



PRELIMINARY EVALUATION OF MULTIELEMENT REGIONAL STREAM-SEDIMENT DATA, ISKUT RIVER AREA (104B)

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INTRODUCTION

Multi-element geochemical data from regional stream-sediment surveys provide a useful base with which to determine geochemical characteristics of an area and thus, to assist in the design of more detailed, exploration oriented studies. The Eskay Creek area is of particular interest because of the enigmatic deposits found recently with abnormally high grades of gold and silver. The general area was sampled in 1988 as part of the Regional Geochemical Survey program of the Geological Survey Branch of the British Columbia Ministry of Energy, Mines and Petroleum Resources. Analytical data emerging from that survey were provided to us for evaluation.

The analytical data were obtained from the -80-mesh fraction of stream sediment samples analyzed by atomic absorption techniques for 21 constituents (Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Mo, U, W, Sn, Hg, As, Sb, Ba, Cd, V, LOI, F and Au), and water samples (from stream-sediment sample sites) analyzed for uranium, fluorine and pH. In addition, a number of categorical variables were recorded for each sample site such as grain size, sediment colour, stream velocity and lithology underlying the basin contributing to a stream sediment sample site.

METHODOLOGY

Our initial work has been oriented toward the recognition and characterization of background populations for the various metals analyzed, and the identification of thresholds for those elements that are clearly anomalous in known mineralized areas. The approach we have taken includes:

- Updating the information pertaining to lithology underlying the drainage basin for each sample in the light of the most recent geological mapping.
- Grouping of samples with related lithologies to produce groups with sufficient data for the evaluation procedure to be used.
- Interpretation of particular groups of data using probability graphs.
- Examination of the spatial plots of those elements for which multiple populations were identified.

In particular, we examined the analytical data reported for 660 stream-sediment samples from map area NTS 104B, that is, the Iskut River area which embraces the Snip deposit, Eskay Creek area and the Sulphurets camp, and chose two extreme groups of data with which to begin our study: samples reflecting drainage basins underlain by sedi-

mentary rocks of the Bowser Lake Group, and samples which reflect volcanic lithologies of the Hazelton Group. These groups are coded SLSN and BRCC respectively in the publicly available government data file. The latter group includes units that locally have been referred to as Jack, Unuk River, Betty Creek, Mount Dilworth and Salmon River formations although the correlations are commonly uncertain. We edited these data groups substantially with the assistance of up-to-date geological information from Dr. P. Lewis. The resulting modified files were then examined sequentially using probability plots (Sinclair, 1976; Stanley, 1988).

RESULTS

Results of our study are discussed in terms of the shapes of the histograms (numbers of interpreted data subpopulations) and selection of thresholds for the variables studied.

In nearly all cases we were able to interpret the shapes of probability graphs (cumulative histograms) as indicative of either a single lognormal population or combinations of lognormal populations. In general, we can classify variables from each geologically defined group into four subgroups of increasing complexity of cumulative histograms.

The interpretation of probability plots is subjective, but experience has shown that different subpopulations of a particular geochemical variable are commonly the product of different processes. For example, high subpopulations of metals such as copper and lead in many cases are related to mineralization, whereas, the lower subpopulations for these metals represent samples derived from unmineralized terrains. Where sufficient independent data are available the various processes represented by data subpopulations can be identified with reasonable certainty. As a general rule, we have ignored two very specific types of population as follows: outlier values which we define for our purposes as representing less than 1 percent of a data set at either the high or low ends of a distribution, and pseudo-subpopulations that may appear where a significant proportion of values occurs near the detection limit of the analytical procedure. This latter situation is of little concern for the metal variables considered here because, in general, we are more interested in higher values than in lower values; this need not be true with such variables as loss on ignition (LOI) or pH.

