6a. The Geochemical Map of Ontario Pilot Project: Summary of Preliminary Results From the 90th Meridian Project

J.A.C. Fortescue and R.D. Dyer

Sedimentary and Environmental Geoscience Section, Ontario Geological Survey, Sudbury

INTRODUCTION

The geochemical traverse of the 90th meridian (sampling was completed along 90° 45' W) represents the second phase of the Meridian Project which was initiated in 1992 with the geochemical traverse of the 80th meridian (Fortescue et al. 1992). The Meridian Project was designed to test the feasibility of a Geochemical Map of Ontario (GMO), similar to province wide geological and geophysical maps.

CHOICE OF LOCATION

The 90° 45' W meridian (Fig. 6a.1) was chosen for a province-wide geochemical traverse for several reasons: 1) To test the effectiveness of lake sediment and water sampling over Precambrian terrain in northwestern Ontario; 2) to maximise potential geochemical contrast due to the presence of large greenstone belts separated by wide expanses of granitic rock; and 3) the relative lack of deep overburden over much of the line.

Bedrock Geology

The bedrock geology underlying the sampled line consists entirely of the Precambrian Superior Province. Greenstone belts transected by the sampled line include the Shebandowan Belt, Sturgeon Lake Belt, Savant Lake Belt, Meen-Dempster Belt and North Caribou Belt. Broad expanses of granitic rocks lie between these greenstone belts.

Quaternary Geology

The Quaternary materials which underlie the meridian consist of tills, glaciofluvial deposits and minor clay. From the USA-Canada border northward to Lake St. Joseph the Quaternary cover is commonly a thin, discontinuous layer of till with scattered patches of glaciofluvial deposits. From Lake St. Joseph to Williams Lake the sampled line crosses an area dominated by thick till. North of this the surficial cover varies from thin to thick till and glaciofluvial deposits.

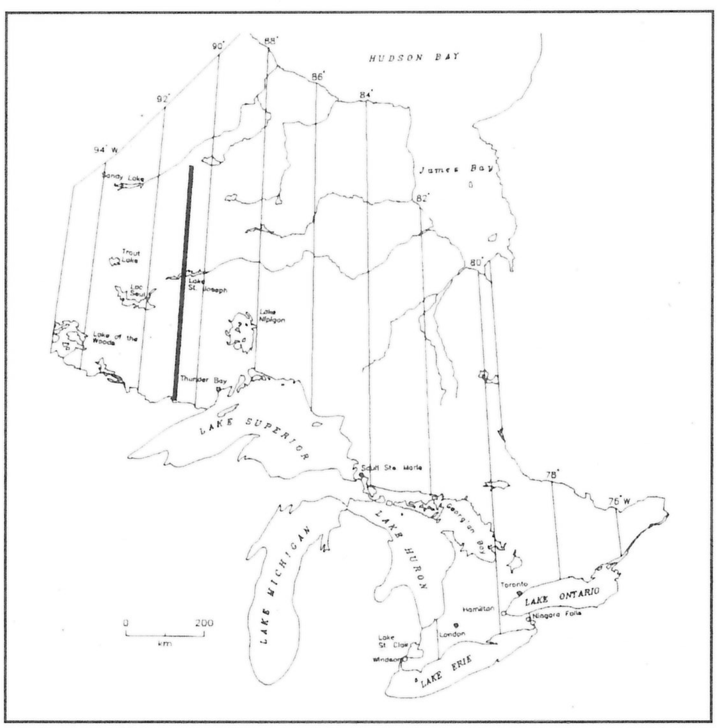


Figure 6a.1 Location map of the 90° 45' meridian..

METHODOLOGY

The 90°W meridian sampling plan called for the collection of lake sediment and water from adjacent 10 x 10 km cells (micromodules) along the meridian (Fig. 6a.2). This overall sampling plan is identical to that used for the 80th meridian in 1992.

