Ontario

Ontario Geological Survey
Open File Report 5927

The Application of Water and Soil Geochemistry to Detect Blind Mineralization in Areas of Thick Overburden

1995

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ERRATUM

OFR 5927

Application of Water and Soil Geochemistry to Detect Blind Mineralization in Areas of Thick Overburden

Further statistical treatment of water chemistry data presented in OFR 5927 suggests that the data presentation technique used for some figures may exaggerate the significance of water "anomalies" spatially related to mineralization. Figures 6 to 19 show the areal distribution of concentrations of constituents in surface water. "Surface water", as defined for these figures, refers to flowing creek water, bog water from surface pools, and shallow groundwater, collected from small piezometers screened at <2 m depth. Bog water and shallow ground water samples were used at each of the 4 sites to increase overall sample density close to mineralization.

As can be seen from the element frequency distributions in Appendix II, the three media have different concentration ranges. They also have different statistical means and background concentrations. The effect of combining data from the 3 media may have artificially enhanced the apparent "anomalies" spatially related to mineralization. The increase in concentration is considerably less significant when each data set is viewed separately.

Additional data are currently being gathered to determine the impact of combining the data sets with respect to the interpretations contained in the report. Until additional results become available, it is recommended that the above noted figures and associated interpretations be viewed with caution.

The results and interpretation of soil geochemistry based on enzyme leach methodology are not affected by this issue.

Ontario

ONTARIO GEOLOGICAL SURVEY

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The Application of Water and Soil Geochemistry to Detect Blind Mineralization in Areas of Thick Overburden

By

R. G. Jackson

1995

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ABSTRACT

A multi-media geochemical study was initiated at several sites in the Abitibi greenstone belt where mineralization is covered by glaciolacustrine or glaciofluvial sediments. The objective was to determine if the dispersion of elements in water saturated overburden is sufficient to produce a detectable response at surface in water from drainage pathways, organic-rich media in drainage pathways, and A and B horizon soils.

Sampling was carried out over known gold and base metal mineralization in 4 areas of Northeastern Ontario: the Shoot Gold Zone in Taylor Township, several sub-economic gold deposits in Hislop Township, the Holt-McDermott and Worvest Gold deposits in Holloway Township, and the Patton base metal mineralization in Stimson Township The mineralization was covered by 20 to 40 m of glacial overburden. The most common sediment at surface was glaciolacustrine clay but in 2 areas, glaciofluvial sand or till was exposed locally in windows through the clay.

Distinct geochemical anomalies were obtained in soils, surface water and, to a lesser extent, organic stream bank and peat media. Surface water trace element geochemistry exhibited a more consistent and interpretable relationship to mineralization for trace elements than did peat or organic bank geochemistry. However, spotty gold anomalies of limited areal extent were observed in the organic media in close association with the water anomalies.

A multi-element geochemical response was obtained in surface soils above all deposits studied. In areas of clay cover, the B-horizon analyzed by an enzyme leach/ICP-MS method yielded "rabbit ear" anomalies which straddle the sub-crop of the mineralization. In some cases, similar anomalous patterns were observed for Au (INAA)

in A horizon soils above the B horizon trace element anomalies. In sand or till, the A horizon analyzed by INAA for Au and by enzyme leach/ICP-MS for trace elements gave a clearer response to gold mineralization than the B-horizon.

Electrochemical processes seem to be the most likely mechanism for transporting ions to the surface through clay cover where they collect at certain preferred adsorption sites. However, high sulphide content is not required for the development of electrochemical cells. A variety of geological features, exposed to contrasting redox conditions, may give rise to a cell. In addition to mineralization, these may include faults, lithological boundaries, and both lateral and vertical variations in glacial materials. Where these features occur in close proximity to one another, superimposed electrochemical fields may result in complex dispersion patterns.

The Application of Water and Soil Geochemistry

to

Detect Blind Mineralization

in

Areas of Thick Overburden

R. G. Jackson

Introduction

The discovery of new deposits in the Abitibi greenstone belt, one of the most highly productive geological environments in Canada, has been hampered by large areas of extensive clay and glaciofluvial cover (Shipulin et al. 1973, Smee and Sinha 1979). The geochemical analysis of sample media, such as stream sediments and soils, have had limited success in identifying exploration targets using conventional aqua regia or total digestions.

As a result, exploration has relied heavily on geophysical methods to interpret the geology and define drill targets. However, for many gold targets, the relationship between the location of orebodies and geophysical anomalies cannot always be predicted reliably. Even for VMS deposits with high sulphide content, the detection of mineralization at depth using geophysical methods may be difficult due to limits in depth penetration and interference by conductive overburden or cultural effects.

Drift prospecting, using overburden drilling technology for sample collection, has been an effective geochemical method for finding new mineralization (Sauerbrei et al. 1987). However, the interpretation of till data is often difficult due to complex glacial stratigraphy, multiple ice directions and the influence of topography on glacial erosion and deposition. The method is also expensive. In practice, this results in a low sample density and limited area of coverage. Many targets may be missed.

The development of an inexpensive geochemical method for detecting a buried or blind deposit through thick overburden would be a significant advancement in mineral exploration, particularly in the clay belt. The present study attempts to explore several approaches toward this end.

Recent Developments in Applied Geochemistry

A number of developments in applied geochemistry suggest that the effectiveness of surficial geochemical methods should be re-examined in areas of thick overburden.

First, the development of an electrochemical model of element dispersion has altered our traditional view of the role that groundwater plays in transmitting dissolved ions from oxidizing bedrock or till to the surface. The conventional model of dispersion has generally been regarded as a process of dissolution at source, transport as some stable entity by means of groundwater flow and deposition under changing pH and Eh conditions (Drever 1988, Rose et al. 1979). An important factor in determining the relationship between surface anomalies and their source was considered to be hydrological flow patterns.

In areas of extensive clay cover, the vertical movement of groundwater to the surface is severely restricted due to the low hydraulic conductivity of clay (Smee and Sinha 1979, Smee 1983). As a result, the use of surface sample media such as water, stream sediment and soil has not been widely applied in areas of thick overburden outside the former Soviet Union (Miller 1979, Andropova et al. 1992).

Electrochemical models of dispersion suggest that the flow of ions to the surface is controlled by differences in redox conditions vertically within the mineralization (Sato and Mooney 1960, Bolviken and Logn 1974, Govett 1973, Sivenas and Beales 1982). The oxidized portion of the deposit near surface acts as a cathode in contrast to the relatively reduced portion (anode) at depth. Positive ions are released to the groundwater regieme at depth through oxidation reactions. The electrons produced flow vertically along the relatively conductive mineralized zone to the cathode near the bedrock/overburden interface. The positive ions flow vertically through the country rock parallel to the deposit until they reach the bedrock surface. Due to the higher electrical conductivity of the overburden, the ions then flow horizontally at the base of the overburden to the cathode to close the cell circuit. This relationship is shown diagramatically in the "Discussion of Dispersal Mechanisms" later on in this report.

This results in a build-up of cation concentrations to either side of the subcropping mineralization. Levels are theoretically low directly over the deposit. A satisfactory explanation of how some of these ions then disperse vertically to the surface has not been advanced although simple diffusion along concentration gradients has been suggested (Smee 1983).

Numerous field studies have demonstrated the existance of soil anomalies above buried and blind deposits despite upwards of 150 m of overburden and 500 m of unmineralized rock (Andrapova et al. 1992, Bolviken and Logn 1974, Govett 1975, Govett 1976, Govett and Chork 1977, Govett et al. 1984, Govett 1987, Jin et al. 1989, Smee 1983). These have been recognized using a variety of digestion methods although weak digestions appear to yield better contrast than strong extractions. Laboratory experiments have also confirmed that electrochemical dispersion does occur in response to potential gradients around a redox cell (Govett et al. 1976, Smee 1983).

A second development in applied geochemistry that has improved the ability to detect low trace element signals at surface is the re-examination of partial and/or selective digestions as a means of isolating a particular form of an element. Partial and selective digestions have been around a long time but they have recently been the focus of much research for both mineral exploration and environmental applications (Chao 1984).

Conventional surficial geochemical methods have generally utilized some form of an aqua regia digestion. This extraction is near total for most trace elements bound in adsorbed, organic and hydroxide form as well as some mineral forms (sulphides, carbonates and phylosilicates). It is a weak partial extraction with respect to most oxide and silicate minerals.

Alternatively, analysis of samples has been carried out to determine total metal content. In gold exploration, neutron activation analysis is often used in order to obtain reliable gold data at a low detection limit. Strong acid digestions (hydrofluoric/perchloric/nitric acid mixtures) have also been employed.

In areas of thick overburden, the weak signal from mineralization at depth that may be present in an adsorbed phase may be swamped by relatively high levels of metals bound in the lattices of mineral grains to which they are adsorbed. Several innovative methods have recently been described for isolating this adsorbed component (Andropova et al. 1992).

One promising approach is the use of a patented enzyme leach developed initially at the USGS and currently marketed by Activation Laboratories Inc. (Clark 1992). This digestion is considered to be selective for Mn hydroxides coating the mineral grains in soils and stream sediments.

A third development in geochemistry which improves the ability to detect weak surface anomalies is the advent of ICP mass spectrography (ICP-MS). This multi-element method is capable of determining trace elements in acid extractions or natural water over 4 to 5 concentration orders of magnitude with sensitivities at the sub-parts per billion level (Hall 1992). This provides multi-element data equivalent in sensitivity to single element data achieved by conventional graphite furnace/atomic absorption spectrophotometry. Gold can be determined along with a wide range of pathfinder and alteration-related elements.

Surface water geochemistry has not been widely applied to mineral exploration outside the former Soviet Union (Miller 1979). One of the main reasons for this has been that ICP emission spectrography, which has been the multi-element method of choice in the past, has relatively high detection limits for many pathfinder elements that are important in mineral exploration (Hall 1993). However, for those elements that are readily detectable, low density geochemical mapping projects have demonstrated that the composition of bedrock and mineralization is one of the most important factors in determining the composition of water (Miller et al. 1979, Simpson et al. 1993).

Dispersion studies around abandoned tailings sites have shown that, apart from the effect of tailings, surface waters analyzed by ICP-MS have natural elevated levels of many elements that can be attributed to sub-economic mineralization surrounding mine sites (Jackson and Hall 1994). However, the natural background of these elements is often at the sub-parts per billion level. Both chalcophile elements (Cu, Zn, Mo, As, Sb) and lithophile elements (Ti, Li, Rb) reflect areas of mineralization.

In addition to soil and water, the trace element content of organic sample media may assist in the detection of low trace element levels dispersed along drainage pathways. Organic stream bank and bog margin samples have proven to be effective for mineral exploration in areas where overburden is thin or till-dominated (Larsson 1976, Nuutilainen and Peuraniemi 1977). Their effectiveness in areas of clay cover has not been adequately tested.

In summary, there appears to be evidence in the literature for the dispersion of trace elements to the surface through barren rock or thick deposits of transported overburden. It may be possible to detect the products of this dispersion in soil using partial digestions that are specific to adsorbed element phases. It may also be possible to detect anomalies in surface waters that leach the soils provided that sufficiently low analytical detection limits can be achieved by ICP-MS. Alternatively, organic sample media in drainage pathways may serve as natural concentrators of low level trace element anomalies in the surface and shallow groundwater.

Study Objectives

A multi-media orientation survey was initiated at several mineralized sites to determine the geochemical signature at surface of gold and base metal mineralization buried beneath clay and glaciofluvial cover. Three groups of surficial media were sampled: water in drainage pathways, the organic-rich substrate to water in drainage pathways, and soils developed on the glacial substrate.

The research program was designed to determine the following:

1) What sample media reflect mineralization?

2) What sample site selection criteria apply?

3) Are there preferred analytical methods?

4) Which elements reflect mineralization?

5) What spatial relationship do anomalies have to mineralization?

6) What is the optimum sample density?

Study Locations

Four areas in northeastern Ontario were selected for study (Figure 1). Each area is host to one or more mineral deposits. The 4 areas and their associated deposits are:

1) Taylor Township.
    a) Shoot Gold Zone
2) Hislop Township
    a) South Gold Zone
    b) Central Gold Zone
    c) West Breccia Gold Zone
3) Holloway Township
    a) Holt-McDermott Gold Deposit
    b) Worvest Gold Deposit
4) Stimson Township
    a) Patton Base Metal Occurrence

The properties in Holloway Township are owned by American Barrick Resources Corporation. Both deposits are economic. The Taylor and Hislop properties are owned by St. Andrew Goldfields Ltd. The various zones have defined reserves but are uneconomic at this time. The Stimson property is held by Noranda Exploration Co. Ltd. There are no reported reserves for this occurrence but there are several drill intersections which establish the extent and continuity of the mineralization.

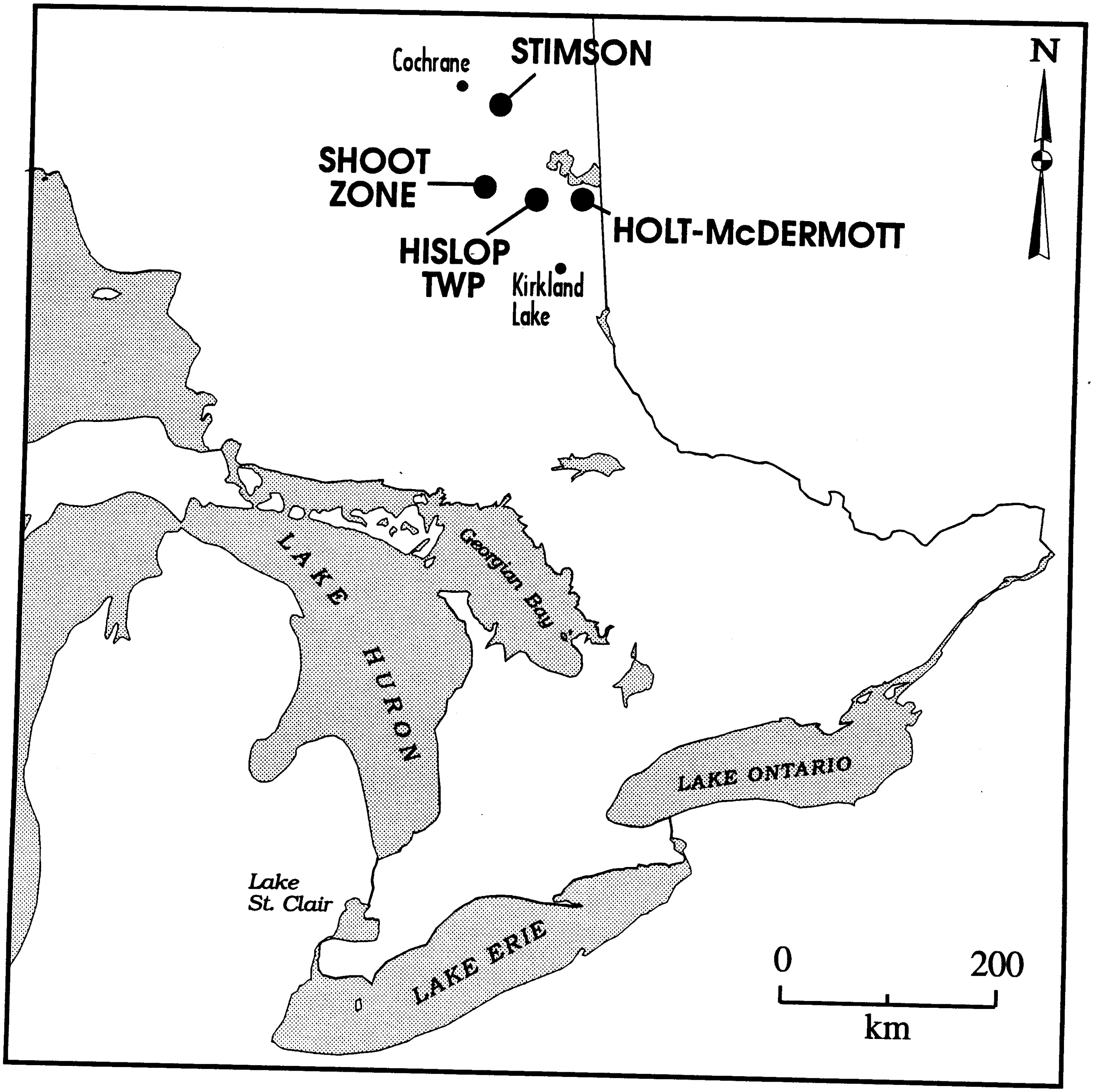


Figure 1. Location map of the study areas.

Bedrock and Surficial Geology

Regional Bedrock Geology

The study sites are located within the southern Abitibi greenstone belt. The oldest rocks in the area consist of metavolcanic and associated metasedimentary rock units intruded by synvolcanic peridotitic and granodioritic plutons (Jackson and Fyon 1991). The volcanic rocks are characterized by abundant ultramafic flows. Large foliated tonalite-granodiorite batholiths were subsequently emplaced followed by more massive granodiorite, granite, feldspar ± quartz porphyry and syenitic bodies. During and following this event, alluvial-fluvial clastic metasedimentary rocks and alkalic metavolcanic rocks were deposited.

Regional deformation resulted in the development of large scale, steeply dipping shear zones (i.e., Destor-Porcupine Fault Zone). The deformation was initiated prior to the deposition of the supracrustal sequence and continued for some time after. The rocks were folded isoclinally around axes which trend east-west and dip 45° to 90°. Metamorphic grade is generally greenschist facies.

The Taylor, Hislop and Holt-McDermott properties are all located along the Destor-Porcupine Fault Zone (DPFZ), a steeply dipping shear zone which is spatially associated with major gold camps along its 300 km strike extent. The Shoot Zone is hosted by the Bowman assemblage which consists of komatiitic rocks interlayered with magnesium-rich basalt. These rocks are in fault contact with wackes of the Hoyle assemblage.

The Hislop and Holt-McDermott mineralization is hosted by the Kinojevis North assemblage. This steeply dipping south-facing sequence includes tholeiitic basalt, minor rhyolite and interflow metasedimentary units. These rocks are in fault contact with ultramafic to mafic volcanic rocks of the Kidd-Munro assemblage.

The Stimson property is located west of the Lake Abitibi batholith and north of the Cochrane-Milligan Shear Zone. The mineralization is hosted by rocks of the Stoughton-Roquemaure assemblage which consists of north-facing, steeply dipping mafic volcanic rocks interlayered with numerous conductive interflow metasedimentary units.

Regional Surficial Geology

The study sites are characterized by an extensive cover of glacial overburden deposited during the Wisconsinan stage of the Quaternary continental ice age. Rare outcrop is observed on the Hislop and Holt-McDermott properties. More generally, overburden thickness is 20 to 40 m.

The glacial stratigraphy in the area is comprises up to 4 packages of glacial sediments related to 3 advances and one possible readvance (Veillette 1989, McClenaghan et al. 1992, Bird and Coker 1987, Steele et al. 1989). The 2 oldest advances that yield preserved deposits deposited till and related glaciofluvial or glaciolacustrine sediments. These are present locally infilling recessively weathered fault zones and other deep depressions.

These earlier deposits are overlain by a widespread package of till, glaciofluvial, and glaciolacustrine sediments laid down during the Matheson advance. Ice direction was generally 130-170° Az. The glaciolacustrine clay, deposited in postglacial Lake Ojibway, is the most common glacial sediment exposed on the present surface. Locally, this surface is interupted by esker sands and gravels or windows of till.

A late stage ice readvance is recorded in the area north of Timmins area where Cochrane Till is locally observed. These deposits consist of clay-rich till characterized by high carbonate content. Cochrane Till has not been recognized in any of the study areas but may be present in the Stimson area.

As a consequence of this glacial stratigraphy, the composition and character of the surficial deposits varies significantly both vertically and laterally (McClenaghan et al. 1992). Variation in the trace element chemistry of tills in the area has been correlated with changes in the pebble lithology abundance in the till. Also, the proportion of carbonate clasts may be an important factor in determining element mobility.

Grain size of the sediments likely varies from one extreme of dominantly clay in the glaciolacustrine deposits to the other extreme of sand and gravel in the glaciofluvial sediments. The till itself may vary locally and regionally with respect to the proportions of clay and silt relative to coarser material. The main groundwater aquifer, other than that within the fractured bedrock zone, is anticipated to be the relatively porous glaciofluvial deposits which commonly underly the glaciolacustrine sediments. Based on the hydrological properties of varved clays, it is unlikely that groundwater can percolate through these deposits to the surface except under rare conditions (Smee and Sinha 1979).

Geology of the Shoot Gold Zone

The Shoot gold zone consists of free gold in quartz veins developed in an altered ultramafic unit (O. Zavisiczky, personal communication). The only associated sulphide is a very minor dusting of fine grained pyrite. The ultramafic rock is bounded by syenite porphyry to the north and south. The mineralization is sub-parallel to the DPFZ which subcrops 250 m to the north of the zone (Figure 2).

The Shoot zone is 10 to 15 m wide by 200 m long, strikes N70°E, and dips 45° to the south. No information is available on the grade and tonnage but the mineralization is sub-economic at the present time.

The bedrock is overlain by 30 to 40 m of glacial overburden. A south-southeast-trending esker crosses the eastern end of the mineralization. The esker consists of well sorted sand with minor coarser grained layers. It is locally underlain by till. Marginal to the esker, the stratigraphy consists of 2 to 3 m of lodgement till overlain by 15 to 25 m of medium-grained sand. This is capped by up to 20 m of glaciolacustrine clay.

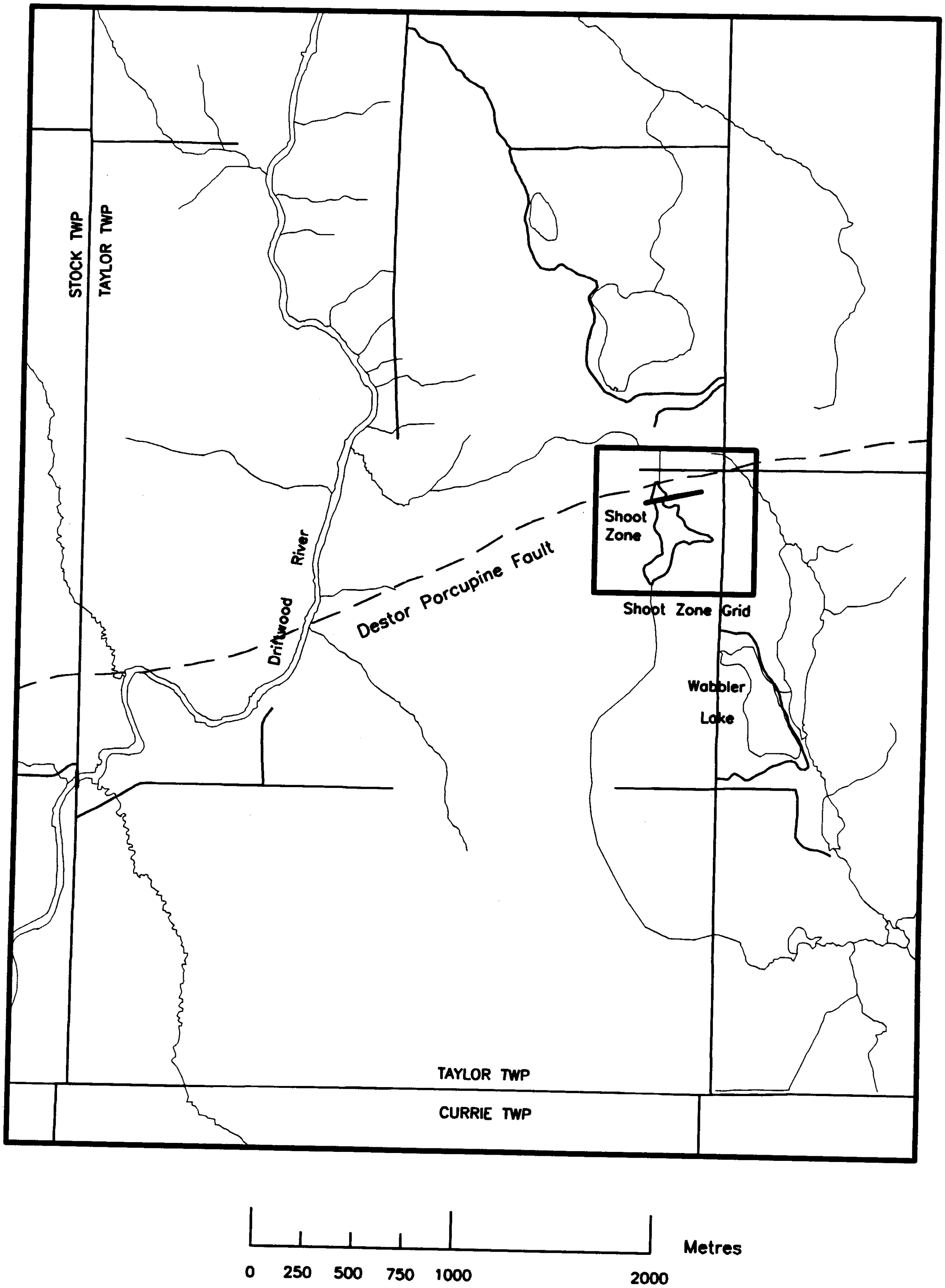


Figure 2. Location of the Shoot Gold Zone grid.

The area is relatively flat. The relief between the crest of the esker and the surrounding clay plain is less than 10 m. Numerous springs occur along the margin of the esker. On the west side of the esker, water breaks to surface close to the Destor-Porcupine Fault and flows to the south mostly in the sub-surface. It crosses the Shoot Zone within a 50 m wide alder-vegetated drainage pathway which then opens up into a sphagnum bog south of the zone. Elsewhere the drainages have preferred north or west trending orientations.

The soils developed on the esker sands are typical podzolic profiles. They consist of a thin A_0/A_1 horizon, a grey to white A_2 horizon and a reddish-brown B horizon. The soils developed on the clay plain have been modified by agricultural activity. They consist of a dark brown mixed surface layer approximately 30 cm thick overlying a grey to brown mottled B-horizon.

Vegetation is mostly poplar, birch, and spruce. However, where fields have been cleared, grass is dominant. The drainage pathways contain alders. The bogs are vegetated by sphagnum moss, laborador tea and locally alders. Black spruce occurs in some areas.

Geology of the Hislop Gold Deposits

Three sub-economic zones of gold mineralization occur along a northwest-trending contact between andesite to the north and chlorite schist to the south (P. Atherton, personal communication). These deposits are, from northwest to southeast, the West Breccia Zone, the Central Zone and the South Zone (Figure 3). In total, the mineralized horizon is 15 to 20 m wide by 1000 m long. The system is sub-parallel to the DPFZ which subcrops in the vicinity of the Pike River located north of the mineralization.

Gold occurs in close association with chalcopyrite. However, together with pyrite, the sulphide content is only in the order of 2 to 10%. The host rock is a carbonate breccia (dolomite and ankerite) which occurs within a fault zone along which syenitic or lamprophric dikes have been intruded. The syenitic dikes often contain molybdenite.

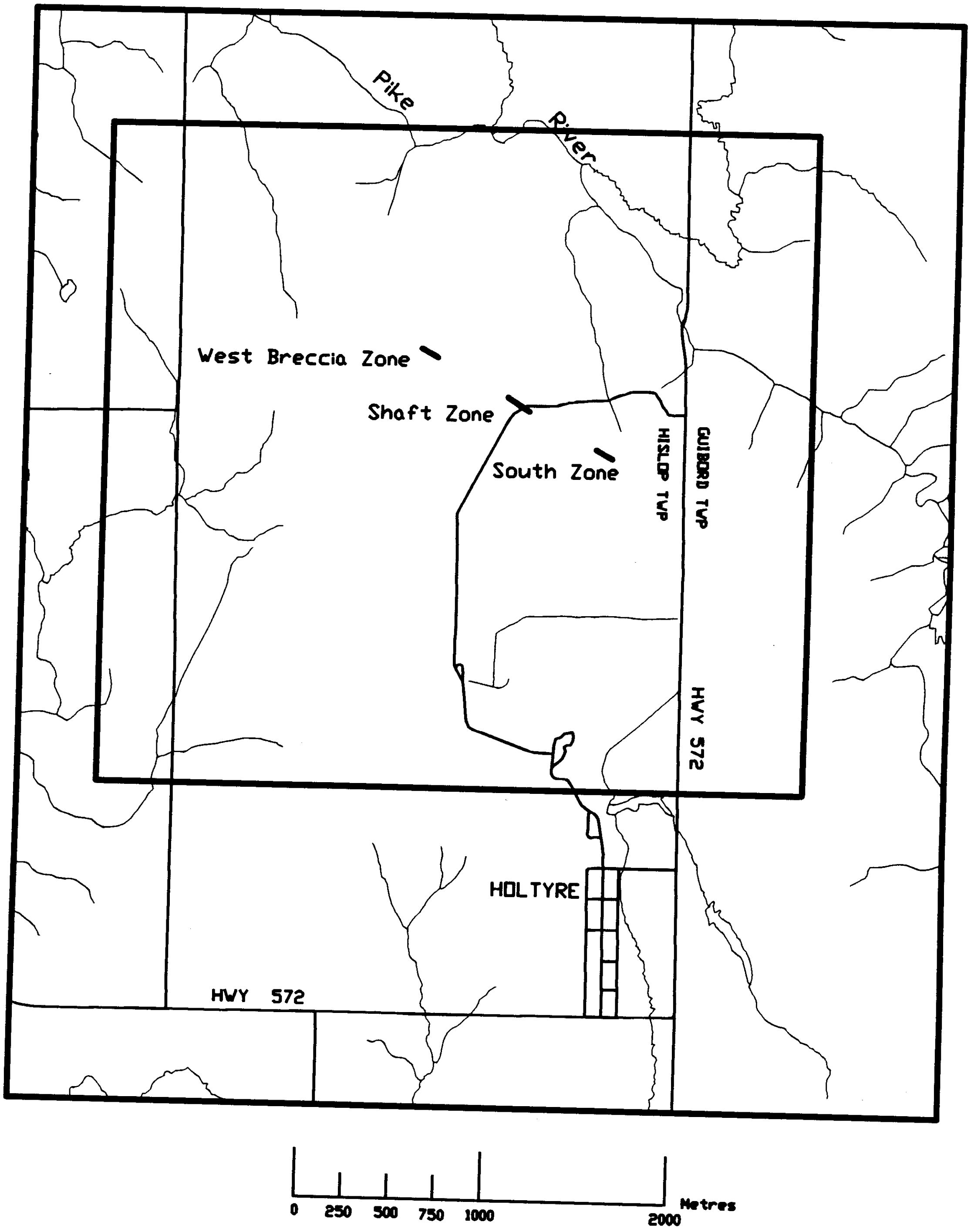


Figure 3. Location of the area hosting the Hislop Gold Deposits.

The bedrock is generally overlain by 20 to 30 m of overburden although outcrop is present locally. The overburden consists of a very compact clay-rich boulder till overlain by a relatively thin layer of varved clay. The till is exposed at surface in the area of the West Breccia Zone. Elsewhere, the region is clay covered.

Relief is relatively flat except in the vicinity of the major streams which have eroded down through the clay deposits. Drainage consists mostly of surface flow along streams trending north and west. The South Zone lies beneath a large sphagnum bog at the head of a drainage system. The peat is only 0.5 to 1.0 m deep in this bog. Elsewhere, the soils consist of a thin A_0 horizon and brownish B horizon developed on a grey C horizon of till or clay. Vegetation is similar to that at the Shoot Zone except for the absense of cultivated fields.

Mine infrastructure is present in the area of the Central Zone and may be a source of contamination. A road from the mine crosses one of the streams just down-drainage of the sphagnum bog. The effect of this road is unknown.

Geology of the Holt-McDermott Gold Deposits

The Holt-McDermott and Worvest gold deposits occur within silicified, carbonate (calcite, ankerite) breccia zones marginal to the DPFZ (Figure 4). Both the hanging wall and foot wall rocks are tholeiitic basalts. Highly altered felsic intrusive dikes are commonly associated with the mineralization (M. McGill, personal communication).

Both deposits are economic. The grade and tonnage of the ore produced to date is as follows (C. Todd, personal communication):

Holt-McDermott Deposit	1,000,000 tonnes @ 4.3 g/t
Worvest Deposit	620,000 tonnes @ 3.7 g/t

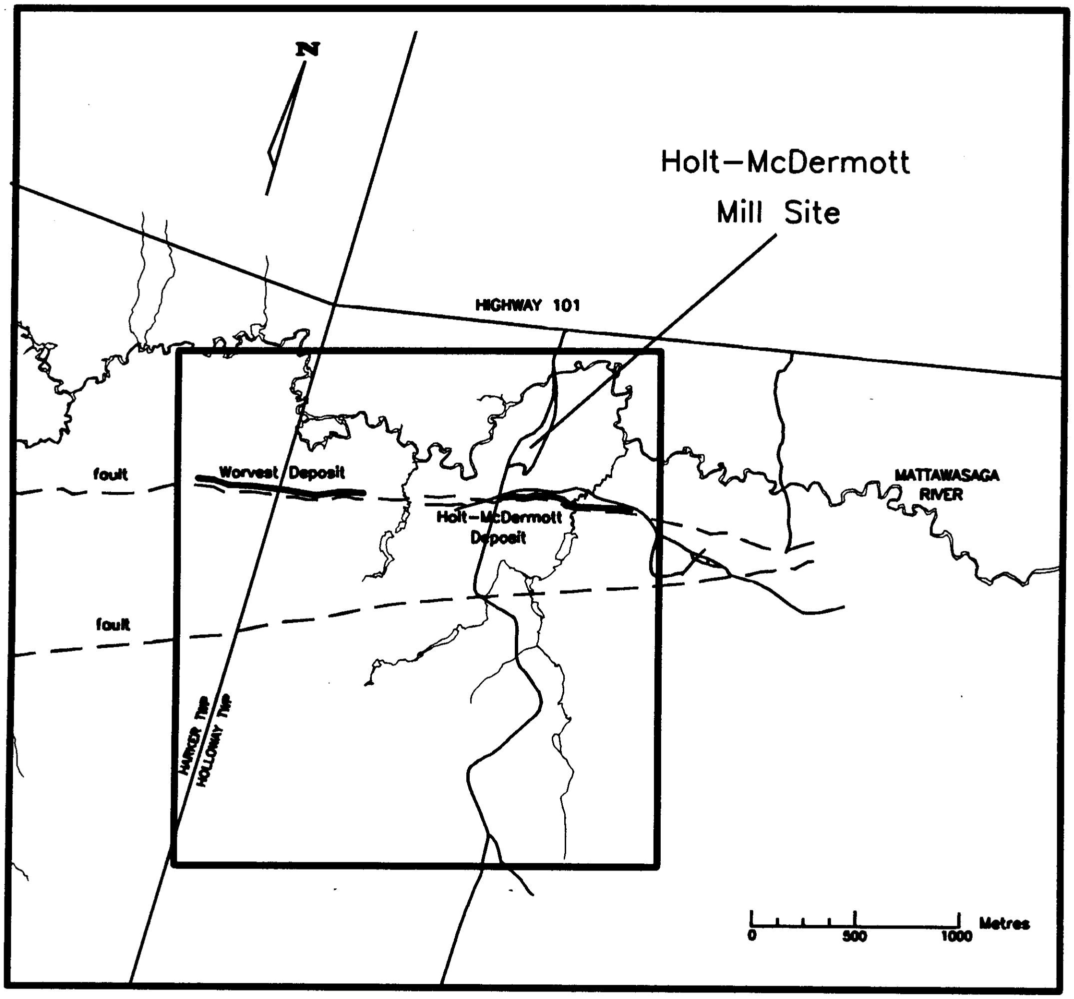


Figure 4. Location of the area hosting the Holt-McDermott Gold Deposit.

The gold occurs with fine grained pyrite. However, the sulphide content is generally less than 6%. Ore zones vary from 5 to 20 m in width within an alteration zone 40 to 50 m in width. Each deposit is approximately 300 m in strike length. They trend westward and dip steeply to the south.

Overburden is generally 20 m thick but locally varies from 0 to 40 m. None of the mineralizated outcrops in the undisturbed areas were sampled. The overburden is dominantly clay overlying a relatively thin lodgement till. Soils consist of a good A_0/A_1 horizon and are in contact with a grey to brown mottled B horizon.

Drainage is controlled primarily by surface flow in a northward direction into Mattawasaga Creek which flows to the west. Small beaver swamps occur locally.

The area has been cut over in recent time. Consequently, the vegetation is mostly scrub brush dominated by young poplar and alders. However, spruce is present in the region as a whole. The flood plain of the Mattawasaga Creek consists of sphagnum bog with stunted black spruce.

Mine infrastructure is a potential source of contamination in the area. A haulage road from an open pit mine to the mill could be responsible for some of the observed response to the Holt-McDermott mineralization. Also, the tailings are located at the southern boundary of the study area. Leakage may occur from the base of the tailings dam into the creek which ultimately crosses the Holt-McDermott deposit. There is no known sources of contamination in the area of the Worvest deposit.

Geology of the Stimson Base Metal Mineralization

The Stimson Cu-Pb-Zn mineralization (Patton occurrence) consists of disseminated chalcopyrite, galena, and sphalerite with associated pyrite and pyrrhotite (R. Dahn, personal communication). It occurs within felsic tuff and agglomerate that are overlain by graphitic sediments. These rocks are marginal to an intrusive complex. Individual but related intrusions vary from mafic to felsic in composition. The mineralized zone may be cut off on the east by this intrusion. A major north-trending fault truncates the horizon to the west underneath Patton Creek (Figure 5).

The zone is approximately 100 m wide by 300 m long, trends N60°E, and dips steeply to the north. Within this, there are narrow higher grade sections which average 2 to 3% Zn, 1% Pb and 0.5% Cu. The mineralization produces good IP and EM anomalies.

The bedrock is overlain by 30 to 40 m of overburden. This predominantly consists of glaciolacustrine clay. At surface, the clay is extremely dense and sticky. Based on reports by drillers, the clay overlies a relatively thin boulder till at the base of the sequence. However, the glacial stratigraphy may be more complex than this.

The area is relatively flat with a relief of less than 10 m. The clay surface has been dissected by a west and north trending drainage system. In between the streams, a 30 to 50 cm peat or moss layer overlies the clay. The ground is generally water saturated due to the water retention ability of the organic layer. The clay was commonly a light brown colour despite the water saturated conditions. However, in some areas, a more predictable grey gleyed profile was observed.

Black spruce is the dominant vegetation type with minor poplar and tamarack. The drainage pathways are vegetated by alders. Blow-down is extensive due to the inability of the trees to root deeply into the dense clay.

Sampling and Analytical Procedures

Sampling Procedures

Drainage Sites

Water samples were collected from both the surface and sub-surface. The surface sites consisted of flowing streams, springs, and stagnant pools. In the absense of surface water, a shallow sump was dug and allowed to fill up with porewater contained in the peat layer.

