A Comparison of Multi-Media Geochemical Data Using a GIS

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Geochemical data sampled from a variety of media are commonly used in mineral exploration programs to assist in targeting specific mineral deposits. Media such as till, soil, humus, vegetation, rock and lake sediments can provide unique and complimentary information on metal patterns within the surficial environment. Much research on the processing and interpretation of geochemical data obtained from individual surveys has been undertaken; however, little work has been conducted on the relationships, both statistical and spatial, between geochemical surveys sampled from different media. Klassen *et al.* (1997) and Harris (1997) have presented preliminary results on comparisons between different media in central Labrador and northern Ontario, respectively.

The objective of this study is to compare geochemical responses from different media focusing on the elements Zn and Cu in two geographically and geologically distinct areas of Canada. This work is in part a summary of the work undertaken to date by Rencz and Harris from the Geological Survey of Canada. The first area is in central Labrador, an area comprising four structural provinces, the Superior, Churchill, Grenville, and Nain, while the second is in the Superior province of northern Ontario (see Figure 1). The two areas are characterized by differing geology, physiography and spatial extent as well as varying geochemical survey densities and patterns. This provides an opportunity to compare and contrast the effect of a number of parameters—physical, chemical and artificial (survey patterns)—on the concentration of Zn and Cu in different media.

The Labrador test site is characterized by intrusive and high grade metamorphic rocks overlain by less deformed volcanic and sedimentary assemblages while the northern Ontario test site comprises lower grade Archean volcanic assemblages (Swayze Greenstone Belt) intruded by granitoid rocks of variable composition. Both study areas, typical of much of the Canadian Shield, are characterized by low relief, poor drainage, numerous lakes and glacial overburden of variable thickness and composition. Figure 1 shows the extent of the two study areas as well as the distribution of geochemical sample points of the various surveys, while Table 1 summarizes the various geochemical surveys for each area.

Variograms were employed to determine whether geochemical samples are spatially correlated. Data anisotropy, due to glacial transport and regional stratigraphy, were identified and modelled. The lithogeochemical, Quaternary and lake sediment geochemical point data have been interpolated to continuous surface maps using kriging and inverse distance weighted algorithms.

A number of different methods were employed to compare the data. Surveys that sampled media at the same point (e.g., till, soil and humus survey of the Swayze Greenstone Belt) were compared on a point-to-point basis. Comparing data sampled at different sites required a different strategy. Firstly a nearest neighbour approach was utilized whereby a sample point from one medium (usually the medium characterized by the lowest sampling density) was compared to the nearest point from another medium. Both Euclidean distance and direction (reflecting glacial dispersion and orientation of regional stratigraphy) are accounted for in these procedures as the nearest-point search algorithm records distance and direction as crucial attributes. Thus similarity between samples from different media can then be analyzed with respect to distance and direction to the nearest point. Secondly, point values from one data set were compared to interpolated values from another data set and thirdly, all data sets were interpolated (gridded) and compared. Various techniques including visual inspection of RGB (red-green-blue) ternary diagrams, correlation analysis and boolean analysis of anomaly maps, are used to compare the geochemical data.

In both study areas, the patterns of Zn and Cu in all media reflect variation in the underlying bedrock.

Figure 2 are plots of the median value (the median value is used as it is less affected by outliers and thus results in a more accurate measure of background concentrations [Garrett, 1993]) for Zn and Cu (log concentration) for each lithological unit in the Swayze Greenstone Belt. Zn and Cu concentration is highest in ultramafic-mafic intrusive and metasedimentary rocks. Generally, the curves for both Zn and Cu vary sympathetically by lithology although Cu is more variable. Zn concentration in soil and till is the most similar as reflected in the moderately high correlation between these media (see Table 2). Zn in rock is the least variable across lithology, which may indicate higher background values in all lithologies due to preferential substitution of Zn in silicate (pyroxenes, amphiboles) and oxide (magnetite) minerals as well as sulphide minerals. The curves for Cu are, in general, more variable than Zn, which may reflect differences in mobility as well as the preferential concentration of Cu in sulphide minerals.

Correlation between media for Zn and Cu is generally low. For example in the Labrador test site correlation between Zn and Cu in till and lake sediment using the grid-to-grid method was .2 and .21, respectively. Table 2 presents correlations between Zn and Cu (log-transformed) for different media based on the interpolated grids for the Swayze area.

