fies the display of the element data sets and also facilitates the interpretation of the geochemical patterns.

The success of the Hemlo experimental study also raises a number of questions. One is, to what extent is geochemical data for elements homogeneous within a particular "Landscape Domain"? Another is, to what extent does a Landscape Domain underlain by two or more "geochemical domains" smooth out the differences between the geochemical response of different bedrock types? The purpose of the study described here is to answer these questions and to further develop the standardized approach to the multielement geochemical study of humus in the conditions which are found on the Canadian Shield in Ontario.

In order to achieve this purpose, two 200 m long lines were selected for study where the overburden, soil, and vegetation, together with the slope and aspect, were practically identical. One of the lines is located over typical granitic rocks of the Canadian Shield and the other over metavolcanic terrain including a small area of zinc and base metal mineralization.

The fieldwork for the study is part of a larger investigation completed in September, 1985, designed to investigate environmental decline geochemistry of lakes and forested areas. The line sampled over metavolcanic terrain is near Hanes Lake (Latitude 47°07'N, Longitude 83°54'W) and the granitic terrain sampled is at Barbara Lake (Latitude 47°17'N, Longitude 84°20'W) both located to the east of Lake Superior south of Montreal River (Figure 1). The scope of the environmental study which includes the study described here is outlined by Fortescue and Webb (1985).

OBJECTIVES

The objectives of this study are:

1. to use the conceptual model developed at Hemlo to carry out two small scale humus studies along two 200 m cut lines, one at Barbara Lake located over granitic terrain, and the other at Hanes Lake over metavolcanic terrain which includes a small base metal mineralized zone
2. on the basis of the Barbara Lake and Hanes Lake studies, to discover variations in the abundance of elements in humus derived from bedrock within the same "Landscape Domain"
3. to draw conclusions regarding the interpretation of multielement geochemical data patterns in humus in the two landscapes at the Global (i.e. province-wide), Regional, and Local levels of geochemical survey.

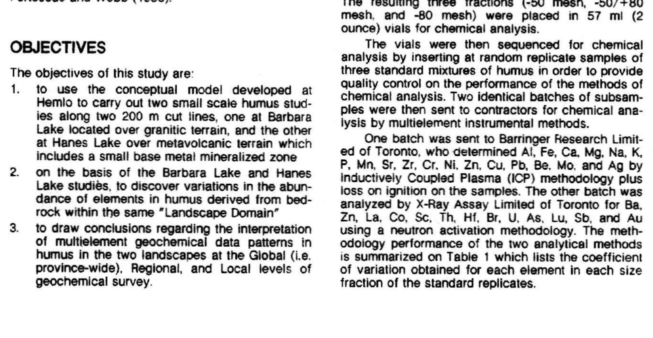

Figure 2a. Location of the Barbara and Hanes Lakes landscapes studied.

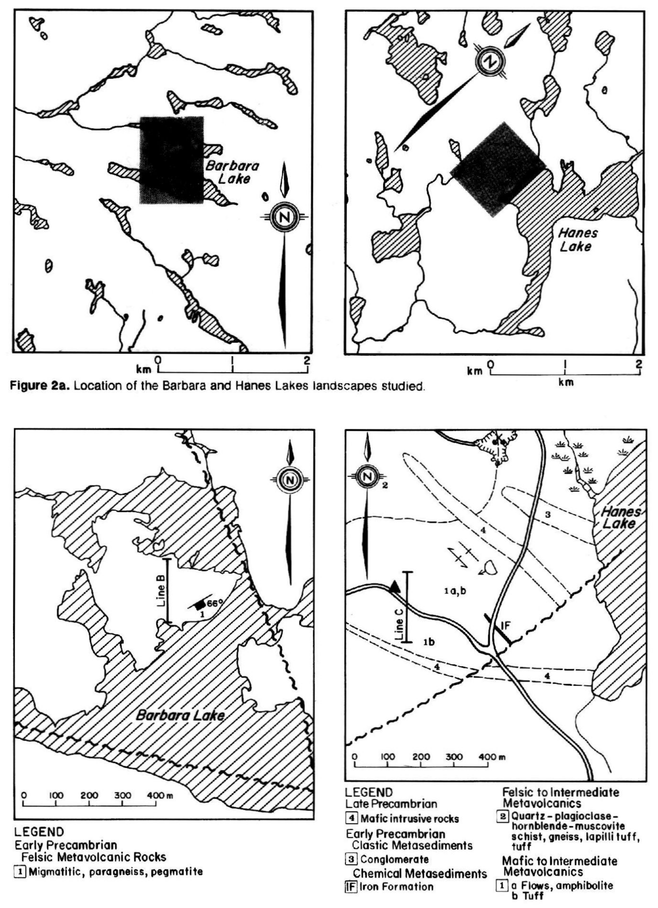

Figure 2b. Detailed location maps of Lines B and C together with general geological features of the sampled areas.

humus samples were collected at 10 m intervals and the samples designated by letters of the alphabet (i.e. BA, BB, BC etc.). These code letters are also used on the graphical displays of the geochemical data (see Figure 5). Prior to sampling, each line was surveyed for relief and wooden pegs placed along it to mark sample points. Generalized descriptions of the soil and vegetation were later made at each sample point together with a tape recording of details of the vegetation cover. Samples of the common plants along each line were collected, pressed, and taken to Toronto where they were identified at the Royal Ontario Museum.