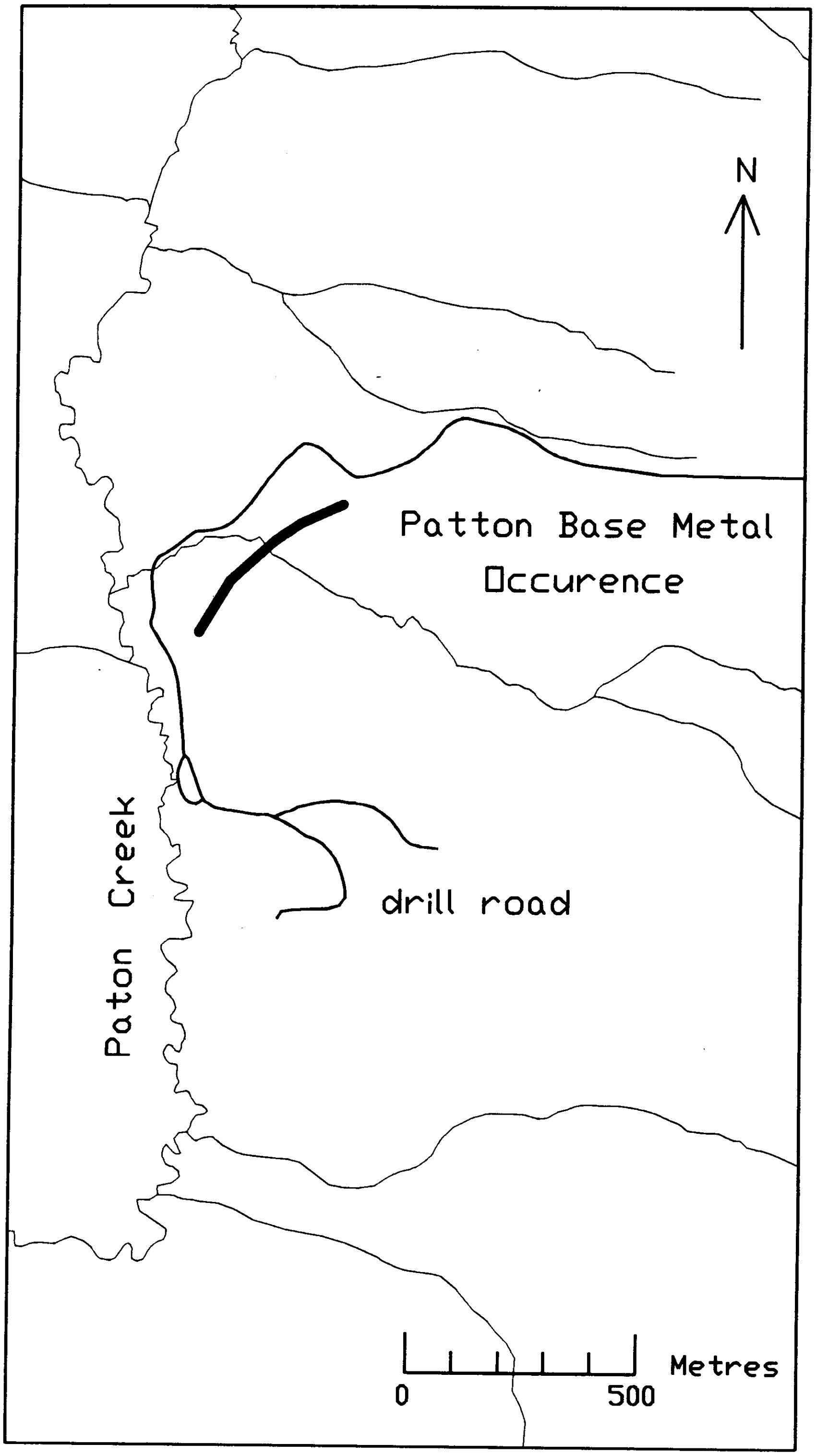


Figure 5. Location of the Patton Base Metal occurrence in Stimson Township.

In addition to surface water, shallow groundwater samples were collected from sites in alder-vegetated drainage pathways and within bogs. A 1" diameter PVC drive point piezometer was pushed down to the interface between the peat and clay. After a period of approximately 24 hours, the water was sampled using a polyethelene hose and a Waterra pump. Most of these sites were located in the vicinity of mineralization to determine the difference in chemistry between surface water and shallow groundwater.

The pH and conductivity of the water was measured *in-situ* using either a YSI6000 Water Quality Analyzer or Hanna portable pH and conductivity meters. Translucent NALGENE 1 L bottles were used for sample collection.

Samples were also obtained from the surface materials that are the substrate to the water samples. In streams, this consisted of the organic-rich materials in contact with the water, usually bank material overhanging the creek. However, organic sediment in the bottom of the creek was the preferred sample medium if present. Clastic bottom stream sediments were not sampled unless they contained a high organic content.

In the peaty area, a surface peat sample was collected from a depth of about 30 cm. A peat sample was also obtained from just above the peat/clay interface at sites where a shallow groundwater sample was collected. This was obtained using a peat auger. At all sites tested, the depth to the peat/clay interface was less than 2.5 m.

Soil Sites

One or more soil traverses were sampled in each area on lines oriented perpendicular to the strike of the mineralization. At each site, relatively organic-rich surface soil, to be referred to as the A horizon, was collected at a depth of about 5 to 10 cm. However, depending on the nature of the substrate and the degree of humus development, the organic content of this material could vary significantly.

Additionally, an organic-poor soil, to be referred to as the B horizon, was sampled at a depth of 30 to 75 cm. If the soil substrate was sand, a true brown to reddish brown B horizon was sampled beneath the grey A_2 horizon of a podzolic soil profile. However, in the areas of clay cover, the 'B horizon' was generally mottled grey to beige in colour. On the Hislop property, in addition to the A and B horizon samples, C horizon soils were collected at a depth of 50 to 100 cm .

Sample Treatment and Analytical Procedures

Water

The water samples were filtered to less than 0.45 µm within 24 hours using a glazed glass filter assembly and 47 mm Millipore HAWP cellulose acetate filters. The filtered water was transferred to smaller NALGENE bottles and acidified as required for specific determinations as follows:

1) trace elements

125 mL acidified to 0.4% HNO_3 acid strength by volume

2) As, Sb, Se and Hg

125 mL acidified to 1% HNO_3 acid strength by volume

3) Ca, Mg, Na, K, SO_4 and Cl

125 mL unacidified

4) alkalinity

125 mL unacidified

Only ultrapure acids certified to be low in trace elements were used to acidify the samples. An Eppindorf repeater pipette was used to transfer the acid to the bottles. This assembly does not have any rubber parts that come in contact with the water or the acid. Rubber is a common source of trace element contamination during sample treatment.

The samples were analyzed as follows:

1) Cu, Pb, Zn, Co, Ni, Fe, Mn, Ga, Ge, Mo, Cd, Ag, Bi, As, Sb, Se, Hg, Tl, Br, I, Li, Be, Al, Ti, V, Cr, Sc, Rb, Sr, Y, Zr, Nb, Sn, In, Te, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re, Au, Th and U by ICP-MS at Activation Laboratories in Mississauga, Ontario

2) As, Sb, Se and Hg by hydride generation/ICP-MS at Elemental Reseach Inc in Vancouver, B.C.

3) Ca, Mg, Na and K (major cations) by ICP-ES; SO_4, Cl (major anions) by ion chromatography at Chemex Laboratories in Vancouver, B.C.

4) alkalinity by titration at the Geosciences Laboratories, Sudbury, Ontario

Drainage Substrate Media

The drainage sediments were freeze-dried and disaggregated using a mortar and pestle. They were then sieved using nylon screens to obtain the less than150 µm fraction for analysis. This fraction was analyzed for the following parameters:

1) Cu, Pb, Zn, Co, Ni, Fe, Mn, Mo, Cd, Ag, As, Sb, Hg, Bi, Be, Na, Mg, Ca, K, Al, Ba, Cr, Ga, La, P, Sc, Sr, Ti, Tl, U, V and W by aqua regia/ICP-ES at Chemex Laboratories in Vancouver, B.C.

2) As, Sb and Se by hydride generation/ICP-ES at Chemex Laboratories in Vancouver, B.C.

3) Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb and Lu by INAA at Activation Laboratories in Mississauga, Ontario.

4) organic content by loss on ignition at the Geosciences Laboratories in Sudbury, Ontario.

Soil

The soil samples were freeze-dried and disaggregated using a mortar and pestle. The clay and A horizon samples were sieved through nylon screens to obtain the less than150 µm fraction for analysis. The sand samples were sieved to obtain the less than 250 µm fraction. These fractions were analyzed as follows:

1) Cu, Pb, Zn, Co, Ni, Mn, Mo, Cd, Ag, As, Sb, Li, Be, Cl, Sc, Ti, V, Ga, Ge, Se, Br, Rb, Sr, Y, Zr, Nb, Ru, Pd, In, Sn, Te, I, Cs, Ba, Ta, W, Bi, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Re, Os, Ir, Pt, Au, Hg, Tl, Th and U by enzyme leach/ICP-MS at Activation Laboratories in Mississauga, Ontario.

2) Cu, Pb, Zn, Co, Ni, Fe, Mn, Mo, Cd, Ag, As, Sb, Hg, Bi, Be, Na, Mg, Ca, K, Al, Ba, Cr, Ga, La, P, Sc, Sr, Ti, Tl, U, V and W by aqua regia/ICP-ES at Chemex Laboratories in Vancouver, B.C.

3) As, Sb and Se by hydride generation/ICP-ES at Chemex Laboratories in Vancouver, B.C.

4) Au, Ag, As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sn, Sr, Ta, Th, U, W, Zn, La, Ce, Nd, Sm, Eu, Tb, Yb and Lu by INAA at Activation Laboratories in Mississauga, Ontario.

5) organic content by loss on ignition at the Geosciences Laboratories in Sudbury, Ontario.

Data Quality

Water

Standards, field duplicates and blanks were inserted into the analytical sequence of the water samples. The frequency of insertion was about 1 per 15 samples. The Ottawa River standard SLRS-3 was used as a certified reference standard. Blanks consisted of RO (reverse osmosis) water obtained from the Geosciences Laboratories in Sudbury.

The quality control information for the water is summarized in Appendix I for those elements significantly above the detection limit. Sample site reproducibility was good relative to the range of the natural background for most elements except Cr, Ba, Hg and Th. Analytical precision based on repeated analysis of the standard was better than the sample site reproducibility as might be expected.

Certified reference values for SLRS-3 are available for only a few elements. Some elements were high or low compared to this standard. Copper and Mn were high by 20%. Molybdenum and Sb (ICP-MS) were high by 300%. The Zn values were low at only 40% of the accepted value. However, since the samples were collected in the same time period and submitted as one batch, these relative accuracy differences do not complicate the interpretation of the water data.

Some contamination was observed in the blanks. The elements affected were Ca, Cr, Mg, Cu, Se, Br, Sr, Mo, Sn, I, La, Ce, Nd and Hg. In all cases except Hg, the level of contamination is small compared to the range of the natural background. Samples collected as part of other projects at the OGS were not similarly affected. The RO water used as the blank may not have been sufficiently pure to give an accurate estimate of contamination of the unknowns.

Overall, the quality of the water data is considered to be good relative to the range of the data. Contamination is minor and relative accuracy for most elements is adequate.

Drainage Sediments and Peat

In general, the quality of the data appears to be good. Detailed precision estimates were not made for the organic bank and peat data since little of this data is discussed in this report. The reproducibility of the gold determinations by INAA was ± 4 ppb.

Soil

Standards and field duplicates were inserted into the analytical sequence of the soils and organic drainage media. The frequency of insertion was about 1 per 20 samples. Certified standards were not available for the type of samples collected and the analytical methods used. Instead, standards were prepared from bulk material collected in the field.

The quality control data for the soils analyzed by enzyme leach/ICP-MS is summarized in Appendix I for those elements significantly above the detection limit. Sample site reproducibility was generally ± 20 to 30% of the regional threshold as estimated at the 90% confidence limit. Above the regional threshold, reproducibility is very poor particularly for elements that exhibit an anomalous relationship to mineralization. This includes Cu, Zn, Ga, As, Rb, Zr, Mo, Cd, Sn, Sb, I, Ba, La, Nd, Gd, Dy, W, Pb and Th. This high variability in the immediate vicinity of mineralization may be related to the dispersal process that brings ions to the surface through thick overburden.

In contrast, analytical precision for the standard was very good although this estimate is based on relatively few analyses of one sample. Two exceptions are Cl and Te for which poor precision was obtained.

The soils were also analyzed by aqua regia/ICP-ES and INAA. Only a small portion of this data has useful application and these include Au, As, Mo and W as determined by INAA. The sample site reproducibility for Gold was ± 50%. For As, Mo and W, reproducibility was ±10%.

Geochemical Response to Mineralization in Surface Waters

Regional Variation in Background

Geochemical background varies between areas for most elements (Appendix II). These variations appear to be related to differences in rock type between the areas rather than differences in the nature of the surficial environment. For example, the Cu background in the area of the Shoot Zone and in Hislop Township is distinctly higher than that in the 2 other areas. This could be related to the presence of ultramafic rocks. Similarly, the areas hosting Au mineralization all exhibit a higher As background as might be expected.

Regional difference in Pb, Zn, Cd, Mo, Ca, Mg, Sr and I are related to pH to some extent (see Effect of pH). However, in stream samples where pH is similar from area to area, the Zn background is distinctly higher in the Stimson area possibly reflecting the base metal potential of the region.

Regional thresholds for selected elements are summarized in Table 1. For most elements, this corresponds to the upper limit of background for the 4 areas considered collectively. The local threshold may be lower. This is the case for Cu at the Stimson property where the local threshold is 2 ppb compared to 4 ppb in the other areas where ultramafic rocks are more prevalent.

The upper limit of background variation observed in water from areas of thick overburden is very similar to that observed for lake and stream water collected from the Kirkland Lake, Matachewan and Gowganda areas as part of a tailings dispersion study (Jackson and Hall 1994). This is a significant observation given that the areas to the south are all in bedrock-dominated terrain with thin till cover between outcrops.

Response to Mineralization

Shoot Gold Zone

In the vicinity of the Shoot Zone, surface water is anomalous in Pb, Zn, Sn, Rb and, locally, Sb and Cu. The distributions of Pb, Sn and Rb illustrate this response (Figures 6, 7 and 8).

Table 1. Geochemical thresholds for selected elements in surface water

Element	Method	Regional Threshold
Cu ppb	ICP-MS	4.0
Pb ppb	ICP-MS	0.3
Zn ppb	ICP-MS	5.0
Mo ppb	ICP-MS	1.0
Sb ppb	hydride/ICP-MS	0.1
Sn ppb	ICP-MS	0.3
W ppb	ICP-MS	0.02
Rb ppb	ICP-MS	3.0
Na ppm	ICP-ES	3.0
Cl ppm	ion chromatography	1.0
SO4 ppm	ion chromatography	4.0

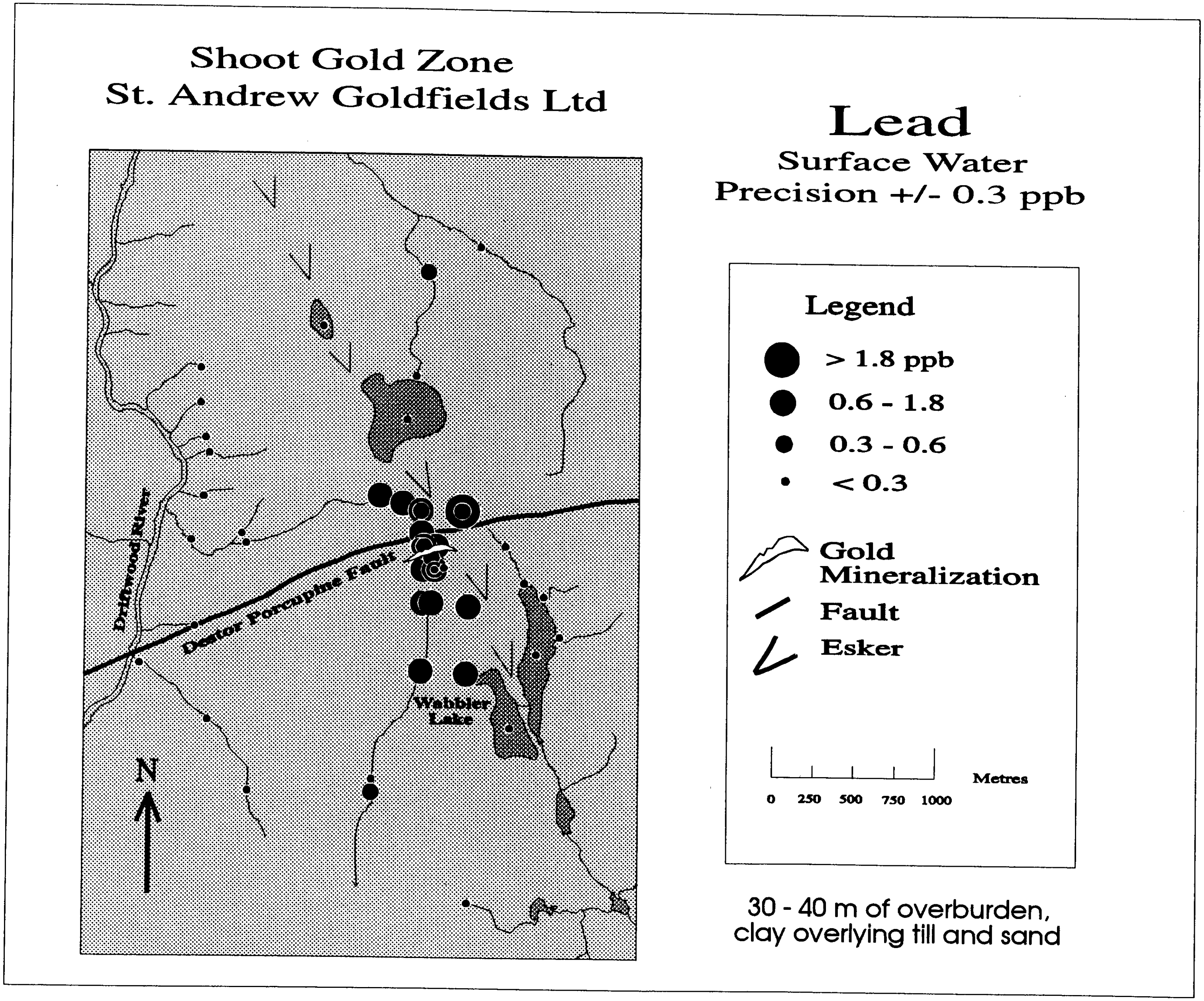


Figure 6: Dispersion of Pb in surface water in the vicinity of the Shoot Gold Zone.

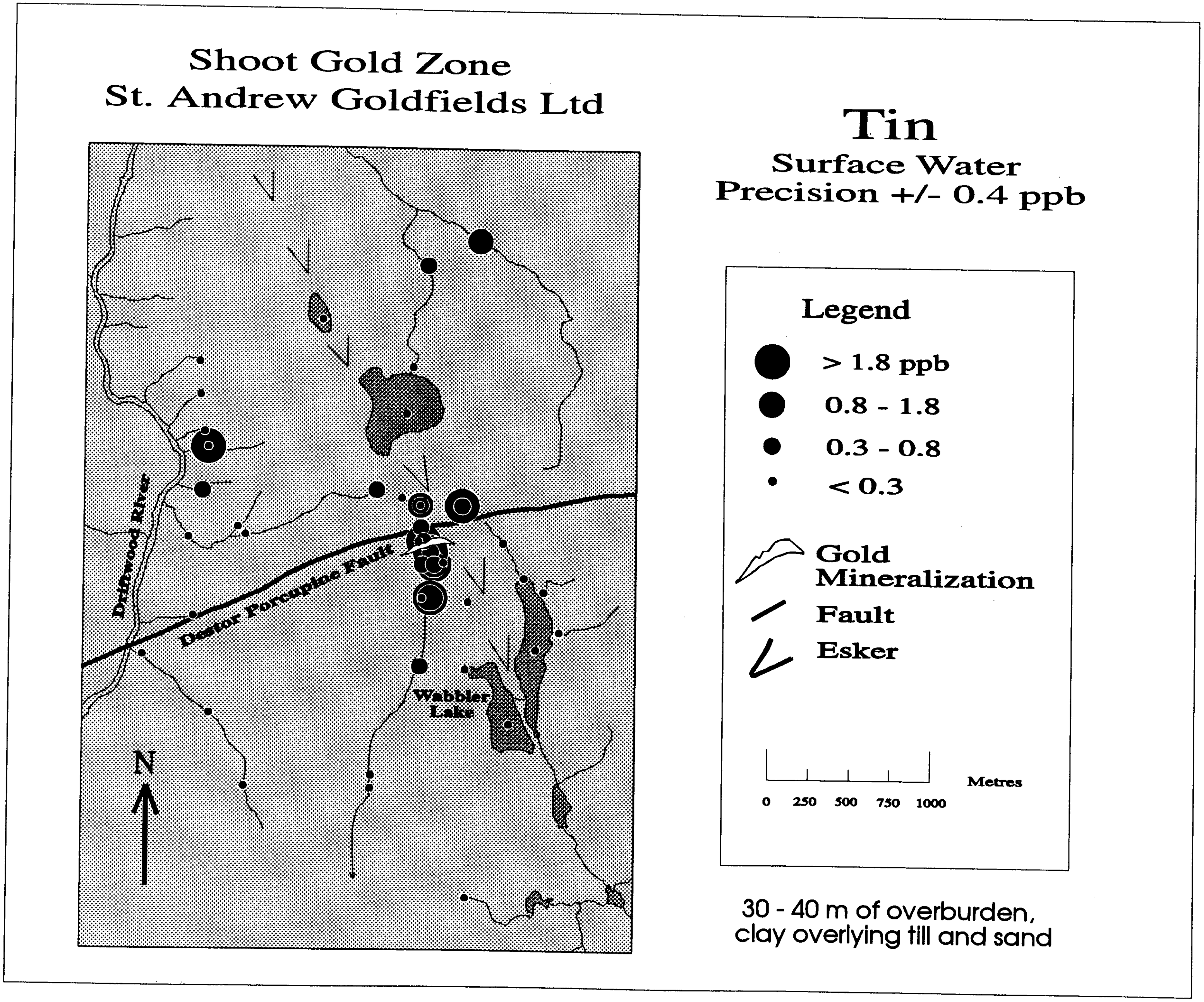


Figure 7: Dispersion of Sn in surface water in the vicinity of the Shoot Gold Zone.

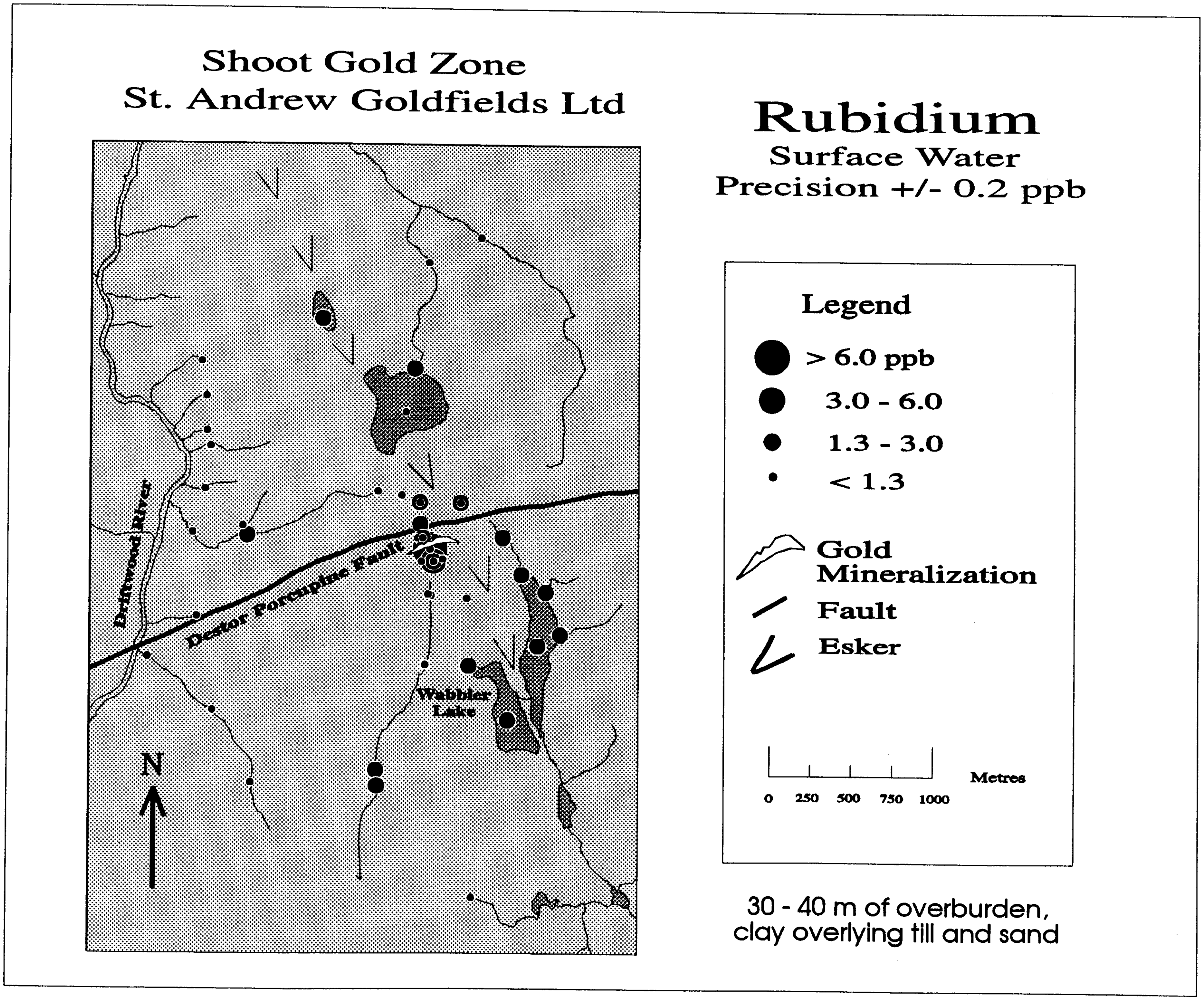


Figure 8: Dispersion of Rb in surface water in the vicinity of the Shoot Gold Zone.

The source for Pb appears to be the Destor-Porcupine Fault in the vicinity of the Shoot Zone. However, a spring feeding Wabbler Lake to the southeast of the zone is also anomalous suggesting a large halo may be centred on the deposit.

The distribution of Sn exhibits a similar pattern. Tin is a lithophile element that is generally considered to be relatively immobile. The Sn anomaly is slightly more restricted in area compared to Pb. Other Sn anomalies occur nearby but these lack multi-element associations in water. However, organic stream bank anomalies appear to be associated with these sites.

The distribution of anomalous Rb is even more restricted than Pb and Sn. It is anomalous in surface pools collected from a bog immediately south of the Shoot Zone.

Another characteristic of the water in the vicinity of this mineralization is the presence of natural acidity in the surface waters. The pH of surface pools, small creeks, and spring-fed lakes located along the margin of the esker ranges between 3.5 and 5.5 (Figure 9). The high acidity is confirmed by zero alkalinities in water samples from these sites. The control pH exerts on the concentration of some elements is discussed in the section, "Effect of pH".

It is possible that the esker, which crosses the eastern end of the Shoot Zone, may be responsible for the extent of the geochemical anomalies as well as the low pH of the surface pools. Additional sampling along the esker is required to determine its influence remote from mineralization.

Water was also collected from two PVC piezometers installed on the property by a previous operator. These are located above the sub-crop of the mineralization. They penetrate to the groundwater aquifer in the glaciofluvial deposits underlying the clay. It was not possible to purge the piezometers prior to sampling.

Distinctly anomalous levels of W, Cu, Rb, Sn, Pb, Mo, and Sb are apparent (Table 2). The levels of Zn are lower than those observed at surface. While this data may give some indication of

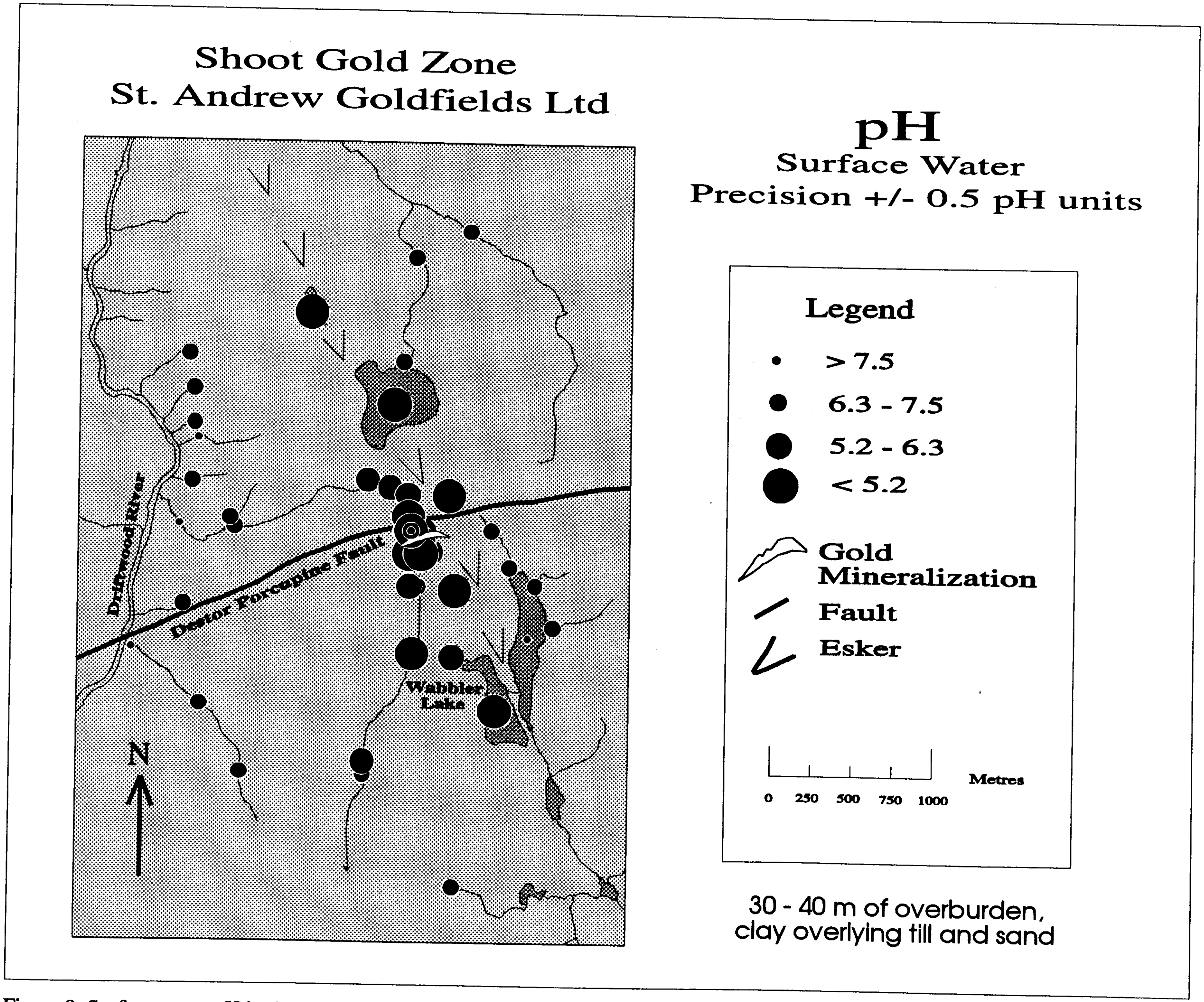


Figure 9: Surface water pH in the vicinity of the Shoot Gold Zone.

Table 2. Groundwater composition in the vicinity of the Shoot Gold Zone.

Element	Regional Background	Surface Water	Deep Groundwater
Pb ppb	< 0.3	0.29 - 3.02	0.31 - 1.13
Zn ppb	< 5.0	2.37 - 18.44	0.80 - 5.04
Sn ppb	< 0.3	0.26 - 7.39	1.47 - 6.33
Rb ppb	< 3.0	0.29 - 11.04	3.31 - 10.83
Sb ppb	< 0.1	0.04 - 0.37	0.67 - 0.77
Cu ppb	< 4.0	1.64 - 9.15	7.83 - 10.51
Mo ppb	< 1.0	0.1 - 0.4	6.7 - 13.2
W ppb	< 0.02	0.01 - 0.03	0.01 - 16.51
pH	5.4 - 7.7	3.5 - 7.5	7.2 - 8.8

the base flow composition relative to the surface flow, the data could be suspect given the contamination problem associated with PVC materials.

Hislop Gold Deposits

The composition of surface water in Hislop Township appears to reflect several different features. The distributions of Mo, Sb, Zn, and W illustrate these responses (Figures 10, 11, 12 and 13).

The region underlain by andesite is generally anomalous in Mo particularly compared to the range of Mo in other study areas (Figure 10). Elements which exhibit a similar response include Cu, Ga, U, Na, K, Ca, Mg, Sr, SO_4, Cl and Br. These anomalies are possibly related to the Destor-Porcupine Fault Zone which underlies this area.

In contrast to this signature, the distribution of Sb shows a clear response to the Central Zone and South Zone mineralization (Figure 11). An anomalous surface stream adjacent to the Central Zone drains to the north where it has resulted in additional anomalous samples over a distance of 1 km. It is possible that this strong response is due at least in part to surface contamination from mine infrastructure located in the area of the Central Zone. Other elments which characterize this Central Zone anomaly include Cu, Mo, Cd, Ga, Li, Rb, Na, K, Ca, Mg, Sr, Ba, SO_4, Cl and Br.

The Sb anomaly in response to the South Zone mineralization is located in a large sphagnum bog with no known source of contamination. A larger anomalous halo is apparent from the Zn distribution (Figure 12). On the other hand, the W anomaly is very localized (Figure 13). Other elements which are anomalous include Pb, As, Cu, Cd, Li, Ca, Mg, Na, K, Sr and Cl.

There is no observed response in surface water at the West Breccia Zone, an area of exposed glacial till. However, sample coverage is limited in this region.

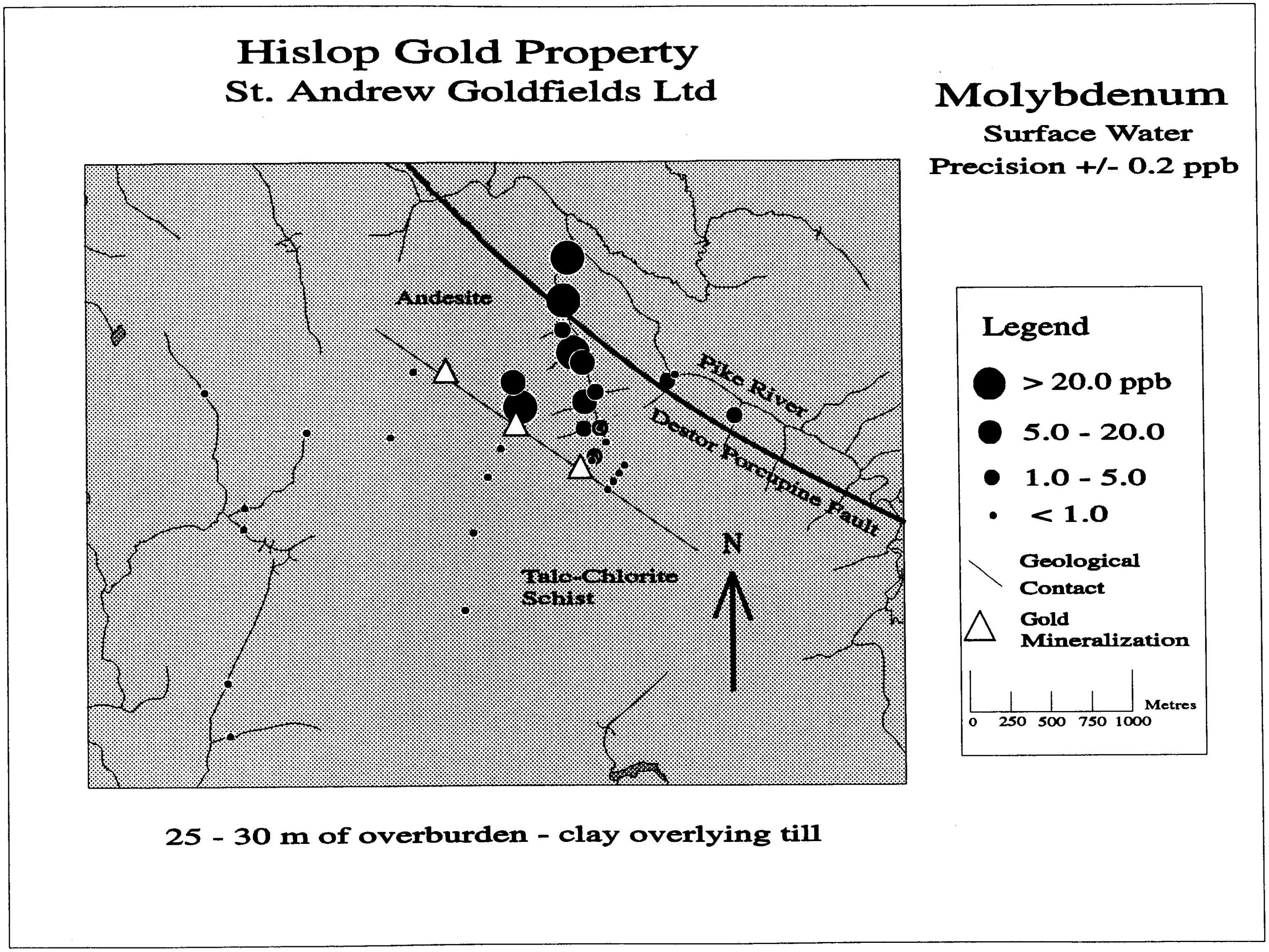


Figure 10: Dispersion of Mo in surface water in the vicinity of the Hislop Gold Deposits.

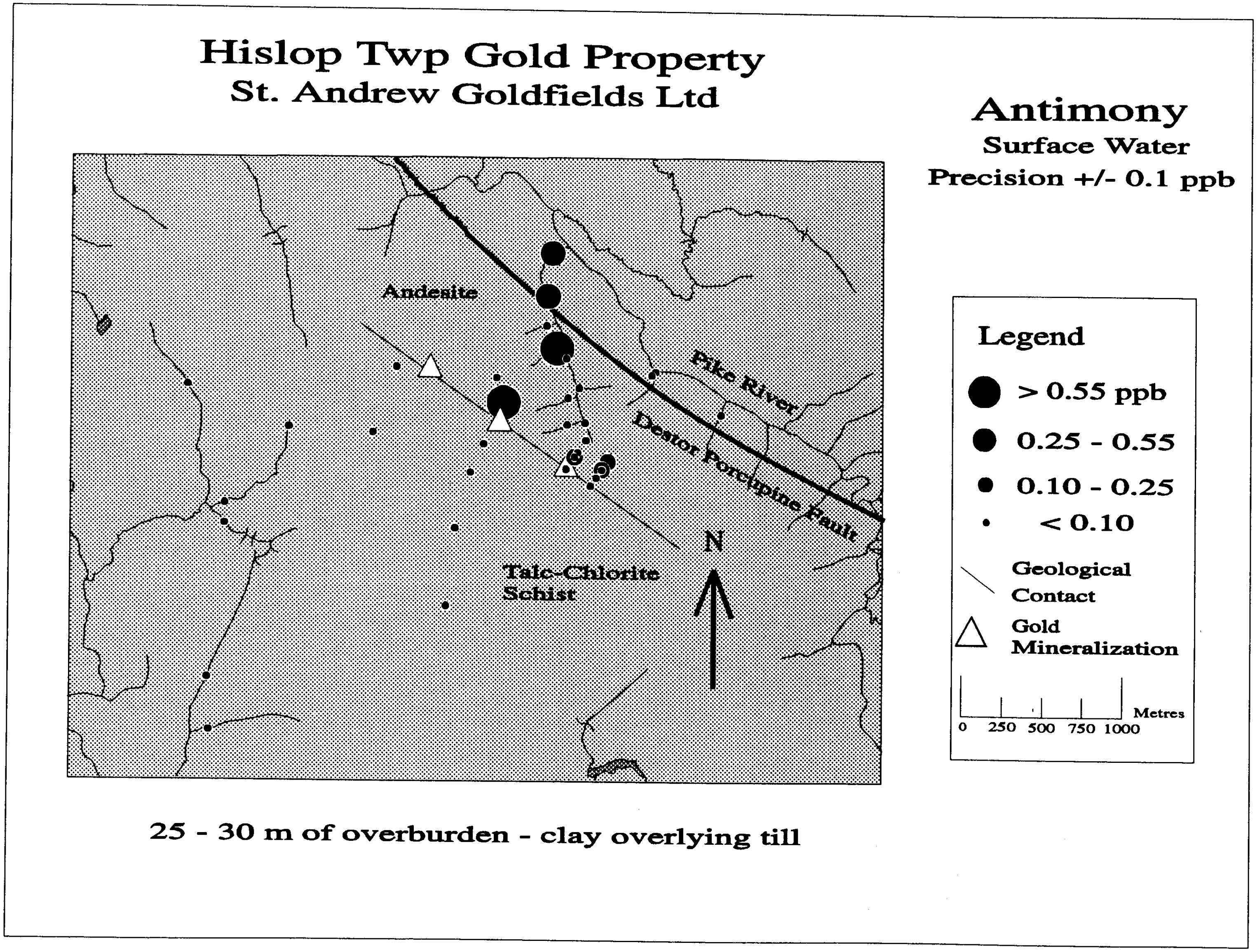


Figure 11: Dispersion of Sb (hydride/ICP-MS) in surface water in the vicinity of the Hislop Gold Deposits.