In order to reduce the intersample variance (inherent natural variability) of organic, mineral and geochemical constituents inherent within the sample media over the 100 km^2 area of each micromodule, where possible, 4 sample stations were established in each micromodule (one per micromodule quarter) with the intention of creating composites (sample composites and data composites). For each micromodule, a 4 sample composite of lake sediment "upper" material was created. This was accomplished by extruding the top 8 cm of each core from each of 4 micromodule quarters into the same bag. A "lower" sample from each micromodule quarter (depth > 14 cm) was bagged separately and is roughly equivalent to a pre-Ambrosia sample from the 1992 80th Meridian project. Geochemical data from the micromodule quarter "lower" lake sediment samples will be composited to arrive at one value for the module.

Field work along the meridian was completed during late July and early August 1993. Almost all of the laboratory work was completed by the end of November 1992.

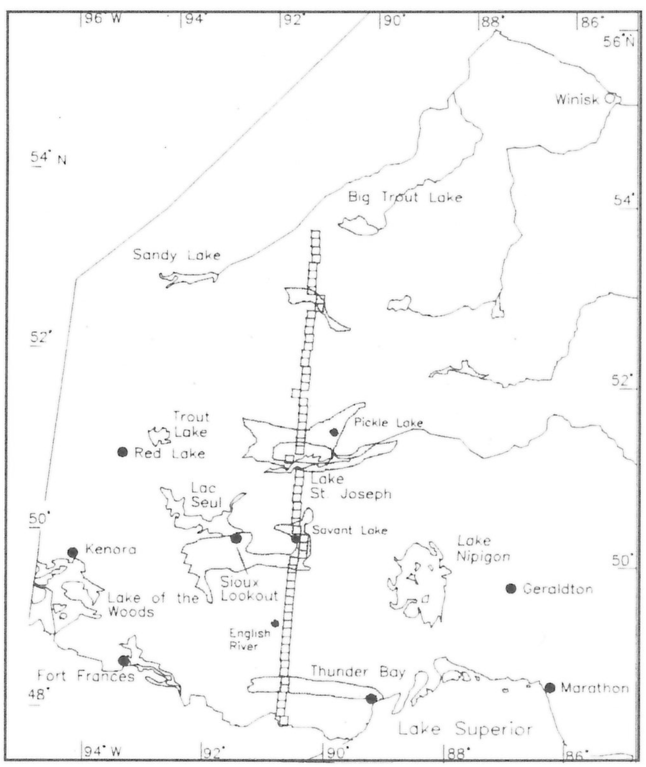


Figure 6a.2 Micromodules sampled along the 90° 45' meridian. Shaded areas represent major greenstone belts transected by the meridian.

SAMPLING PROCEDURE

As with the 80th Meridian project, the lack of road access in much of northwestern Ontario precluded the use of surface vehicles for sample collection. Consequently, a Bell 206B, equipped with floats and the OGS lake sediment sampling gear was contracted for this purpose.

Lake waters were composited on the helicopter float. This involved successively adding 250 ml of lake water from each of 4 micromodule quarters into a 1 l high density polyethylene bottle. A 250 ml sample from each micromodule quarter was also kept as an archive. Surface water was sampled from shallow lakes (depth < 5 m). On deep lakes (lake depth > 5 m) a deep water sample was taken using a 15 foot long 3/4" Tygon tube sampler. These bottles were stored in a refrigerator at the end of each day prior to pH determinations, filtration and acidification.

In all of the 61 micromodules both "lower" and "upper" lake sediment samples were collected using a simple gravity sampler as described by Fortescue (1988). The lake sediment cores were extruded on the helicopter float and the samples placed in whirl-pak plastic bags for transport to the laboratory.

During helicopter sampling a Trimble Pathfinder Basic Global Positioning System (GPS) receiver was used to record exact UTM coordinates of lake sample sites and to facilitate helicopter navigation between sample sites. The use of this instrument reduced the helicopter time required between lake sample sites and expedited the transfer of sample station UTM coordinates to a computer database.

In the helicopter, sample station positions were also recorded manually on customized 1:50 000 scale laminated topographic maps.