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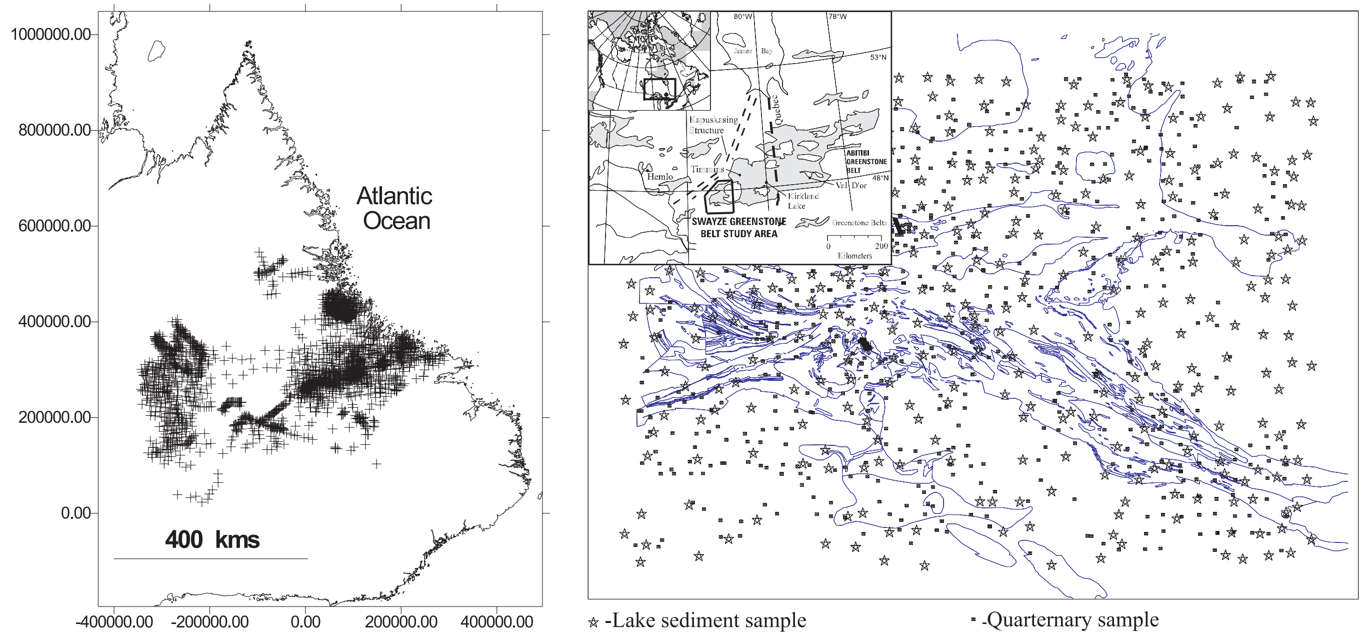

Figure 1: *Location map for sample sites and media used in this study.*

Table 1: ***Description of geochemical surveys***

Labrador

Media	Sample Density	Size Fraction	Analytical Method	Source
Till	variable - 1 per 4 km^2 to 1 per 100 km^2	clay-sized (<0.002 mm)	AAS – aqua regia digestion	Klassen and Thompson,1995
Till	as above	silt and clay size (<0.063 mm)	ICP-AES	as above
Lake Sed	1 per 13 km^2	< 0.177 mm (80 mesh)	AAS and INNA	GSC National Reconnaissance Program (NGR) – Friske and Hornbrooke,1991

Swayze Greenstone Belt

Media	Sample Density	Size Fraction	Analytical Method	Source
Till	1 per 4 to 7 km^2	silt and clay size (<0.063 mm)	ICP-OES – (AR)	Ontario Geological Survey, Bernier,1994
Soil	as above	silt and clay size (<0.063 mm)	as above	as above
Humus	as above	< 0.177 mm (80 mesh)	as above	as above
Lake Sed	1 per 10 km^2	< 0.177mm (80 mesh)	AAS and INNA	GSC (NGR)
Rock	variable (av. spacing ~ 200 m)	whole-rock samples	variable	GSC, OGS, proprietary