Humus samples were collected using a 25 by 30 cm board and a sharpened spade. The board was first placed on the surface to be sampled, which was usually within 1 m of the sample point. A cut through the humus layer to the mineral soil was then made with the spade all around the board. The resulting sod was overturned on to the board and any mineral matter on its undersurface removed with a trowel and stiff brush. The intact sod was then placed in a 25 kg (50 pound) multiwalled paper sack and sealed. The sealed bags were transported to Toronto and allowed to become air dry prior to subsampling.

SUBSAMPLING AND CHEMICAL ANALYSIS

When the bagged humus samples were completely dry, the sacks were opened, the sample crushed gently in a plastic tub, and passed through a 50 mesh (i.e. 300 micron) stainless steel sieve. The -50 mesh material was divided into two parts, one part being further sieved to -80 mesh (i.e. 180 micron). The resulting three fractions (-50 mesh, -50/+80 mesh, and -80 mesh) were placed in 57 ml (2 ounce) vials for chemical analysis.

The vials were then sequenced for chemical analysis by inserting at random replicate samples of three standard mixtures of humus in order to provide quality control on the performance of the methods of chemical analysis. Two identical batches of subsamples were then sent to contractors for chemical analysis by multielement instrumental methods.

One batch was sent to Barringer Research Limited of Toronto, who determined Al, Fe, Ca, Mg, Na, K, P, Mn, Sr, Zr, Cr, Ni, Zn, Cu, Pb, Be, Mo, and Ag by Inductively Coupled Plasma (ICP) methodology plus loss on ignition on the samples. The other batch was analyzed by X-Ray Assay Limited of Toronto for Ba, Zn, La, Co, Sc, Th, Hf, Br, U, As, Lu, Sb, and Au using a neutron activation methodology. The methodology performance of the two analytical methods is summarized on Table 1 which lists the coefficient of variation obtained for each element in each size fraction of the standard replicates.

Nickel	99.0	Thulium	0.50
Rubidium	78.0	Iodine	0.46
Zinc	76.0	Indium	0.24
Copper	68.0	Antimony	0.20
Cerium	66.4	Cadmium	0.16
Neodymium	39.6	Mercury	0.086
Lanthanum	34.6	Silver	0.080
Yttrium	31.0	Selenium	0.050
Cobalt	29.0	Palladium	0.015
Scandium	25.0	Bismuth	0.0082
Niobium	20.0	Gold *	0.0040
Gallium	19.0	Tellurium*	0.0040
Nitrogen	19.0	Ruthenium	0.0010
Lithium	18.0	Rhenium *	0.0007
Lead	13.0	Platinum	0.0005
Praseodymium	9.10	Rhodium*	0.0002
Boron	9.00	Osmium *	0.00002
Thorium	8.10	Iridium	0.000002
Samarium	7.02		

Crustal abundance from Ronov and Yaroshevsky (1972) unless otherwise stated.

*Based on crustal abundance data for rocks from Bowen (1979).

**Note that 1% = 10 000 ppm.

The Global Level geochemical data are displayed in two ways; a table of mean values for each element is prepared for purposes of general overview and a scan sheet is prepared showing the abundance for each element (in Clarke (K) units) plotted on a trace of the daylight surface of a traverse line, drawn to scale (see Figures 5 and 6). Note that the scale used on the scan sheets is arithmetic with one range for elements of relatively low abundance (i.e. 0.1 to 2.0 K) and another for elements of high abundance (i.e. 1.0 to 20.0 K). The low abundance range is indicated by grey shading on the scan sheets whereas the high abundance range is in black.

Regional Level

The humus lines sampled at Barbara and Hanes Lakes are considered to be located within the same *Landscape Domain* but, because of differing bedrock types underlying them, are considered to be in different *Geochemical Domains*. They belong to the same landscape domain because the lines have similar aspect, slope, relief, overburden cover, soil cover, and plant cover. The Barbara Lake line is underlain by granitic rocks, and that at Hanes Lake by metavolcanics including a small mineralized zone.

The aim of Regional Level data processing is to produce generalized information on the abundance level and variability of elements of interest within each geochemical domain in a study. An advantage of the Barbara Lake/Hanes Lake study is that the landscapes sampled are considered to belong to the same landscape domain which is often not true in other areas. For example at Hemlo (Line L), five landscape domains were identified along a single line traverse (Fortescue 1985).

In order to produce a *Resultant Plot* for humus data for an element along a traverse line, the abundance levels for the element (in K units) in all three size fractions at one sample point are averaged and

Table 1. Data for the performance of the analytical methods for 32 elements as evidenced by the mean of 10 replicates of each of three standard mixtures.

