provides:

- Summary statistics of control reference standards.
- Identification of unacceptable analytical batches (usually defined as 2.5 standard deviations of the control reference mean and/or analytical duplicates that exceed user-defined tolerances).
- Graphical representation of analytical drift from batch to batch.
- Thompson and Howarth plots with precision estimates and calculated detection limits.

The CONTROL program is designed for use with the Regional Geochemical Survey data, but is easily applied to other large-scale geochemical sampling programs. Copies of the software are available to interested parties on request.

ORIENTATION SURVEYS

In 1988, several stream sediment orientation surveys were conducted in areas of proposed future RGS projects on southern Vancouver Island (92B, C, F), Lower Mainland (92G) and the Bowser Basin (104A). In addition, samples were collected to prepare for a land-use study in the Purcell Mountains. An open-file compilation of the results of the 1987 and 1988 orientation studies is planned.

SOUTHERN VANCOUVER ISLAND AND LOWER MAINLAND

Stream sediment orientation sampling on Vancouver Island focused on deposits hosted by the Sicker Group and associated with Tertiary intrusions in the Nanaimo Group (Table 5-1-1). On the mainland, veins and stratiform deposits are hosted by pendants of Gambier Group in the Coast plutonic complex.

The sampling design used in the northern Vancouver Island orientation project proved to be highly effective and was used again with some minor modifications [*compare* Matysek and Day (1988) and Table 5-1-2].

TABLE 5-1-1
STREAMS SAMPLED FOR THE SOUTHERN VANCOUVER ISLAND AND LOWER MAINLAND ORIENTATION SURVEY

Stream	Deposit Name and Type	Number of Samples[1] S	M	B	Z	H	Length of Traverse (km)
McKay Creek (92F/14)	Mount Washington Copper Tertiary intrusion in Nanaimo Group	11	11	6	1	1	5.2
Murex Creek (92F/14)	Murex deposit Tertiary intrusion in Nanaimo Group	12	12	7	1	1	5.7
Franklin River (92F/02)	Thistle mine Cu-Au-quartz vein in Sicker Group volcanics	9	13	6	1	1	7.6
Cous Creek (92F/02)	Rex showing Disseminated molybdenite in Karmutsen Basalt	10	11	5	1	1	5.4
Salmonberry Creek (92F/04)	Epic-Mowgli showings Epithermal shear zone mineralization, associated with Eocene intrusion	10	10	5	1	1	4.9
Silver/Solly Creeks (92B/13)	Lara deposit Stratiform polymetallic massive sulphide in Sicker Group sediments	10	9	5	1	1	4.1
Stawamus River (92G/11)	War Eagle prospect Shear zone sulphides (Cu-Pb-Zn) in Gambier Group pendant	12	12	6	1	1	7.1
Background (un-mineralised)		14	17	12	12	12	

[1] S = Stream sediment samples, M = Moss-mat samples, B = 10-kilogram fine sediment samples, Z = large moss-mat samples, H = sieved-gravel sample.

PRELIMINARY RESULTS: McKAY CREEK, MOUNT WASHINGTON

The Mount Washington copper-gold-silver deposit is hosted by a Tertiary quartz diorite stock which intrudes an outlier of Comox Formation (Nanaimo Group) uncomformably overlying Karmutsen Formation mafic lows (Wilton, 1987).

McKay Creek, which drains the area of the deposit, falls approximately 1000 metres over a distance of 6 kilometres. Banks and bed vary from bedrock (Karmutsen Formation) in the steeper sections, to till and alluvium in the lower reaches. Sediment samples were collected from ten stations. Samples were also collected from two streams draining unmineralized parts of Mount Washington, to provide geochemical background information.

Dispersion patterns for arsenic, copper, molybdenum, and to a lesser extent, antimony, silver, lead and zinc in stream sediments and moss-mat sediments show the familiar exponential anomaly decay downstream of a spatially re-

TABLE 5-1-2
ORIENTATION SURVEYS SAMPLING DESIGN

Sample Type	Stream: Drains mineralization	Stream: No mineralization
Collection[1]		
1-kg moss	Every 500 m	One station
2-kg sand	Every 500 m	One station
10-kg sand	Every 1000 m	One station
2-kg moss	Up to two stations	One station
10-kg sieved gravel (18 mesh)	One station	One station
Preparation		
1-kg moss	Dry, sieve to 80-mesh, discard organics	
2-kg sand	Dry, sieve to 80-mesh	
10-kg sand	Dry, sieve to −45+80, −80+170, −170	
2-kg moss	Dry, sieve to −45+80, −80+170, −170	
10-kg gravel	Dry, sieve to −45+80, −80+170, −170 prepare heavy-mineral concentrate with tetrabromoethane (TBE, S.G. = 2.9)	
Analysis		
All fractions except concentrates	Aqua regia digestion on 0.5 g followed by: 30-element by ICP-ES As,Sb,Bi,Te,Ge,Se by hydride - ICP-ES Hg by flameless AAS Aqua regia digestion on 10 g followed by Au by MIBK pre-concentration	
Concentrates	Non-destructive instrumental NAA Au and 30 other elements	

[1] At least 10% of all samples are duplicates.

stricted source (Figure 5-1-2). Anomaly contrast is greater than 10 for most elements at the station nearest the source and the anomaly is detected at the lowest station where concentrations are typically five times regional background levels. The trend for gold in moss-mat sediments is unusual but shows that anomaly contrast is greater than 50 at the lowest station compared to 3 for stream sediments. High gold concentrations in the finest fraction analyzed (–170 mesh, very fine sand and finer) show that the high contrast for moss-mat sediments is due to entrapment of fine sediment in the mats.