Results of this preliminary study are listed in Table 4-12-1 for samples from sedimentary terrains and in Table 4-12-2 for samples from volcanic terrains. For each of these geological groups of data, variables are subdivided according to increasing complexity of cumulative histograms (*i.e.*, increasing numbers of modes). Thresholds are given for all variables (*cf.* Sinclair, 1991)

TABLE 4-12-1

SUMMARY OF SUBPOPULATIONS AND SOME IMPORTANT CHARACTERISTICS, REGIONAL GEOCHEMICAL SURVEY DATA FOR DRAINAGE BASINS UNDERLAIN BY HAZELTON GROUP ROCKS (SLSN) (NTS 104B)

ONE POPULATION (n = 194)

Variable	Geom Mean	95% range (units) (2nd figure is threshold)
Ag	0.14 ppm	0.03 - 0.65
Co	17 ppm	6 - 35
Cu	42 ppm	19 - 91
Fe	3.48%	2.32 - 5.21
Mn	638 ppm	285 - 1,430
Sn	0.9 ppm	0.2 - 3.7
W	2.1 ppm	1.0 - 4.4
pH	6.98	6.15 - 7.80
U	1.9 ppm	1.1 - 3.6

TWO POPULATIONS (n = 194)

Variable	Pop'n	Geom Mean %	Lower Threshold (units)
As	A	71 3%	27 ppm
	B	12 97%	
Mo	A	12 2%	4.7 ppm
	B	1.6 98%	
Au	A	32 5%	20 ppb
	B	2.5 95%	
Pb	A	52 2%	18 ppm
	B	7.7 98%	
V	A	126 7%	72 ppm
	B	45 93%	
Fw	A	93 10%	60 ppb
	B	34 90%	
Zn	A	525 4.5%	285 ppm
	B	124 95.5%	
LOI	A	9.4 23%	5.29%
	B	3.0 87%	
F	A	470 16%	368 ppb
	B	266 84%	
Sb	A	6.3 5%	2.0pp
	B	0.5 95%	
Ba	A	1260 22%	993 ppm
	B	842 78%	
Cd	A	1.5 16%	0.48pp
	B	0.1 84%	

THREE POPULATIONS (n = 194)

Variable	Pop'n	Geom Mean %	Lower Threshold (units)
Hg	A	630 3%	213 ppm
	B	84 93.5%	32 ppm
	C	5.6 3.5%	
Ni	A	166 2%	140 ppm
	B	97 84%	53 ppm
	C	18 14%	

* arithmetic mean

TABLE 4-12-2

SUMMARY OF SUBPOPULATIONS AND SOME IMPORTANT CHARACTERISTICS, REGIONAL GEOCHEMICAL SURVEY DATA FOR STREAM SEDIMENT SAMPLES FROM DRAINAGE BASINS UNDERLAIN BY VOLCANIC ROCKS (BRCC), NTS MAP AREA 104B

ONE POPULATION (n = 78)

Variable	Geom Mean	95% Range (units) (2nd figure is threshold)
Cd	0.5	.05 - 5 ppm
Sn	1.0	.2 - 3.6 ppm
Ag	0.4	.06 - 2.3 pp
Ni	33	5 - 227 ppm

TWO POPULATIONS (n = 78)

Variable	Pop'n	Geom Mean %	Threshold
pH	A	7.18 95%	6.35
	B	3.20 5%	
Zn	A	660 5%	295 ppm
	B	142 95%	
Fe	A	4.04 95%	2.48%
	B	1.55 5%	
Uw	A	0.32 14%	.08 ppb
	B	0.02 86%	
Mo	A	20 15%	7 pp
	B	2.7 85%	
U	A	6.7 10%	3.8 pp
	B	2.3 90%	
W	A	26 4%	5 ppm
	B	2.6 96%	

THREE POPULATIONS (n = 78)

Metal	Pop'n	Geom Mean %	Lower Threshold
Fw	A	121 (17%)	40 pp
	B	32.5 (71%)	19.5
	C	10 (12%)	
Ba	A	2510 (10%)	1720 ppm
	B	1270 (87%)	902
	C	630 (3%)	
As	A	282 (15%)	103 ppm
	B	26 (77%)	6.2
	C	1.7 (8%)	
V	A	117 (15%)	92 ppm
	B	65 (65%)	44
	C	33 (20%)	
F	A	794 (3%)	669 ppm
	B	501 (75%)	391
	C	324 (22%)	
Mn	A	1740 (5%)	1320 ppm
	B	747 (91%)	316
	C	126 (4%)	
Au	A	158 (27%)	34 ppb
	B	8.7 (64%)	2.3
	C	1.1 (9%)	