Element	(K,ppm)	-50 Mean(ppm)	-50 C/V%	-50/+80 Mean(ppm)	-50/+80 C/V%	-80 Mean(ppm)	-80 C/V%
Al	83 600	21 200	3.2	16 464	13.1	23 518	4.9
Fe	62 200	9 238	3.1	7 930	9.5	9 879	5.5
Ca	46 600	10 800	3.4	10 162	3.2	11 018	3.7
Mg	27 640	2 048	7.5	1 635	8.9	2 213	4.0
Na	22 700	5 635	10.3	3 709	19.3	6 544	6.2
K	18 400	5 097	14.0	3 757	15.3	5 635	14.4
Ti	6 320	1 131	7.8	838	9.3	1 391	5.4
P	1 120	887	5.6	984	3.2	844	3.9
Mn	1 060	1 645	5.6	1 909	6.9	1 533	6.4
Ba	390	394	8.2	339	10.1	386	6.3
Sr	384	96	2.7	74	11.1	108	3.1
Zr	162	50	14.2	29	15.4	60	6.8
V	132	26.0	5.7	18.6	12.2	28.3	6.9
Cr	122	20.0	5.4	15.9	18.0	22.4	6.0
Ni	99	10.9	9.6	10.4	7.8	10.8	8.1
Zn[1]	76	415.9	4.8	458.4	10.2	419.8	7.0
Zn[2]	76	390.0	7.2	406.0	24.6	385.0	25.4
Cu	68	19.1	5.2	18.1	3.3	19.0	3.7
La	35	11.8	5.3	9.7	4.6	12.7	3.1
Co	29	7.24	6.8	7.22	6.9	7.35	4.1
Sc	25	4.08	5.1	3.10	8.7	4.45	3.1
Pb	13	71.3	19.8	84.5	2.7	73.20	2.1
Th	8.1	2.54	14.7	1.81	8.0	10.85	10.6
Hf	2.8	3.84	8.3	1.75	30.4	4.53	9.7
Br	2.5	12.27	9.7	12.70	10.5	11.33	6.9
U	2.3	0.77	14.3	1.81	8.0	2.85	17.6
Be	2.0	0.34	7.9	0.30	16.7	0.38	8.7
As	1.8	6.64	5.9	7.45	6.1	6.58	5.0
Mo	1.2	-	-	-	-	-	-
Lu	0.54	0.16	8.8	0.12	9.3	0.17	7.1
Sb	0.20	1.05	7.2	1.26	5.5	1.00	4.3
Ag	0.08	-	-	-	-	-	-
Au	0.004	-	-	-	-	-	-

[1]Barringer Data [2]X-Ray Assay Laboratory Data

then a rolling mean of three averaged values is calculated. The Resultant Plot includes a horizontal line on a graph denoting the average level of the element in all the humus samples (ratio value of 1.0) plus plots of the rolling mean values divided by the average level (plotted as ratio values). In this way mean values for an element in different geochemical domains can be identified together with the sample site to sample site variation within the rolling mean values (Figure 7).

Resultant Plots are useful for making comparisons between background levels of elements in humus within different landscape and/or geochemical domains within the same general study area. A standardized system of reporting of this type is particularly useful as an aid to the interpretation of humus geochemical data patterns in new areas where the extent of geochemical domains is not known owing to a cover of Quaternary materials.

The Local Level

An exploration geologist using the results of a humus survey requires the most accurate spatial information regarding variations in abundance of elements within an area surveyed. At this level of detail the "parts per million" unit is used in the display of element data to fall in line with current practice in mineral exploration. Because of the heterogeneity of the humus material sampled and the intimate mixture of organic and mineral matter which constitutes humus it is not practical to divide the material into an organic and a mineral fraction for chemical analysis. However, at the Local Level, enhancement of the data patterns may be achieved by normalizing the humus element values by the data for Loss on Ignition. Consequently the display of an element of interest at the Local Level involves a graph showing geochemical values plotted against the distance between sample sites with, and without, the normalization for Loss on Ignition. In this case each data point is plotted separately with no rolling mean calculation of the type used for the Regional Level data.

Summary

In this study an attempt has been made to standardize the display of multielement geochemical data sets obtained from humus for use at each of three levels of detail. The Global Level is designed to be used for all elements for comparisons and interpretations on a province-wide basis; the Regional Level display is designed to highlight different abundance levels between geochemical domains and to indicate the abundance variations within each domain and the Local Level is designed to provide detailed information on geochemical patterns within a given domain in a form suitable for comparison with results from other, parallel, exploration surveys. The experimental approach developed has the goal of proving data display methods which can be used later on for image processing and interpretation of multielement geochemical data in real time.

DESCRIPTION OF FIELD AREAS

The landscape traverses at Barbara and Hanes Lakes are summarized on Figures 3 and 4 and located as shown on Figures 2a and 2b.

THE BARBARA LAKE AREA

The Barbara Lake line is underlain by felsic intrusive and metamorphic rocks of Archean age which are not subdivided into granitic and migmatic rocks. The rocks outcrop around the margins of Barbara Lake and on the shores of the island upon which Line B is located. Outcrops of bedrock occur on and beside the traverse line.

The overburden along Line B is shallow and

[...]

and pyrrhotite occurring in massive and disseminated forms within black and white chert, parallel to the bedding. The cherty units were observed to contain thin laminae of argillite similar to the nearby iron formations. Calcite rhombs up to 2.0 cm in diameter were found in one trench which displayed intense shearing in the wall rocks. The width of the mineralized zone is approximately 100 m.

Grunsky also reported the chemical analysis of a sample of sulphides in banded chert/siltstone collected from the mineral showing. It was found to contain 23 ounces Ag per ton, 0.01 ounce Au per ton, 60 ppm Cr, 1200 ppm Cu, 10 ppm Pb, 820 ppm Zn, 200 ppm Ni, and 42% Fe (Grunsky 1980, p.44). Data from Line C indicates that this estimate of the width of the mineralized zone is consistent with that from the geochemical data (described below).