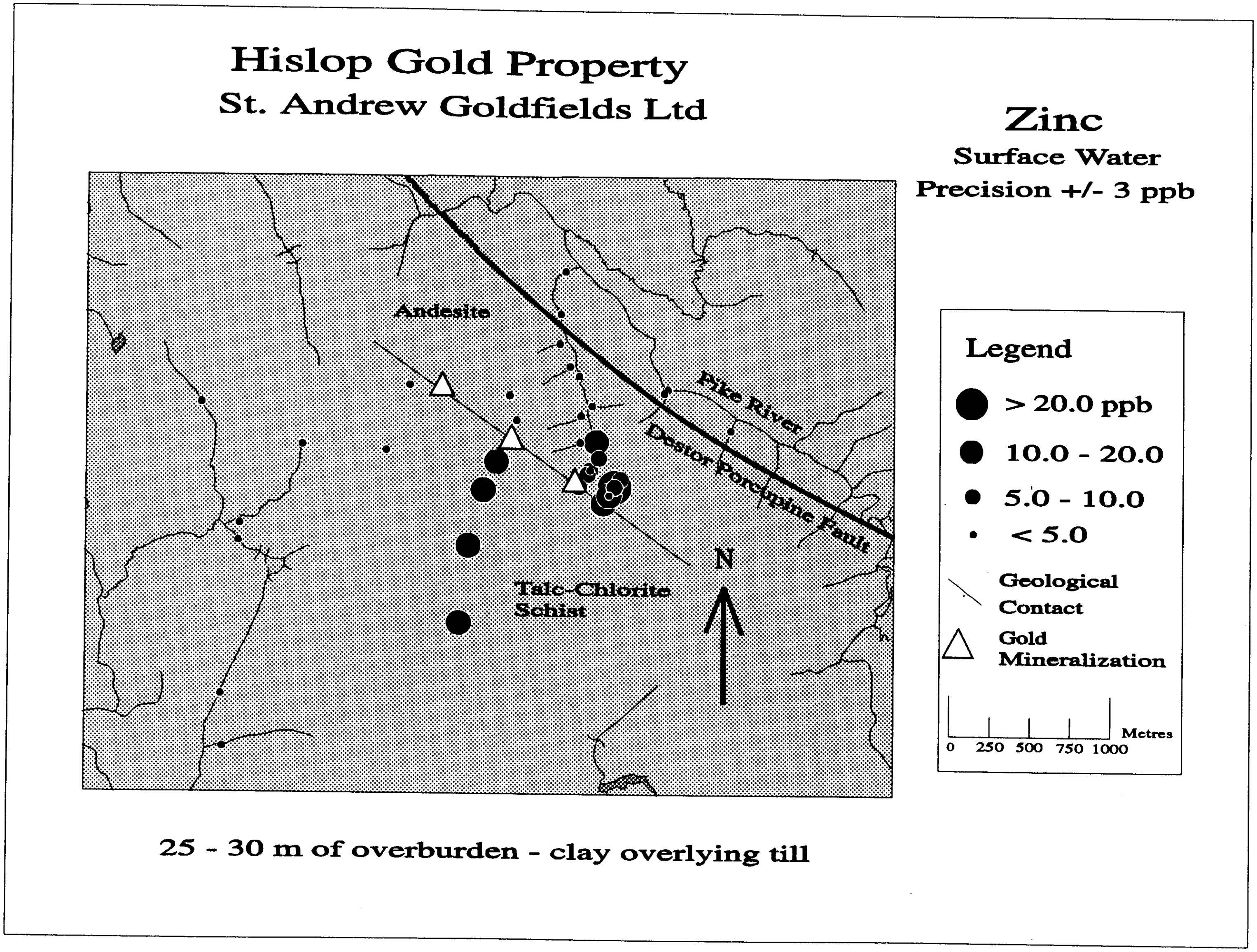
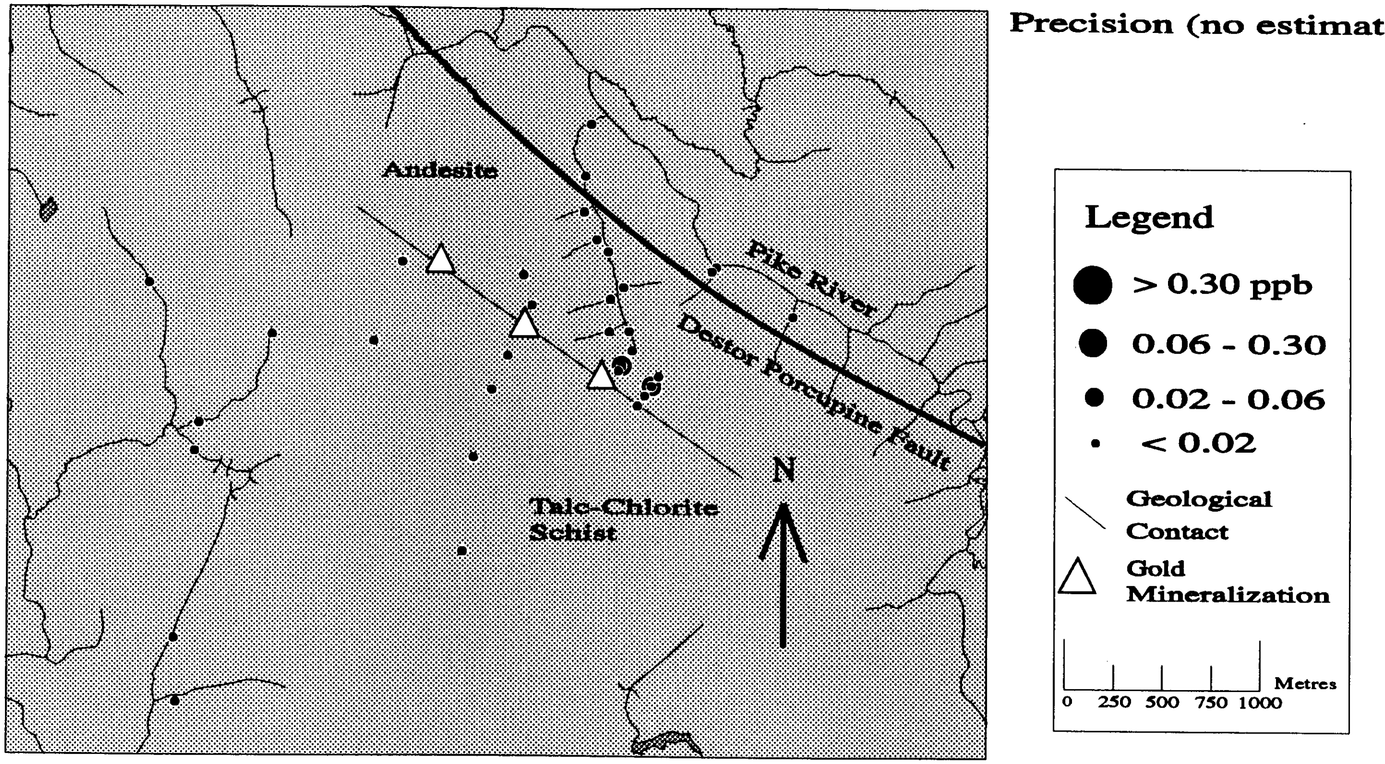


Figure 12: Dispersion of Zn in the surface water in the vicinity of the Hislop Gold Deposits.

Hislop Gold Property
St. Andrew Goldfields Ltd

Tungsten
Surface Water
Precision (no estimate)



25 - 30 m of overburden - clay overlying till

Figure 13: Dispersion of W in surface water in the vicinity of the Hislop Gold Deposit.

The mineralized horizon in Hislop Township appears to be characterized in general by low pH (Figure 14). Surface pools in this area are naturally acidic as was observed in the vicinity of the Shoot Zone. Low pH is not associated with the Holt-McDermott gold mineralization or the Stimson base metal mineralization where clay cover is dominant. In Hislop Township, the geochemical composition of the till, in contrast to the clay, may be responsible for this feature.

Holt-McDermott Gold Deposits

The composition of surface waters on The American Barrick property reflect sources of metals from the tailings disposal area, Holt-McDermott deposit, Worvest deposit and other mineralization in the area. The distributions of SO_4, Na and Cl illustrate this response and demonstrate the utility of major cations and anions in surface water geochemical exploration (Figures 15, 16 and 17).

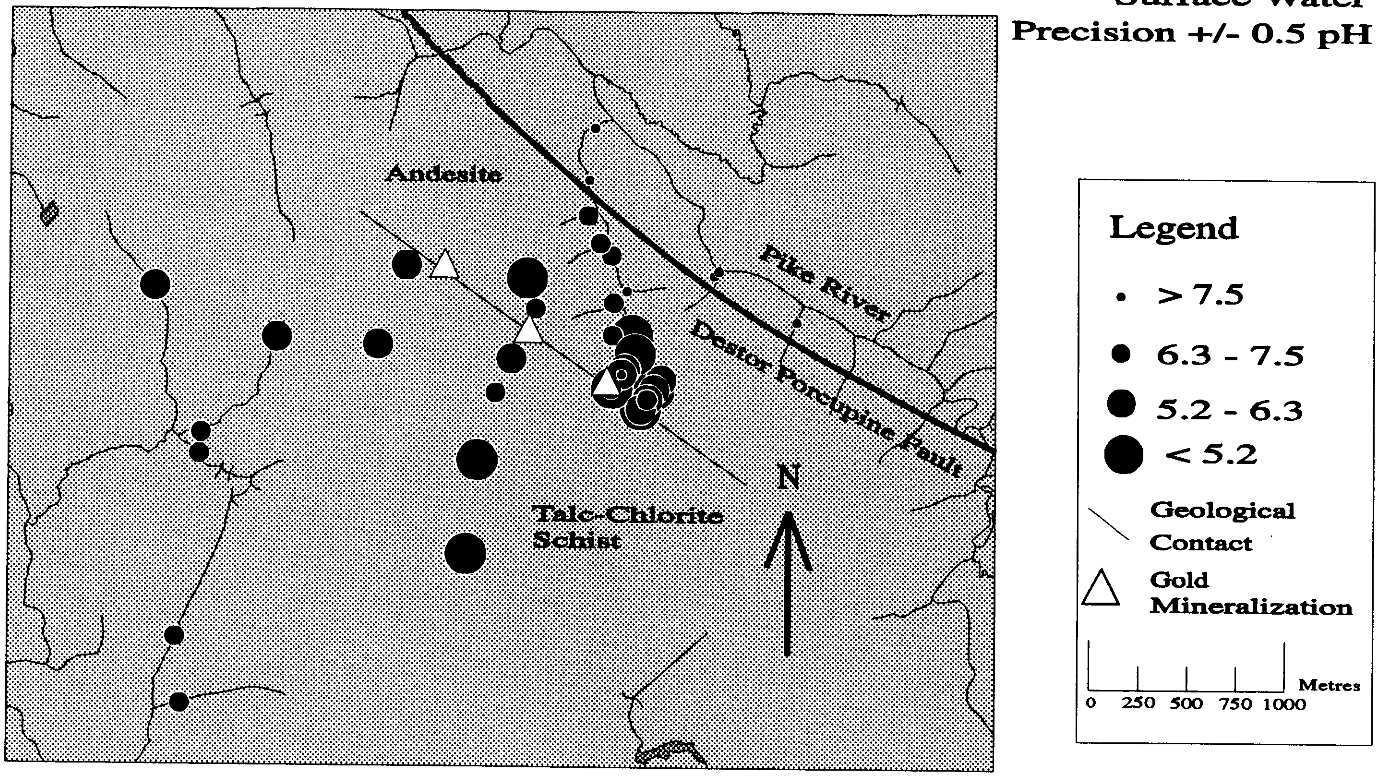
Anomalous stream water at the southern extent of coverage is related to leakage from the base of the tailings dam. Stream flow is northward toward the Holt-McDermott deposit but SO_4 levels decrease to background before reaching the deposit site (Figure 15). Other elements which are anomalous include As, Sb, Ga, Mo, U, Rb, Na, Cl and Br.

Two samples down-drainage from the Holt-McDermott deposit are anomalous in SO_4, Na and Cl (Figures 15, 16 and 17). This could be in part due to contamination since a haulage road separates these 2 sample sites. Other elements which are anomalous, in these samples, include Cu, Mo, W, Sb, U, Sr, Rb and Br.

Samples in the vicinity of the Worvest Deposit are also anomalous in SO_4 (Figure 15). These anomalies occur in borh surface and shallow groundwater samples. There is no source of contamination in this area and it is unlikely that the sulphate could be derived from the PVC tubing. Other anomalous elements in the shallow groundwater samples include Cu, Ga, Sb, Sn, U, Sr, Li, Rb, Na, Cl and Br. A few of these elements are also anomalous in surface water at these sites.

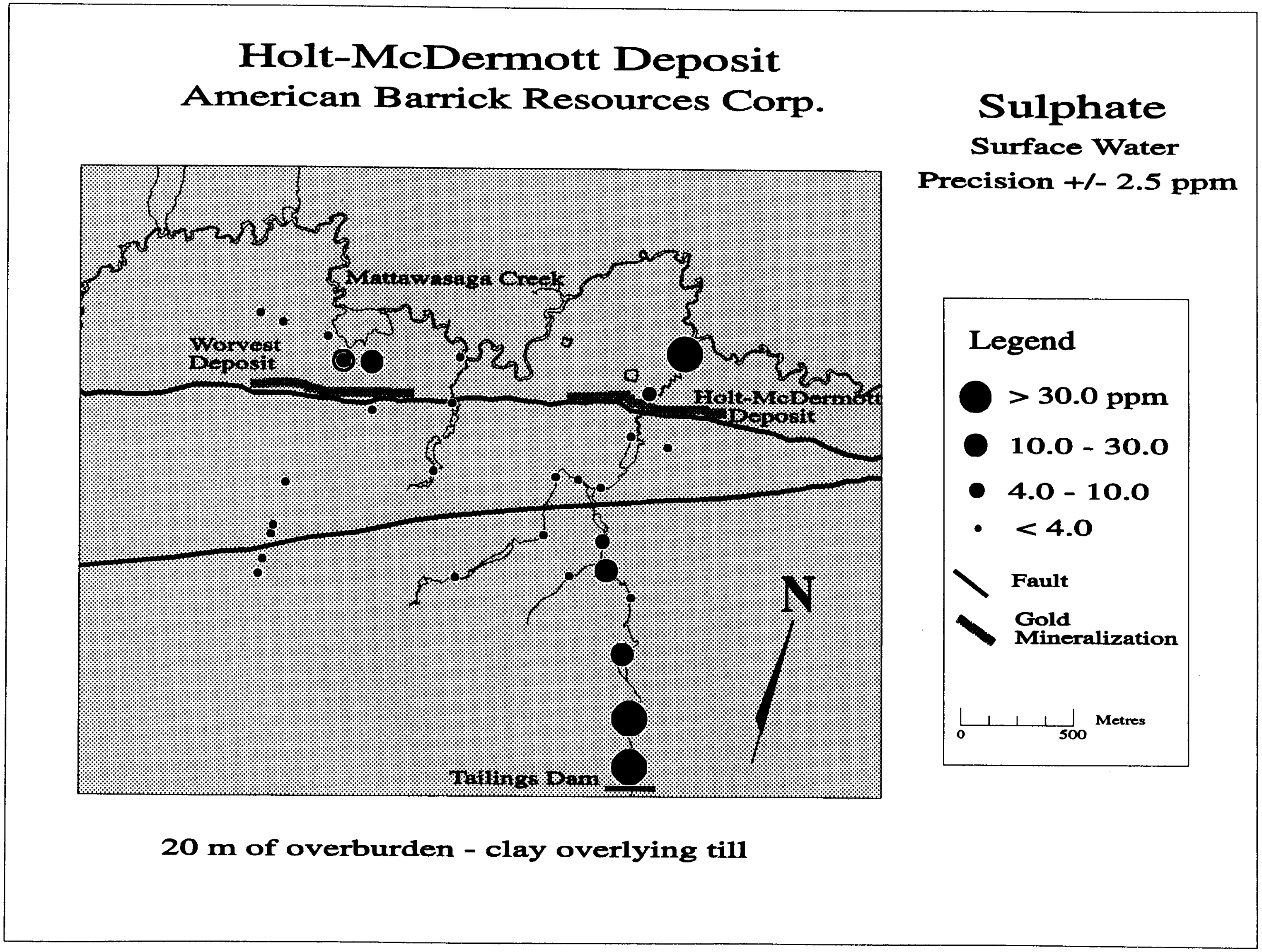
Hislop Twp Gold Property
St. Andrew Goldfields Ltd

pH
Surface Water
Precision +/- 0.5 pH units



25 - 30 m of overburden - clay overlying till

Figure 14: Surface water pH in the vicinity of the Hislop Gold Deposits.



Holt-McDermott Deposit
American Barrick Resources Corp.

Sulphate
Surface Water
Precision +/- 2.5 ppm

20 m of overburden - clay overlying till

Figure 15: Dispersion of SO_4 in surface water in the vicinity of the Holt-McDermott Gold Deposit.

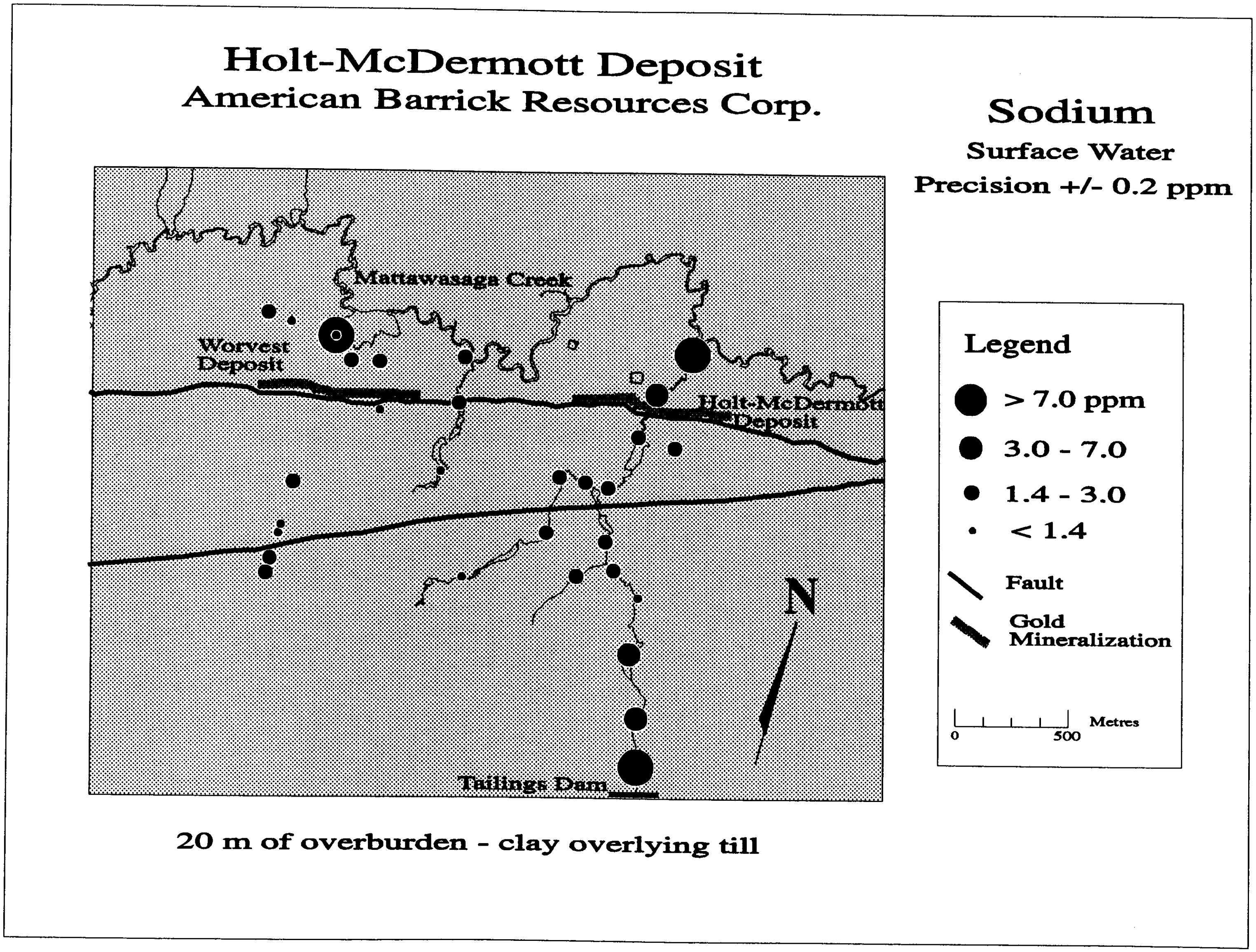
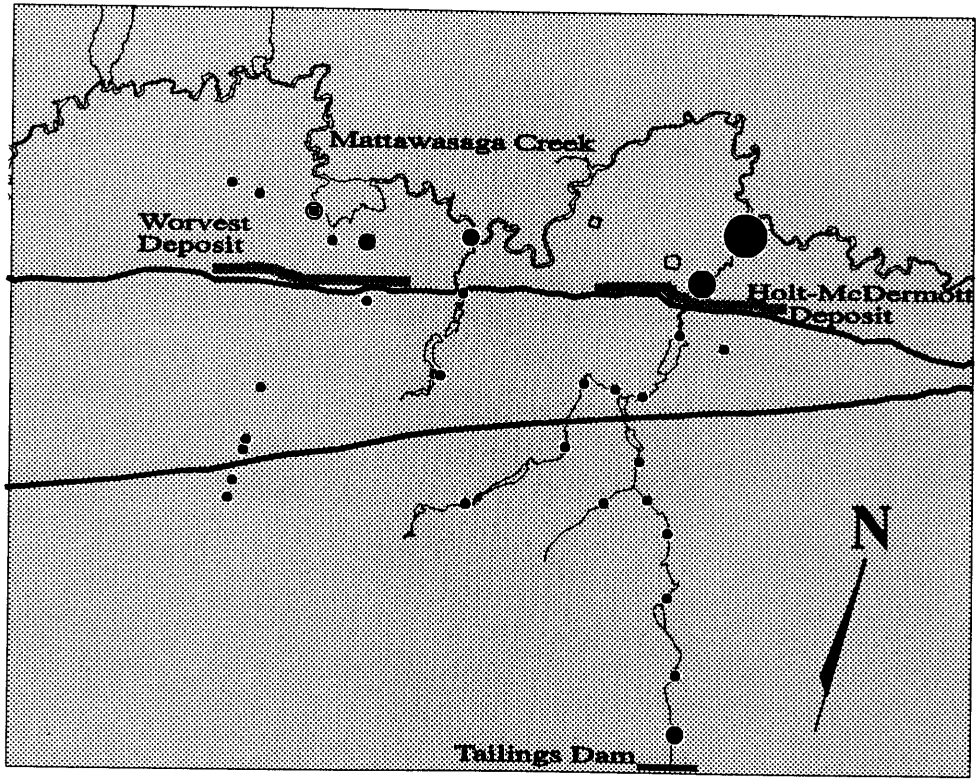


Figure 16: Dispersion of Na in surface water in the vicinity of the Holt-McDermott Gold Deposits.

Holt-McDermott Deposit
American Barrick Resources Corp.

Chloride
Surface Water
Precision +/- 0.6 ppm



Legend
- ● > 4.0 ppm
- ● 2.0 - 4.0
- ● 1.0 - 2.0
- • < 1.0
- ╲ Fault
- ▬ Gold Mineralization

0 500 Metres

20 m of overburden - clay overlying till

Figure 17: Dispersion of Cl in surface water in the vicinity of the Holt-McDermott Gold Deposits.

A fourth anomaly was observed for some elements along the township line in the southwestern portion of the area proximal to a fault. Anomalous elements include As, Ga, Mo, U and Rb. Mineralization is known to subcrop beneath 20 m of clay in this area.

Stimson Base Metal Mineralization

The distribution of Cu illustrates the best response to the Stimson mineralization (Figure 18). The highest Cu values are observed in a 1 m wide creek with moderate flow to the west. However, levels decrease to background downstream within 250 m of the initial response. Shallow groundwater samples are anomalous within a sphagnum bog located along the edge of the Patton Creek flood plain west of the mineralization. These waters receive seepage from higher ground to the east which overlies the mineralization.

Other elements which yield multi-sample anomalies in the creek include Ga, Ge, U, K, Ca, Mg, Sr, Ba, SO_4, Cl, Br and I. Elements which are anomalous locally in shallow groundwater and surface pools above the mineralization include Zn (Figure 19), Pb, Sn and Sb.

Water was also collected from 3 cased drill holes from which there was flowing water. These holes penetrate the mineralization at a depth of 150 m. The samples were anomalous in Cu, W and Mo relative to regional backgrounds established for surface waters (Table 3). The levels of Pb and Zn were well below background. All drill holes testing the Stimson mineralization are down-drainage of the surface water anomalies and are not a source of contamination in this study.

Effect of pH

The pH of surface waters varies from area to area. In general, the pH ranges between 5.4 and 7.7 which is normal for the Boreal Forest landscape. However, natural acidity characterizes the area of the Shoot Zone and the Hislop mineralization. In both areas, the overburden at surface consists of 2 contrasting materials: clay/sand at the Shoot Zone and clay/till on the Hislop property. Acidic

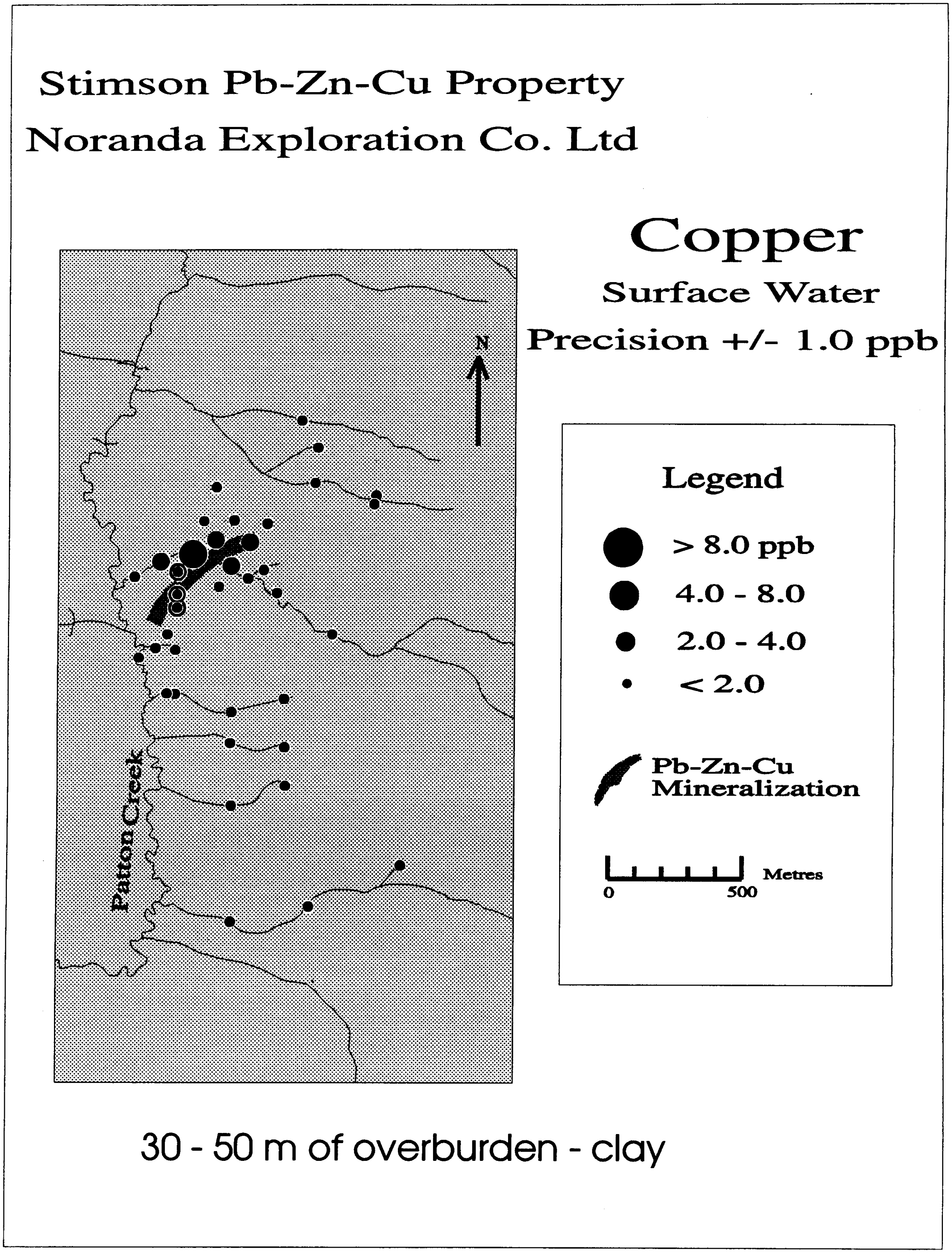


Figure 18. Distribution of Cu in surface water in the vicinity of the Stimson base metal mineralization.

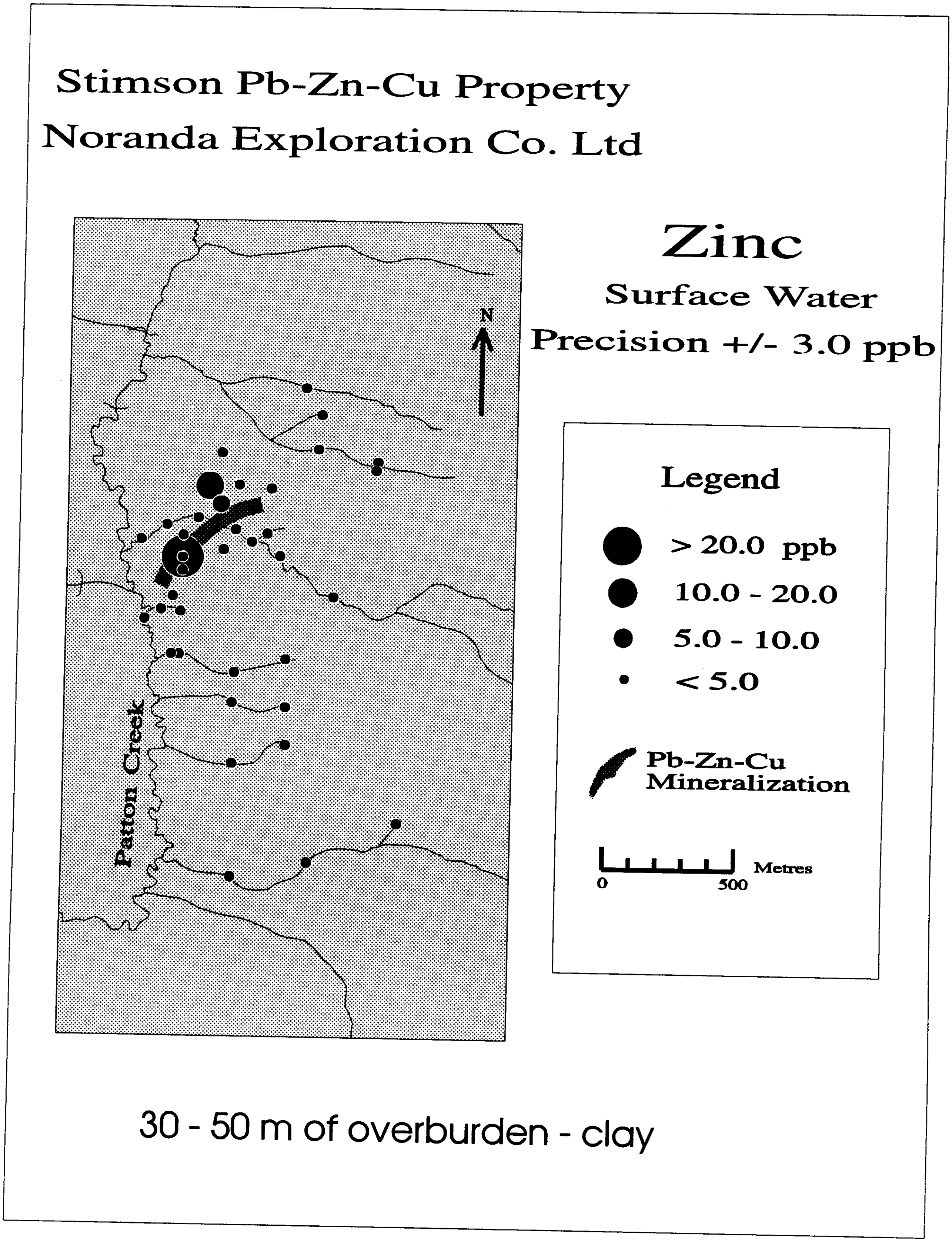


Figure 19. Distribution of Zn in surface water in the vicintiy of the Stimson base metal mineralization.

Table 3. Groundwater composition in the vicinity of the Stimson base metal mineralization.

Element	Background	Surface Water	Groundwater
Pb ppb	< 0.3	0.03 - 0.98	< 0.01 - 0.04
Zn ppb	< 5.0	0.01 - 23.41	0.01 - 0.65
Sn ppb	< 0.3	0.03 - 4.62	0.04 - 0.06
Rb ppb	< 3.0	0.16 - 1.26	1.24 - 2.10
Sb ppb	< 0.10	0.06 - 0.46	< 0.03
Cu ppb	< 2.0	2.0 - 4.21	4.98 - 7.50
Mo ppb	< 1.0	0.1 - 0.9	5.9 - 8.6
W ppb	< 0.02	< 0.01	0.03 - 0.33
pH	5.4 - 7.7	5.6 - 7.4	7.7 - 7.8

waters are not observed on the Holt-McDermott and Stimson properties where clay is a pervasive cover. Contrasting glacial materials may be a factor in influencing the pH of the surface water.

The background concentrations of Pb, Cd and Zn appear to increase with decreasing pH (Figure 20). This relationship is not a simple logarithmic one as a straight line relationship does not exist when the trace element data is log transformed. A similar but sympathetic relationship is observed for Mo.

Despite this pH control, anomalous residual values are apparent above the background trend. These samples occur in close proximity to mineralization at both the Shoot Zone (Taylor Township) and the South zone (Hislop Township).

The backgound trend for Zn as shown in Figure 20 is defined by the observed trend at the Hislop, Holt-McDermott and Stimson properties (Figure 21). In the area of the Shoot Zone and the Hislop mineralization, a high percentage of samples are anomalous in Zn even with respect to low pH waters.

Most elements are not significantly influenced by pH (Figure 22). This may be a function of the high contrast between anomalous values and the background response as appears to be the case for Cu. For other elements such as Rb, there is simply no relationship.

Elements which are almost entirely controlled by pH include Ca, Mg, Sr and I (Figure 23). However, even these exhibit some anomalous residuals for samples in the vicinity of mineralization.

Usefulness of Water Conductivity Measurements

In general, conductivity does not show a consistent relationship to mineralization. It primarily reflects the major cation composition of the water, particularly Ca. However, where the major cations themselves appear to reflect mineralization, anomalously high conductivity is observed.

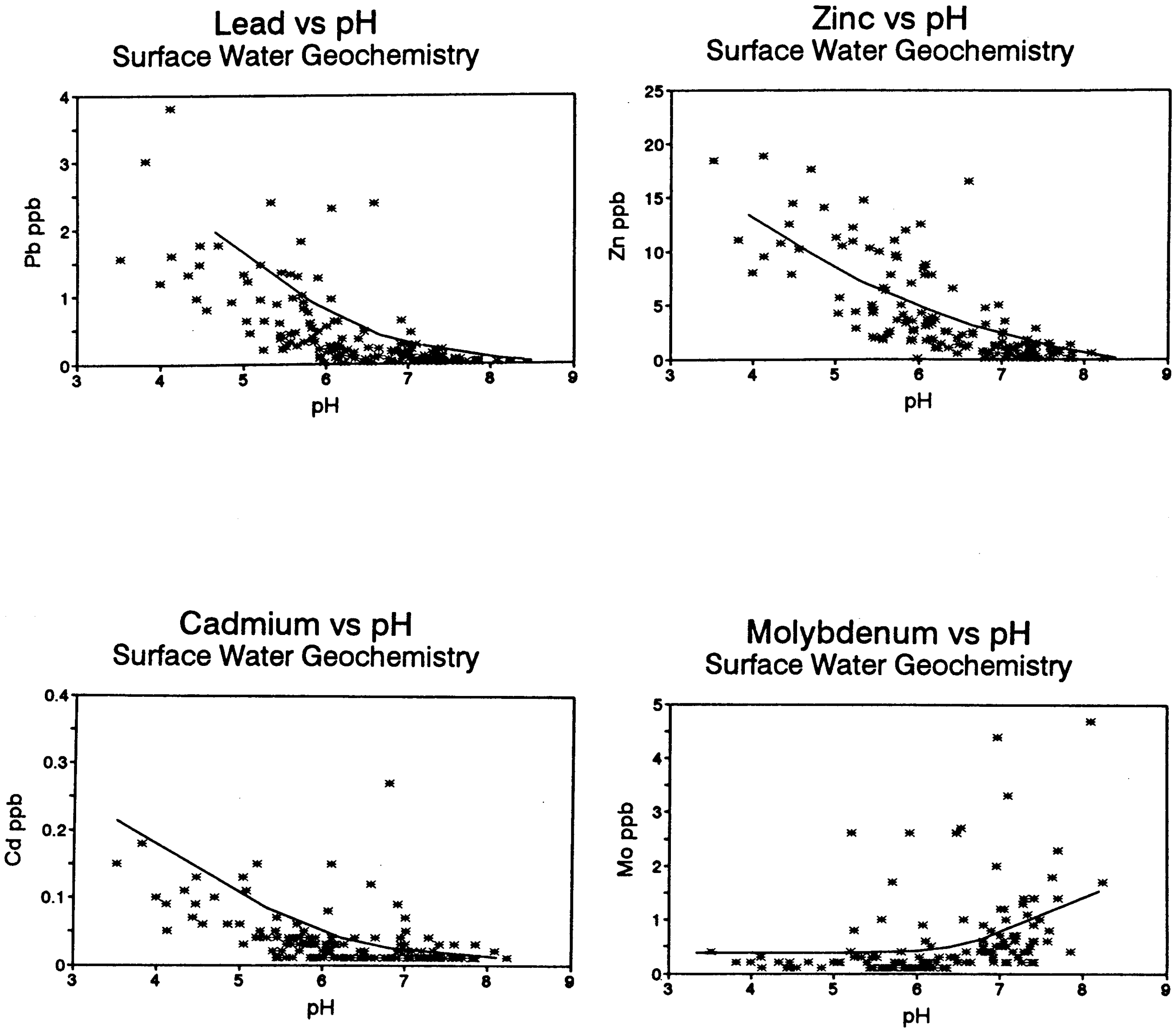


Figure 20. Variation in Pb, Zn, Cd and Mo in surface water as a function of pH.