FOUR POPULATIONS (n = 78)

Metal	Pop'n	Geom Mean %	Threshold (units)
Cu	A	480 (6%)	229 ppm
	B	109 (26%)	63
	C	50 (65%)	27
	D	17 (3%)	
Pb	A	107 (7%)	58 ppm
	B	31 (23%)	20
	C	13 (65%)	6.3
	D	3.1 (5%)	
Hg	A	2510 (5%)	630 ppm
	B	169 (65%)	60
	C	32 (20%)	13
	D	4.7 (10%)	
Co	A	40 (5%)	29 ppm
	B	21 (50%)	15
	C	13 (36%)	8
	D	4.2 (4%)	

DISCUSSION

The two data groups dealt with represent surficial geochemical responses to two contrasting geological environments, that is, sedimentary and volcanic terrains. Even a cursory comparison of results in Tables 4-12-1 and 4-12-2 indicates that histograms of variables from the sedimentary group (Table 4-12-1) are less complex (*i.e.*, fewer modes) and metal abundances are generally much lower than for the volcanic group (Table 4-12-2). For about half the variables (*i.e.*, Ba, Cu, U, As, Mo, Au, Pb, V, F, Zn and Hg) the high abundance subpopulation for the volcanic-related group is substantially above the value at the 97.5 percentile of the corresponding population related to sedimentary terrains. The generally higher level of metal abundances in the volcanic-related data reflects both differing background populations for the two distinctive rock sequences and the presence of a substantial number of mineral showings and hydrothermal alteration zones localized within or at the margins of the volcanic sequence. It seems likely that for most metals with multiple subpopulations the upper subpopulation correlates with a mineralized source. An exception seems to be barium (*see* Table 4-12-2). In some cases, tin for example, the histograms from the two groups are comparable.

Examples of varying complexity of the form of cumulative histograms are given in Figures 4-12-1 to 4-12-4. Metals showing single lognormal populations are of limited practical use in identifying anomalous samples; we have adopted the mean plus two standard deviations of the lognormal population as an arbitrary threshold in such cases (Sinclair, 1991).

The foregoing observations are consistent with the known concentration of mineral deposits and occurrences in or marginal to the volcanic sequences in the area, and the general absence of showings in predominantly sedimentary terrains. However, there are several surprising results from our study:

- Silver and antimony values are remarkably low and their distributions are simple. This is particularly surprising because many showings in the area contain abundant sulphosalts and have high silver contents.
- Relatively few samples are anomalous in more than one or two elements. For example, among the volcanic-related samples, 27 are anomalous in one or more of copper, lead, zinc, mercury and arsenic (Table 4-12-3). This particular group of elements is important because all the metals are strongly concentrated in the Eskay Creek area and the Sulphurets camp. From a practical point of view results of our evaluation imply that multi-element analyses are essential for stream sediment samples to provide an acceptable level of anomaly recognition.

Despite the limitations discussed above regarding the inefficiency of using single elements for anomaly recognition, several metals are useful on a more regional scale. High zinc values, for example, clearly identify a large area including and extending south from the Eskay Creek deposits. High arsenic values are concentrated in the Sulphurets camp and are associated with high zinc values to the