Line C is oriented in a north-south direction at right angles to the slope of the hillside and the strike of the bedrock. The line is located 30 m east of the trench described above. The most northerly sample site on Line C (CA) is beyond the hangingwall of the mineralized zone A bush road crosses the Line C between stations CJ and CK (Figure 4). No mineralization or staining was observed in rock outcrops on, or near the line along strike from the deposit. The geological section in bedrock underlying Line C is indicated on Figure 4.

The overburden cover along Line C is thin but present along most of the line with few outcrops. It is considered to be less than 5 m deep except at the sample station CU at the extreme south end of the line. The soil is podzolic with a well developed humus layer overlying a grey A_2 horizon. In general the relief along the line is similar to that at Barbara Lake (Figure 3) except that at Hanes Lake the hollows are less well marked and the general slope is towards the south. The roadbuilding caused minimal disturbance to the landscape on either side.

The overstory on Line C includes cedar with minor balsam fir. At the south end of the line there are signs of logging of first growth large trees some decades ago. Along the line there are large birch (*B.Lutea*) and maple (*A.saccharum*) individuals within the overstory. In the vicinity of CG and CH a 15 m high birch clone was conspicuous. The understory in the area is largely maple bushes with some hazel (*Corylus cornata*), dogwood (*C. canadiensis*), and choke cherry (*Prunus pennsylvanica*). The plants covering the ground include michaelmas daisy (*Aster macrophyllus*), raspberry (*R. idaeus var. stringosus*), current bush (*R. lacustre*), and snowberry bush (*S. albus*) in the better drained areas, and grass (*Calamagrostic canadiensis*), sedge (*Carex sp.*), ferns (*P. aquilinium*), club mosses (*Lycopodium dendroidem, L. clavatum*), and mosses (*A. undilatum, Brachythecium sp.*) in damp areas. The mix of plants at any one spot is determined by the nature of the understory and overstory canopy and the moistness of the soil.

SUMMARY

It is evident from the above descriptions that the overburden, relief, aspect, soil cover, and plant cover on Lines B and C are very similar to that of the "Hemlo Model" described above. Consequently Lines B and C are considered to belong to the same *Landscape Domain*.

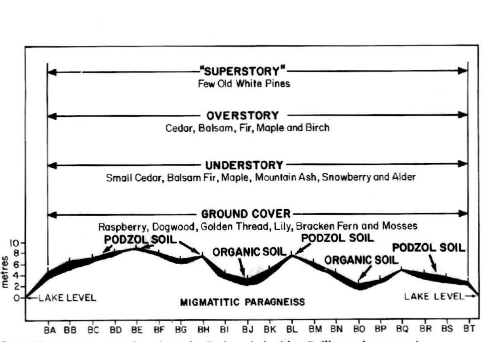

Figure 3. Landscape section along the Barbara Lake Line B, illustrating general relationships between rocks, soils, relief, and vegetation.

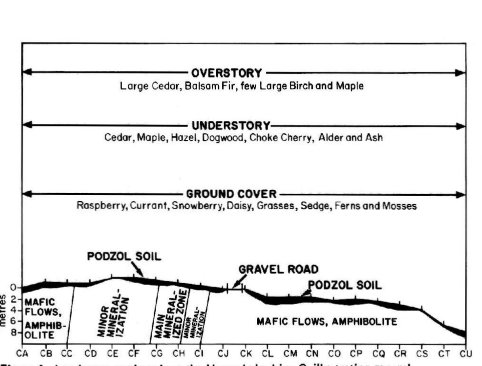

Figure 4. Landscape section along the Hanes Lake Line C, illustrating general relationships between rocks, soils, relief, and vegetation.

The bedrock geology which underlies the two lines is quite different mineralogically and geochemically. Consequently Line B and Line C are said to belong to different *Geochemical Domains*. A further complicating factor is that within the bedrock underlying Line C there is a significant mineralized zone which, as we shall see, gives rise to a significant geochemical anomaly in the humus.

From the theoretical viewpoint, Lines B and C provide an interesting experiment in geochemistry. The Line B geochemical data can be considered to indicate how elements behave in areas where the overburden is thin and forests are growing on granitic terrain. This state of affairs provides background geochemical data for humus geochemical behaviour in vast areas of the Canadian Shield where the vegetation cover is similar to that at Barbara Lake. Similarly, the geochemical data from Line C provides detailed information on the behaviour of elements in areas underlain by metavolcanic rocks in general and small mineralized zones in particular.

The use of Global Level, Regional Level, and Local Level methodologies for processing the geochemical data derived from humus at the two sites provides readers with bases for comparison of the Barbara and Hanes Lakes data sets with other, similar data sets obtained at other locations within the Canadian Shield where the landscape conditions are similar.

DESCRIPTION AND DISCUSSION OF RESULTS

GLOBAL LEVEL ABUNDANCE PATTERNS

The processing of the geochemical data at the Global Level resulted in a lookup table (Table 4) and two multielement scan sheets, one for Barbara Lake (Line B, Figure 5) and the other for Hanes Lake (Line C, Figure 6).

Global values based on the Clarke Index-I relate directly to *estimates* for the level of individual elements in the Earth's crust (Table 3). These estimates are then used as datum levels for the calculation of values listed in Table 4. It should be stressed that high Clarke Index-I values may not be always associated with "geochemical anomalies" due to mineral deposits. Consequently, the description of Global Level data in this Section should be interpreted with caution by scientists involved in mineral exploration.