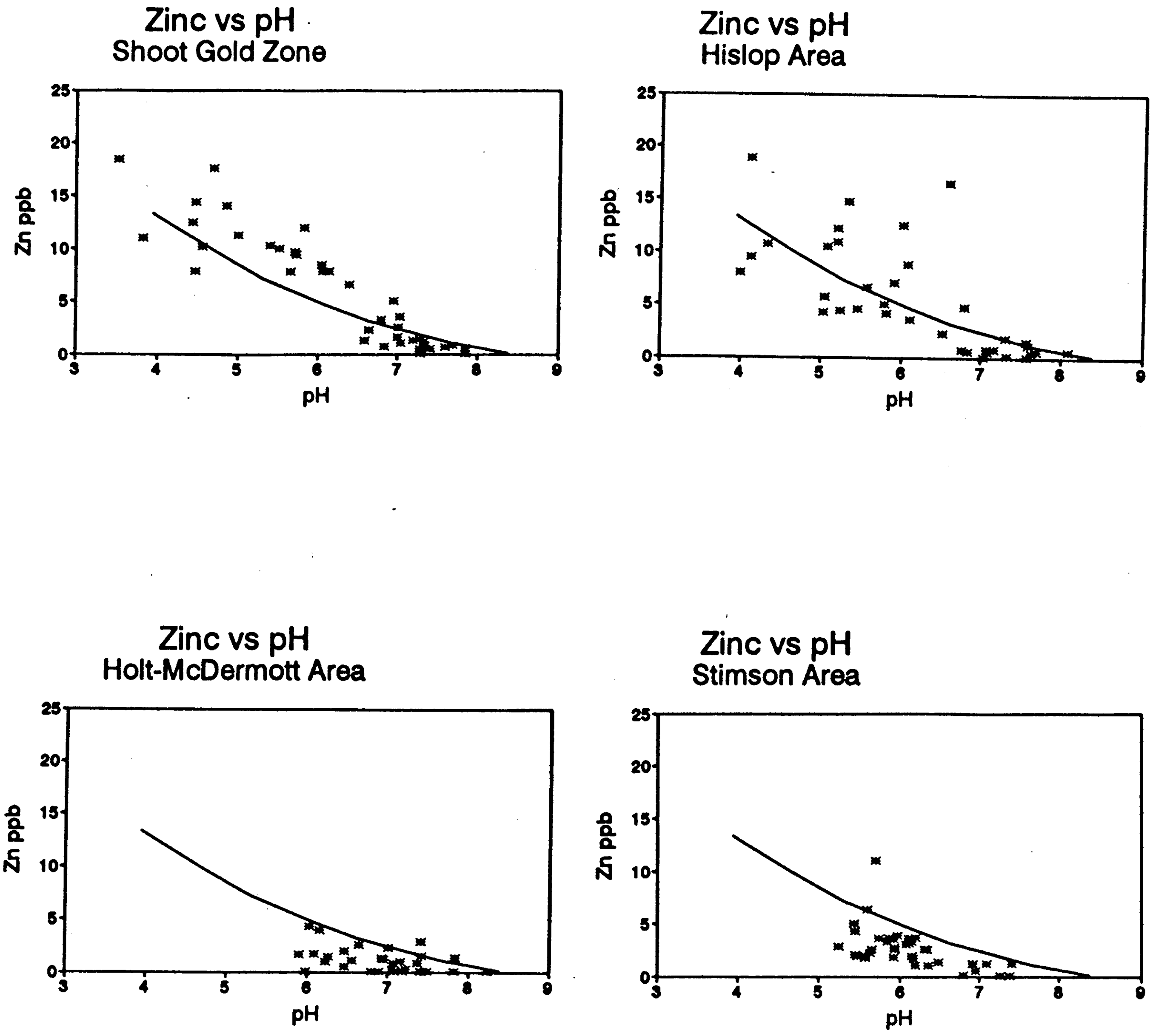


Figure 21. Variation in Zn in surface water as a function of pH for each of the 4 study areas.

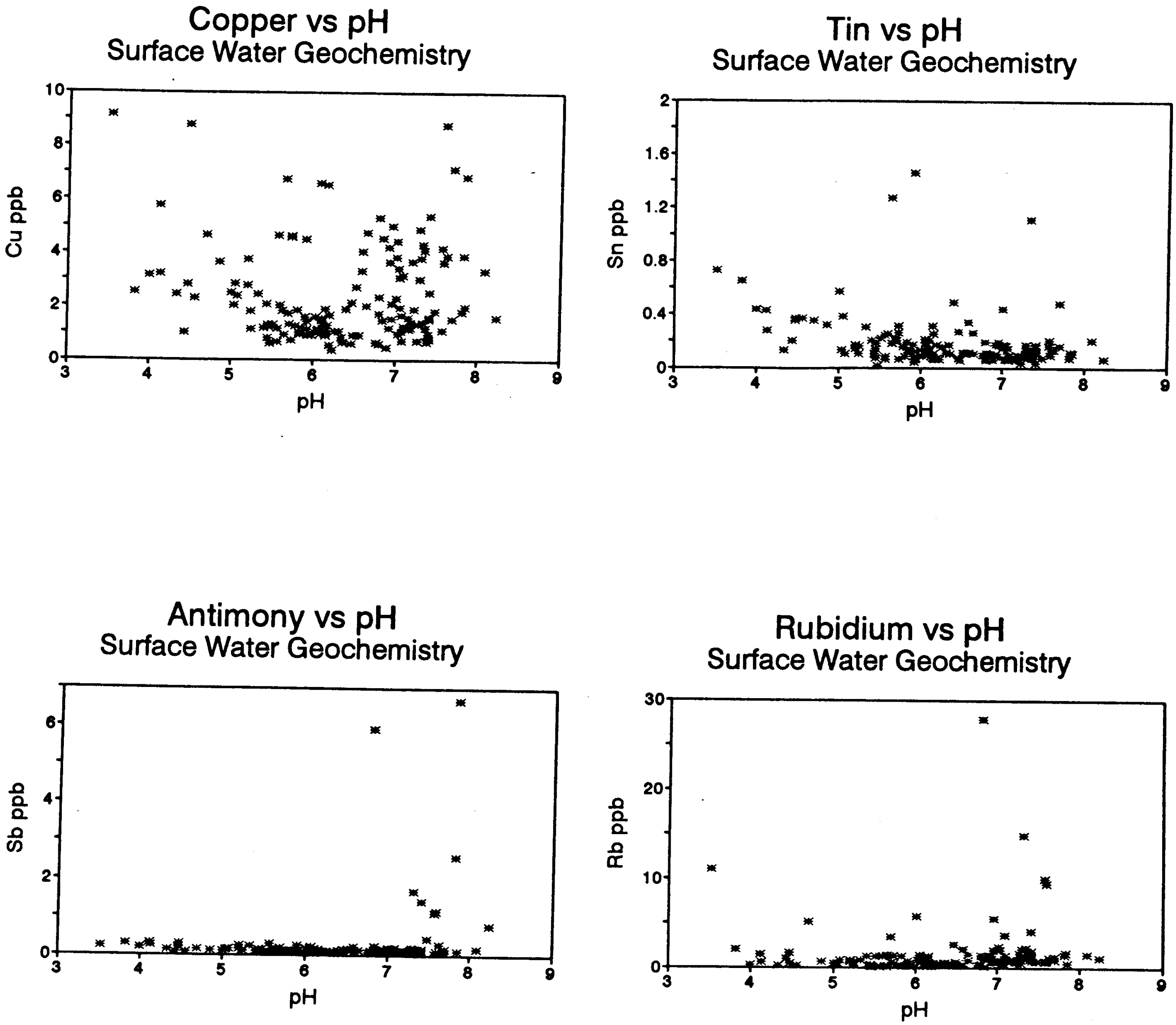


Figure 22. Variation in Cu, Sn, Sb and Rb in surface water as a function of pH.

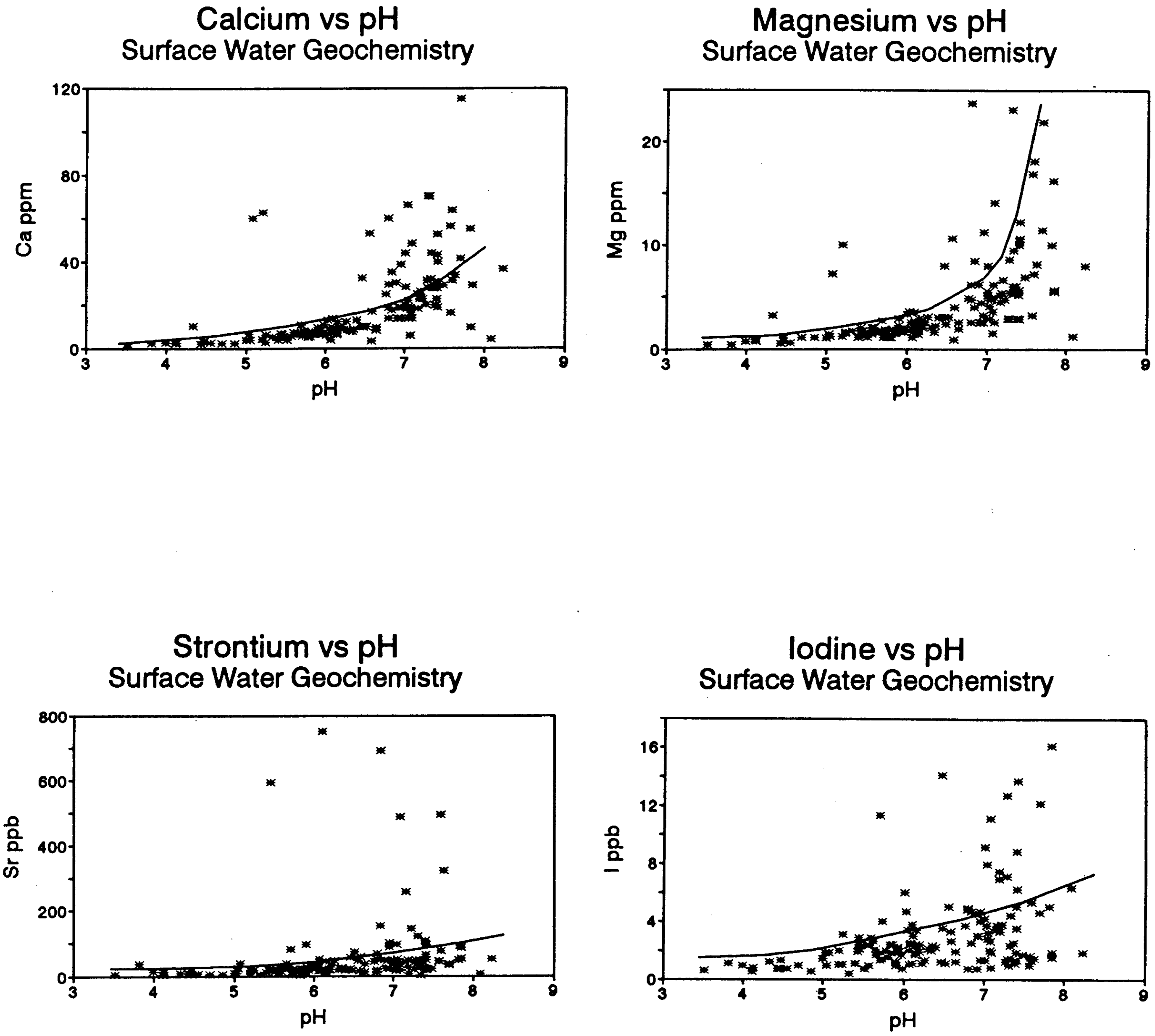


Figure 23. Variation in Ca, Mg, Sr and I in surface water as a function of pH.

The *in-situ* measurement of conductivity is probably a good substitute for the determination of the major cations. This has the added advantage of obtaining useful data in the field that can be followed up immediately. However, this requires more study. There may be important relationships in the trace element data which will only be recognized when these concentrations are looked at in the context of the matrix composition. There are many computer modeling programs which make this possible but which rely on knowledge of the cation composition of the water.

Sample Site Selection Criteria

Water samples were collected from streams, surface pools and from the peat/clay interface (shallow groundwater). A few samples were collected from small lakes thought to be spring fed. It might be expected that differences in water chemistry would exist for these groups of samples.

Some elements are generally higher in surface pools compared to stream water or shallow groundwater (Appendix I). These include Al, Ti, Fe, Pb and Zn. This is related to the more acidic nature of the surface pools. As the surface organic material decomposes, humic acids are added to the surface water. A similar relationship to acidity and organic acids was observed for Al, Ti, and Fe in lake and stream waters collected in the Kirkland Lake, Matachewan and Gowganda areas (Jackson and Hall 1994).

Conversely, some elements are higher in shallow groundwater samples compared to surface waters at the same sites. These include Ca, Mg, Sr, and I. This reflects the more alkaline nature of this water in contact with the glaciolacustrine clay deposits that contain approximately 20% carbonate content (Baker et al. 1985).

Tin is also distinctively higher in shallow groundwater than surface pools or stream water (Appendix I). Tin does not exhibit any clear relationship to pH (Figure 22). If anything, the Sn background concentration increases with decreasing pH. Based on some leaching studies on the PVC piezometers (S. Hamilton, personal communication), contamination may be responsible for the high levels of Sn in the shallow groundwater samples. However, anomalous levels of Sn are observed in stream waters and surface pools at the Shoot Zone suggesting that this element does reflect mineralization. Further study of potential sources of contamination is required to develop effective sampling protocols to minimize contamination effects.

All other trace elements that reflect mineralization are anomalous in both surface pool water and shallow groundwaters although both may not be anomalous at the same site. Trace element anomalies are generally developed along the zone of groundwater flow as marked by alders, cat-tails and open pools. The pools of water that occur along the margins of bogs or broad alder-vegetated drainage pathways appear to be poor sites to collect samples. More detailed sampling is required to better determine the relationship between shallow groundwater anomalies and surface anomalies.

Stream water is a good sample medium provided that creeks are small. Streams exceeding 1 to 2 m in width should probably be avoided. Anomalies do not persist for any great distance along streams. In these studies, maximum length of dispersion is in the order of 200 to 500 m.

Water from the small spring-fed lakes in the vicinity of the Shoot Zone are characterized by natural acidity, an unusual phenomenon for a lake. This may be related to the esker/clay stratigraphic relationships, the presence of mineralization nearby, or a combination of both factors.

Recommended Methodology for Water

Multi-element geochemical anomalies have been observed in surface waters in close association with all mineralized sites studied. In each case, the mineralization is buried beneath 20 to 40 m of overburden which includes an appreciable thickness of glaciolacustrine clay which usually forms the surface material. Anomalies are observed for both gold and base metal mineralization. The sulphide content of the mineralization does not appear to be a factor.

A broad spectrum of elements reflects mineralization although metal associations differ for each of the deposits studied. These include chalcophile elements (Cu, Pb, Zn, Cd, Sb, Mo, Ga, As), lithophile elements (Sn, W, Rb, U, Li, Sr, Ba), halogens (Br, Cl, I), major anions (SO_4) and major cations (Na, K, Ca, Mg). Elements which have not proven to be useful include Al, Ti, Fe, Mn, Co, Cr and V. While potentially useful, Hg, Se and Th are difficult to interpret due to high analytical variability.

The water from surface pools in the vicinity of some mineralization is characterized by natural acidity. This may reflect the diffusion of H^+ to the surface in these areas. This may be related in some way to differences in the character of the overburden (glaciofluvial sand or till covered areas vs clay covered areas). In areas of only clay cover, no natural acidity was observed.

The background concentration of Pb, Zn, Cd and Mo is influenced by pH. However, anomalous residuals above the background trend only occur in the vicinity of mineralization. Care must be taken to consider pH when interpreting the significance of absolute concentrations of these elements.

Conductivity only reflects mineralization if the major cations are anomalous. However, it is a useful parameter to determine as it can be readily measured in the field allowing immediate follow-up of anomalous conductivities.

Stream water, surface pools and shallow groundwater from drainage pathways all seem to be suitable sample media. However, surface pools at the margins of bogs or wide alder-vegetated drainage valleys should be avoided. Samples should be collected from the centre of these drainage pathways or where shallow groundwater flow is most likely to occur. Shallow groundwater should be sampled at the follow-up stage to define the source of the surface anomalies in bogs. Further work is required to determine appropriate equipment for retrieving these samples while minimizing contamination.

The water anomalies are generally restricted in areal size. This medium is appropriate to property scale exploration rather than low density reconnaissance. All available drainage pathways should be sampled along lines 100 m apart. Within bogs, samples should probably be collected at 50 to 100 m intervals along the direction of probable drainage flow.

Suitable sample sites include all available free-flowing streams smaller than 1 to 2 m in width, alder-vegetated drainage pathways and bogs. Where free-flowing streams are absent, surface pools from the centre of the drainage valley or bog should be sampled. If no pools are present, a sump can be dug to a depth of 0.5 m. These should be sampled the following day after the suspended peat has settled to the bottom.

As a follow-up procedure within bogs, piezometers should be installed to the peat/clay interface and left to charge for at least 24 hrs prior to sampling. The type of piezometer required to minimize contamination of the samples is currently under study.

The water samples should be filtered and acidified within 24 hours and kept refrigerated. Cellulose acetate filters with a 0.45 µm aperture are recommended. Samples should be acidified to 0.4% HNO_3 acid strength using ultrapure nitric acid. Pipettes and filter apparatus should not have any rubber parts that come in contact with either the sample or the acid.

The samples should be analyzed for trace elements by ICP-MS. Other useful parameters include sulphate, pH and conductivity. Sulphate should be determined by ion chromatography on an unacidified sample. Conductivity and pH can be determined at the field site using portable meters.

Geochemical Response in Drainage Sediments and Peat

Regional Variation in Background

The drainage sediments (organic bank and peat samples) were collected primarily for a comparison between the effectiveness of water geochemistry, a potential new exploration method, and more conventional approaches to drainage geochemistry which use organic sample media. The drainage sediment results are discussed in this context. The determination of regional thresholds and an in-depth interpretation of the data has not been carried out.

Variation in elemental background between areas is less pronounced for drainage sediments than that observed for water (Appendix III). However, for many elements, distinct differences are apparent between the peat and organic bank samples which make up this sample group.

This appears to be related to variable organic content in these sample media and to differences in pH-Eh conditions at the sample site which control Fe and Mn adsorption or precipitation. For example, Zn, Cu, Ni and As vary proportionally to the amount of Fe and Mn in the sample (Figure 24). Only a few residuals exist which may be related to geological features. Other elements such as Au, Mo, W, Sb and Pb appear to be unaffected by these 2 factors. Their absolute abundance may be a guide to mineralization.

Most of the lithophile elements vary antipathetically with organic content (Figure 25). This reflects their presence predominantly in a mineral form. Regression against organic content indicates that some hydromorphic anomalies are present for some of these elements, in particular, Na, Rb, Sc, and the rare earths.

Response to Mineralization

The distribution of Au (INAA) in organic bank and peat samples shows a consistent relationship to mineralization. At the Shoot Zone, the response is a single sample anomaly in the bog down-drainage of the mineralization (Figure 26). Other anomalous elements over the zone include U and Rb.

On the Hislop property, a large regional Au anomaly occurs down-ice (southward) of the mineralized horizon (Figure 27). Samples close to individual zones are anomalous even in the peat bog where the South Zone subcrops. The regional feature is very similar in location and areal extent

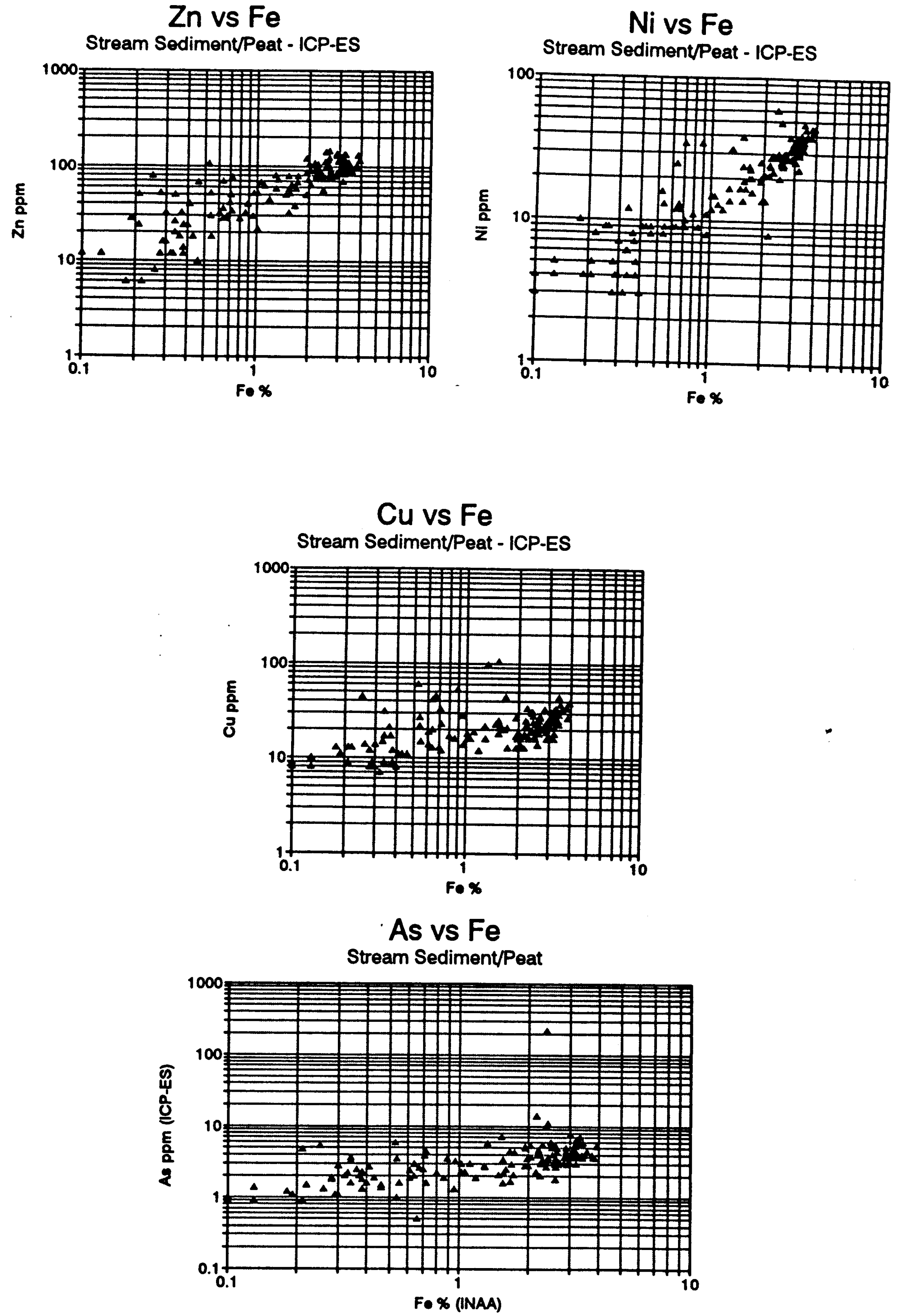


Figure 24. Variation in Zn, Cu, Ni and As in drainage sediments as a function of Fe.

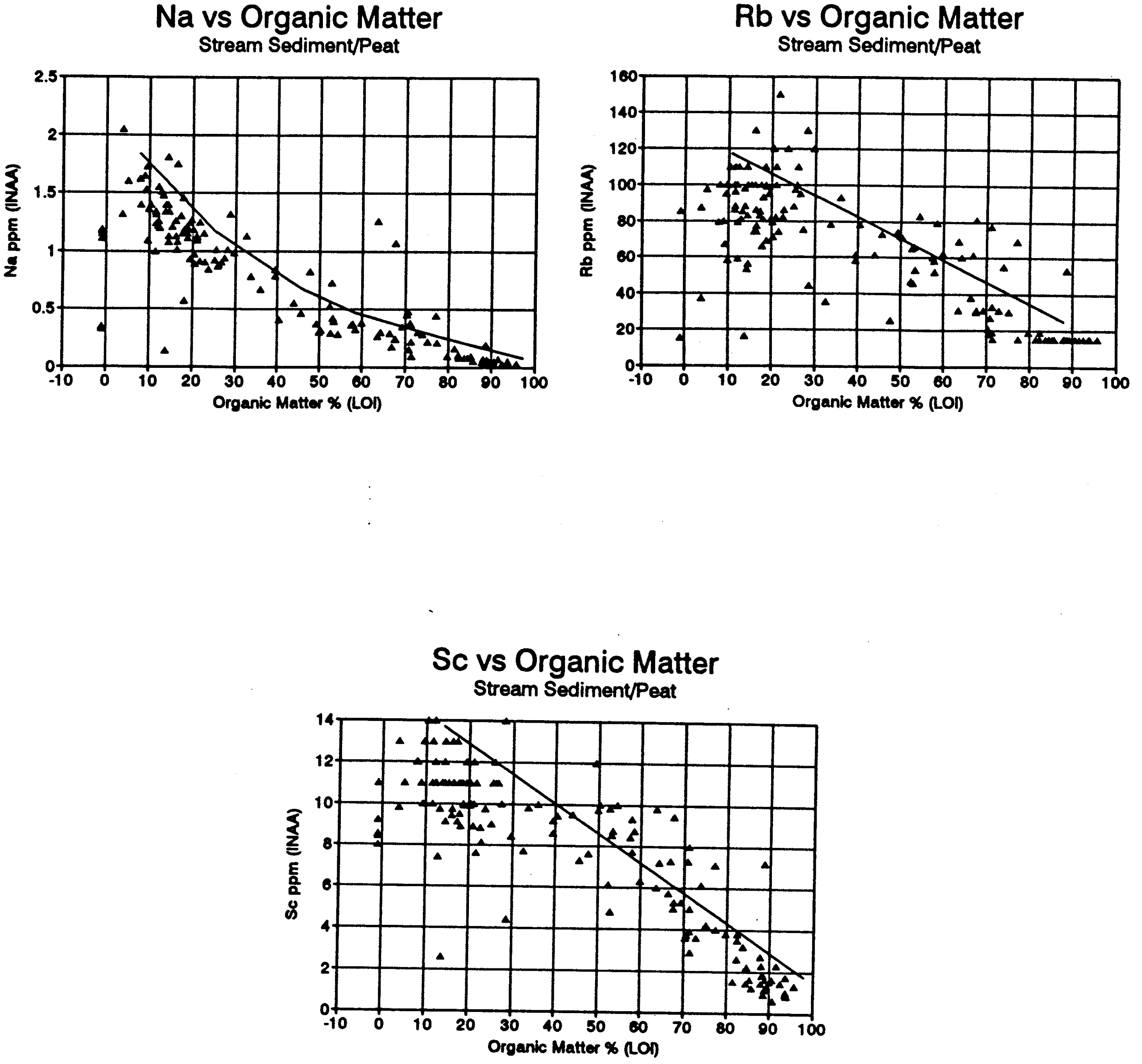


Figure 25. Variation in Na, Rb and Sc as a function of organic content.

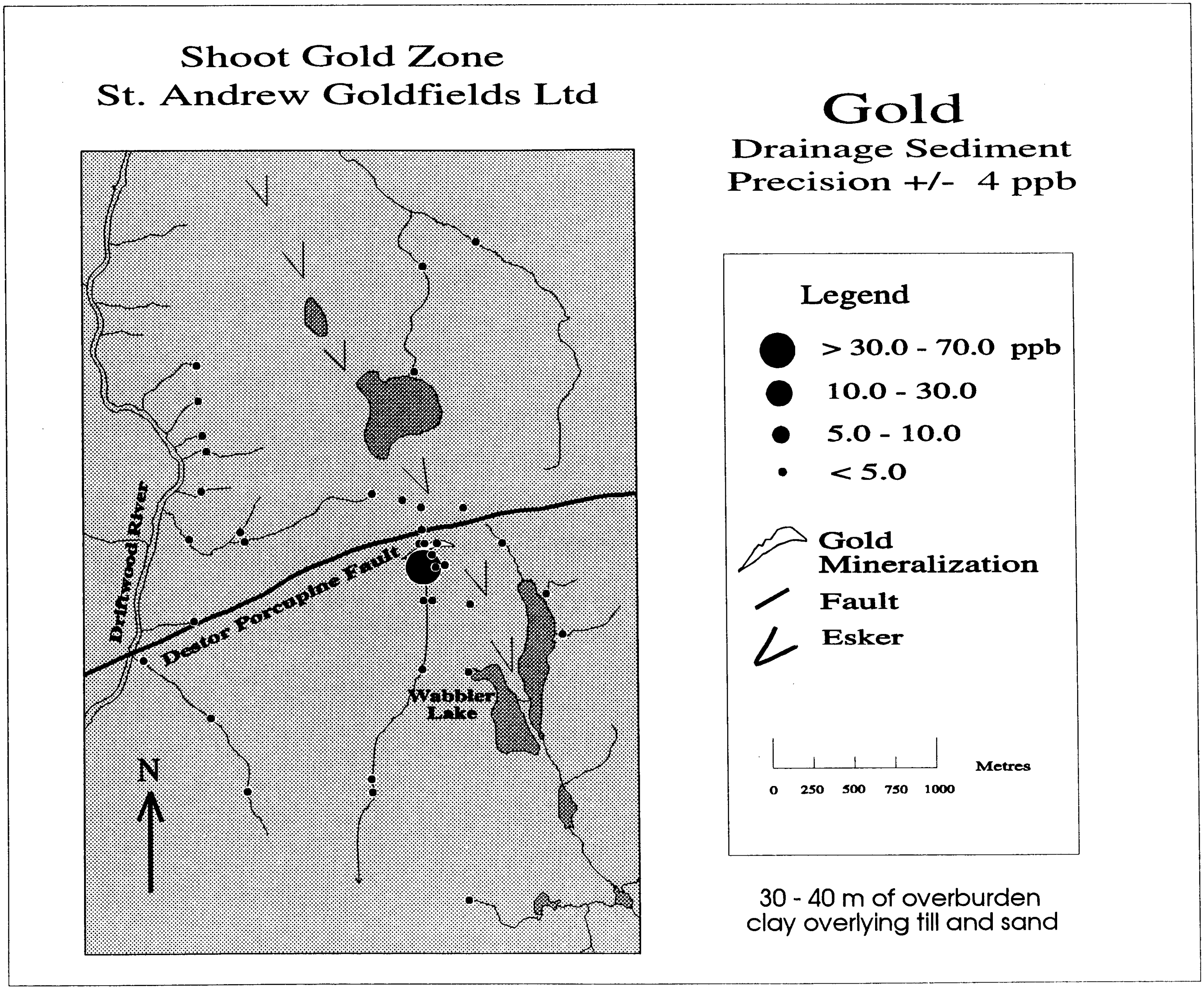
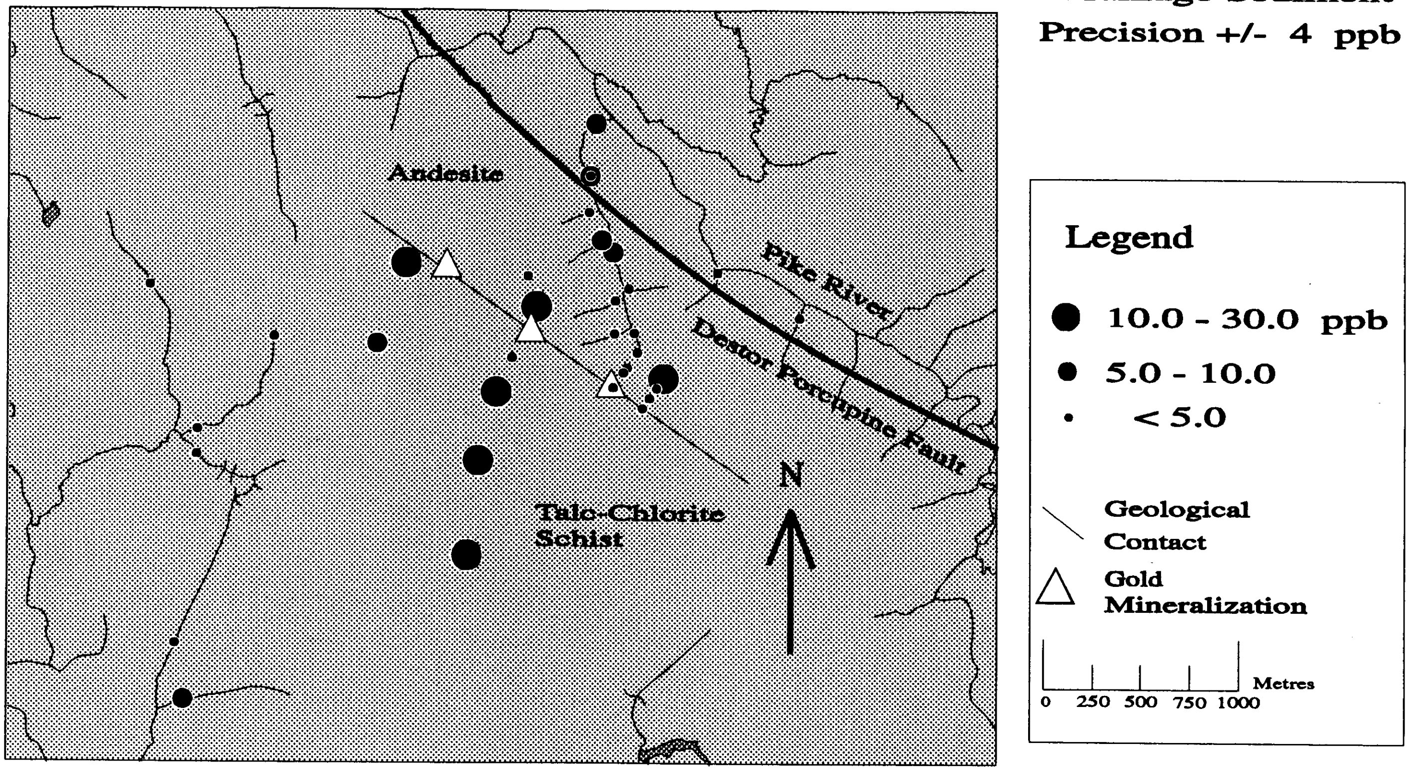


Figure 26: Dispersion of Au (INAA) in drainage sediments and peat in the vicinity of the Shoot Gold Zone.

Hislop Twp Gold Property
St. Andrew Goldfields Ltd

Gold
Drainage Sediment
Precision +/- 4 ppb



25 - 30 m of overburden - clay overlying till

Figure 27: Dispersion of Au (INAA) in drainage sediments and peat in the vicinity of the Hislop Gold Deposits.

to a Zn anomaly observed in water. This anomaly may reflect a glacial dispersion fan in the till exposed either at surface or buried beneath a thin layer of varved clay. Other elements which are locally anomalous close to mineralization are Cu, As, Sb, Mo and, relative to organic content, many of the lithophile elements such as Na, Sc, U and the rare earths.

On the Holt-McDermott property, Au anomalies are associated with the base of the tailings dam and a large area encircling the mine infrastructure and mill site (Figure 28). This may be a contamination feature although the anomaly seems to extend to the west beyond the area of disturbance. Interestingly, surface water anomalies were not obtained at most of these sites but rather exhibit a close relationship to known mineralization. Other elements which are locally anomalous in the bank samples are Ta, As and Mo.

On the Stimson base metal property, a high contrast Au anomaly is located adjacent to the mineralization intersected in several drill holes (Figure 29). Other anomalous elements include Cu, Mo, Sb and W. The area also appears to be characterized by elevated levels of rare earth elements. No anomalies were observed at sites draining the base metal mineralization.

The gold anomalies in these 4 areas occur predominantly in peat or organic-rich stream bank samples. Gold anomalies obtained in organic-poor media were restricted to the Holt-McDermott property where contamination may exist from air-borne dust or road-fill across streams.

In clay terrain, the stream bank samples may tend to have low organic content unless the ground is flat and water saturated. Thus, allowing the development of a good peaty layer over top of the clay as is the case in the Stimson area. Organic-poor sample media should be avoided in areas of clay cover. Where till or glaciofluvial material exists at surface, this restriction does not apply.

The peat geochemistry provides some substantiation of the water anomalies that have been observed in bogs above buried gold mineralization. Gold and other trace element anomalies were

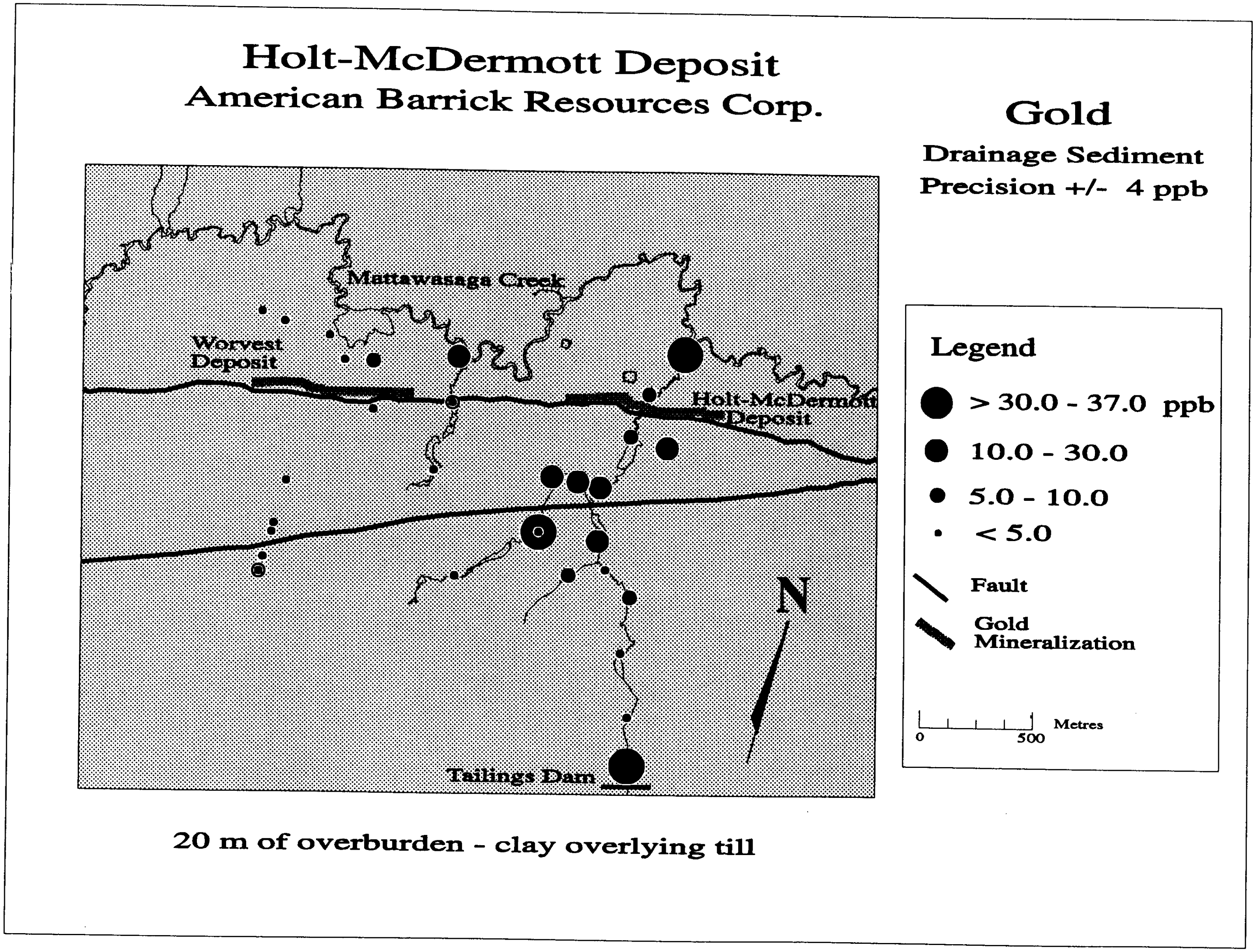


Figure 28: Dispersion of Au (INAA) in drainage sediments and peat in the vicinity of the Holt-McDermott Gold Deposits.