PRE-PROCESSING AND CHEMICAL ANALYSIS OF SAMPLES

The pH of cooled, composite, water samples was measured soon after collection. This was followed by filtration of 400 ml from each 1 l water sample through a 0.45 micron cellulose acetate syringe filter. Two subsamples were created from this filtrate: 1) for trace element analysis, a 125 ml sample was placed in a new pre-cleaned high density sample bottle and acidified to 1% with ultra pure nitric acid; and 2) for major elements and anions, a 50 ml sample was placed in a new sample vial and not acidified. The remaining filtrate was acidified and kept as an archive. Another 250 ml of unfiltered water from the 1 l sample was acidified and kept as an archive. Analysis of the waters for 20+ elements by ICP-MS was done by the Geological Survey of Canada.

Lake sediment samples required pre-processing before chemical analysis. This included oven drying and sieving followed by grinding of the dry lake sediment material. Analysis for 45 major, minor and trace elements and loss on ignition was completed by ICP-OES and NAA by Bondar-Clegg in Ottawa under contract to the Ontario Geological Survey.

The methodology for chemical data for all of the meridian samples included stringent quality control procedures based on replicated analyses of international reference materials and pulp duplicates.

DATA PROCESSING

The geochemical data was processed in a similar manner to that described previously for the 80th Meridian Project (Fortescue and Dyer 1993).

PRELIMINARY RESULTS

a) Lakewater pH data

Figures 6a.3a and 6a.3b illustrate the variation in pH along the meridian using the same format as that for the 80th meridian by Fortescue et al (1992). In the 90th meridian corridor there is an upward pH gradient (increase in alkalinity) from south to north similar to that described from the 80th meridian. The "hump" patterns (centred on modules #37 and #53 in Fig. 6a.3b) correspond to localized areas of the corridor dominated by thick calcarious till. b) Lakewater and Sediment Geochemistry.

In mid-November 1993 data for Fe, Cu, Ce and La (plus many other elements in the 90°45" lakewater samples) became available from the Geological Survey of Canada. After meeting the quality control requirements for this project, some of these data were plotted as a series of sawtooths to facilitate a preliminary examination of the geochemical patterns (Fig. 6a.4A-E).

Also in November 1993, chemical data for the "upper" and "lower" lake sediment samples became available from the contractor . After meeting quality control standards for this project the, "upper" lake sediment sample data for 6 elements (Fe, P, Cu, Ce, La, Pb) and LOI plus the "lower" lake sediment sample data for 9 elements (Fe, K, Ca, P, Cu, Ce, La, Au, Pb), and LOI were combined and plotted as sawtooths in a single Quicklook diagram as described previously by Fortescue and Dyer (1994) (Fig. 6a.4A-E).

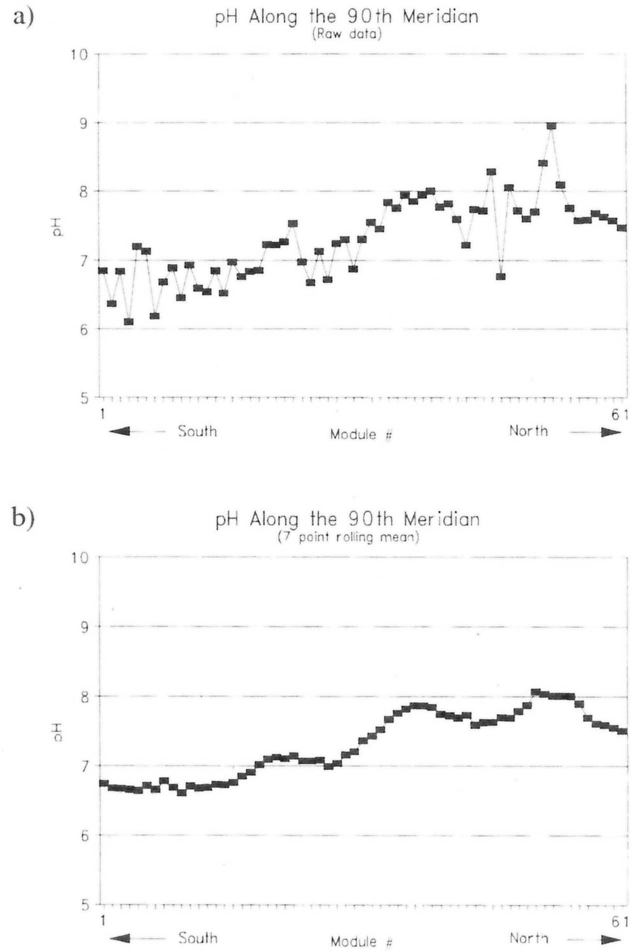


Figure 6a.3 Lake water pH along the 90° 45' meridian (a) Raw data (b) data smoothed using a 7 point moving average.