The lookup table (Table 4) provides readers with an overview of element abundance relationships for three humus fractions in samples collected from Lines B and C. Bearing in mind the constraint described above, the use of the Clarke Index-I transform smooths the data considerably and facilitates a general discussion of abundance relationships within the different geochemical domains. A glance at Table 4 indicates a grouping of the elements according to Clarke Index-I numbers as follows:

A—Elements with relatively high K values (Mn, Ba, Zn, Pb, Br, As, Sb, and Hf)

B—Elements with relatively low K values (Fe, Mg, Cr, Ni, and Co)

C—Elements with intermediate abundance levels (Al, Ca, Na, K, Ti, P, Sr, Zr, V, Cu, La, Sc, Th, U, Be, and Lu)

Table 4. Global Level lookup table for humus data from Lines B and C. Data listed in Clarke Index-I units.

[...]

lead in humus compared with zinc over a mineralized zone. The bromine values are found to be more variable than for lead. For example on Line B (-50 mesh fraction) the range is from 0.68 to 12.00 K with a mean of 6.34 K and a standard deviation of 2.40. Comparable data for Line C range from 0.84 to 7.20 K with a mean of 4.39 K and a standard deviation of 1.80.

Arsenic, Antimony, and Hafnium The abundance for arsenic, antimony, and hafnium in humus is less well known. Similar Clarke levels for arsenic are found at both sites. For example, on Line B (-50 mesh fraction), arsenic values range from 2.5 to 6.1 K with a mean of 4.14 K and a standard deviation of 0.87. These values compare with a range of 1.11 to 3.89 K and a mean of 2.45 K (10 samples) in Domain I at the Williams Property at Hemlo (Fortescue 1985).

Similarly, antimony values on Line B range from 4.0 to 8.5 K with a mean of 5.7 K and a standard deviation of 1.15, and those on Line C range from 3.5 to 7.5 K with a mean of 5.52 K and a standard deviation of 1.03, all in the -50 mesh fraction. Comparable data for antimony in Domain I at Hemlo range from 3.0 to 6.0 K with a mean of 4.15 K (Fortescue 1985). This suggests from levels for arsenic and antimony that the Clarke Index-I values are relatively high for use in humus in parts of the Canadian Shield although further work is required to verify this statement. No data for hafnium was obtained from the Hemlo study.

Other Elements So far we have been concerned with the elements which are grouped together because they are found to have relatively high Clarke Index-I values. Three other elements, silver, gold, and molybdenum, also are found to have high values in the humus. They are not included in this discussion because the performance of the analytical methods by which they were determined in humus was not as reliable as that for the elements discussed above (Table 2). Discussion of the abundance patterns for elements in Groups B and C is postponed to the next section where the Global scan sheets are discussed.

Summary The Global lookup table provides an effective way of looking at multielement geochemical data from humus in order to discover which elements have relatively high values according to the Clarke Index-I scale. This procedure demonstrates how two groups of elements with relatively high levels in humus can be distinguished. One group which includes Zn, Mn, and Ba and, possibly, As and Sb, includes elements likely to be associated with mineralization, and the other group including Pb, Br, and perhaps Hf are found to have high values which could be related to biogeochemical cycling of normal levels in mineral substrate.

The Global lookup table as described here has other uses. For example it can be used as a hard copy introduction to a multielement geochemical data set of the type described in this broadsheet for use in the interpretation of geochemical patterns in humus in real time using image processing and computer graphics as described by Fortescue (1986). Such a procedure does away with the need for a broadsheet but not the lookup table which is used for the initial selection of elements of interest within a data set.

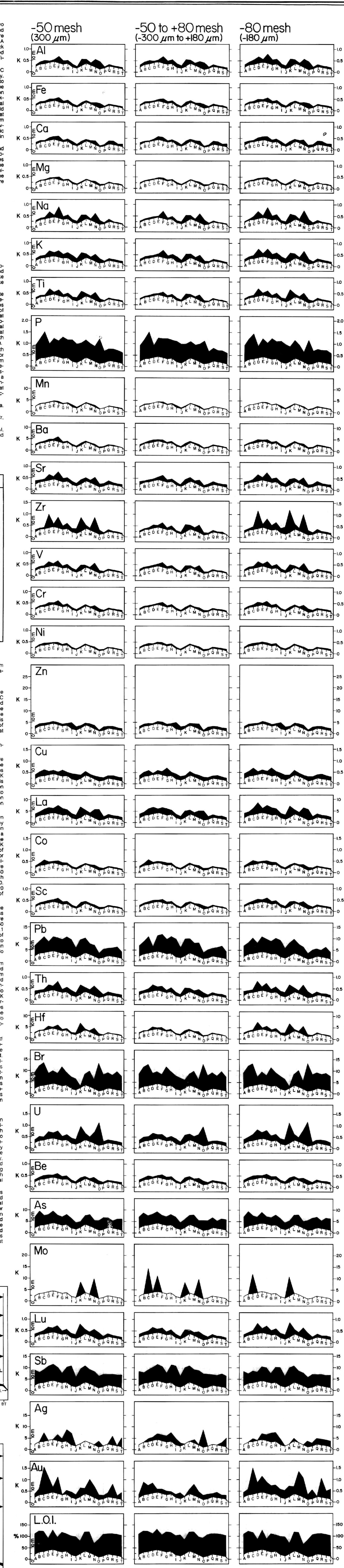

Figure 5. Scan sheet of the 32 elements of interest and Loss on Ignition in the three fractions of humus, Line B, Barbara Lake area.