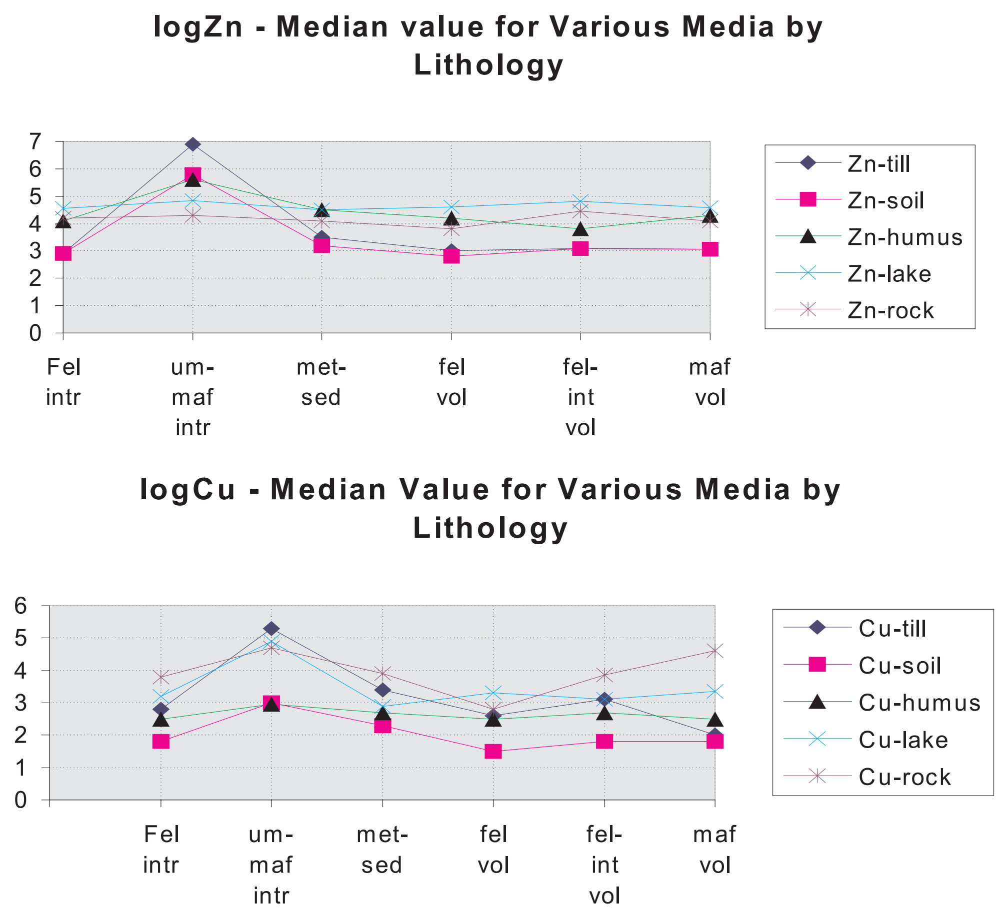

Figure 2: *Median value for log-tranformed Zinc and Copper for various media shown by lithology.*

Table 2: ***Correlation between Zn and Cu in various media based on interpolated values; number in brackets is correlation for Cu, non-bracketed number is correlation for Zn.***

	Humus	Soil	Till	Rock	Lake Sed
Humus		.15 (.52)	.04 (.22)	–.04 (.01)	–.01 (.33)
Soil			.68 (.52)	–.02 (.03)	.18 (.41)
Till				–.01 (.06)	.41 (.3)
Rock					.07 (.01)
Lake Sed					

With respect to the Quaternary media, the highest correlation for both log-transformed Zn and Cu is between soil and till followed by humus and soil. The correlation for Zn in the various Quaternary media is higher than the correlations for Cu, perhaps reflecting the greater mobility of Zn and higher regional background values. The moderate correlation between soil and till indicates that the soil profile is largely formed from underlying glacial till. The difference in correlation between soil and humus for Zn and Cu may in part be explained by the preferential scavenging of Zn by organic matter in humus. Relatively speaking, Zn concentration in humus is much higher than Cu in humus.

Figure 3 is a ternary map of Zn anomalies in rock, lake sediments and till displayed in red, green and blue, respectively, over the Swayze Greenstone Belt. Anomalies were determined by observing upper breakpoints on probability plots and thresholding the data above these levels into binary maps. Very little overlap between the anomalies can be seen with the exception of a small zone (location "A") in the southern portion of the greenstone belt where a Zn anomaly in till is coincident with the same in rock (magenta area). This anomalous zone occurs in the vicinity of the past-producing Shunsby base metal mine. A number of Zn anomalies in lake sediment are evident to the south of this area (green areas) and may reflect southward glacial transport of mineralized material into specific drainage basins.