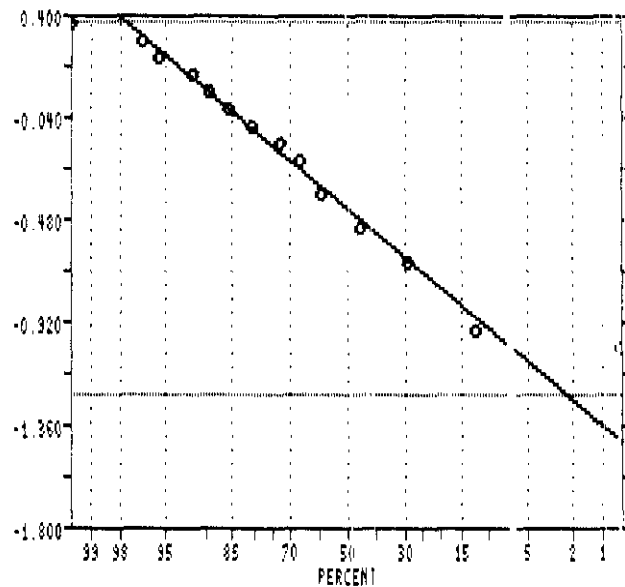


Figure 4-12-1. Log probability graph for silver in volcanic-derived stream sediment samples, Eskay Creek area. Ordinate is $\text{Log}_{10}(\text{metal abundance})$. Open circles are cumulative data; straight line through cumulative data is a visual, best fit, lognormal distribution; horizontal dotted lines are the 2.5 and 97.5 percentiles of the best fit distribution.

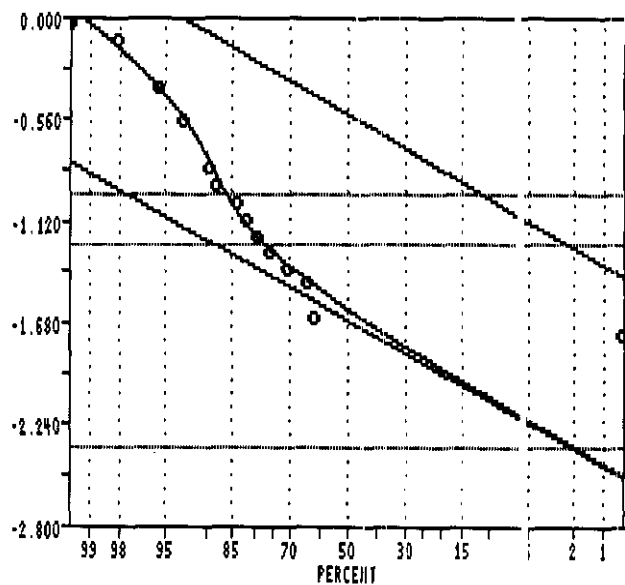


Figure 4-12-2. Log probability graph for uranium in water (U_w) at volcanic-derived stream sediment sites, Eskay Creek area. Ordinate is $\text{Log}_{10}(\text{metal abundance})$. Open circles are cumulative data; curve fitted to open circles is a visual best fit bimodal distribution; sloping straight lines are partitioned lognormal subpopulations; horizontal dotted lines are at the 2.5 and 97.5 percentiles of each of the partitioned subpopulations.

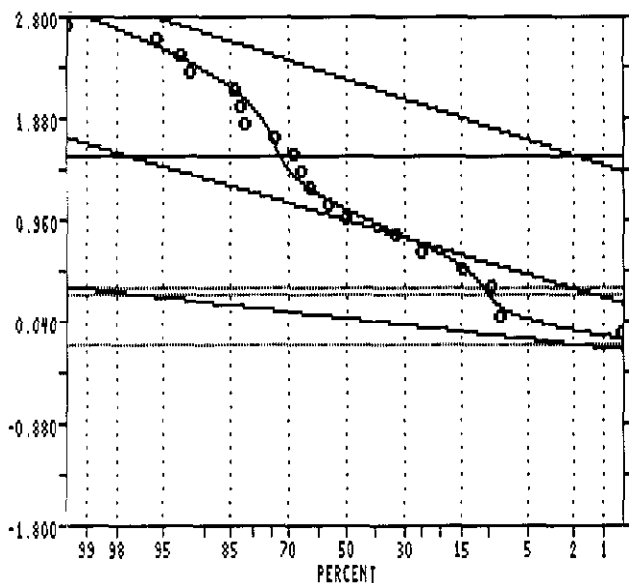


Figure 4-12-3. Log probability graph for gold in volcanic-derived stream sediment samples, Eskay Creek area. Ordinate is $\text{Log}_{10}(\text{metal abundance})$. See Figure 2 for explanation of symbols.