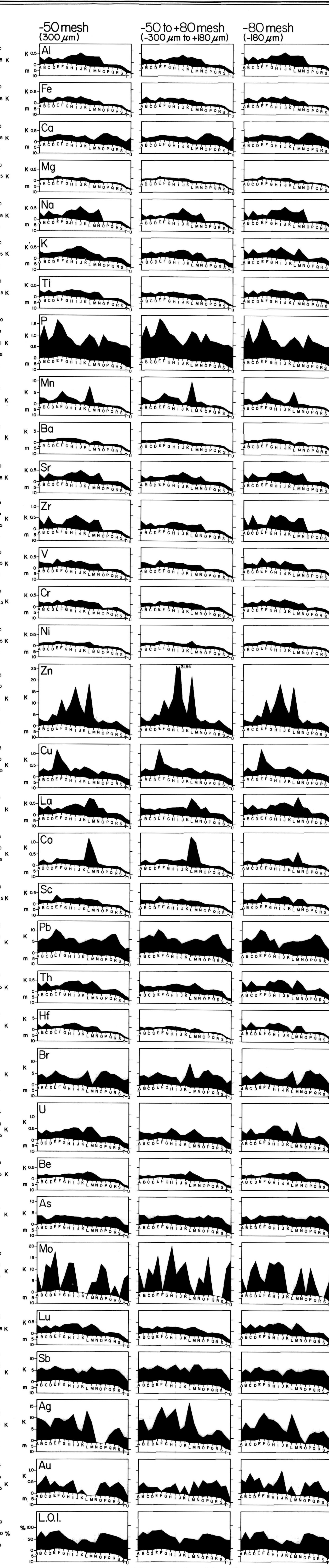

Figure 6. Scan sheet of the 32 elements of interest and Loss on Ignition in the three fractions of humus, Line C, Hanes Lake area.

GLOBAL LEVEL SCAN SHEETS

Figures 5 and 6 are Global Level scan sheets for Lines B and C respectively. Each scan sheet includes geochemical data for 32 elements and loss on ignition with the elements arranged from top to bottom in order of decreasing Clarke Index-I value (see Table 3). This procedure is standardized for scan sheets of this type which include three size fractions of humus in order to facilitate visual interpretation of data patterns. It should be noted that the grouping of elements according to their behaviour in humus which was used in the Hemlo Broadsheet (Fortescue 1985) has not been used here because it is replaced by the Global lookup table.

The two scan sheets (Figures 5 and 6) are considered to be located in the same landscape domain for purposes of this broadsheet. In spite of this they are geochemically different owing to being located on different types of bedrock (see above), Line B being located on granitic rocks and Line C on metavolcanic rocks. Although located some 40 km apart the lines are considered to belong to the same landscape domain because the lines have similar orientation, slope, and relief; similar overburden type and thickness; similar zonal soils; and broadly similar vegetation cover. These similarities enhance the value of the interpretation of the individual element patterns because they can be considered to be caused largely by the geochemistry of the bedrock and surficial geology and not by variations in the landscape domains studied as was the case at Hemlo (Fortescue 1985).

The ranking of elements according to their Clarke Index-I values on Figures 5 and 6 allows for discussion of elements according to their Clarke Index-I values which are found in the Earth's crust (Table 3) and not necessarily in humus. This procedure is justified because it is a general one which can be standardized for multielement geochemical data sets not only in rocks but in mineral soils, tills, biogeochemical samples, and other materials which are used for multielement geochemistry (for example see Fortescue and Webb 1986). It is interesting in this regard that Taylor and McLennan (1985) in a discussion of the geochemistry of the continental crust refer to estimates for as many as 62 elements in rocks. The Global lookup table/scan sheet approach can easily cope with such numbers of elements, the study of which is greatly facilitated by using an image processing computerised methodology. Let us now consider the elements according to orders of magnitude of abundance in humus as evidenced by the Clarke Index-I.

Elements with Clarke Index-I values from 10 000 to 100 000 ppm (Al, Fe, Ca, Mg, Na, and K)

Geochemical patterns for these elements in the three humus fractions from Lines B and C are shown at the top of Figures 5 and 6 where the values for each element are plotted using Clarke Index-I values on a topographic section of each cut line. This procedure was adopted on the Hemlo broadsheet (Fortescue 1985) to focus attention on the importance of aspect and local relief in the interpretation of geochemical patterns in humus.

The elements in this abundance group are commonly major constituents of igneous and metamorphic rock minerals. In humus they range in abundance from 0.033 K (Mg in the -50/+80 mesh fraction from Line B) to 0.301 K (Ca in the -80 mesh fraction from Line C). In general the mean values for these elements are consistently at a lower level in the humus from Line B (granitic terrain) compared with Line C (metavolcanic terrain) in all three humus fractions (Figures 5 and 6). This variation in level from line to line is not due to variations in the mineral content of the humus from line to line as evidenced by the loss on ignition data (Figures 5 and 6, bottom) which seldom varies more than 10% from humus fraction to humus fraction (see tables on the back of this sheet).