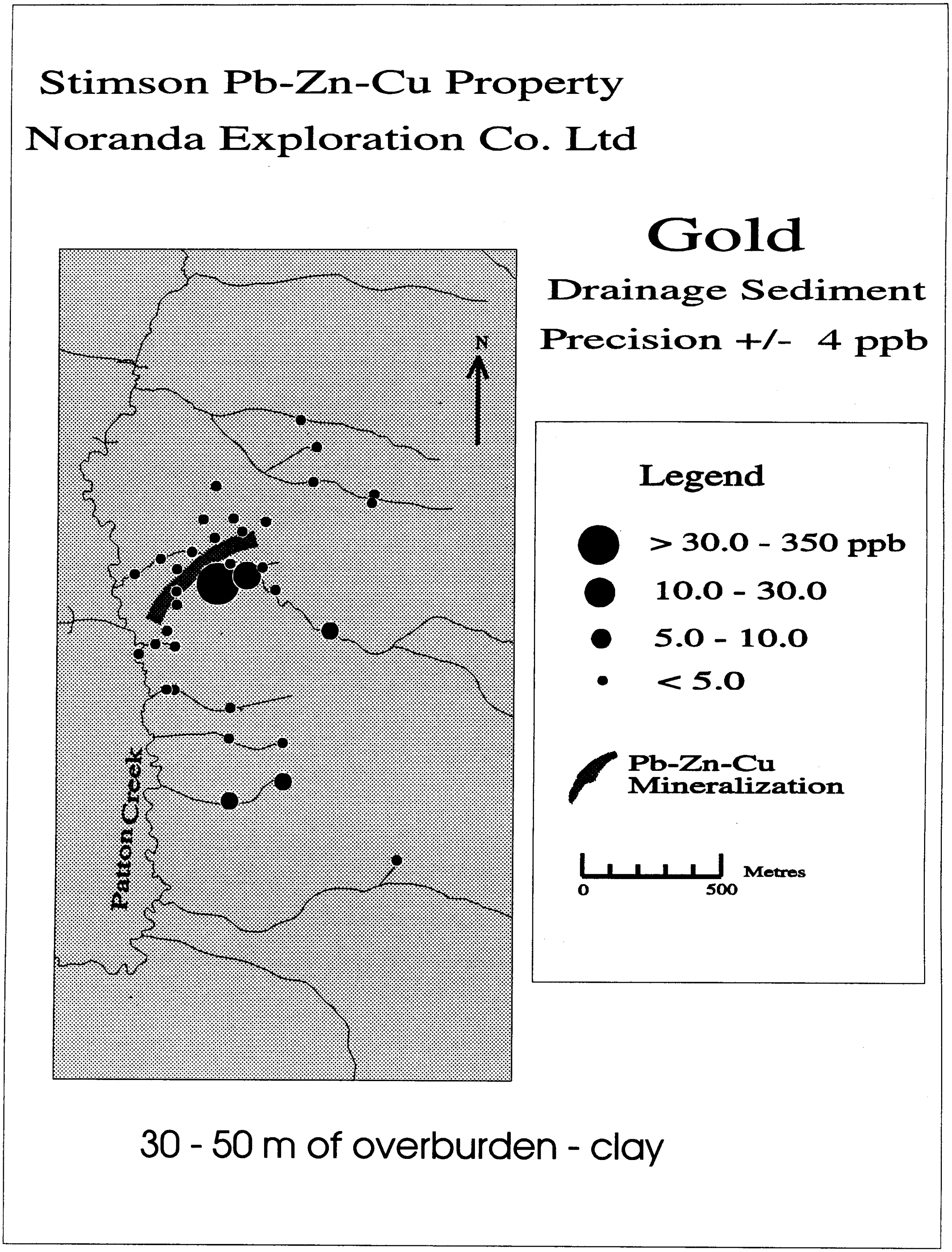


Figure 29. Dispersion of Au (INAA) in drainage sediments and peat in the vicinity of the Stimson base metal mineralization.

obtained locally in peat down-drainage of the Shoot Zone and the South Zone. In these cases, the depth of overburden was 30 to 40 m.

However, in general, surface water appears to exhibit a better geochemical response to mineralization than the peat or stream bank material in contact with the water. In some cases, the organic-rich media were anomalous in Au at sites where surface water trace element concentrations were background (i.e., Stimson area). Since these occurred in areas with no known mineralization, it is unclear whether these anomalies reflect some geological feature or are spurious analytical artifacts. Also, the distribution of Au in drainage sediments near the Holt-McDermott deposit appeared to be affected by contamination from mine infrastructure.

Geochemical Response in Soils

Regional Variation in Background

Geochemical background varies between areas for most elements (Appendix IV). These variations appear to be related to a combination of factors: rock type, mineralization, grain size and organic content.

The upper limit of background fluctuation (threshold) has been established for each parameter (Table 4). However, these may have limited application given the effects of grain size, organic content, and perhaps other surficial factors. Local patterns may be more important than absolute concentration relative to a regional threshold.

Response to Mineralization

Shoot Gold Zone

The B horizon soils analyzed by enzyme leach/ICP-MS exhibit anomalous patterns for Sn, Mo, W, Cu, Pb, Cd, Sr and possibly Zn relative to mineralization. However, these patterns are very complex.

Table 4. Geochemical thresholds for selected elements in B horizon soil

Element (ppb)	Regional Threshold (Clay)	(sand/till)
Cu	90	18
Pb	10	1
Zn	60 - 100	40 - 100
Mo	10	1
Cd	1 - 3	3
Sn	1	1
W	5 - 15	1
Rb	40 - 60	80
Ag	0.2	0.2

The distribution of Cu and W illustrates the relationship of anomalies to the subcropping mineralization (Figure 30 and 31). At the west end of the Shoot Zone, the Cu and W anomalies occur on either side of the subcrop projection with a low directly over mineralization. This pattern has been referred to as a "rabbit ear" anomaly (Bolviken and Logn 1974, Govett 1973). In contrast, there is only a weak response in soils developed on the esker sands at the east end of the zone.

However, the distribution of Cu appears to be affected by other factors besides mineralization. There is a significant decrease in background from the clay soils to the sandy soils over the esker. Also, there appears to be a zone of high background Cu which parallels the clay-sand boundary. Values decrease on the clay plain to the southwest away from this contact and decrease sharply to the northeast over the esker. This feature is observed for many elements, particularly the rare earth suite. Some elements such as Rb (Figure 32) exhibit higher background over the esker sands.

There also appear to be some Cu anomalies over or marginal to the Destor-Porcupine Fault Zone. Other elements which exhibit anomalous patterns related to the fault include Pb, Cd, Sb, W, Sn and Li.

When the Cu distribution is viewed in relation to that of other elements, the Cu anomaly associated with mineralization appears to be part of a metal zonation pattern from west to east along the zone. Both Sn and Mo are anomalous over the west end of the subcropping mineralization as was observed for Cu and W (Figure 33 and 34). Further to the west, the Sn-Mo anomaly has a similar relationship to mineralization as that of Cu, a "rabbit ear" anomaly straddling the extension of the zone. However, the width of the anomalous shoulders are broader and they are separated by a wider area of low values. The net effect is to create a "V" shaped anomaly which points toward the west end of the Shoot Zone.

The distribution of Pb (Figure 35) seems to reflect a combination of the patterns evident in the Cu, Mo and Sn anomalies. At the west end of the Shoot Zone, high Pb values are associated with

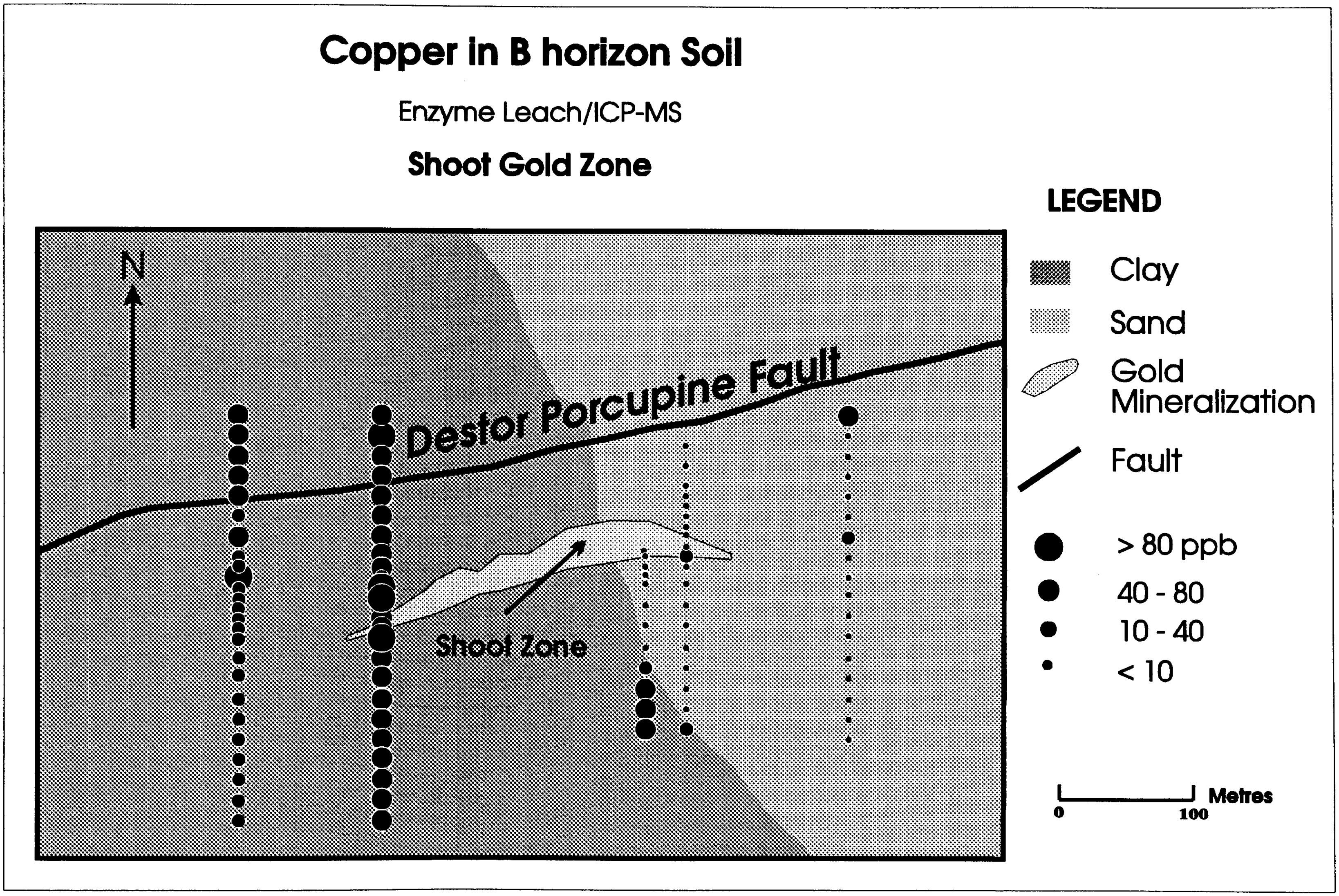


Figure 30: Dispersion of Cu in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

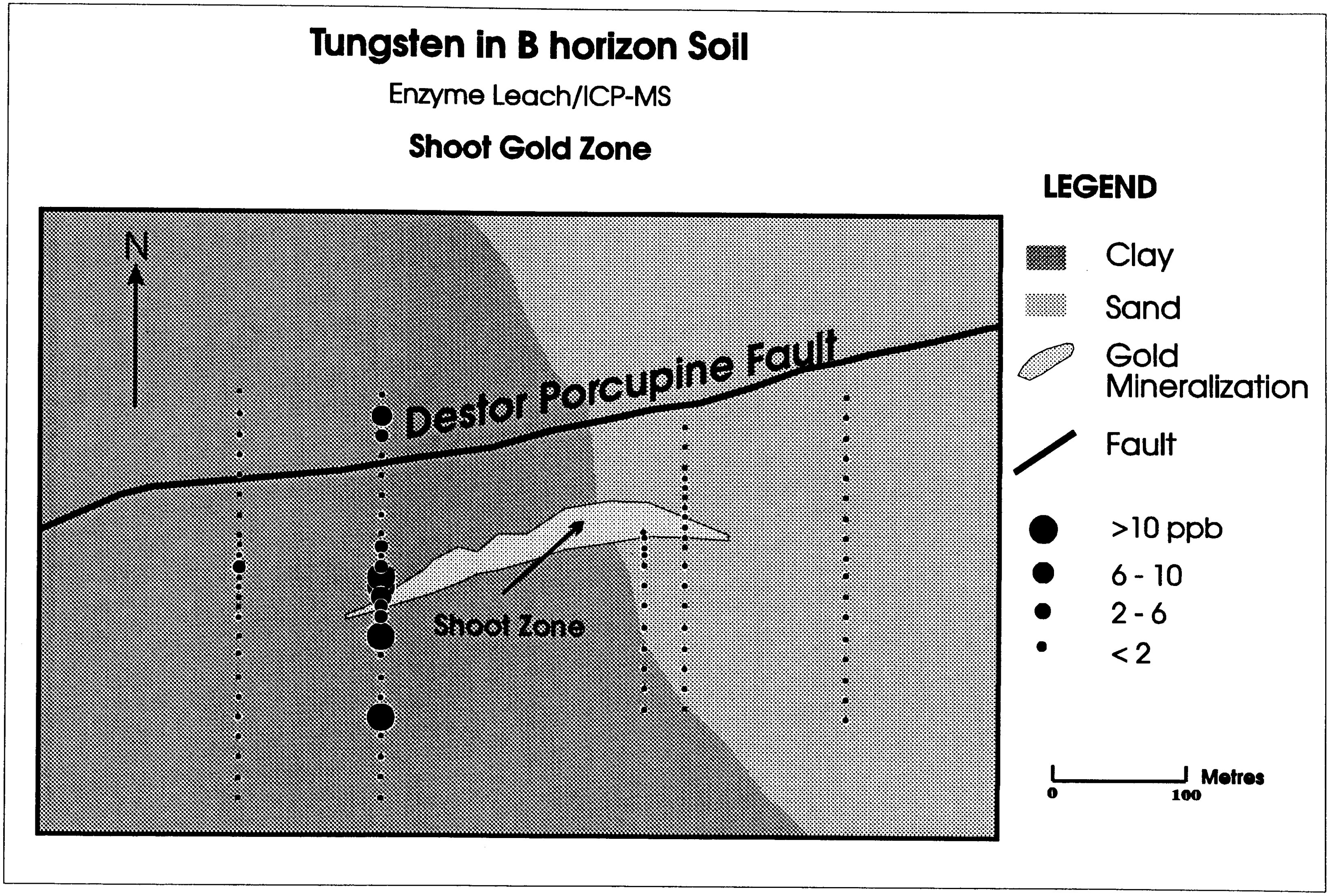


Figure 31: Dispersion of W in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

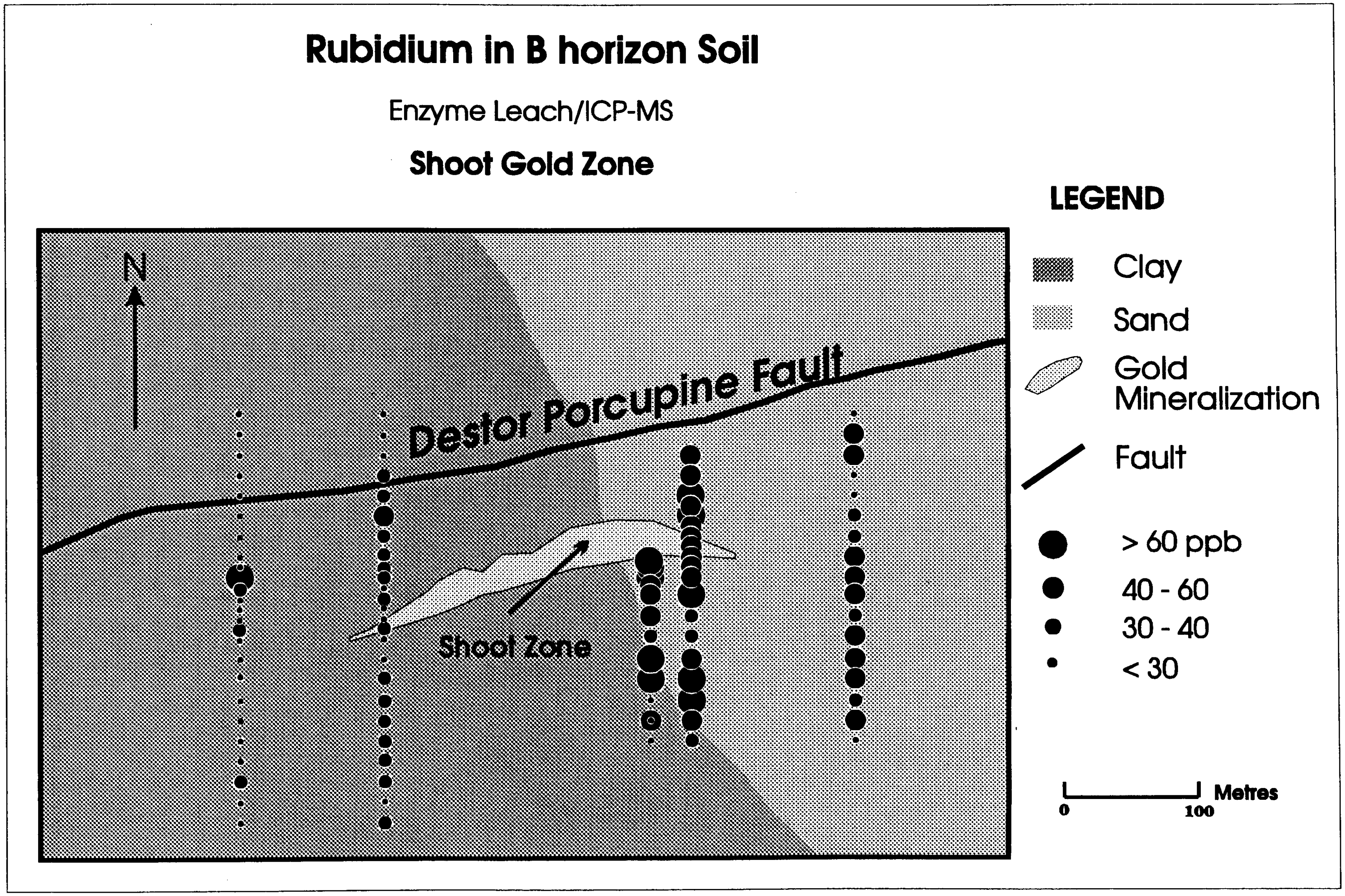


Figure 32: Dispersion of Rb in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

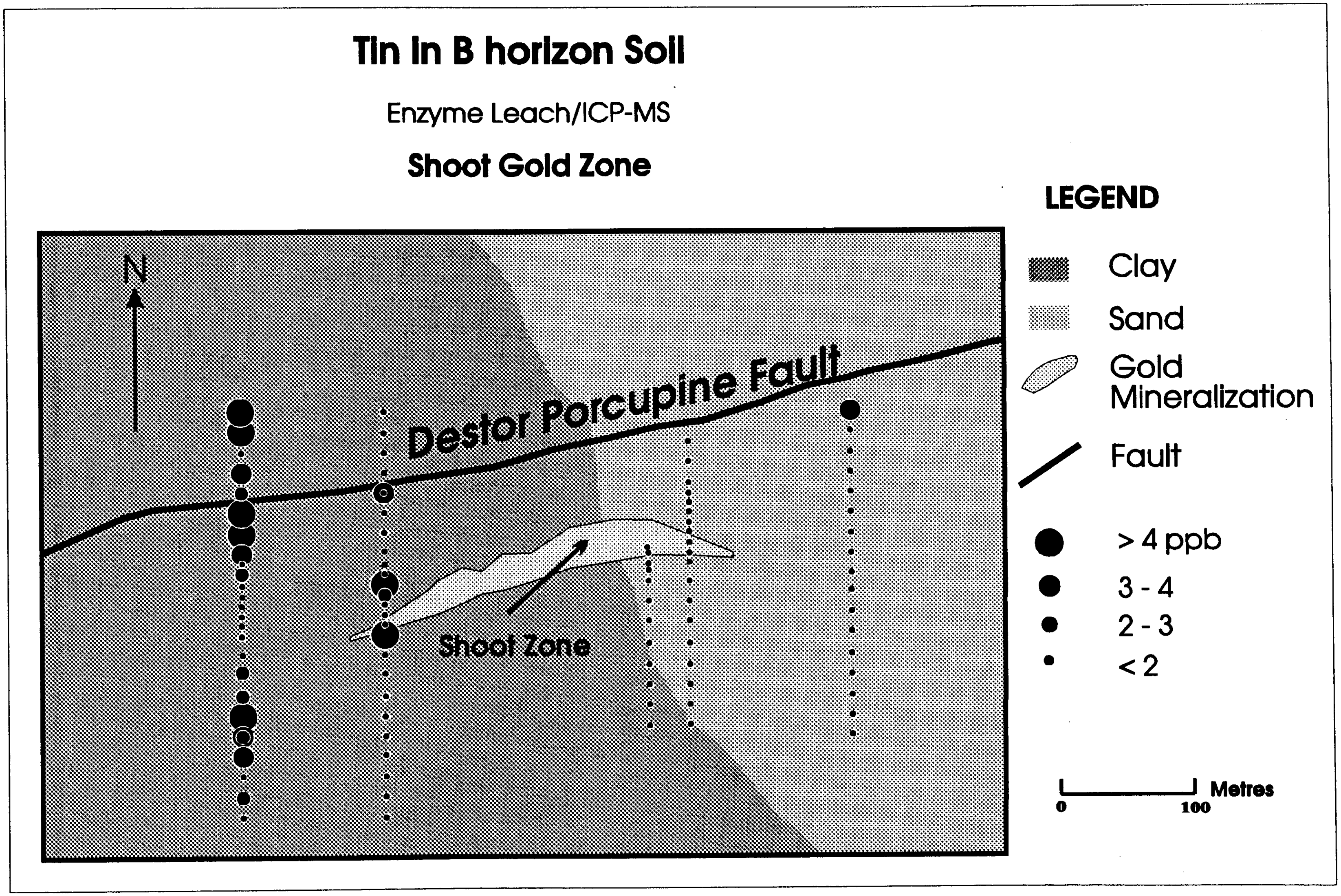


Figure 33: Dispersion of Sn in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

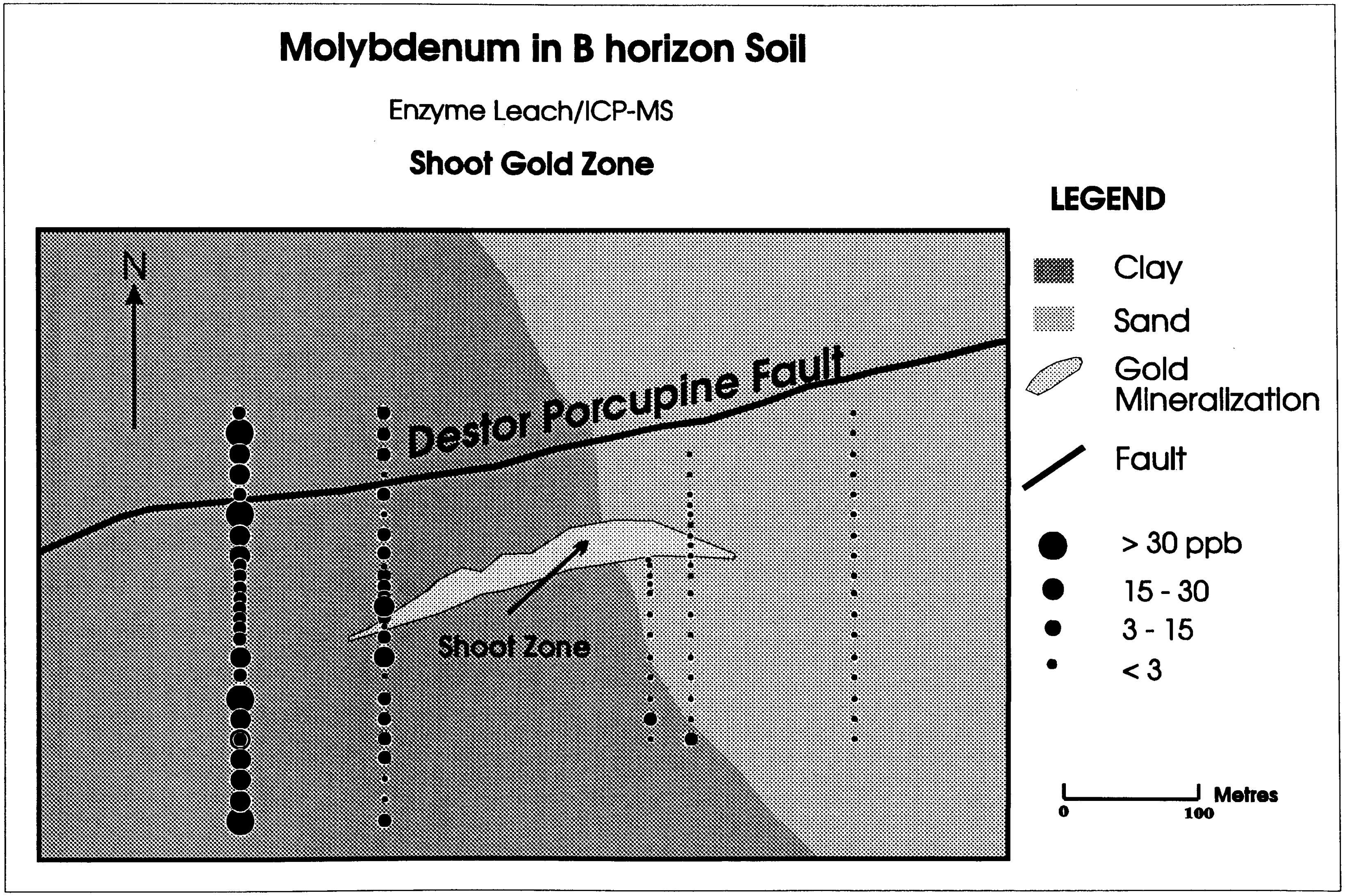


Figure 34: Dispersion of Mo in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

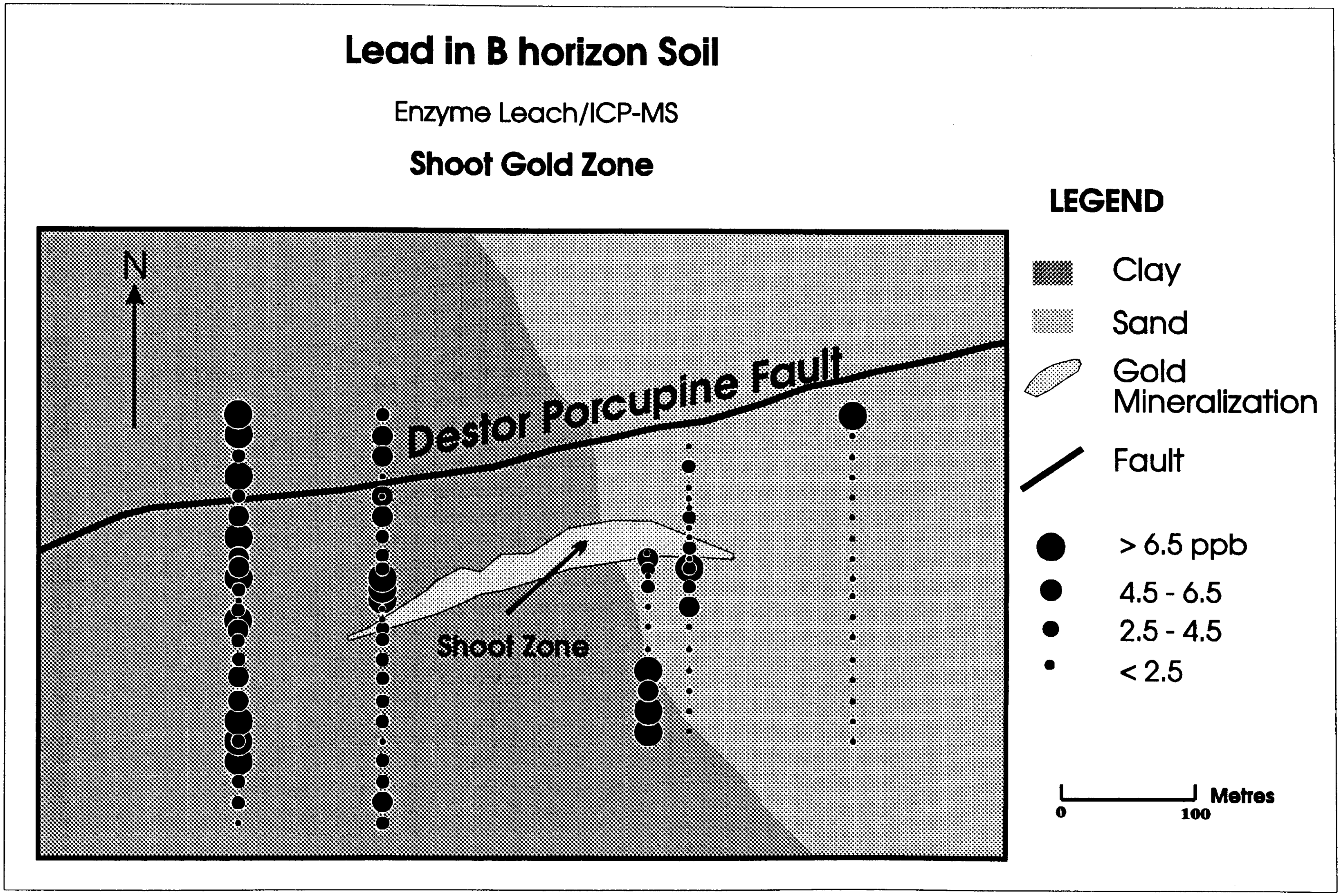


Figure 35: Dispersion of Pb in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

the north shoulder of the Cu-W-Mo-Sn anomaly. In addition, Pb is anomalous in the sandy soils along the south flank of the Shoot Zone's east end.

Anomalous Cd is also observed adjacent to mineralization in these sandy soils (Figure 36). Only a very weak Cd response is associated with the west end of the zone. The Cd anomaly is coincident with a negative Sr anomaly in the sandy soils (Figure 37). However, in the clay soils, a negative Li anomaly appears to be associated with the west end of the mineralization.

It is unlikely that this zonation is related to any primary geochemical signature in the Shoot Zone. Instead, it appears to be related in some way to the dispersal mechanism that enables elements to diffuse to the surface through thick deposits of till, sand and clay. One possibilility is that hydrogen ions may also be diffusing to surface. This could have a significant effect on soil pH and would be a major determinent of how elements partition between the A and B horizons of the soil.

The metal zonation sequence Mo-Sn-Cu-W-Pb-Zn-Cd is very similar to that observed in epithermal mineralized systems. Another possibility is that these elements are differentiating within the surficial environment across the clay-sand interface. This could be a function of their electronegativity properties or contrasting redox potential.

The influence of the clay-sand contact and the mineralization on element abundance is further emphasized by the variation in several elements from southwest to northeast perpendicular to the long axis of the esker. Most elements show some relationship to this contact even though they do not exhibit a recognizable response to the Au mineralization. Bromine, Cu and the rare earth elements increase in concentration toward the contact in clay soils and then decrease sharply in sandy soils whereas Mo decreases toward the contact. Variation in the abundance of the clay-sized fraction may partly explain this phenomenon. However, other factors must be involved since elements such as Rb, Sr, Zn and Cd have similar or higher levels in the sandy soils compared to the clay soils. Also, soils in the vicinity of mineralization appear to exhibit higher variability than background soils as illustrated by Mo, Cu and Sr.

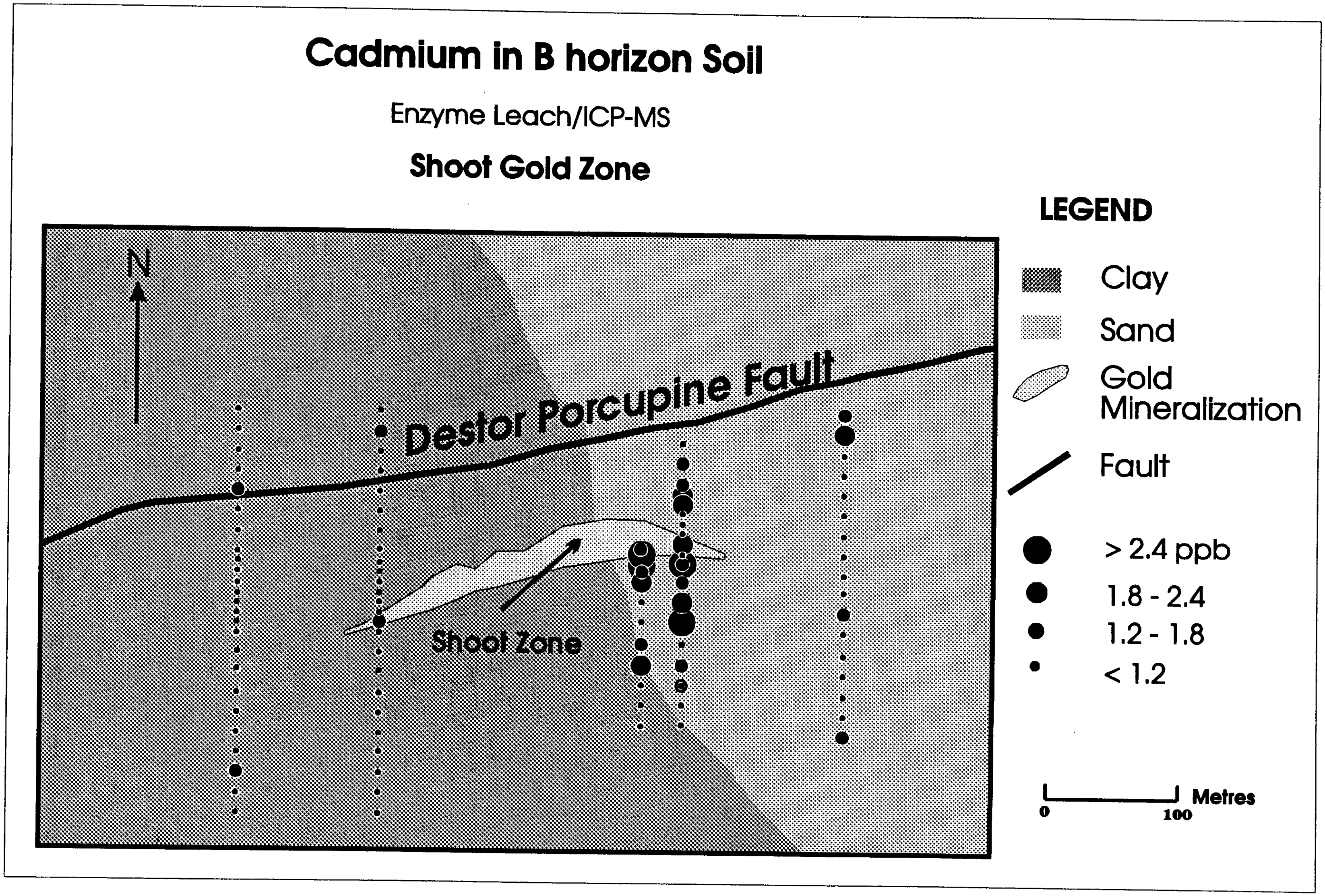


Figure 36: Dispersion of Cd in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

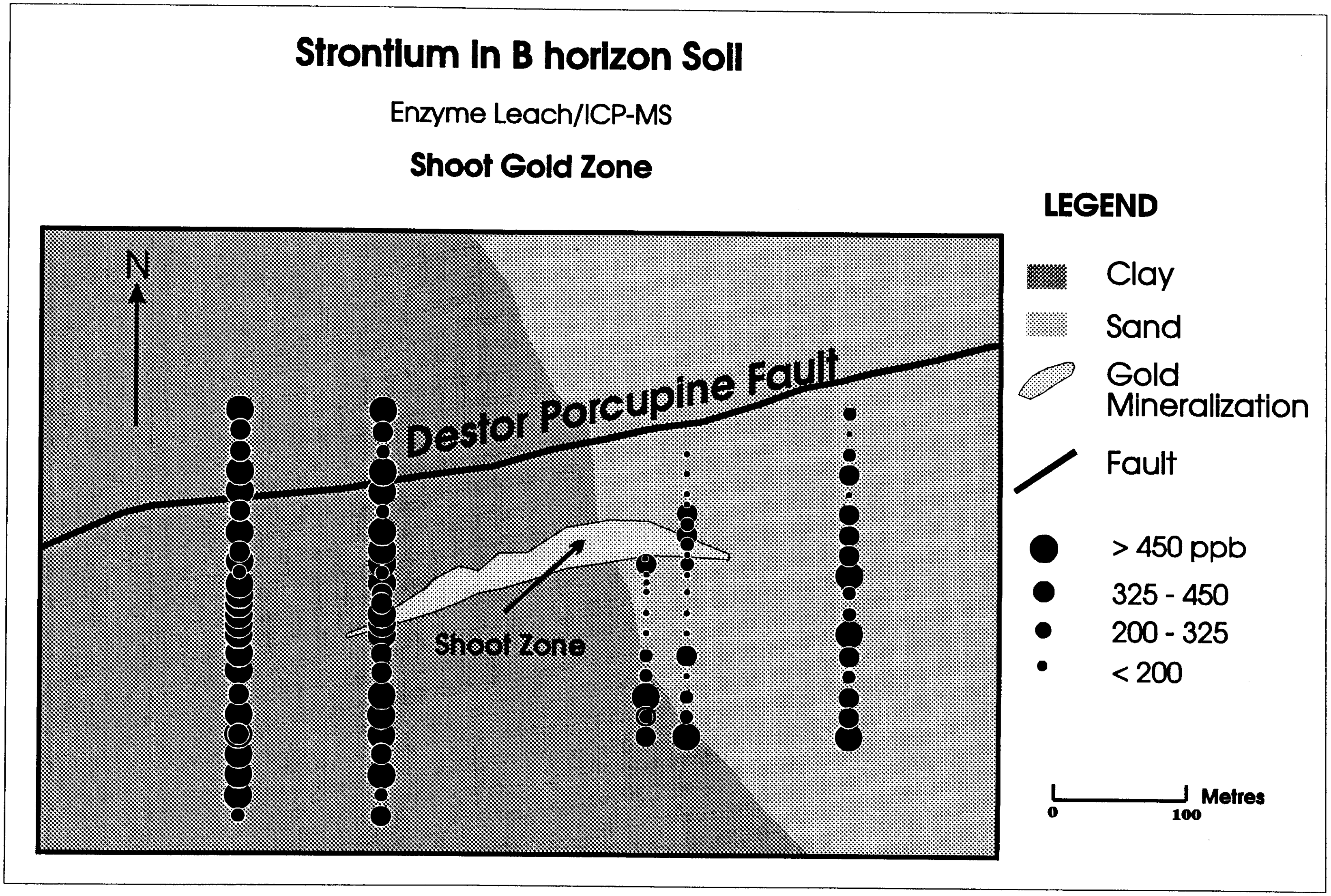


Figure 37: Dispersion of Sr in B horizon soil (enzyme leach/ICP-MS) over the Shoot Gold Zone.