PURCELL MOUNTAINS

A limited orientation survey was conducted in the Purcell Mountains in preparation for a land-use study. The survey sought to define the appropriate sampling medium, sampling density and sample preparation and analysis scheme to enable an evaluation of the area's mineral potential. Samples were collected from two streams draining mineralization typical of the area (Springs Creek, tributary to Toby Creek (82K/8), base metal veins; Victoria Creek (82G/11), Kootenay King stratiform base metal deposit). Samples were also collected from seven streams which are not apparently draining mineralization.

In addition to the standard sampling design (Table 5-1-2), all fractions were analysed for total tin content (ammonium iodide fusion with atomic absorption spectroscopy finish).

SUMMARY OF RESULTS

Moss mats proved to be the most readily available sampling medium. Fine stream sediments were extremely difficult to locate in the steep streams and sieving of gravels for heavy mineral analysis was time-consuming. Moss-mat sediments revealed very similar elemental dispersion patterns to fine stream sediments. Concentrations in moss-mat sediments tended to be greater than in paired sediment samples, reflecting greater concentrations in the finest fraction (–170 mesh). This effect was especially useful for increasing tin concentrations which are typically at the detection limit (1 ppm) in stream sediments. In moss-mat sediments tin concentrations are above the detection limit (up to 14 ppm) downstream from mineralization and average 3 to 4 ppm in streams not draining mineralization.

BOWSER BASIN

Historically, the sedimentary rocks in the Bowser Basin have been regarded as poor hosts for economic metal deposits, although in the Hazelton area, vein and porphyry deposits are associated with Cretaceous granitic stocks intruding the sediments. A Regional Geochemical Survey is planned in 104A which is largely underlain by poorly mapped and explored Bowser Lake Group rocks. This survey will compliment the regional mapping program of the Geological Survey of Canada (Evenchick, 1988).

Orientation was carried out on four streams in 103P, 103I and 93M (Table 5-1-3) and the logistics of sampling in 104A were investigated. Complete chemical results have yet to be received.

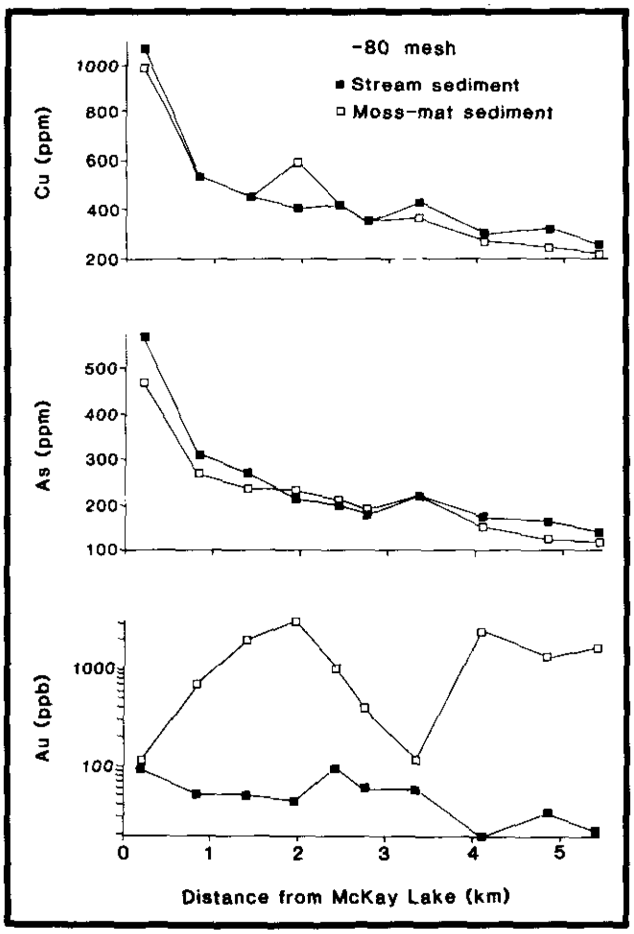

Figure 5-1-2 Stream sediment and moss-mat sediment dispersion patterns in McKay Creek, Mount Washington. Estimated background levels for copper, arsenic and gold are 50 ppm, 20 ppm and 7 ppb respectively in stream sediments and 50 ppm, 24 ppm and 13 ppb respectively in moss-mat sediments.