The patterns for elements in this abundance group are all plotted on Figures 5 and 6 using a range from 0.095 to 0.25 K. This procedure, which was not adopted on the Hemlo broadsheet (Fortescue 1985), serves to enhance the contrast and accentuate the patterns for elements with low K values in humus fractions. On Figures 5 and 6 this plotting procedure indicates that patterns for all six elements differ for the two lines and are characteristic for a particular element. The abundance patterns repeat well from size fraction to size fraction for samples collected along the same line, suggesting that the combined sampling and analytical errors are small compared with the real abundance variations from sample to sample. These generalizations hold true for the majority of element patterns displayed on Figures 5 and 6.

Individual element patterns are discussed below.

Aluminum Similar levels on both cut lines with slightly higher than normal values found above the mineralized zone on Line C.

Iron Similar levels on both lines, with low values in the six southmost sample sites on Line C.

Calcium Relatively high values on Line C compared with Line B. Significant increase in values from sample sites at the south end of Line C.

Magnesium Low on both lines with minor variations in level.

Sodium Variable along both lines. On Line C, low at the south end and relatively high over the mineralized zone.

Potassium Patterns similar to calcium but more noisy on Line C.

Elements with Clarke Index-I Values from 1 000 to 10 000 ppm (Ti, P, and Mn)

Phosphorous and manganese are essential plant nutrients. Titanium is not considered a plant nutrient and is seldom reported above the range 1 to 56 ppm in plant tissues (Bowen 1979). The range in values for these elements in humus reflect these observations. For example, titanium is low in the -50/+80 mesh fractions along both lines which is expected if these fractions are more organic rich than the other two.

Phosphorous As a plant macronutrient, phosphorous is relatively high in humus from both lines. High phosphorous values are associated with high copper values on Line C.

Manganese Very low values on Line B. Medium levels associated with phosphorous and copper values on Line C, also a single high value at sample site CL which may be due to seepage.

Titanium Relatively low in all fractions along both lines. Slightly higher in the -80 mesh fraction.

Elements with Clarke Index-I Values from 100 to 1000 ppm (Ba, Sr, Zr, V, and Cr)

These elements are usually considered to be minor constituents of rocks, are not plant nutrients or often accumulated by plants, and may, under certain circumstances, be indicators of mineralization. It is surprising to find that barium values are relatively low on Line B compared with Line C (Table 5). Although the high mean values for humus on Line C are to some extent due to patterns associated with the mineralized zone (see tables on the back of this sheet) this still does not account for the relatively low barium values on Line B. Taylor and McLennan (1985) quote values for barium of 130 ppm in Archean mafic rocks and 520 ppm and 480 ppm for I and S type granites respectively.

REGIONAL LEVEL ABUNDANCE PATTERNS

The exploration manager, or geochemist, requires a summary of the patterns in humus data which can be used directly in the exploration process. In order to make such plots as meaningful as possible, data for all three fractions of humus samples obtained for element X is combined with a three sample rolling mean procedure described under Display of Geo-

[...]

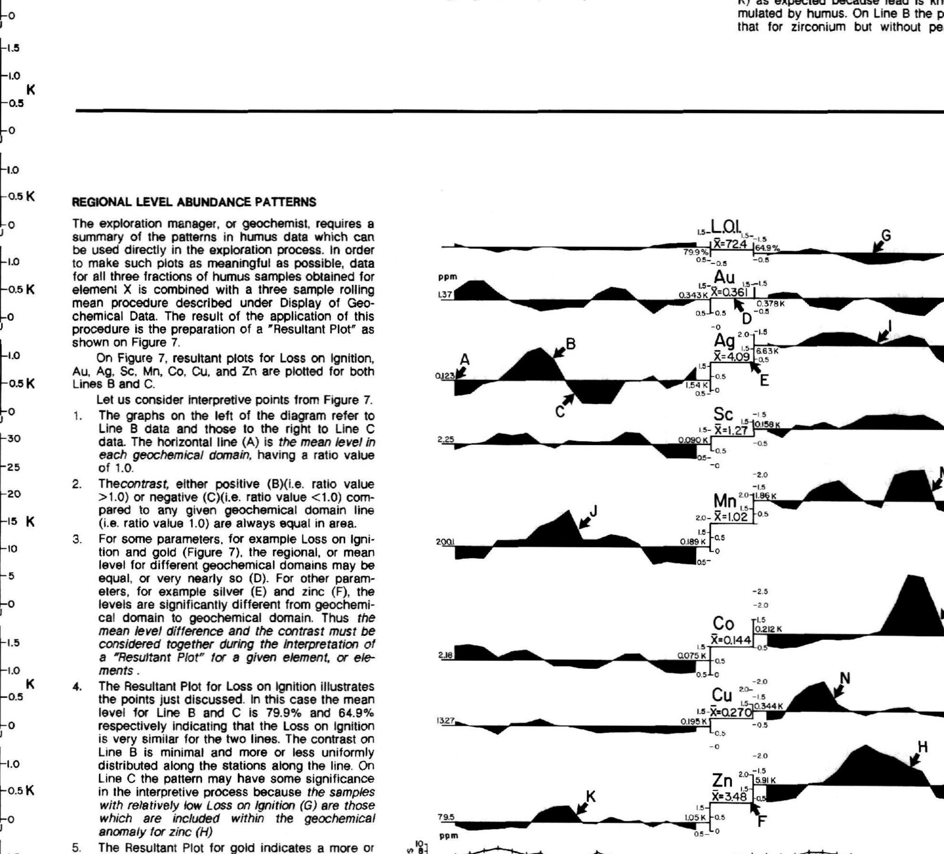

Figure 7. Resultant plot of the 7 elements of interest and Loss on Ignition for both humus lines.