DISCUSSION

The data was found to include several geochemical patterns of potential importance to the GMO Pilot Project as a whole. Figure 6a.4A-E includes a selected sampling of these patterns.

On Fig 6a.4A the bar-graphs summarize the complexity of the: 1) bedrock geology; 2) Quaternary cover; and 3) the physiographic region (i.e the Severn Upland) along the 620 km of the 90°45" meridian sampled during 1993. Compared with the 80th meridian data described by Fortescue and Dyer (1994), these geological conditions and landscape conditions are relatively simple. This uniformity of landscape conditions is enhanced by the lack of clay belts along the 90th meridian. The near identical LOI patterns in the "upper" and "lower" 90th meridian corridor samples (Fig. 6a.4A) also reflects the uniformity of the sample material in lake bottoms along the meridian. The Au pattern in "lower" lake sediment samples is displayed in fig.

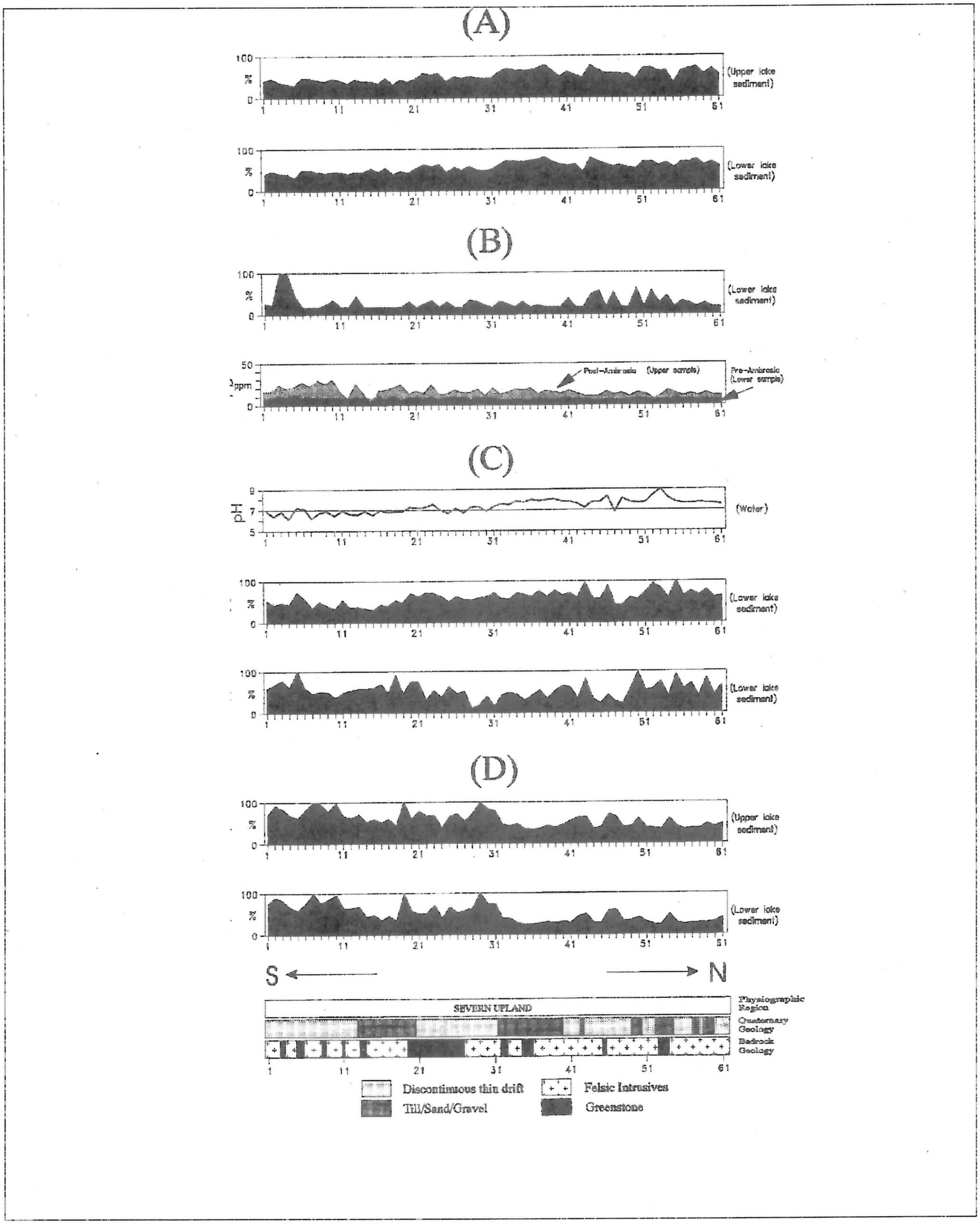
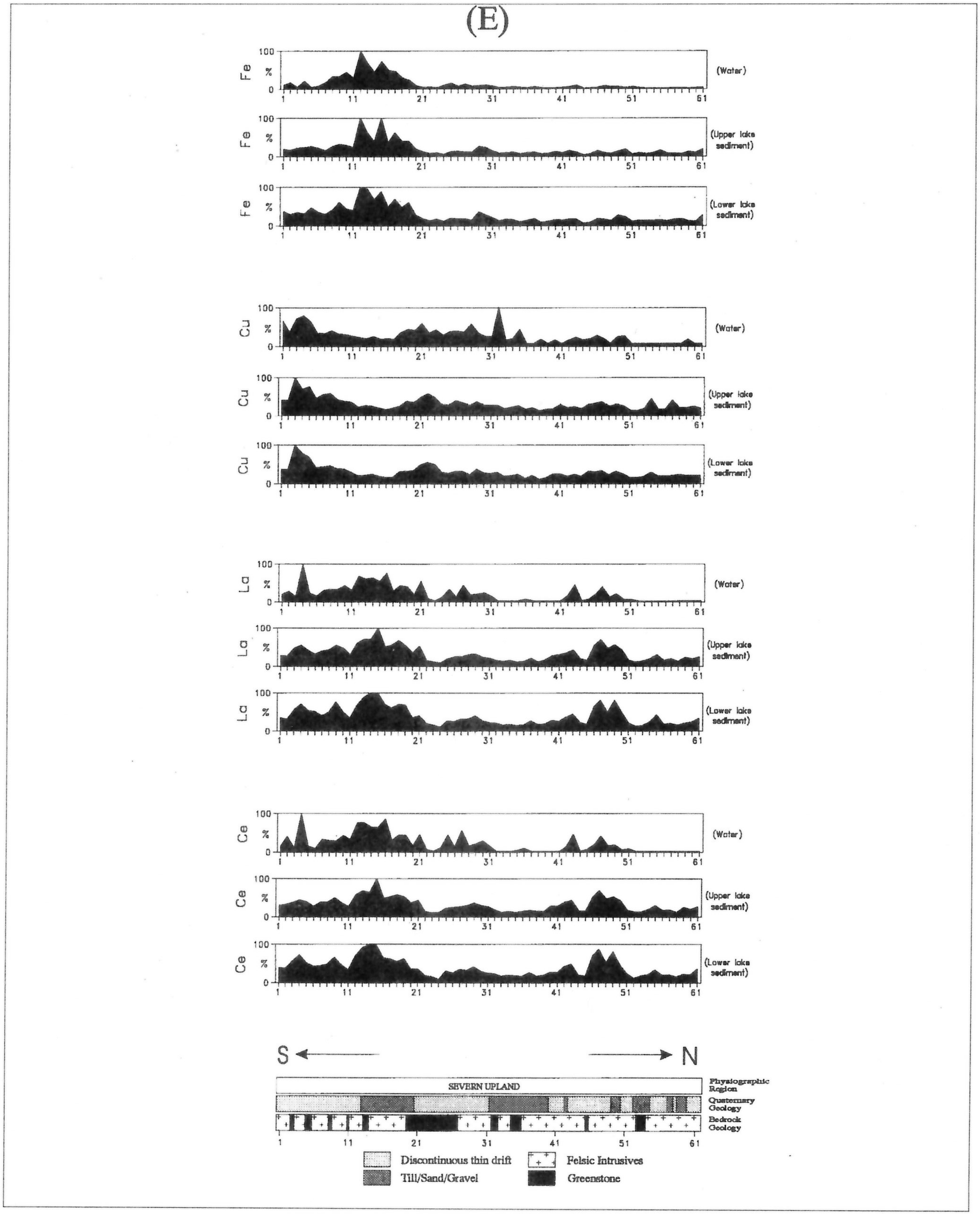