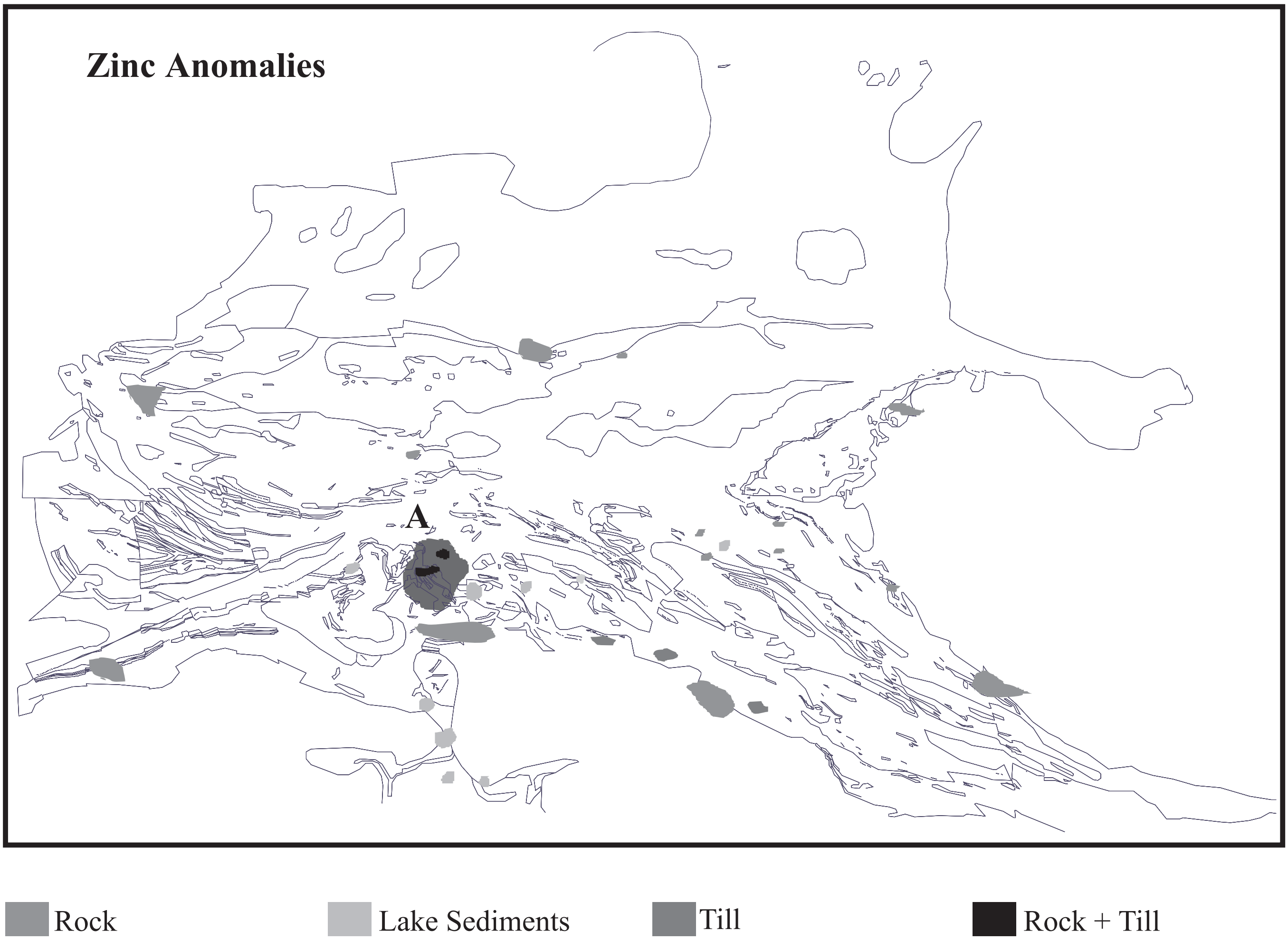

Figure 3: *Anomalous Zinc areas for the various sampling media in the Swayze Greenstone Belt.*

It is evident that Zn and Cu behave differently depending on the surficial material sampled. This difference is reflected in the statistics derived from each data set as well as the spatial behaviour of each element. Zn anomalies are generally more extensive reflecting higher mobility and higher background values. Zn shows less variation across lithology than Cu as Zn can substitute for major oxides in silicate and sulphide minerals while Cu substitutes for sulphide minerals. Thus variations in Cu across lithology are more likely related to mineralization trends (Cu in sulphides) than to bulk lithologic variations, as is the case with Zn. Other differences between Zn and Cu distributions in different media may be the result of different grain size and fractions of the media sampled, biophysical differences (pH, vegetation), variable topography and secondary scavenging by Fe and Mn oxides and organic matter.

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