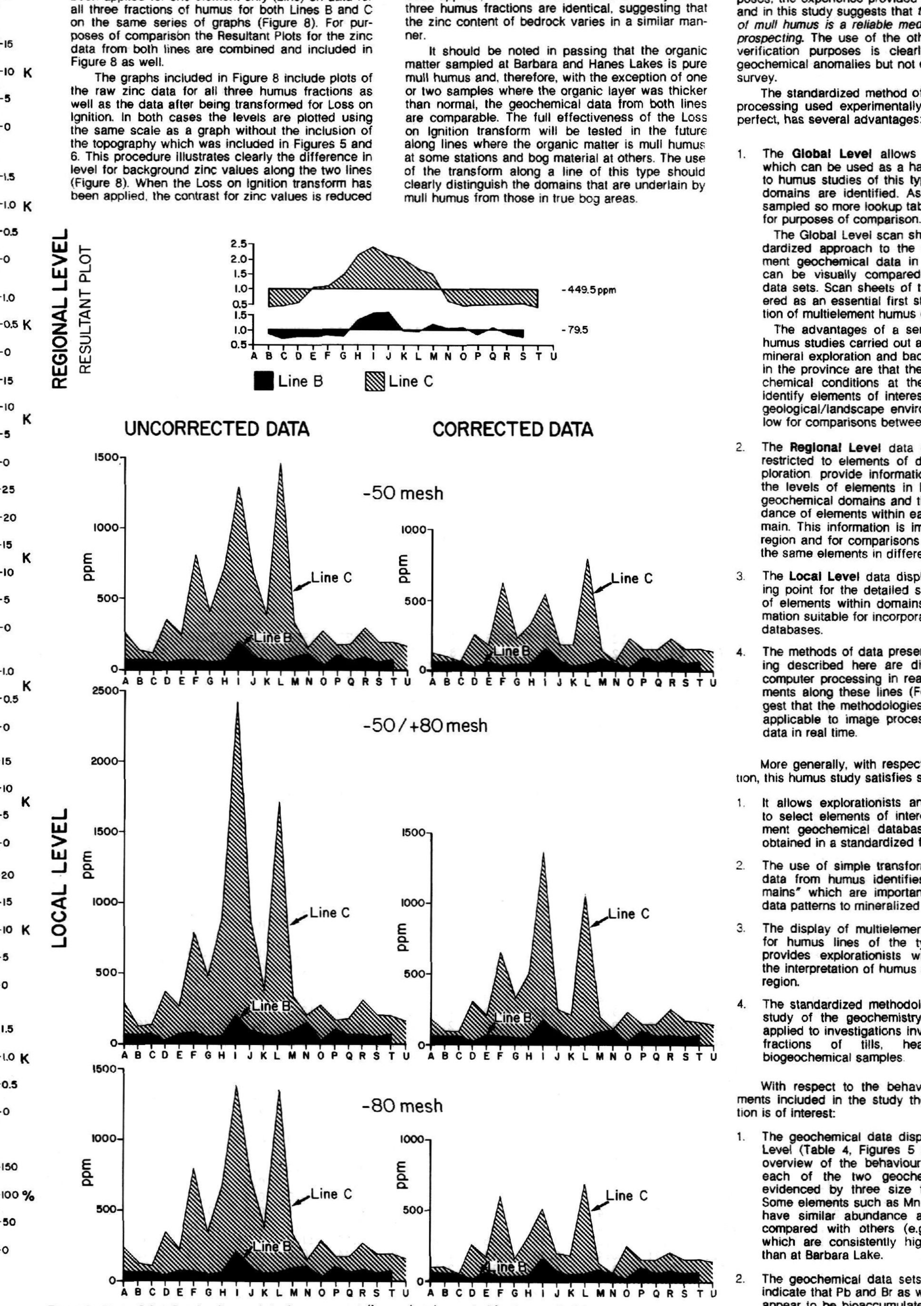

Figure 8. Plots of data for zinc (in ppm), both uncorrected (i.e. raw) and corrected for Loss on Ignition.

Geochemical data listings for individual elements

ELEMENT: Aluminum — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Iron — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Calcium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Magnesium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Sodium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Potassium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Titanium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Phosphorus — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Manganese — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Barium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Strontium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Zirconium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Vanadium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Chromium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Nickel — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Zinc — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Copper — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Lanthanum — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Cobalt — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Scandium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Lead — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Thorium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Hafnium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Bromine — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Uranium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Beryllium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Arsenic — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Molybdenum — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Lutecium — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Antimony — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Silver — LINE: B / LINE: C

Site	-50 ppm	K	-50/+80 ppm	K	-80 ppm	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Gold — LINE: B / LINE: C

Site	-50 ppb	K	-50/+80 ppb	K	-80 ppb	K
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ELEMENT: Loss on Ignition — LINE: B / LINE: C

Site	-50 %	-50/+80 %	-80 %
[illegible]	[illegible]	[illegible]	[illegible]

Quality control data listings

Size Fraction	Sample Number	Al	Fe	Ca	Mg	Na	K	Ti	P	Mn	Ba	Sr	Zr	V	Cr	Ni	Zn	Cu	La	Co	Sc	Pb	Th	Hf	Br	U	Be	As	Mo	Lu	Sb	Ag	Au	LOI
-50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-50/+80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Laboratory		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]