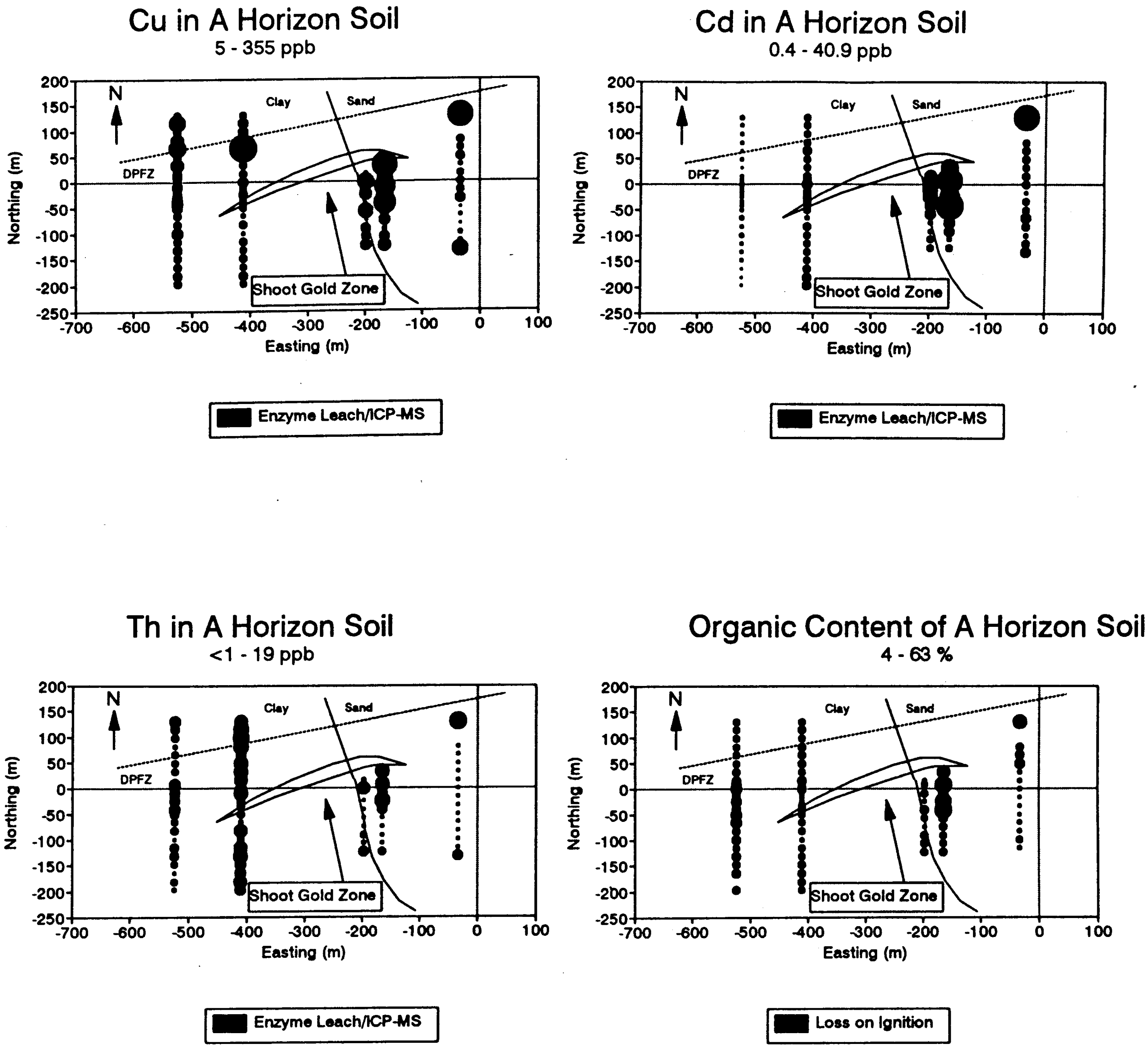
The A-horizon soils also exhibit some relationships to mineralization when analyzed by the enzyme leach/ICP-MS method. The patterns observed for the sandy soils over the east end of the mineralization are essentially confirmed (Figure 38). Absolute levels of elements are higher. This is likely due to the high organic content (20 to 63%) and associated high Mn (greater than 100 000 ppb) of the podzolic A horizon.

However, no anomalies were observed in the clay soils over the west end of the mineralization. The surface soils in this area differ from the B horizon soil in having a slightly higher organic content (5 to 10%) and in having been cultivated at some time. By virtue of being at the surface, they could be more susceptible to leaching of adsorbed metals during surface runoff. The higher organic content of the A-horizon soils developed on the sandy substrate would be more capable of retaining adsorbed metals.

Copper, Mo, Sn and W, elements that were anomalous in the B horizon clay soils at the west end of the Shoot Zone, are anomalous in the A horizon sandy soils at the east end of the mineralization (Figure 38). This suggests these elements are dispersing to the surface in this area and that the metal zonation observed in the B horizon is a function of variable scavenging ability of the soil. However, Th exhibits a negative anomaly at the west end and a positive anomaly at the east end (Figure 38). Clearly, more case studies are needed to determine the significance of these relationships.

The A horizon and B horizon soils were analyzed by other methods in addition to the enzyme leach/ICP-MS method. Both were analyzed by ICP-ES following an aqua regia digestion. This is a stronger digestion which extracts near total concentrations of trace elements from the soils. The A horizon soils were also analyzed by neutron activation analysis (INAA) which gives total element contents.

The distributions of elements in B horizon soils as determined by aqua regia/ICP-ES do not reflect any of the anomalous patterns described above. However, the patterns observed for the A-horizon soils (aqua regia/ICP-ES) were generally similar to those obtained with the enzyme


Cu in A Horizon Soil
5 - 355 ppb

Cd in A Horizon Soil
0.4 - 40.9 ppb

Th in A Horizon Soil
<1 - 19 ppb

Organic Content of A Horizon Soil
4 - 63 %

Figure 38. Dispersion of Cu, Cd and Th in A horizon soil (enzyme leach/ICP-MS and distribution of organic matter in A horizon soil over the Shoot Gold Zone.

leach/ICP-MS method (Figure 39). This may simply reflect the higher element content of hydromorphic origin in the A horizon soils. In the B horizon soils, the aqua regia digestion also releases elements bound in mineral lattices. This component may far exceed that of the adsorbed or complexed forms. As a result, the hydromorphic signal is overwhelmed and not readily recognizable.

The distribution of Au in the A horizon soil as measured by INAA revealed a "rabbit ear" anomaly straddling the Destor-Porcupine Fault Zone on Line 410 W (Figure 40). This anomaly was confirmed by the enzyme leach/ICP-MS data. No distinct anomaly was obtained in close association with the Shoot Zone mineralization.

Many elements in A horizon clay soils, regardless of the digestion or analytical method employed, exhibit a decrease in background approaching the Shoot Zone mineralization. This is illustrated with the distribution of Al as determined by aqua regia/ICP-ES (Figure 40). It is unclear why this pattern should be observed but a similar pattern was obtained for Li in the B horizon soil.

Hislop Gold Deposits

Only one traverse was sampled across the West Breccia Gold Zone on the Hislop property. This area is till covered with a depth of overburden of about 20 m. Three soil horizons were sampled at each site and analyzed by various methods. The A horizon soils contain approximately 10 to 67% organic matter.

Gold in the A horizon, as analyzed by INAA, shows a distinct soil anomaly over the West Breccia Gold Zone (Figure 41). Low values occur in soils directly over the sub-cropping mineralization with anomalous shoulders to either side. A weak response is also obtained with the enzyme leach. Since the soil substrate is till, it should be noted that the highest gold values are located up-ice of the zone.

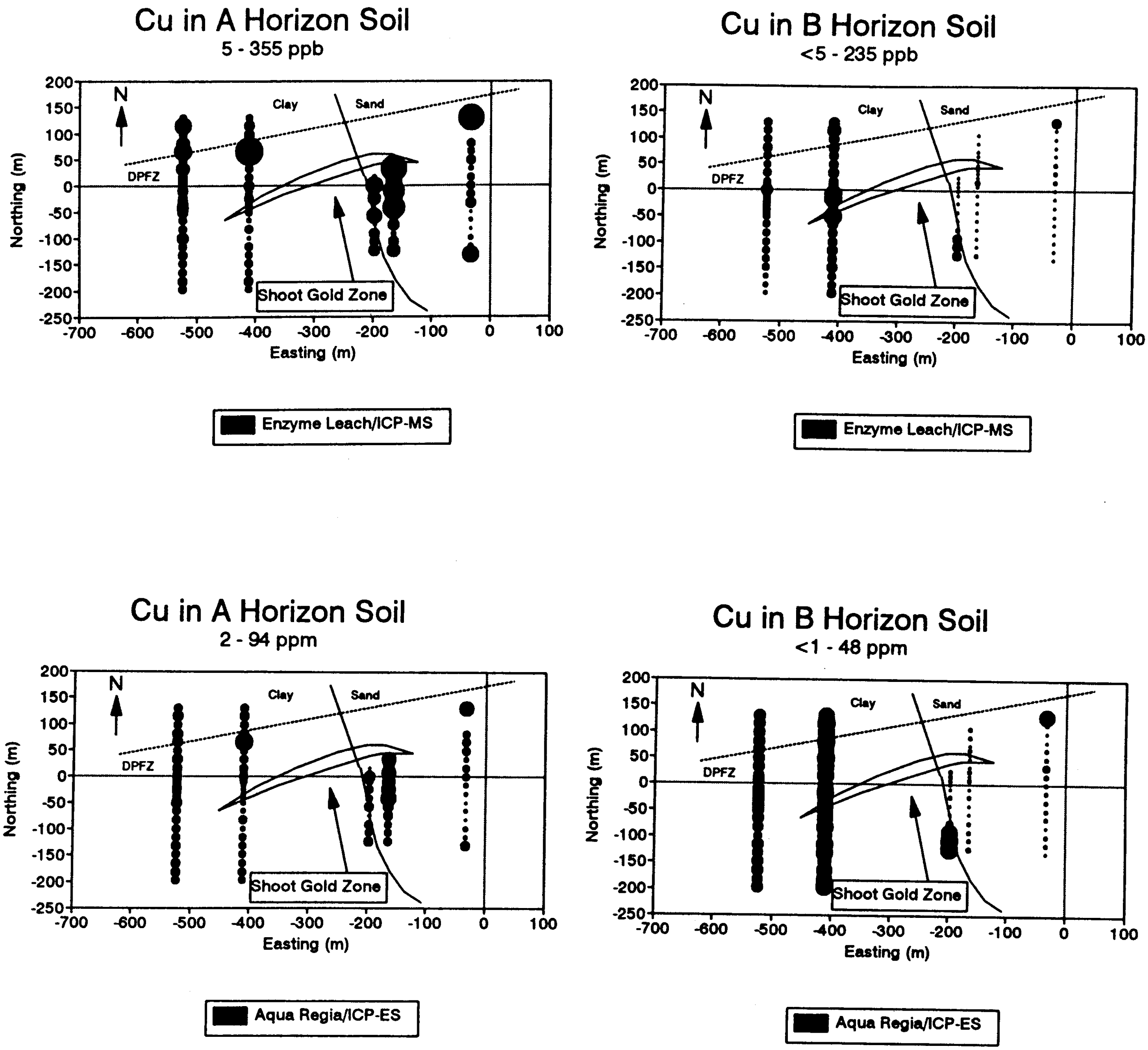
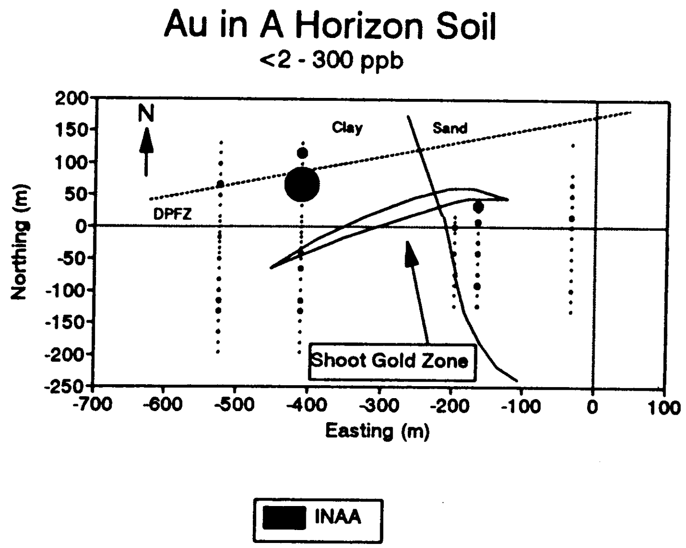


Figure 39. Dispersion of Cu in A and B horizon soil over the Shoot Gold Zone as determined by enzyme leach/ICP-MS and aqua regia/ICP-MS analytical methods.



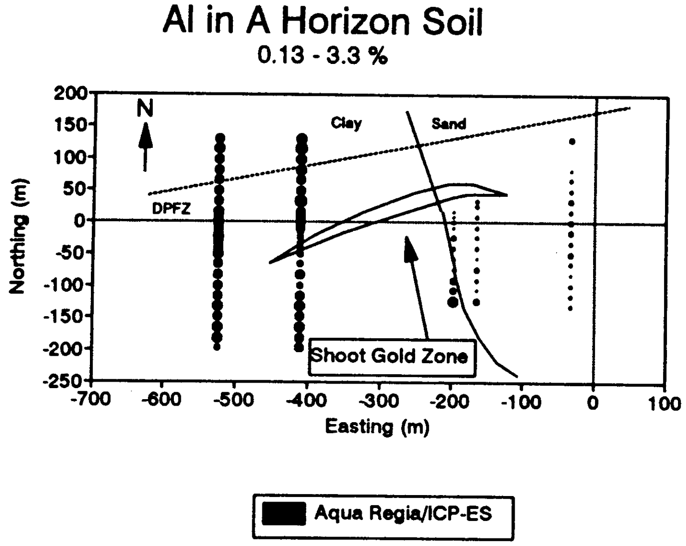


Figure 40. Dispersion of Au (INAA) and Al (aqua regia/ICP-MS) in A horizon soil over the Shoot Gold Zone.

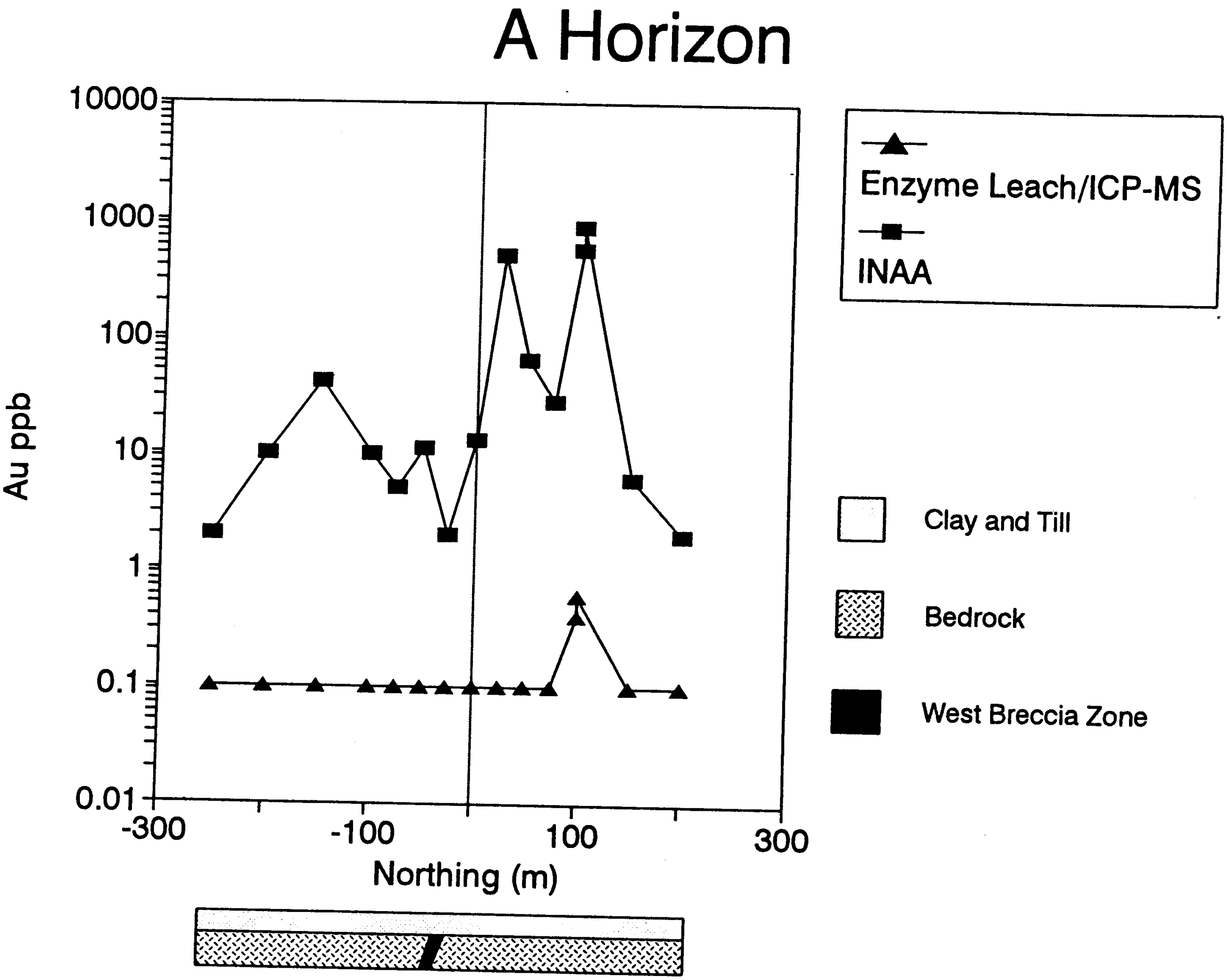


Figure 41. Profile of Au in A horizon soil over the West Breccia Zone, Hislop Township as determined by INAA and enzyme leach/ICP-MS.

The hydromorphic or electrochemical origin of this anomaly is supported by a comparison of the gold patterns in the various horizons (Figure 42). The anomaly in the A horizon is reproduced in the B horizon with the highest value occurring up-ice of the mineralization. However, no anomaly was obtained in the C horizon till.

Other anomalous elements include Mo and W (Figures 43 and 44). The Mo "rabbit ear" anomaly in the A horizon is narrower than that of Au whereas the W anomaly more closely resembles that of Au. In the B horizon, only one of the shoulders is anomalous in Mo based on the enzyme leach digestion. No Mo response is obtained in the C-horizon. The W response in the A horizon determined by the enzyme leach method emphasizes the strong negative anomaly directly over the sub-cropping mineralization. Enzyme leach responses are obtained in the B horizon soil and possibly the C horizon.

In this till covered area, the A horizon analyzed by INAA seems to give the most distinct response as observed for Au, Mo and W. However, contrary to conventional interpretations, the target is the low between the 2 anomalous peaks, not the anomalies themselves. In this particular case, an enzyme leach of either the A or the B horizon, while yielding similar anomalies, offers no advantage over analysis of the A horizon by INAA. The mineralization was not well reflected in the C horizon till.

Holt-McDermott Gold Deposits

Only one traverse was sampled across the Holt-McDermott gold deposit in Holloway Township. This area is clay covered with a depth of overburden of about 20 m. Two soil horizons were sampled at each site and analyzed by various methods. The A horizon soils contain approximately 10 to 91% organic matter.

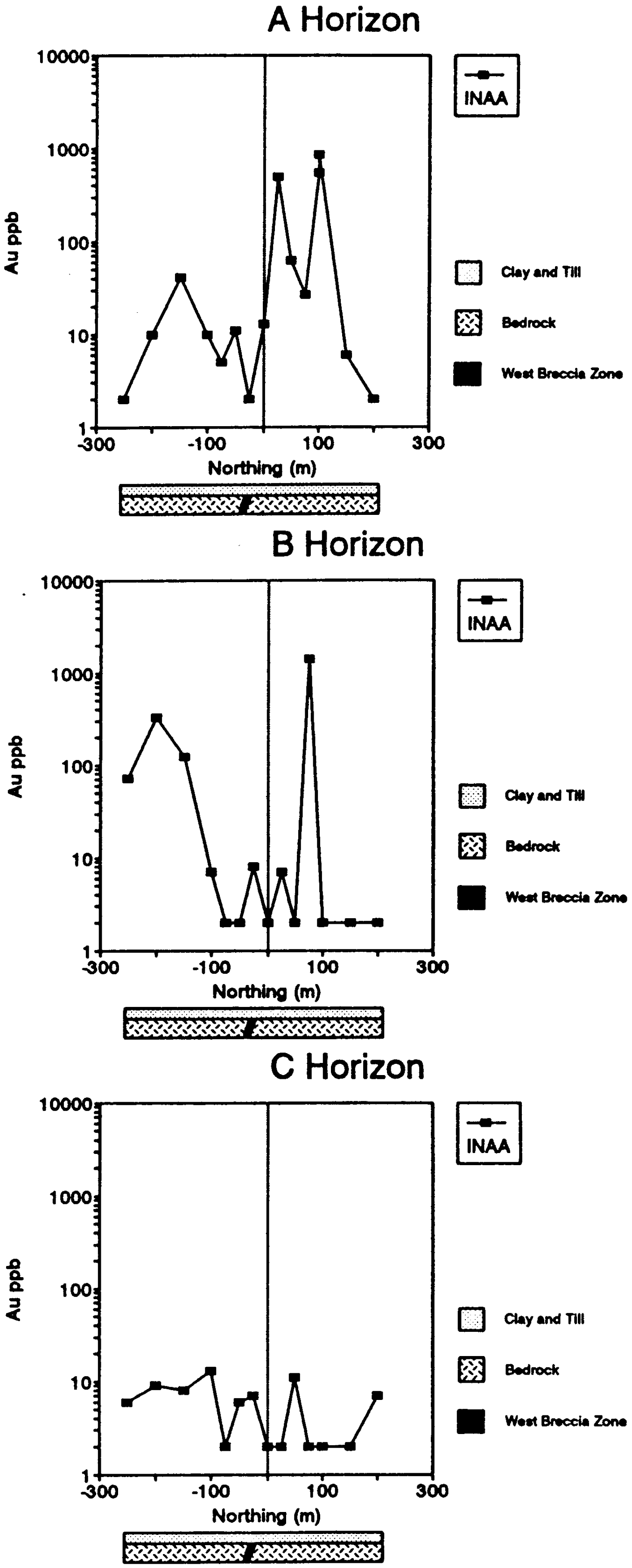


Figure 42. Profile of Au (INAA) in A,B and C horizon soil over the West Breccia Zone.

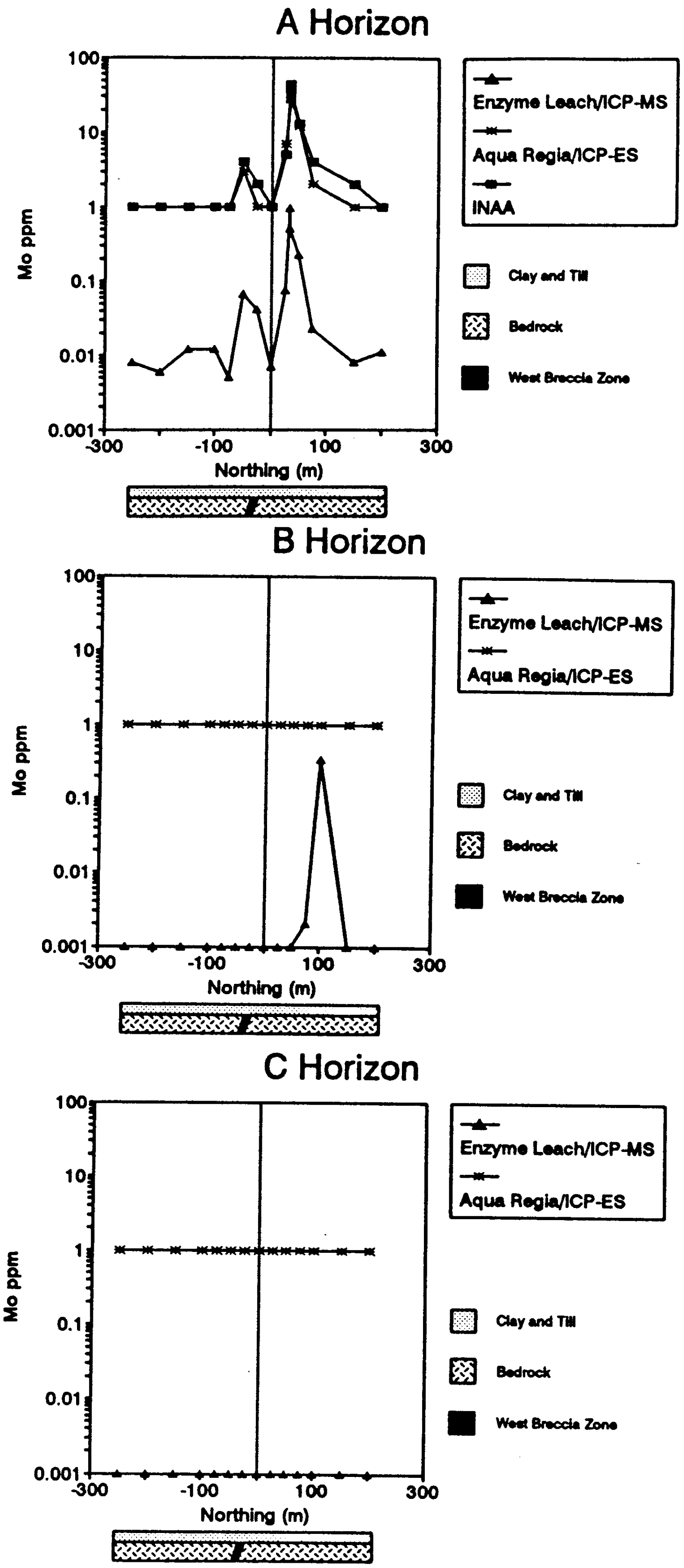


Figure 43. Profile of Mo in A, B and C horizon soil over the West Breccia Zone as determined by several analytical methods.

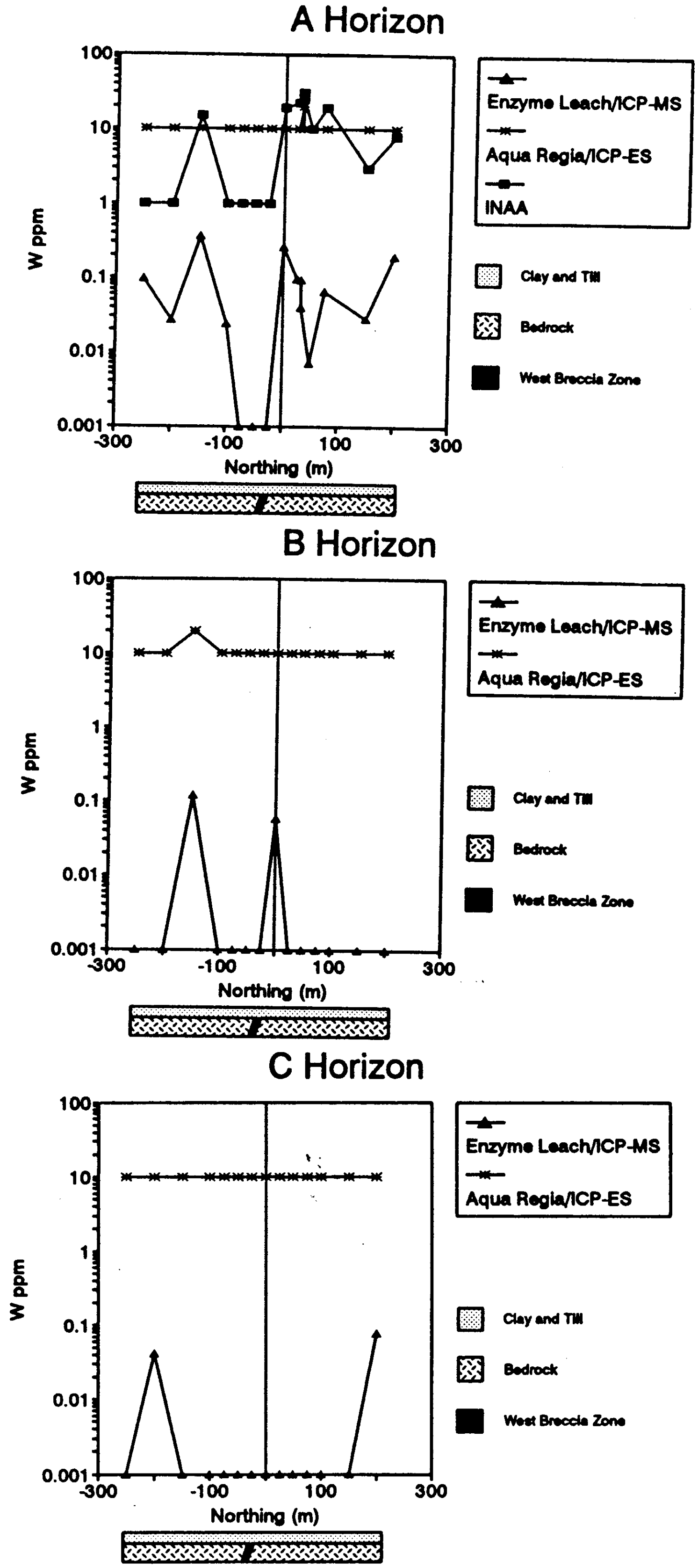


Figure 44. Profile of W in A, B and C horizon soil over the West Breccia Zone as determined by several analytical methods.

A distinct Au anomaly is present in the A horizon soil straddling the mineralization (Figure 45). This anomaly is evident from both the INAA and enzyme leach/ICP-MS data. There appears to be a low centred on the sub-crop of the zone. This is slightly more evident in the enzyme leach data. A weak response is also observed in the B horizon soil as determined by INAA (Figure 46). This response could be the result of contamination due to a haulage road located immediately north of the zero station. However, coincident trace element anomalies in the B horizon soils suggest the Au anomaly is related to natural dispersion. Some of the anomaly is clearly up-ice of the deposit.

The distribution of Sn in the B horizon soil, as determined by the enzyme leach method, defines an anomaly which appears to straddle the mineralization in a similar way to that of Au in the A horizon (Figure 47). In this case, the peak value may even be directly over the sub-crop. However, the A horizon does not appear to be anomalous in Sn. Numerous other elements give a similar response (Figure 48). In addition to Sn, the anomalous elements are Ni, Pb, Pd, W, Sn, Ag, Mo and Ge.

The distribution of elements in the A horizon, as determined by enzyme leach/ICP-MS, show no clear relationship to the Holt-Mcdermott mineralization. Exceptions are the rare earth elements, particularly Ce, Pr, Er and Yb (Figure 49). This response comes closest to the "rabbit ear" anomaly observed for Au in the A horizon. In contrast, the rare earth elements in the B horizon show an anomalous peak almost directly over the deposit.

No anomalous patterns related to mineralization are apparent for either the A or B horizon soils using an aqua regia/ICP-ES analytical method. No other elements aside from Au are distinctly anomalous in the A horizon or B horizon INAA data.

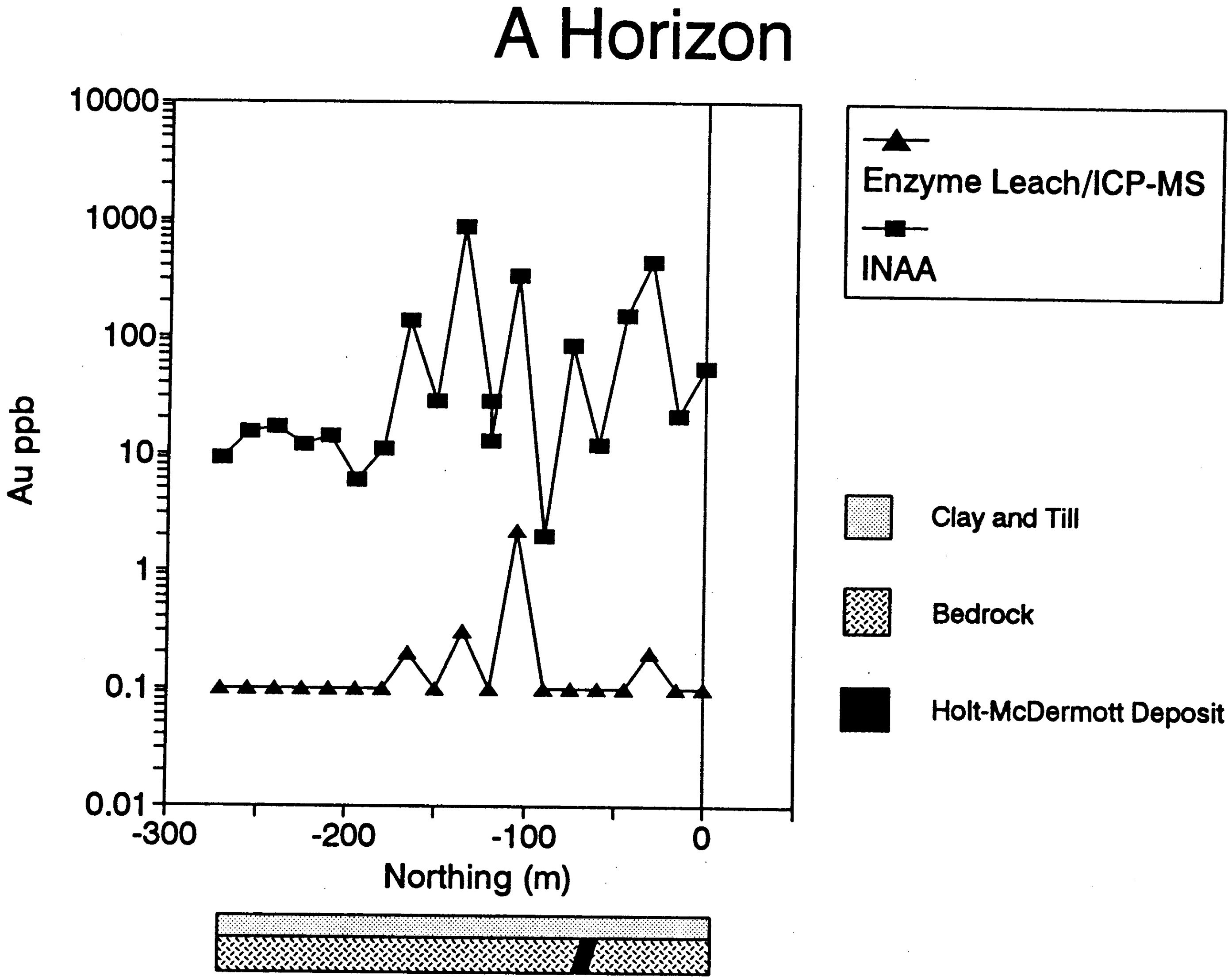
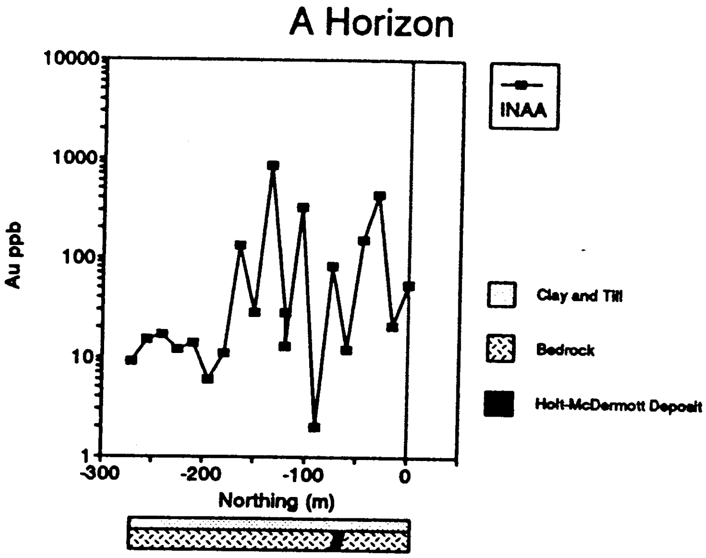


Figure 45. Profile of Au in A horizon soil over the Holt-McDermott Deposit as determined by INAA and enzyme leach/ICP-MS.



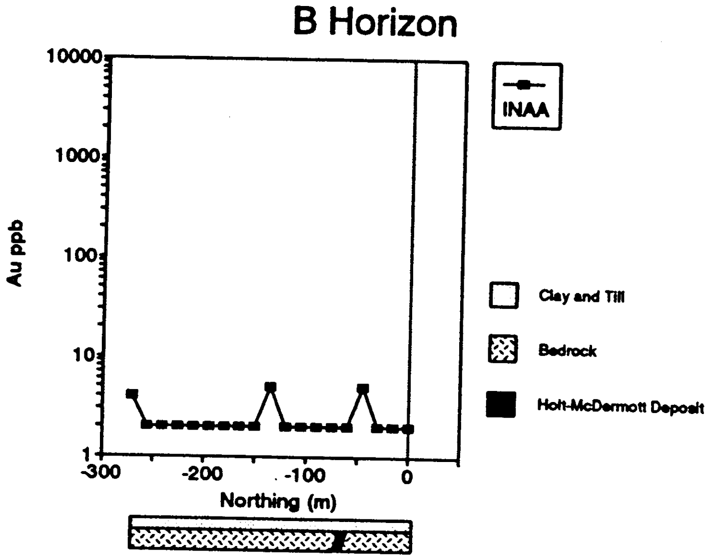
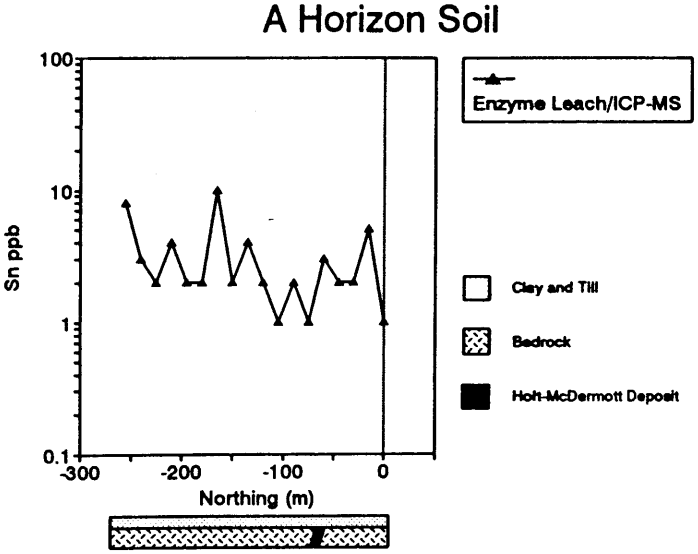


Figure 46. Profile of Au (INAA) in A and B horizon soil over the Holt-McDermott Deposit.



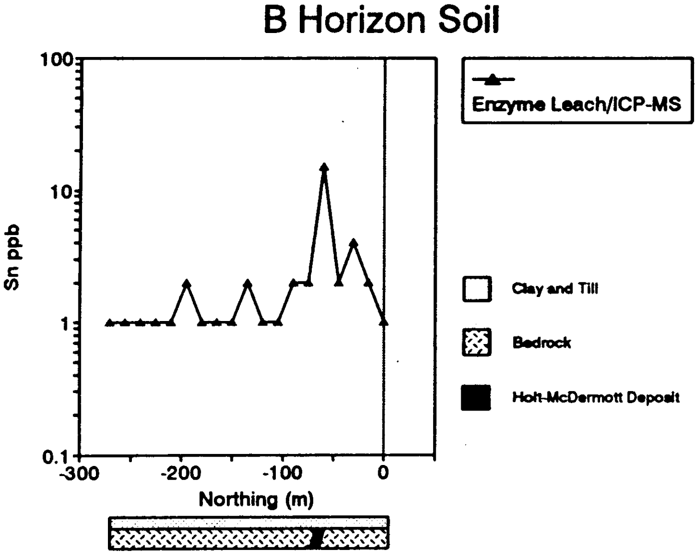
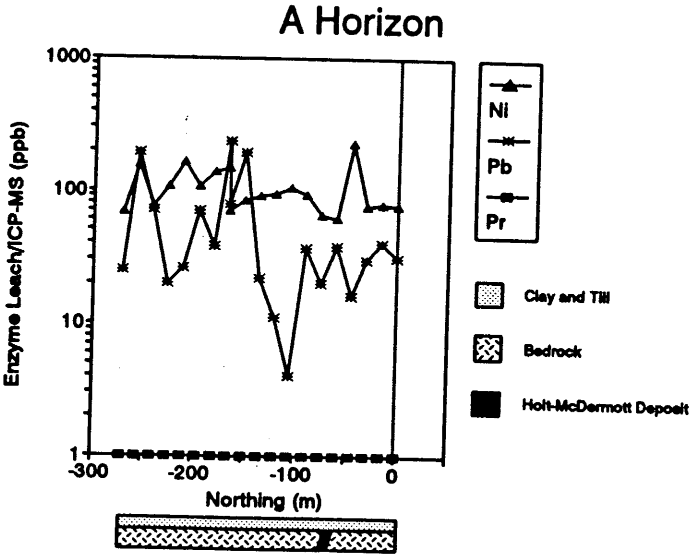


Figure 47. Profile of Sn (enzyme leach/ICP-MS) in A and B horizon soilover the Holt-McDermott Deposit.



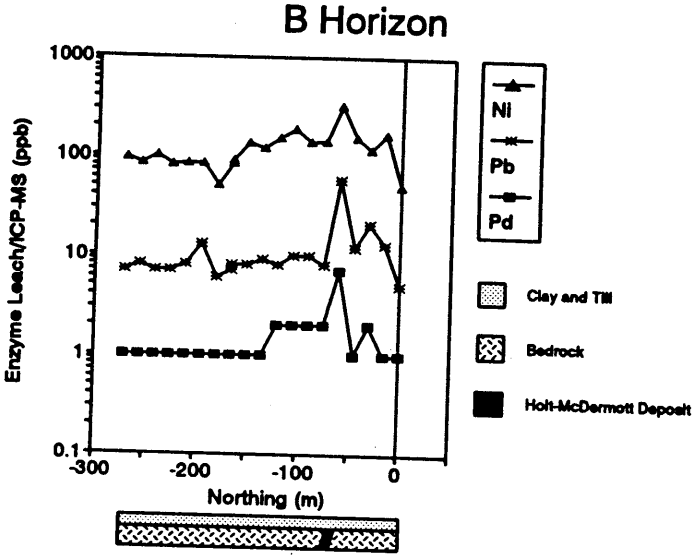


Figure 48. Profile of Ni, Pb and Pd (enzyme leach/ICP-MS) in A and B horizon soil over the Holt McDermott Deposit.