Figure 6a.4 Quicklook geochemical diagram for the 90th meridian corridor project including patterns for: (A) landscape physiography and geology and geochemical data for LOI in "upper" and "lower" lake sediment data sets; (B) geochemical patterns for Au in "upper" lake sediments and Pb in both "upper" and "lower" lake sediments; (C) geochemical patterns for K and Ca in "lower" lake sediments and pH in lakewater samples; (D) P in Figure 6a.5 "upper" and "lower" lake sediments;



(E) data for Fe, Cu, La and Ce in (i) lakewaters; (ii) "upper" and (iii) "lower" lake sediments. For further explanation see text.

6a.4B. This includes a small, well developed, Au geochemical province between #3 and #5 (in Moss Township) at the south of the meridian corridor. Superimposed, "lower" and "upper" 90th meridian patterns for Pb are included in Fig. 6a.4B. In spite of its small size, this plot indicates clearly that Pb levels in the "upper" (post-Ambrosia) sample are consistently higher compared with the "lower" (pre-Ambrosia) sample. The difference between these 2 Pb levels is attributed to Ontario-wide, non-point source, atmospheric Pb pollution which has accumulated in post-Ambrosia lake sediment during the past 80 years (see Fortescue and Vida 1991).

Sawtooth geochemical patterns for pH (water), Ca and K in "lower" lake sediment samples are included in Fig. 6a.4C. The pH and Ca patterns are generally similar to each other with a gradual positive gradient northwards. This is associated with an increase in calcium carbonate (derived from the Hudson Bay Lowlands) in the overburden. In general the major element sawtooths along the 90th meridian are similar to those obtained for the same elements the 80th meridian (Fortescue and Dyer 1994). Note that the level of K is relatively uniform along the entire 90th meridian corridor.

The 2 sawtooth patterns for P (Fig. 6a.4D) show very good repeatability. Both P patterns show an unexplained, Ontario-wide, negative, geochemical gradient from south to north along the meridian. A similar gradient was discovered along the 80th meridian (Fortescue and Dyer 1994).

Figure 6a.4E includes sets of element data plots for Fe, Cu, La and Ce in: 1) lakewater, and 2) "upper"; and 3) "lower"; lake sediment samples. It is of considerable interest that geochemical patterns for: 1) a major element (Fe); and 2) 3 minor elements (Cu, La and Ce); are nearly identical in all 3 sample media. The meridian geochemical province pattern for Fe, Ce and La between # 11 and # 21 (Fig.6.4E) is underlain by granitic rocks including some minor mafic greenstone units.

CONCLUSIONS

1) Preliminary analysis of element data patterns obtained from composite lake water and sediment samples collected at 10 km intervals along 620 km of the 90° 45" meridian corridor suggests that verified baseline geochemical data patterns for Fe, Cu, La and Ce (and other elements not discussed here) can be obtained as part of the geochemical database accumulated during meridian corridor sampling.

2) Preliminary analysis of both major and minor element natural and anthropogenic data patterns obtained from lake sediments collected along the 80th and 90° 45" meridian corridors suggests that Ontario-wide, geochemical patterns can be mapped successfully by the meridian corridor approach to geochemical mapping being developed during this Pilot Project.

ACKNOWLEDGEMENTS

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