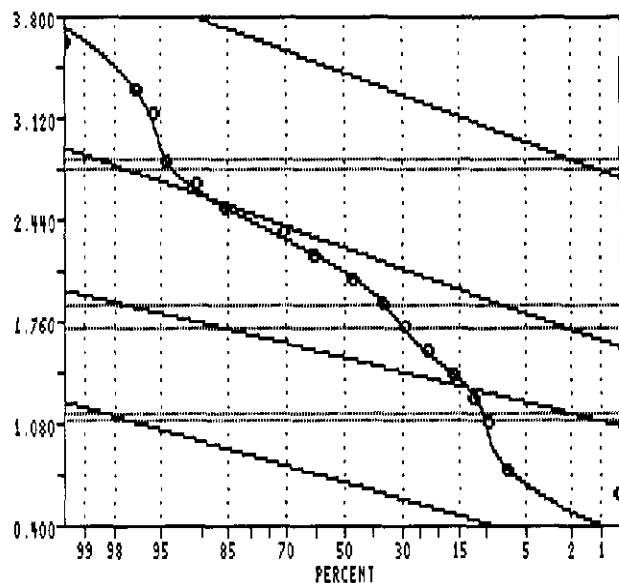


Figure 4-12-4. Log probability graph for gold in volcanic-derived stream sediment samples, Eskay Creek area. Ordinate is $\text{Log}_{10}(\text{metal abundance})$. See Figure 4-12-2 for explanation of symbols.

south of Eskay Creek. The fact that many samples are "one metal anomalous" may be partly related to mineral zoning and secondary dispersion patterns. If this is so, closer spaced samples are essential to identify such patterns.

The following comments relate to the volcanic-related data set: uranium in water, molybdenum and to a lesser degree uranium, have very similar cumulative distributions; of these uranium in water is particularly well defined as a mixture of two lognormal populations. Association of these elements is to be expected because of their geochemical similarity in surficial environments. A small percentage of values that represent a high subpopulation relates spatially to small intrusive bodies. Zinc background is normal for volcanic terrains.

Complex distributions are difficult to interpret with confidence. Several three-population variables (Sb, Au, Ba, F_w and Mn) seem to have one of their constituent populations generated artificially near the detection limit; hence, they are interpreted here as bimodal variables. Gold has two clearly defined and abundant populations. The relatively high abundance of an upper population (27%) probably reflects the widespread occurrence of mineralized and altered zones within the volcanic sequence and the biased location of samples relative to known mineralization.

Copper and lead (and possibly mercury) have very similar, complex histograms. The upper subpopulations of each of these three elements appears to be related spatially to known mineralization but, as indicated previously, stream-sediment samples are generally high in only one of the three metals.

Values for pH are largely concentrated near 7; however, a very small subpopulation (4 samples) of extremely low values ($\text{pH} < 5.4$) represents strongly acid conditions associated with extensive gossan development over pyritic zones.

These low (anomalous) pH values appear erratically located because of the scale of sampling combined with the short distances over which local acidities are diluted (neutralized).

CONCLUSIONS

Stream-sediment samples in the Iskut River area, taken as part of a Regional Geochemical Survey, provide useful information to guide further surveys and exploration. In particular, thresholds have been determined for all variables for the two geologically defined data groups in the publicly available data that we examined.

TABLE 4-12-3
NUMBERS OF SAMPLES (VOLCANIC TERRAINS) THAT ARE ANOMALOUS IN REGIONALLY IMPORTANT METALS AND COMBINATIONS OF THOSE METALS

Anomalous Metal Association	No. of Samples
Hg	3
Cu	3
Cu+Hg	1
Cu+Hg+As	1
Hg+As	1
As	6
As+Pb	1
Pb	4
Zn	7
Total Anomalous Samples	27

A need for more closely spaced stream-sediment samples has been demonstrated for follow-up work, to provide a basis for recognizing primary and secondary dispersion patterns.

Anomalous samples are rarely anomalous in more than one element. Clearly, multi-element analyses are essential; otherwise, many anomalous samples will not be recognized.

ACKNOWLEDGMENTS

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drainage basins of many of the sample sites. Comments by Dr. J.F.H. Thompson improved the manuscript.

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NOTES