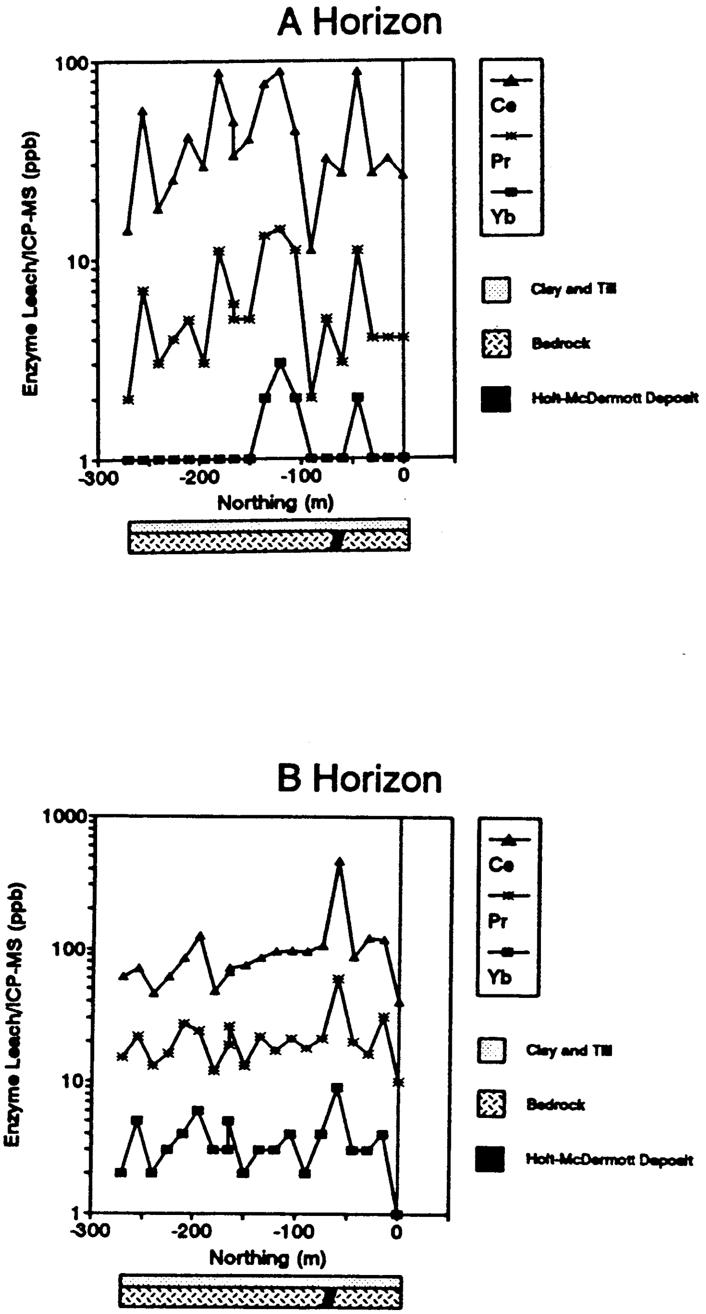


Figure 49. Profile of Ce, Pr and Yb (enzyme leach/ICP-MS) in A and B horizon soil over the Holt-McDermott Deposit

Stimson Base Metal Mineralization

At the Stimson property, one traverse was sampled across the Patton base metal mineralization. A second traverse was sampled 500 m to the east on the strike extension of the horizon. Drilling indicated that the mineralization did not extend to this line. However, there is no IP data to confirm that sulphide mineralization is absent in this area. The soils are developed on clay. The organic content of the A horizon is 40 to 92%.

The B horizon soils analyzed by enzyme leach/ICP-MS appear to yield "rabbit ear" anomalies straddling the mineralization for a variety of elements (Figure 50). These include Ti, Zn, Ga, Pb, Ag, Cs, Nb, Rb, Sn and possibly Br. Cadmium levels appears to be high across the width of this anomaly. In contrast, the distribution of W yields a negative response. Some elements appear to become anomalous toward the northern end of L. 300 W. These include V, Cu, As, Nb, Mo, Cd and Pb. The significance of this anomaly is not known.

Along strike 500 m to the east, the 'rabbit ear' anomalies appear to close in to form one solid anomaly off the end of the mineralization (Figure 51). The net effect may be an ellipsoid anomaly with a central low directly over the mineralization. This is in contrast to the "V" shaped Mo-Sn anomaly observed off the end of the Shoot Zone mineralization.

The trace element response in the A-horizon over the base metal zone on L. 300 W is not known since these samples were not analyzed by the enzyme leach method. However, a weak Au "rabbit ear" anomaly (INAA) straddles the mineralization and mirrors the anomalies observed in the B horizon (Figure 52). On L. 200 E, the A-horizon soils were analyzed by the enzyme leach method. A clear response was not obtained despite a good anomaly in the B horizon enzyme leach data. Anomalies were not obtained in either the A or B horizon soils using the aqua regia/ICP-ES method.

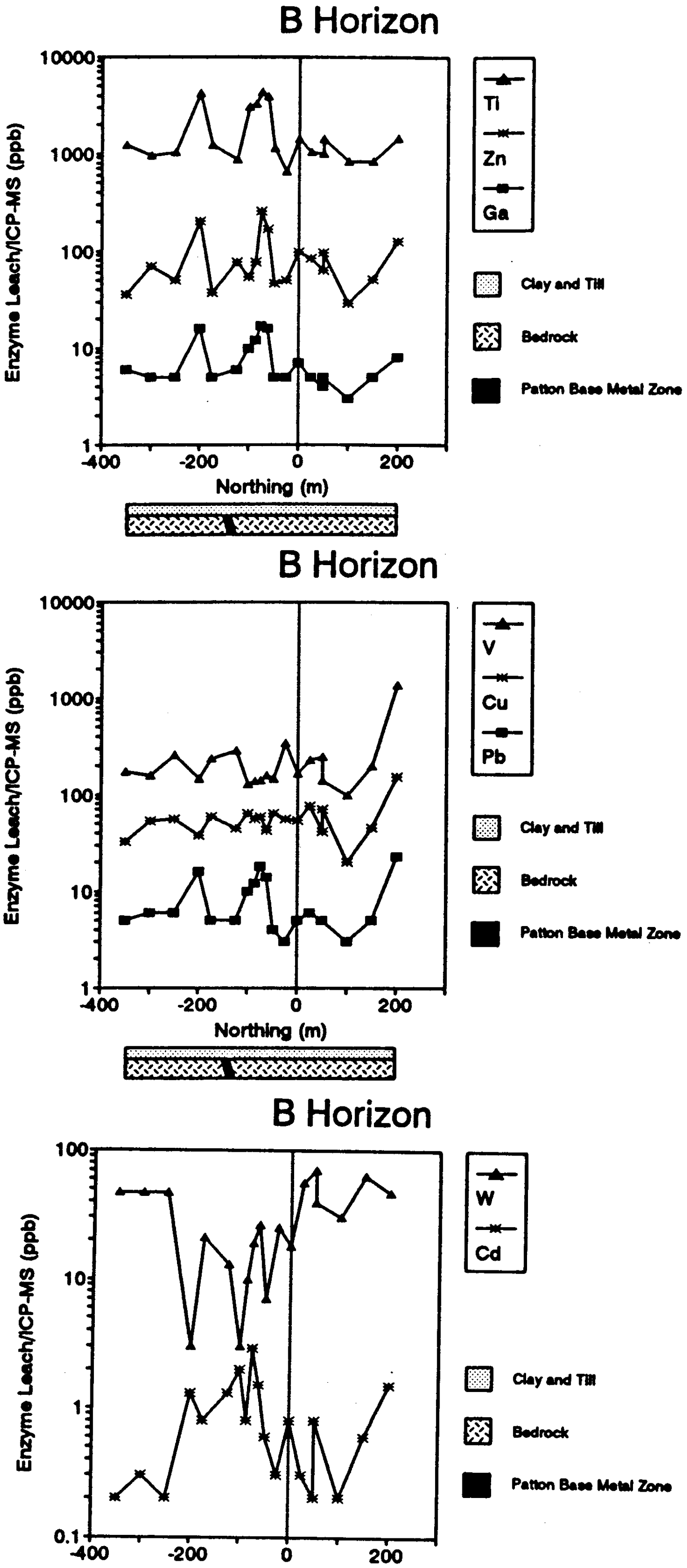


Figure 50. Profile of Ti, Zn, Ga, V, Cu, Pb, W and Cd (enzyme leach/ICP-MS) in B horizon soil over the Stimson base metal mineralization.

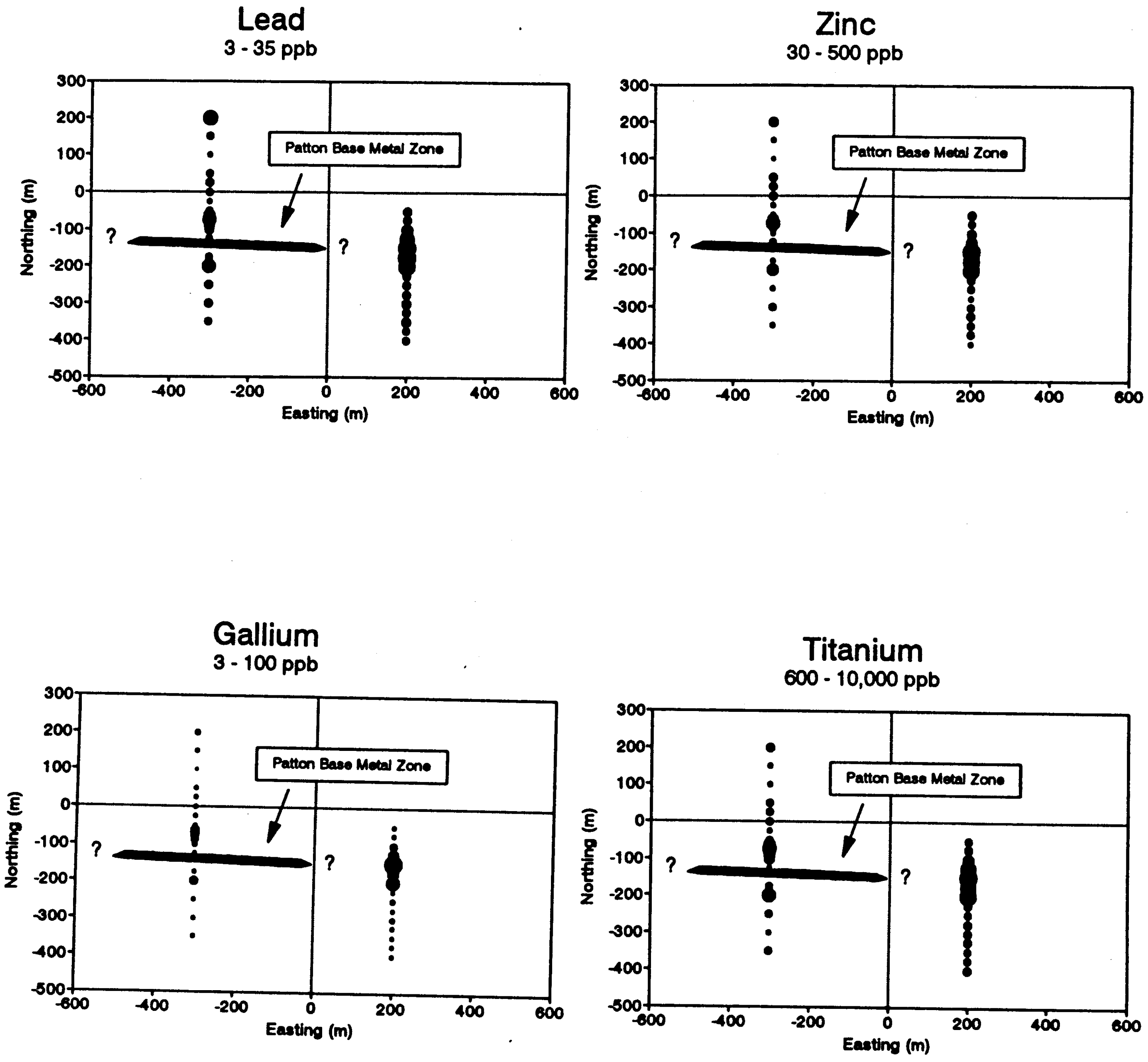


Figure 51. Dispersion of Pb, Zn, Ga and Ti (enzyme leach/ICP-MS) in B horizon soil over the Stimson base metal mineralization.

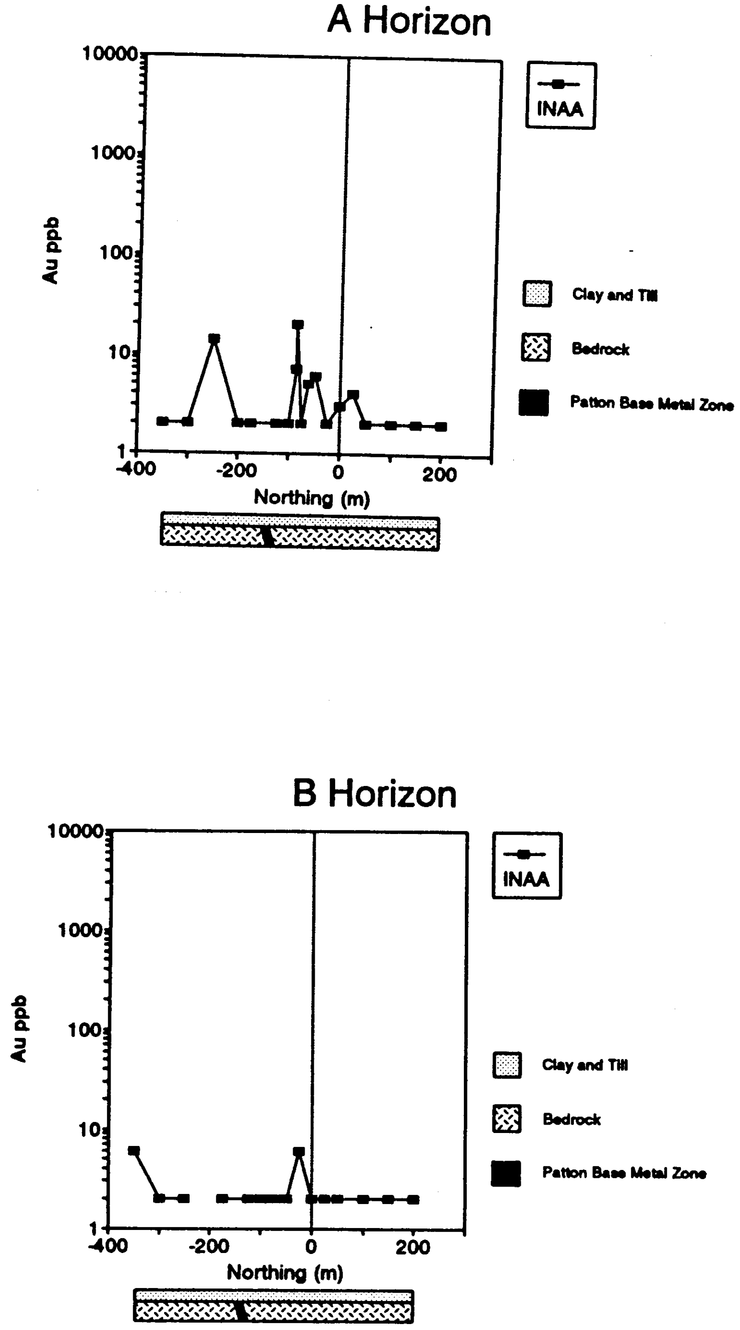


Figure 52. Profile of Au (INAA) in A and B horizon soil along line 300 W over the Stimson base metal mineralization.

Summary of Anomaly Characteristics

Anomalous patterns are complex in their relationship to mineralization. The most common signature observed is that of 2 anomalous peaks which straddle the sub-crop of the mineralization. This has previously been referred to as a "rabbit ear" anomaly (Govett 1973, Bolviken and Logn 1974). However, in some cases, an anomaly is observed directly above the mineralization. This may be a function of insufficient sample density to resolve the 2 shoulders of the anomaly.

A second characteristic of these anomalies is their signature along the strike extension of the mineralization. At the Shoot Gold Zone where the most extensive sampling was carried out, the "rabbit ear" enzyme leach anomalies in the B horizon soil appear to increase in width as does the low between the 2 peaks. The net effect is to produce a "V" shaped anomaly which points toward the end of the mineralized zone.

Alternatively, limited sampling at the Stimson base metal property suggests that in some cases, a broad anomaly occurs along strike from the mineralization. The width of this anomaly is about equal to the distance between the 2 peaks of the "rabbit ear" response which straddles the mineralization sub-crop. However, it lacks the characteristic low between the two peaks. The net effect may be an ellipsoid anomaly encircling the mineralization with low values in the centre directly over the zone.

A third feature is the apparent element zonation pattern observed at the Shoot Gold Zone. Along strike from the western end of the mineralization, the anomaly is defined by Mo and Sn. Over the western end of the zone, the anomaly is most pronounced with respect to Cu and W but also anomalous are Mo, Sn and Pb. Over the eastern end of the mineralization and its strike extension, the zone is anomalous in Pb, Zn, Cd and Sr. However, anomalies in the A-horizon soils over the eastern end of the mineralization suggest that this apparent metal zonation may be due to the way elements partition between the A and B horizons.

One final feature is the occurrence of gold anomalies (INAA) in the A horizon which mirror the trace element anomalies obtained in the B horizon soil analyzed by the enzyme leach/ICP-MS method. These anomalies exist even where the soil substrate is clay. This confirms that Au, along with the other trace elements, is moving more or less vertically from the bedrock to the surface through tens of metres of overburden generally considered to be impervious to vertical geochemical dispersion. The organic medium appears to be a natural concentrator of this low flux of gold. Similar Au anomalies appear to exist in the B horizon although they are less distinct due to lower absolute levels that approach the detection limit. Where C horizon till was sampled beneath a Au anomaly in the A and B horizon, no anomalies were obtained.

This observation has great importance to the interpretation of conventional humus geochemistry at least in areas of thick overburden. The source of the Au humus anomalies may not be directly beneath the highest values particularly when 2 peaks occur in close proximity along a line. Based on these results, the exploration target is actually the low between the 2 peaks. In areas of thick overburden, it is quite possible to miss drilling the source of a surface anomaly by failing to recognize this relationship.

Optimum Soil Horizon and Analytical Method

The B horizon as analyzed by the enzyme leach/ICP-MS method consistently yielded a recognizable response to mineralization under all terrain conditions. No anomalies were obtained when the samples were analyzed by aqua regia/ICP-ES.

The magnitude of the enzyme leach anomalies varied with the nature of the substrate on which the soils were developed. A uniform clay substrate appears to be the most suitable surficial medium for the concentration of elements diffusing to the surface for most elements except Au. Generally, a weak poorly defined response was observed if the substrate was sand or till.

It is likely that clay and silt sized particles (less than 63 μm) are the primary adsorptive component of these soils. This might explain why, at the Shoot Zone, most element levels are significantly lower in the esker sand compared to the clay. However, it is not clear why Pb, Zn, Cd and Rb levels are similar or higher in the sand compared to the clay. In any case, more comparable data might be achieved if all samples were sieved to less than 63 µm. This would require the collection of large samples in areas of well sorted sands.

Sample depth did not appear to be a critical factor in the soils developed on clay except in the case of cultivated soils. The surface mixed layer, usually about 30 cm thick, did not give similar results to samples collected below this zone. In general, a sample depth of 50 to 75 cm is recommended in areas of glaciolacustrine clay cover.

However, in soils developed on sand and till, sample depth may be an important factor. Over the West Breccia Zone, weak anomalies in the B horizon (5 to 30 cm depth) were not reproduced in the C horizon samples (30 to 70 cm depth). For this substrate, the sample should be collected from the reddish-brown layer beneath the grey to white A_2 horizon, if present (podzolic soil), or the black organic A_1 horizon.

In areas of predominantly sand and till, the A horizon is the recommended sample medium. The Au content of the A horizon (INAA) generally gave a similar pattern to that obtained for trace elements in the B horizon (enzyme leach/ICP-MS) for both gold and base metal targets. A similar "rabbit ear" response was observed regardless of substrate provided a good humus layer was sampled.

Where only one anomalous peak is observed, more detailed sampling is probably warranted to resolve the anomaly into its 2 constituent parts or to identify the other shoulder of the "rabbit ear" anomaly. Alternatively, B horizon soils could be collected and analyzed by the enzyme leach/ICP-MS method. This data may better resolve the anomaly than Au in humus (INAA).

Similar Au anomalies were obtained in the A horizon enzyme leach data. However, depending on sample density and the magnitude of the INAA anomalies, only one shoulder of the "rabbit ear" response was often detected due probably to the limitations in analytical sensitivity.

The trace element distributions in A horizon soils developed on clay generally did not reflect mineralization. However, in areas of sand and till, similar if not better anomalies were observed in comparison to patterns in the B horizon enzyme leach data.

The amount of organic matter in the sample does not appear to be a major factor provided it is greater than about 15 to 20% semi-decomposed to well decomposed organics. This may require more study. Generally similar trace element patterns were obtained for A horizon samples analyzed by aqua regia/ICP-ES. However, for many elements determined, the detection limits exceed the natural range of the data.

Recommended Methodology for Soils

A multi-element geochemical response was obtained in surface soils above all deposits studied despite the presence of 20 to 40 m of overburden consisting of till, sand and clay. In most areas, the clay layer was at the top of the glacial stratigraphic sequence and was the substrate on which the soils were developed. Anomalies were observed for both gold and base metal targets.

A broad spectrum of elements reflect mineralization at any one site. The most consistently useful elements appear to be the noble metals (Au, Ag, Pd), the chalcophile elements (Cu, Pb, Zn, Ni, Cd, Sb, Mo, Ga, As, Ge), the lithophile elements (Sn, W, Rb, U, Li, Sr, Ba, Ti, Cs, Nb), and in some cases, the rare earth elements suite. The alkali earth, siderophile, and halogen elements did not generally exhibit a consistent relationship to mineralization.

The anomalous response across a zone is typically 2 "rabbit ear" peaks which straddle the sub-crop of the mineralization. Samples take directly over the zone often exhibit anomalously low levels of elements. In plan, the anomaly may take the form of an ellipsoid encircling the mineralization with low values in the centre directly over the zone. In some cases, the "rabbit ear" response may widen off the end of the deposit to form "V" shaped anomalies that point toward the mineralization. Lateral element zonation has also been observed in some cases.

Different soil horizons and analytical methods are recommended for specific terrain types. In areas of predominantly clay cover, the B horizon should be sampled at a depth of 50 to 75 cm where it typicallly has a mottled appearance. The sample should probably be sieved to obtain the less than 63 µm fraction although the less than 150 µm fraction appears to yield good results. The fine fractions should be analyzed using the enzyme leach/ICP-MS method. If the exploration target is gold, A horizon samples should also be collected and analyzed for Au by INAA.

In areas of predominantly sand and till, the A horizon should be sampled. The less than 250 µm fraction should be analyzed for Au by INAA and for trace elements by the enzyme leach/ICP-MS method. The organic content of the sample should be determined by loss on ignition analysis to assist interpretation.

Large broad anomalies should be followed-up by in-fill sampling to resolve the anomaly into its characteristic "rabbit ear" form prior to defining a drill target. The collection and analysis of both A and B horizon samples at this stage is advisable to ensure identification of the central low over the sub-crop of the buried or blind mineralization.

High sample site variability appears to characterize areas of mineralization. For this reason, field duplicates may exhibit poor reproducibility. Bulk samples should be collected in the field area for the preparation of internal standards. Quality control assessment should be based on the repetitive analyses of these standards inserted at a frequency of 1 per 20 unknowns.

Discussion of Dispersal Mechanisms

Distinct geochemical anomalies have been obtained in surface soils, water and, to a lesser extent, in organic bank samples and peat at every study site despite 20 to 40 m of overburden containing thick varved clay sequences. This supports the results of other case studies in areas of thick transported overburden (Andrapova et al. 1992, Bolviken and Logn 1974, Govett 1976, Govett et al. 1984, Govett 1987, Jin et al. 1989, Smee 1983).

High concentrations of trace elements have been observed in moderately flowing streams up to 1 m wide by 0.5 m deep. To yield these concentrations in mid-August, a steady flux of elements must be transmitted to the surface. Based on the hydraulic conductivity of varved clay, it is unlikely that groundwater can physically flow vertically through clay at sufficient rates to produce the observed anomalies except under unusual conditions (i.e., highly fractured clay, artesian pressure).

Electrochemical processes seem the more likely mechanism for bringing ions to the surface through the clay cover. Such a model of dispersion has been previously advanced (Bolviken and Logn 1974, Govett 1973, Smee 1983). This model suggests that an oxidizing sulphide body induces a natural electrochemical field (Figure 53). The oxidized portion of the body acts as a cathode and the relatively reduced portion behaves as an anode. Electrons flow through the mineralization from the anode to the cathode. To balance the charge and complete the circuit, positive ions flow through the groundwater saturated bedrock adjacent to the sulphide body toward the bedrock/overburden interface and into the cathode. It has been suggested that a concentration build-up of elements occurs marginal to the subcrop of the mineralization where current density is high. This leads to diffusion of elements vertically to the surface through the overburden due to the existance of concentration gradients.

This model is consistent with many of the observations of this study. However, some of the results suggest that several modifications to the model are required.

First, the deposits studied vary markedly in their sulphide content yet each yields similar anomalies in soil and water. The electrochemical model is predicated on the oxidation of sulphide-rich bodies. Self potential anomalies have been documented for these types of deposits (Sivenas and

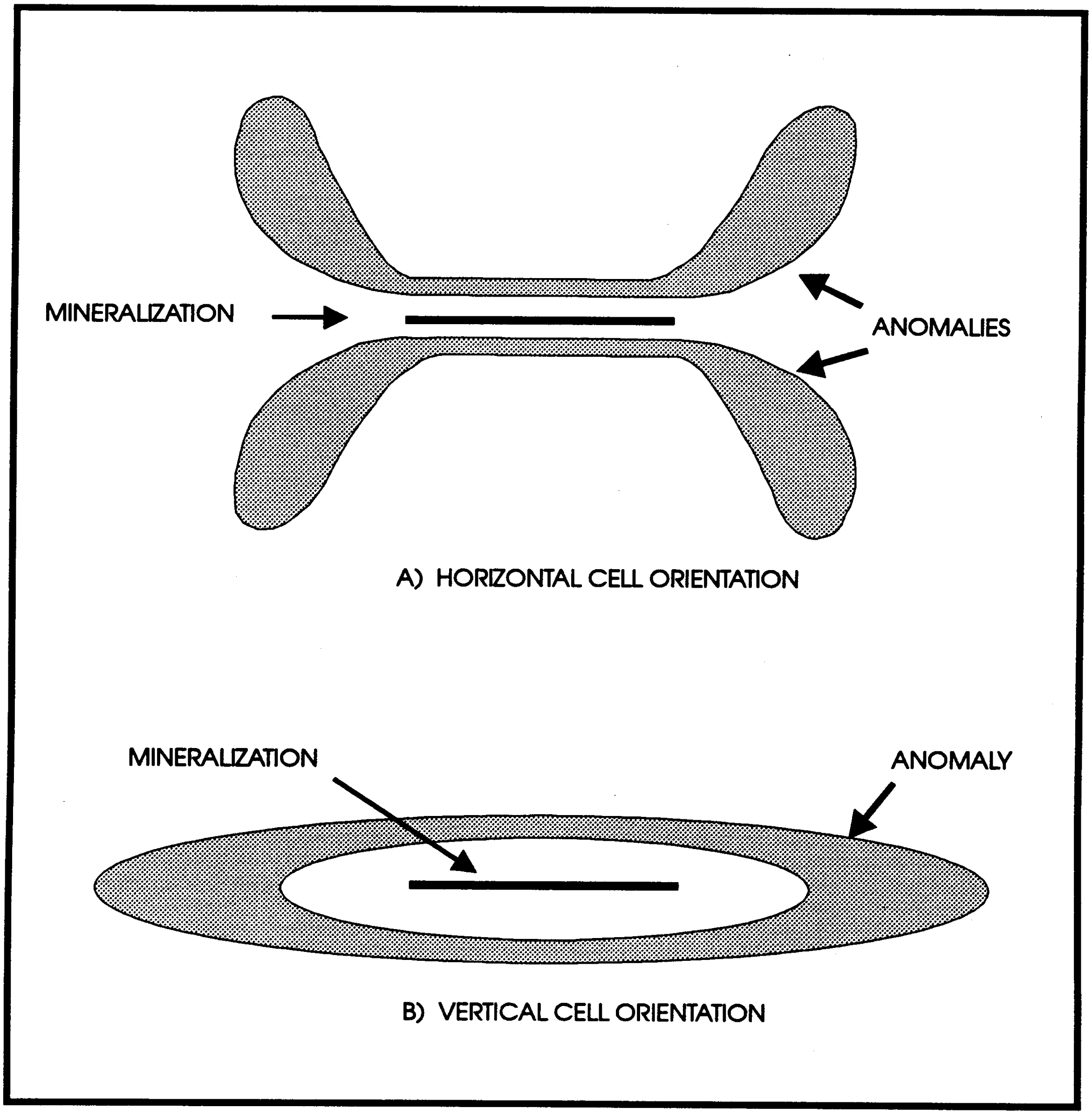


Figure 53. Model of electrochemical element dispersion in areas of thick clay cover.

Beales 1982, Govett 1976). However, the Shoot Zone mineralization is very low in sulphide content while the Hislop and Holt-McDermott deposits contain only 2 to 10% sulphides. Even the Destor-Porcupine Fault north of the Shoot Zone gives rise to an anomaly. This suggests that the sulphide content is not a significant factor in the dispersal process.

Second, several aspects of the anomalies are unusual. Element anomalies in soil appear to be zoned around mineralization under some circumstances. At the Shoot Zone, anomalies are zoned laterally along the deposit across the contact between glaciolacustrine clay deposits and an esker complex. Multiple traverses over the Shoot Zone and Stimson mineralization indicate that the shape of anomalous patterns may differ from one area to another. This may be due to differences in the configuration of surficial deposits exposed at surface. Also, it should be noted that both positive and negative anomalies occur.

These observations suggest that elements may differentiate laterally and vertically in the surficial environment in response to superimposed electrochemical fields induced by a variety of geological features occurring in close proximity to one another. Any geological configuration that gives rise to differences in redox potential could initiate oxidation/reduction reactions and the flow of ions.

For example, a geological discontinuity could be a mineralized zone, a lithological contact, or a fault. These features may only be distinguishable on the basis of their anomaly metal association, orientation and lateral extent.

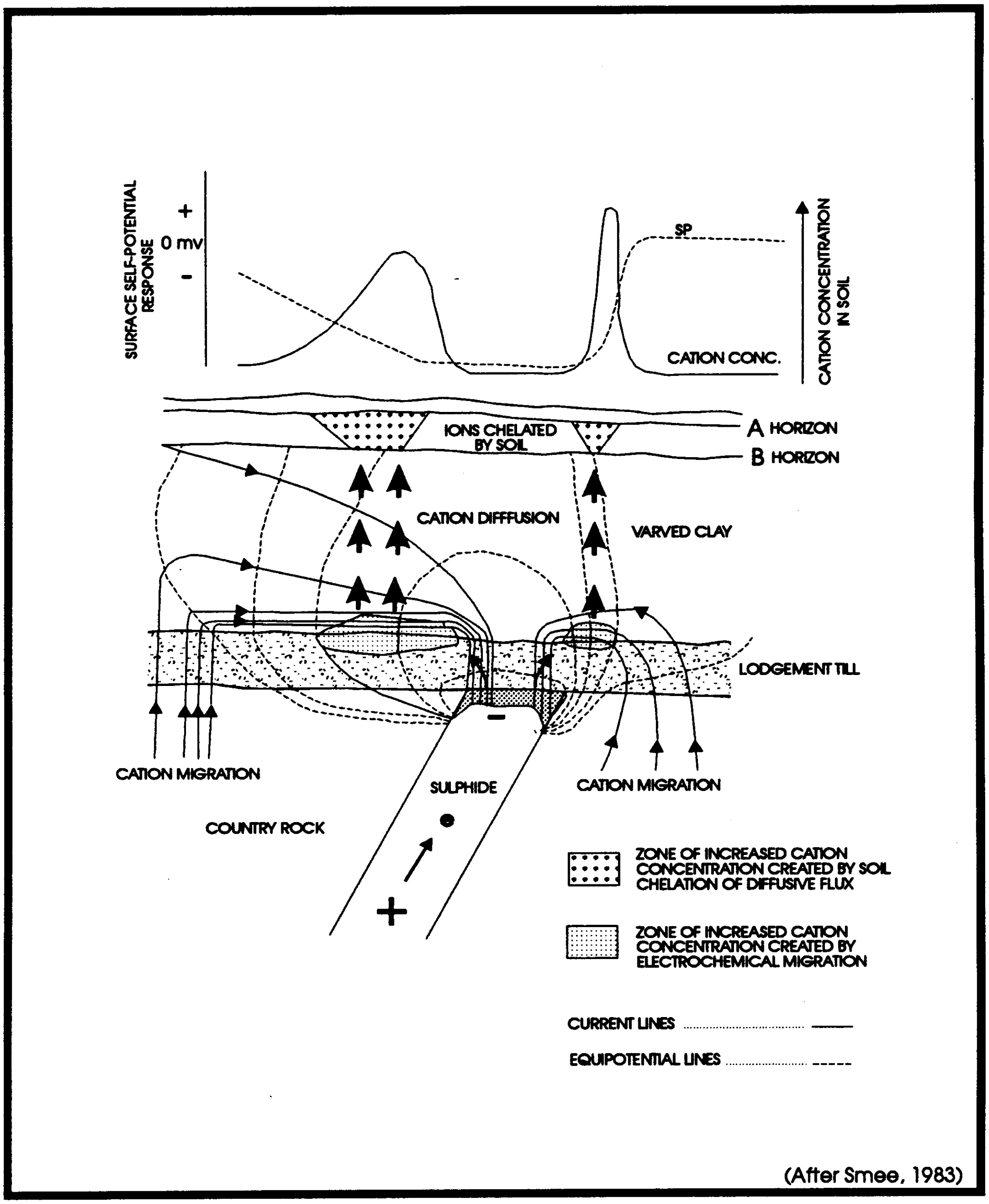
The glacial stratigraphy itself may generate a redox cell depending on the properties of the materials. Under most conditions, differences in redox potential will exist from the surface down to bedrock. This may be sufficient to cause the flow of ions. Even if the material is uniform in physical character, the surface deposits should exist under relatively more oxidizing conditions than the deeper deposits. Where the glacial stratigraphy is complex as in the case of clay overlying buried glaciofluvial sand deposits, aquifers within the more porous layers may result in relatively more oxidizing conditions at depth compared to the overlying deposits.

Under neutral to alkaline conditions, most metals occur as complexes with available anions, commonly HCO_3, SO_4, Cl, Br and I, rather than as simple ions (Drever 1988, Shipulin et al. 1973). More than one charged species will occur at any one time. The charge of some will be positive while others will be negative. The stability and relative abundance of these species will depend on the bulk composition of the water, pH, Eh and inter-action with the rock and overburden. Regardless of the electrochemical cell configuration, the result is the flow of ions from the base of the overburden to the surface. This would account for variations in background observed between areas due to different geology.

Differences in element species and charge may result in element zonation under some circumstances. Positively charged particles will flow away from the anode whereas negatively charged ions will move away from the cathode. This may explain the patterns observed at the Shoot Zone where a redox cell is envisioned across the boundary between the clay (anode) and the esker sand (cathode). This effectively creates a cell that is horizontal in the near surface. This secondary field may have modified a simple pattern of elements streaming to the surface on either side of the mineralization (Figure 54).

The natural acidity in the area of the Shoot Zone may also be related to a cell across the clay/sand interface. The highly mobile H^+ would stream away from the anode in the clay toward the cathode in the sand. Surface drainage would be affected by the high concentration of H^+ in the narrow window of exposed esker sands.

In the absence of lateral discontinuities in the overburden, soil anomalies would probably exhibit ellipsoid shapes with a central low directly over the mineralization. This is because the orientation of the cell is vertical. While data is limited, this shape best explains the observed anomaly at the Stimson property.



(After Smee, 1983)

Figure 54. Schematic electrochemical anomalies in soil based on different cell orientations for a steeply dipping orebody.

Consequently, the ability to interpret surficial geochemical patterns may depend on the geological complexity of the area and lateral variation in glacial sedimentary units. The interference effects caused by faults, major lithological boundaries and the distribution of glacial deposits may obscure dispersal patterns related to mineralization. More case histories are needed to document these relationships.

Conclusions

The collective results of surface water, peat, organic stream bank and soil geochemistry support the hypothesis that ions disperse from the bedrock to the surface through at least 40 m of glacial overburden inclusive of thick clay deposits. The dispersal mechanism is likely electrochemical rather than hydrological. Relative differences in redox potential within bedrock and overburden may generate natural electrochemical fields which mobilize and transport ions to the surface.

The collection and analysis of surface water samples is an effective first pass approach to identifying exploration targets at the property scale. Suitable sample sites include streams, alder-vegetated drainage pathways and bogs.

Surface water geochemistry appears to have a more consistent and interpretable relationship to mineralization than peat or organic bank geochemistry. Within bogs, the composition of peat locally reflects the presence of mineralization but more detailed studies are required to determine the relative effectiveness of sampling water and peat at both the surface and peat/overburden interface in a bog. Organic stream bank samples may be a useful sample medium under some circumstances. However, in landscapes dominated by clay deposits, organic-rich bank material may not be generally available.

A multi-element geochemical response was obtained in surface soils above all deposits studied despite the presence of 20 to 40 m of overburden consisting of till, sand and clay. In most areas, the clay layer was at the top of the glacial stratigraphic sequence and was the substrate on which the soils were developed.

Soil geochemistry appears to be an effective follow-up approach to water anomalies. However, different sampling and analytical procedures are recommended for specific types of surficial overburden. The best medium in clay environments is the B horizon. Samples should be analyzed for trace elements by the enzyme leach/ICP-MS method. If the exploration target is gold, A horizon samples should also be collected and analyzed for Au by INAA. However, in sand or till environments, the A horizon is the preferred medium regardless of exploration target. These samples should be analyzed for Au by INAA and for trace elements by the enzyme leach/ICP-MS method.

Interpretation of soil data may be complex. The most common geochemical response is that of 2 anomalous peaks straddling the sub-crop of the mineralization. The source of the anomaly does not lie beneath the area of high soil concentrations but rather beneath the are of low levels located between 2 adjacent highs. This observed relationship is counter to conventional concepts of soil data interpretation.

More case histories are needed to better establish the geochemical patterns related to mineralization. The shape of the anomaly is considered critical to effective interpretation of enzyme leach data. A consistent relationship to mineralization needs to be established in order to develop confidence in identifying significant "rabbit ear" couples. Otherwise, anomalies will appear to be everywhere in exploration data where the precise location of mineralization is not known.