MOSS-MAT SEDIMENT INVESTIGATIONS

In addition to the orientation surveys which involve comparison of several sampling media, two programs have been initiated to further increase understanding of sediment accumulation in moss mats.

SPATIAL VARIATION

Detailed within-station sampling was carried out in March, 1988 at Gold Valley Creek (92L/2) near Zeballos, and Red Dog Creek, which drains the Red Dog copper-molybdenum deposit (92L/12), near Holberg (Matysek and Day, 1988). At each of eight stations, six large moss-mat samples were collected to investigate how the height above the stream bed affects the type of sediment trapped in the mat. As well as the usual suite of elements, magnetite was removed from all samples. Preliminary results from Gold Valley Creek show that magnetite concentrations are strongly correlated with gold concentrations, confirming that gold is trapped in mosses due to its high density.

TABLE 5-1-3
STREAMS SAMPLED FOR THE BOWSER BASIN ORIENTATION SURVEY

Stream	Deposit Name and Type	Number of Samples[1] S	M	B	Z	H	Length of Traverse (km)
Wesach/Hall creeks (103I/15)	Bear, Gold Cap Motherlode Pb-Zn-Cu-Au vein	7	5	3	2	1	3.1
Flint Creek (103I/16)	Seven Sisters Au-Ag-Cu vein	9	9	5	1	1	4.0
Stirrit Creek (93M/12)	Bear Cu-Mo porphyry	9	8	4	3	1	2.5
Kit Creek (103P/08)	Kit Mo-quartz vein stock-work hosted by grano-diorite	6	6	3	0	1	2.0
Background (un-mineralized)		12	10	11	6	11	

[1] S = Stream sediment samples, M = Moss-mat samples, B = 10-kilogram fine sediment samples, Z = large moss-mat samples, H = sieved-gravel sample.

SEASONAL VARIATION

A study of the seasonal variation of elemental concentrations in moss-mat sediments and sandy sediments was begun in November 1988 at McKay and Murex creeks (Mount Washington, 92F/14). Samples will be collected approximately every month from a bar on each stream. Both bars were divided into four or five 10 to 20-square-metre cells and two sediment and moss samples will be collected from each cell at each visit. Although it is impossible to resample exactly the same location at each visit, the study will indicate if seasonal variability is apparent when compared to spatial variation.

PENDING STUDIES

ANALYSIS OF ARCHIVED RGS SAMPLES

To encourage mineral exploration in previously sampled RGS areas, the Geological Survey Branch is planning to add a number of new elements (gold, arsenic, antimony, tungsten, chromium, rare earths) to the existing RGS database. Analyses of archived pulps will be performed through non-destructive neutron activation analysis. After consultation with staff and industry advisory committees, map sheets 92H, I, J, O and P have been selected for analysis (Figure 5-1-1). These map sheets cover an area of over 78 000 square kilometres and take in over 4300 RGS sample sites. To avoid, "data overload" on the majority of non-computer-oriented users of the RGS releases, simplified data-display formats will be developed to assist in disseminating results.

EXPLORATION IN GLACIATED TERRAINS

Plateau areas which account for over 20 per cent of the province's landmass are characterized by complex glacial deposits. Selection of exploration techniques in these areas is dependant on the type and thickness of the surficial deposits. The mineral exploration industry has avoided these areas because British Columbia's surficial geology database is poor (less than 15 per cent coverage). A program of systematic mapping of surficial geology as well as development of appropriate exploration techniques has been proposed for next year. Results of the surficial surveys will be integrated with the Ministry's bedrock mapping and geochemical surveys to guide and stimulate more effective exploration.

GEOCHEMICAL RESPONSES AROUND MINERAL DEPOSITS

A project will be initiated to assemble data on the geochemical response in soils and sediments around selected mineral deposits. The study will compile information on deposits and their geological and geochemical environments; a list of elements that are enriched or depleted, and the dimension of the halos for each anomalous element; and a record of elements that do not respond. These data will be published together with an interpretative summary on the controls of dispersion of indicator elements within the secondary environment. It is hoped that this catalogue will provide detailed geochemical guidelines for exploration in a systematic format; it will also be useful in assessing the mineral potential of a region.

ACKNOWLEDGMENT

Wayne Jackaman provided excellent assistance in field and office projects.

REFERENCES

Evenchick C. (1988): In the Field, Bowser Basin, *Mining Review*, September/October 1988, pages 32-37.

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, This volume.

Matysek, P.F. (1985): An Evaluation of Regional Stream Sediment Data by Advanced Statistical Procedures, Unpublished M.Sc. Thesis, *The University of British Columbia*, 95 pages.

——— (1987): A New Look for the Regional Geochemical Survey Data, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 385-394.

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, pages 493-502.

Thompson, M. and Howarth, R.J. (1978): A New Approach to the Estimation of Analytical Precision, *Journal of Geochemical Exploration*, Volume 9, pages 23-30.

Wilton, H.P. (1987): Mount Washington (Domineer, Murex), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia, 1986, pages B29-B32.

NOTES