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APPENDIX I:

QUALITY CONTROL SUMMARIES

Data Quality Summary for Waters Analyzed by ICP-MS

Element	Detection Limit (ppb)	Range of Controls (ppb)	Analytical Precision (+/- ppb)	Sample Site Reproducibility (+/- ppb)
Li	0.1	0.3	0.2	-
Al	1	520	5	80
Ca	1	78000	1000	1000
Sc	0.1	0.3	-	-
Ti	0.1	16	0.1	15%
V	0.1	1.4	0.1	0.3
Cr	0.1	2.6	0.2	very poor
Mn	0.1	80	4	5
Fe	1	800	13	120
Co	0.01	0.65	0.01	0.05
Ni	0.01	2	0.1	0.4
Cu	0.01	5	0.2	1
Zn	0.01	12	5	2
Ga	0.01	3.5	0.5	0.5
Ge	0.01	0.04	-	-
As	0.1	2	0.1	0.3
Se	0.05	7	0.15	0.2
Br	5	25	10	6
Rb	0.01	2	0.15	0.2
Sr	0.01	50	3	8
Y	0.01	0.45	0.2	0.7
Zr	1	1	-	-
Nb	1	1	-	-
Mo	0.1	0.6	0.1	0.2
Ag	0.01	0.01	-	-
Cd	0.01	0.05	-	-
In	0.01	0.05	-	-
Sn	0.01	1.4	0.05	0.3
Sb	0.03	0.35	0.1	0.1
Te	0.1	0.1	-	-
I	0.2	7	0.5	1.3
Cs	0.01	0.02	-	-
Ba	0.01	18	1	poor
La	0.01	1.4	0.15	0.25
Ce	0.01	2	0.2	25%
Pr	0.01	0.25	0.03	25%
Nd	0.01	1.2	0.15	poor
Sm	0.01	0.18	poor	poor
Eu	0.01	0.03	-	-
Gd	0.01	0.12	0.01	0.02
Tb	0.01	0.03	-	poor
Dy	0.01	0.07	0.01	0.015
Ho	0.01	0.01	-	-
Er	0.01	0.06	0.01	0.02
Tm	0.01	0.01	-	-
Yb	0.01	0.11	-	poor
Lu	0.01	0.08	-	-
Hf	0.01	0.04	-	-
Ta	0.01	0.01	-	-
W	0.01	0.01	-	-
Re	0.01	0.01	-	-
Au	0.001	0.001	-	-
Hg	0.005	0.06	poor	poor
Tl	0.01	0.01	-	-
Pb	0.01	1	0.06	0.3
Bi	0.01	0.01	-	-
Th	0.01	0.9	poor	poor
U	0.01	1	0.3	0.3

Data Quality Summary of Waters Analyzed by Other Methods

Element	Analytical Method	Detection Limit (ppb)	Range of Controls (ppb)	Analytical Precision (+/- ppb)	Sample Site Reproducibility (+/- ppb)
As	hydride/ICP-MS	0.01	1.6	0.04	0.1
Sb	hydride/ICP-MS	0.03	0.12	0.01	0.04
Se	hydride/ICP-MS	0.05	0.25	0.01	0.03
Hg	hydride/ICP-MS	0.005	0.05	0.01	0.02
Cl	chromatograp	0.1	1.8	0.3	0.4
SO4	chromatograp	0.1	3	0.2	0.5
K	ICP-ES	0.1	0.6	0.1	0.1
Mg	ICP-ES	0.1	8.4	0.1	0.1
Na	ICP-ES	0.1	7.2	0.1	0.3
Ca	ICP-ES	0.1	65	0.4	3
alkalinity	titration		200 (mg/l)		10 (+/- mg/l)

Data Quality Summary for Soils Analyzed by the Enzyme Leach/ICP-MS Method

Element	Detection Limit (ppb)	Range of Controls (ppb)	Analytical Precision (+/- ppb)	Sample Site Reproducibility (+/- ppb)	Comments
Li	10	60	3	10	1 ppb
Ti	20	1600	400	400	
V	5	450	7	100	
Mn	10	2000	5	600	
Co	1	30	1	10	
Ni	5	150	8	40	
Cu	5	140	1	35	erratic above 150 ppb
Zn	10	100	6	30	erratic above 150 ppb
Ga	1	10	1	5	erratic above 15 ppb
As	5	20	2	6	erratic above 25 ppb in A horizon
Br	50	250	45	50	
Rb	1	100	-3	20	erratic above 100 ppb
Sr	1	1200	15	100	
Y	1	50	1	15	(poorer in B than A)
Zr	1	120	3	15	erratic above 160 ppb
Mo	1	40	3	12	erratic above 40
Cd	0.2	4	0.2	1	erratic above 5 ppb
Sn	1	4	0.5	1	erratic above 4 ppb
Sb	1	10	1	2	erratic above 10 ppb
I	15	140	15	40	erratic above 100 ppb (poorer in B than A)
Ba	1	1200	7	400	erratic above 1200 ppb
La	1	60	2	12	erratic above 60 ppb (poorer in B than A)
Ce	1	140	2	15	better in A
Pr	1	30	1	12	better in A
Nd	1	100	2	15	better in A, erratic above 100 ppb
Sm	1	15	1	5	
Eu	1	4	1	1	
Gd	1	15	1	5	erratic above 15 ppb
Dy	1	10	1	3	erratic above 10 ppb
W	1	300	1	60	A horizon
		10		1	B horizion erratic above 10 ppb
Pb	1	20	1	10	A horizion erratic above 20 ppb
		8		2	B horizon erratic above 8 ppb
Th	1	30	2	5	erratic above 30 ppb

Poor precision: Cl +/-100%, Te
No Estimate: Be, Sc, Ge, Se, Nb, Ru, Rh, Pd, Ag, In, Cs,
Tb, Ho, Er, Tm, Yb, Lu, Hf, Ta, Re, Os, Ir, Pt, Au,
Hg, Tl, Bi, U

Data Quality Summary for Soils Analyzed by INAA (selected elements)

Element	Detection Limit (ppb)	Range of Controls (ppb)	Analytical Precision (+/- ppb)	Sample Site Reproducibility (+/- ppb)
Au	2 ppb	800	3	50
As	1 ppm	40	0.4	3
Mo	1 ppm	40	1	5
W	1 ppm	25	1	5

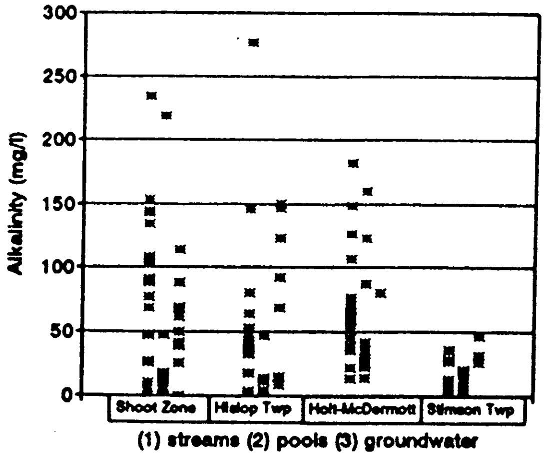
Poor precision: Ba

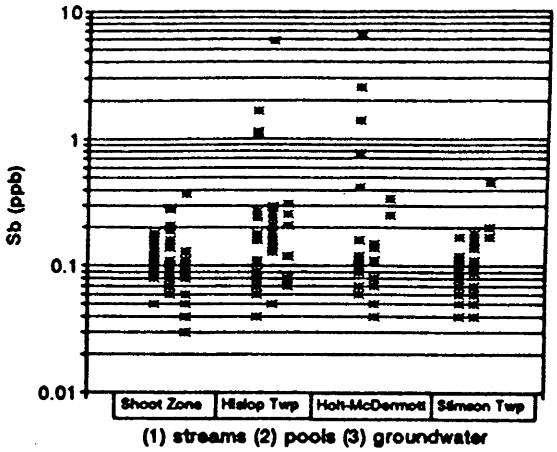
Data Qality Summary of Loss On Ignition Analyses for Soil Samples

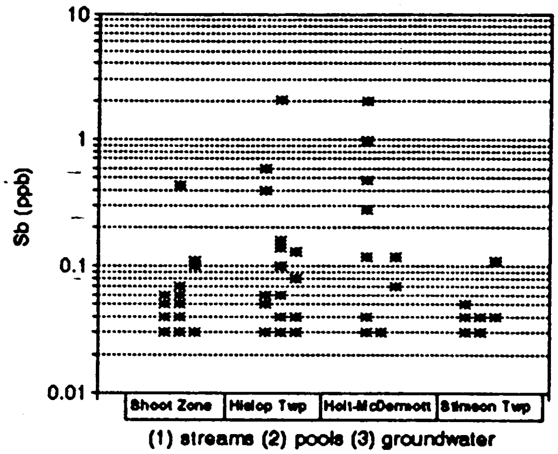
Analytical Method	Detection Limit (g)	Range of Controls (g)	Analytical Precision	Sample Site Reproducibility (+/- g)
furnace (450 deg. C)	0.01	80	1%	5

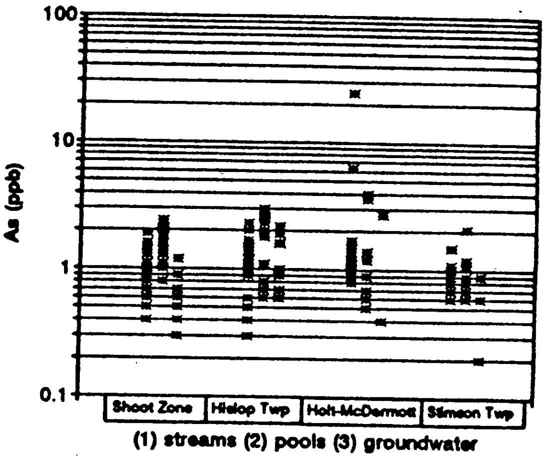
APPENDIX II:

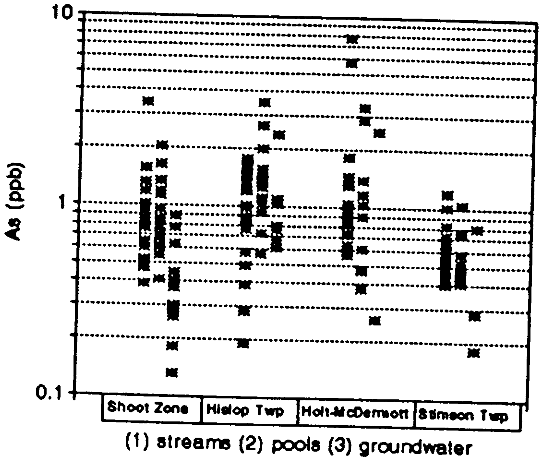
ELEMENT FREQUENCY DISTRIBUTIONS FOR WATER BY AREA AND SAMPLE TYPES

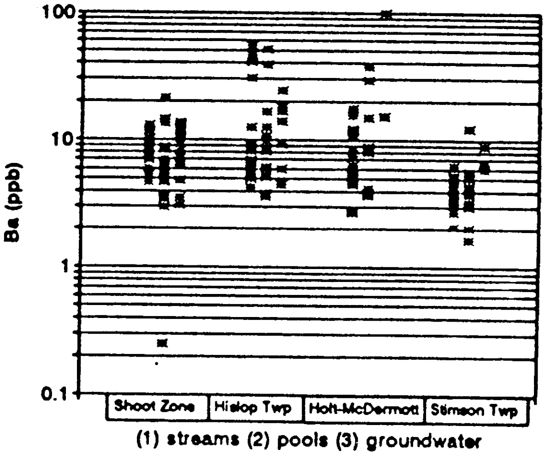

Alkalinity (mg/l)
Water/Titration


Antimony (ppb)
Water/ICP-MS

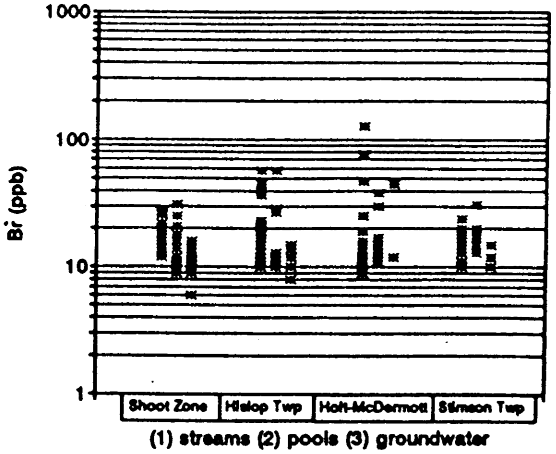

Antimony (ppb)
Water/hydride ICP-MS


Arsenic (ppb)
Water/ICP-MS

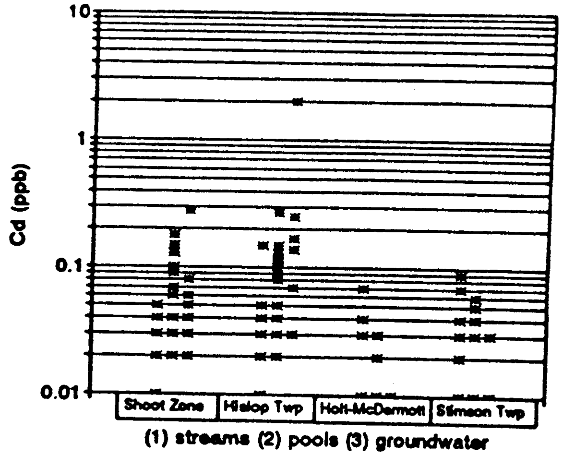

Arsenic (ppb)
Water/hydride ICP-MS


Barium (ppb)
Water/ICP-MS

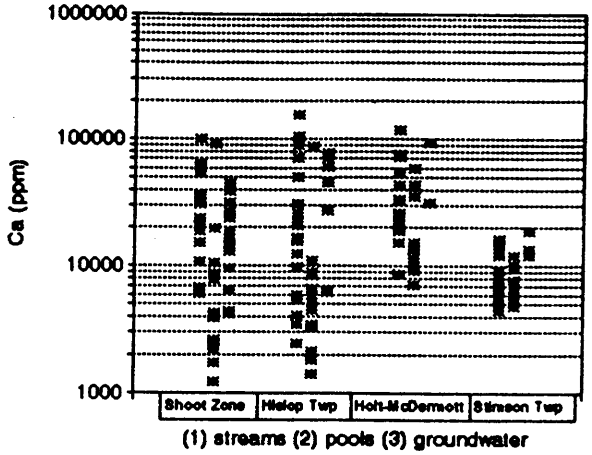
Bromide (ppb)
Water/ICP-MS



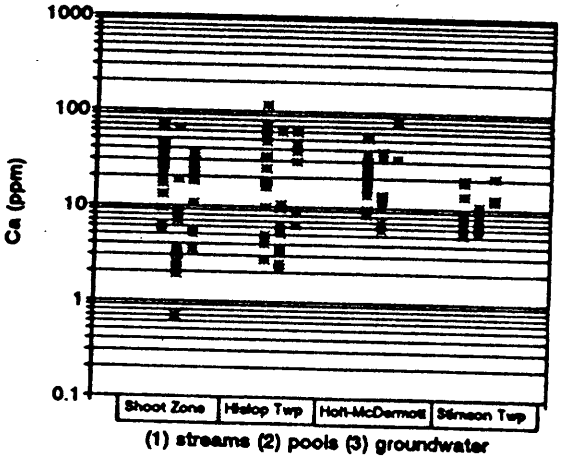
Cadmium (ppb)
Water/ICP-MS



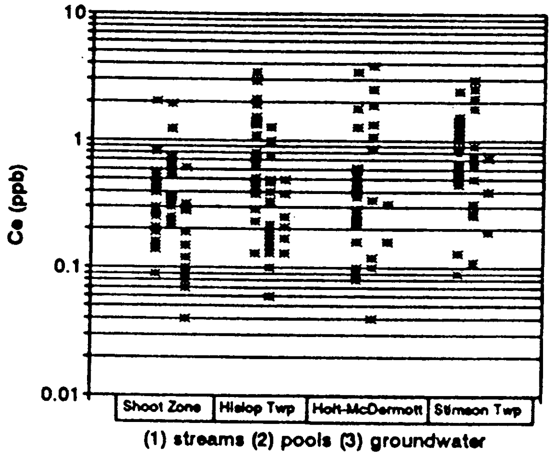
Calcium (ppm)
Water/ICP-MS



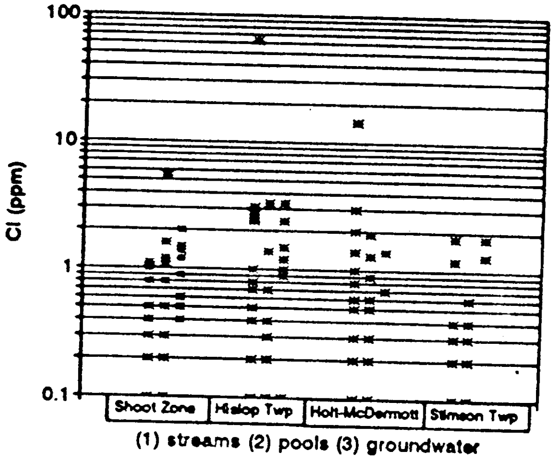
Calcium (ppm)
Water/AAS



Cerium (ppb)
Water/ICP-MS

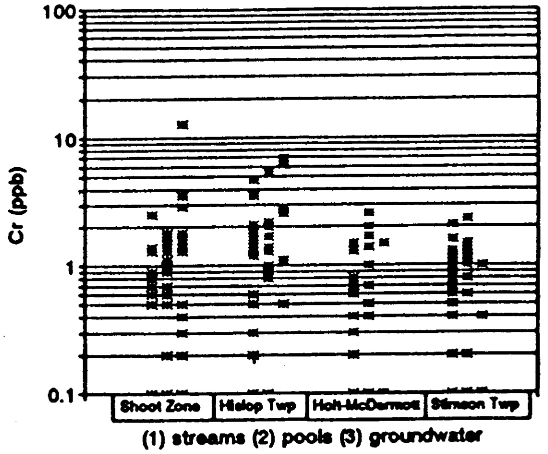


Chloride (ppm)
Water/ion chromatography



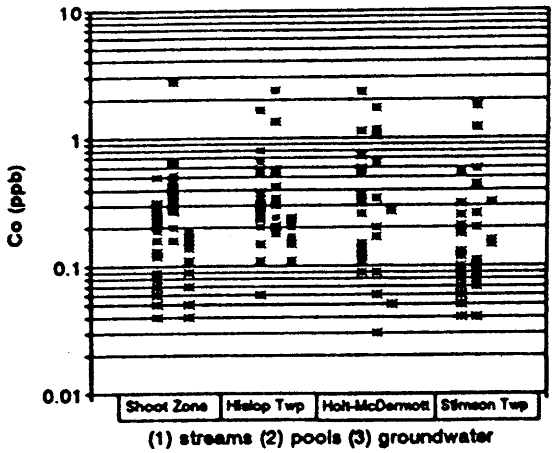
Chromium (ppb)

Water/ICP-MS



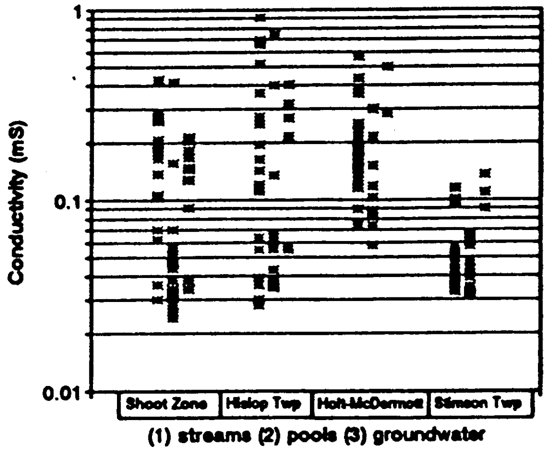
Cobalt (ppb)

Water/ICP-MS



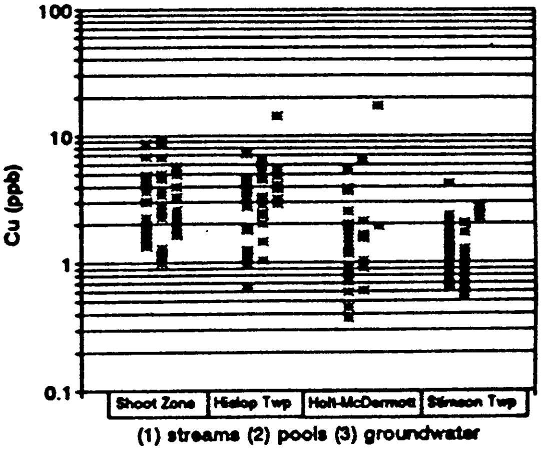
Conductivity (mS)

Water/Conductivity Meter



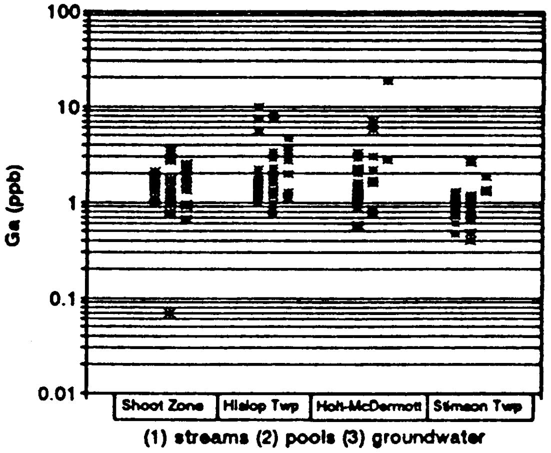
Copper (ppb)

Water/ICP-MS



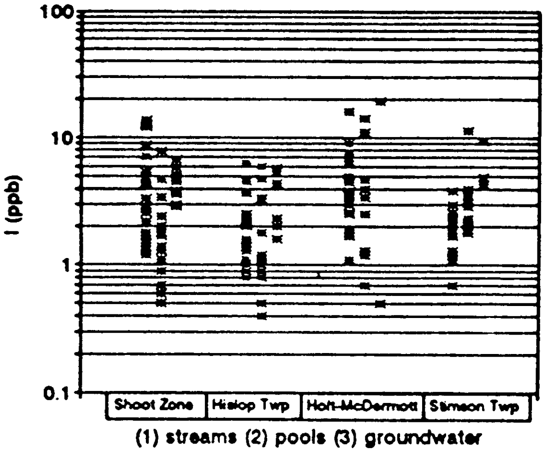
Gallium (ppb)

Water/ICP-MS

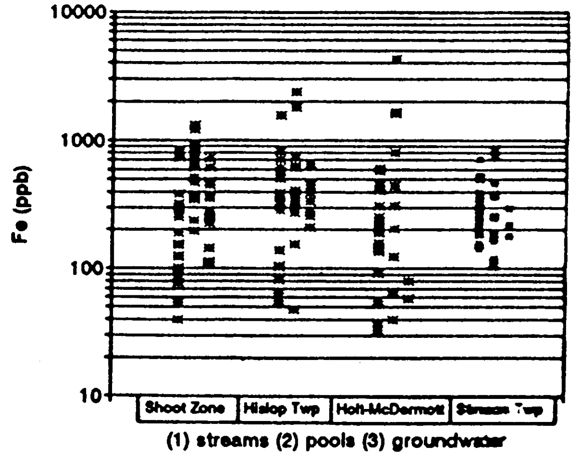


Iodide (ppb)

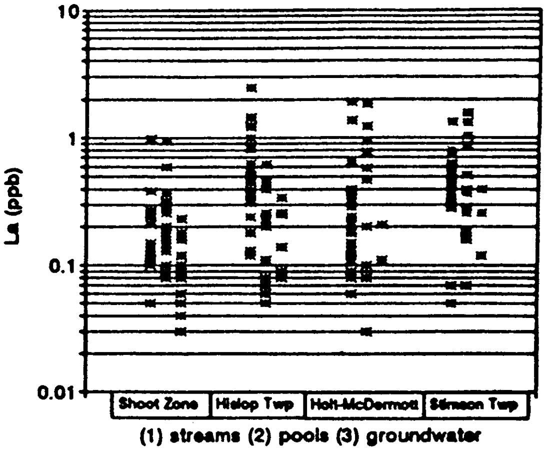
Water/ICP-MS



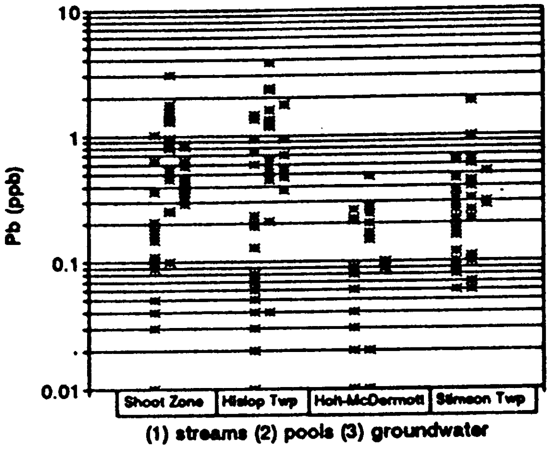
Iron (ppb)
Water/ICP-MS



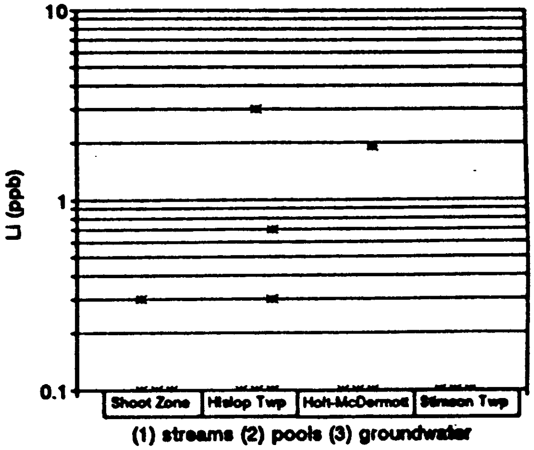
Lanthanum (ppb)
Lanthanum Frequency Distribution



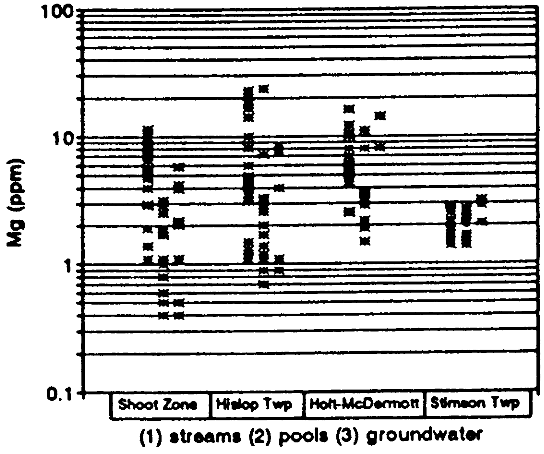
Lead (ppb)
Water/ICP-MS



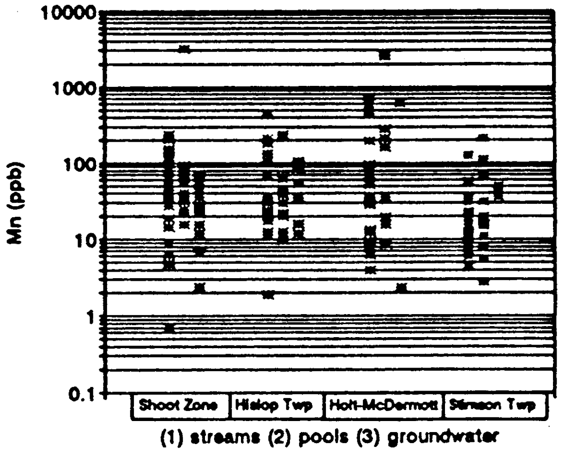
Lithium (ppb)
Water/ICP-MS



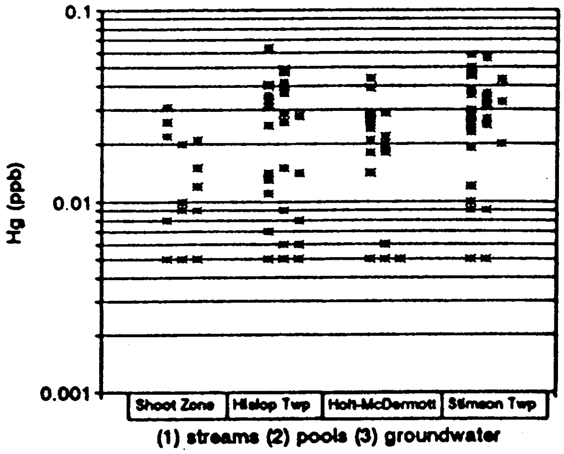
Magnesium (ppm)
Water/AAS



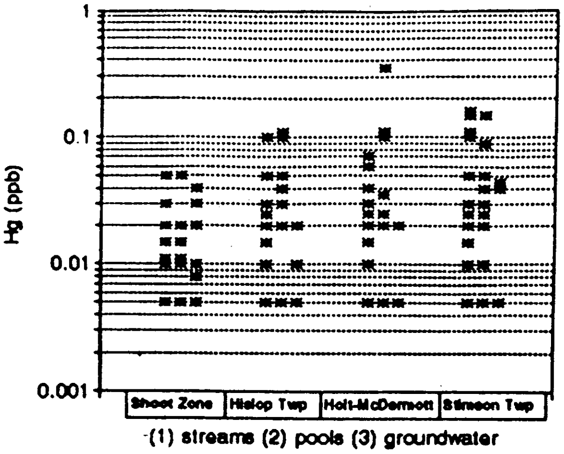
Manganese (ppb)
Water/ICP-MS



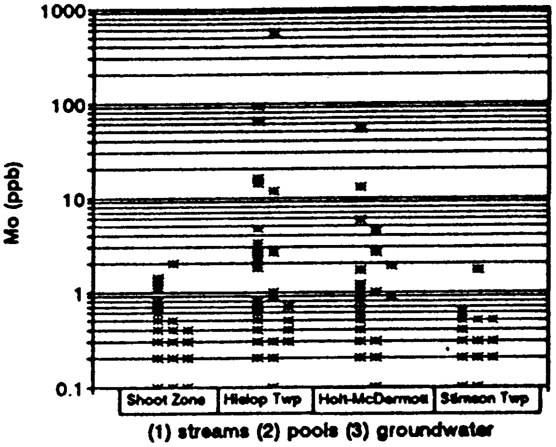
Mercury (ppb)
Water/ICP-MS



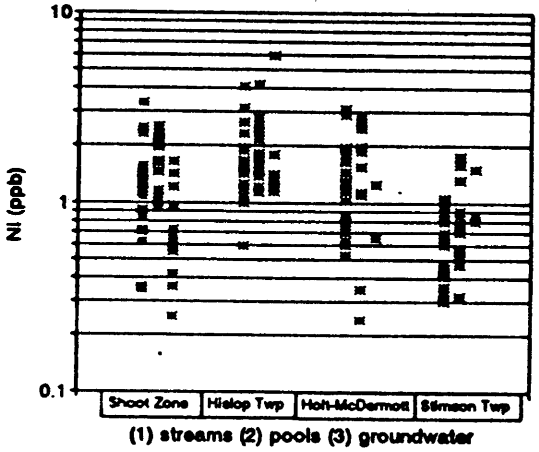
Mercury (ppb)
Water/hydride ICP-MS



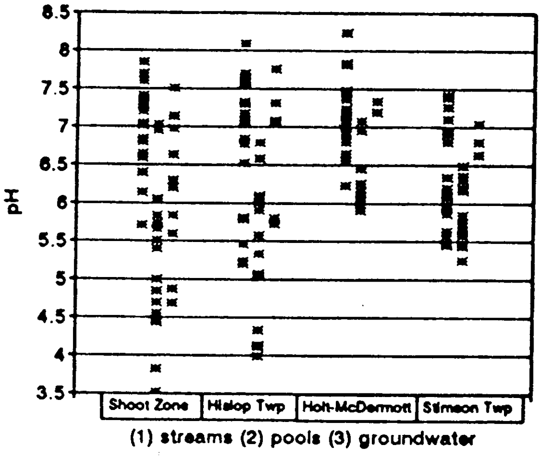
Molybdenum (ppb)
Water/ICP-MS



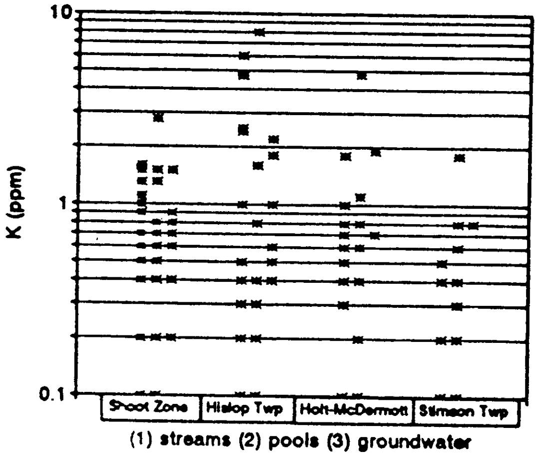
Nickel (ppb)
Water/ICP-MS



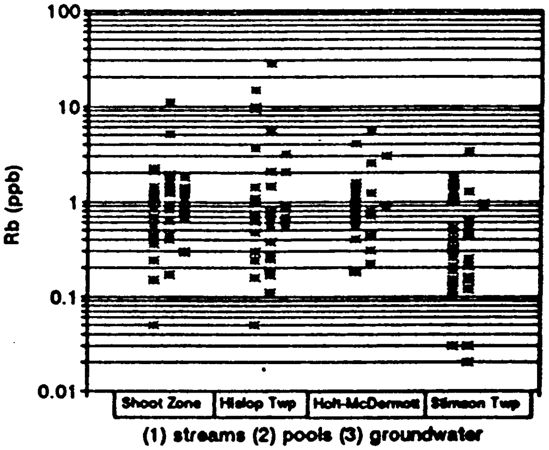
pH
Water/pHmeter



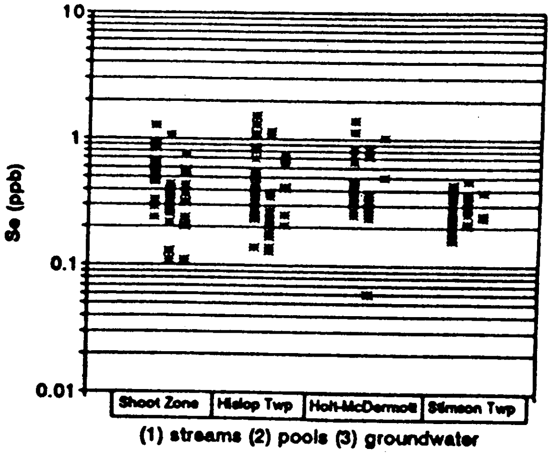
Potassium (ppm)
Water/AAS



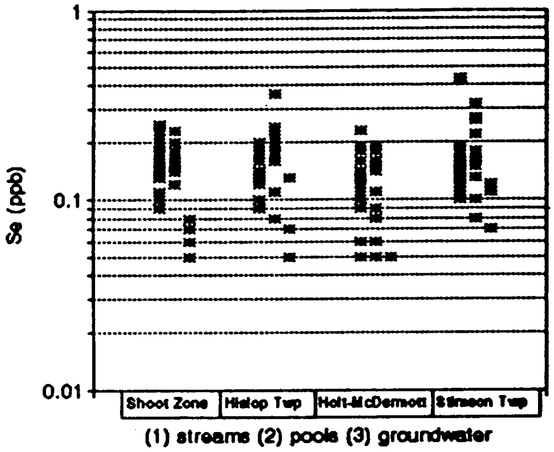
Rubidium (ppb)
Water/ICP-MS



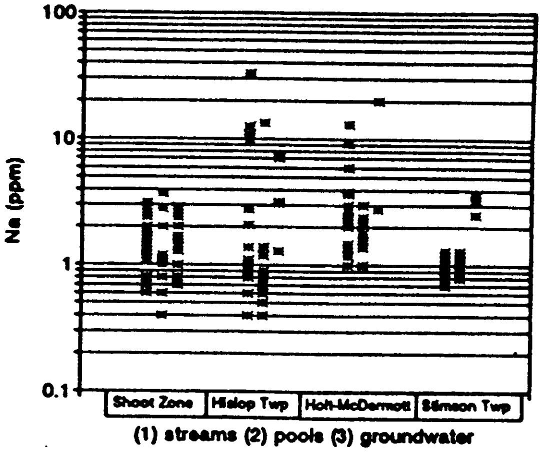
Selenium (ppb)
Water/ICP-MS



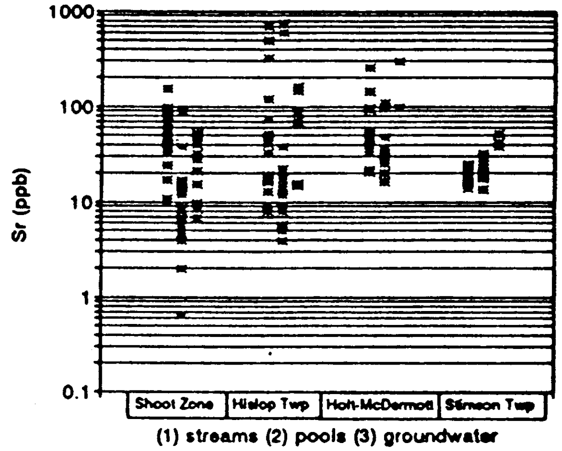
Selenium (ppb)
Water/hydride ICP-MS



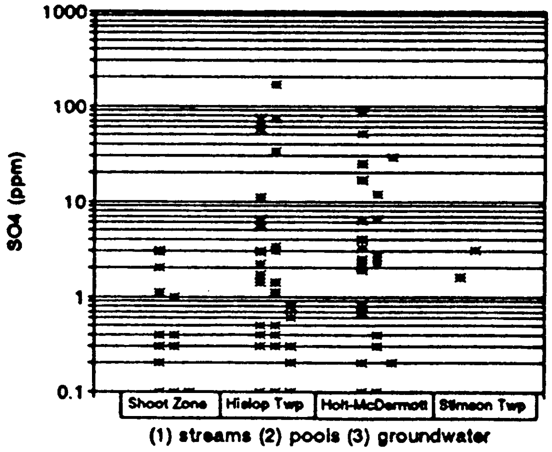
Sodium (ppm)
Water/AAS



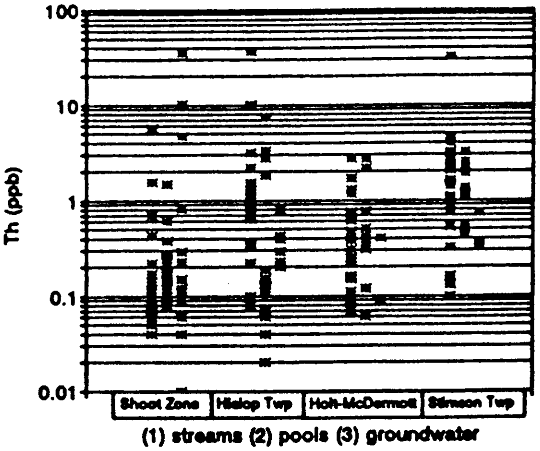
Strontium (ppb)
Water/ICP-MS



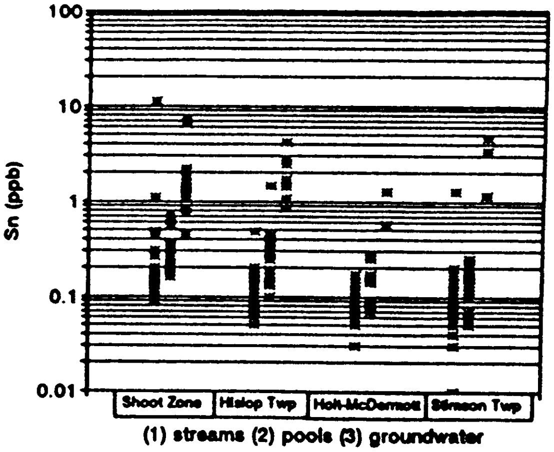
Sulphate (ppm)
Water/ion chromatography



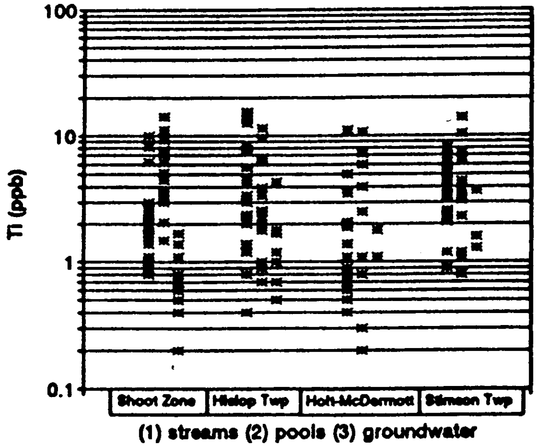
Thorium (ppb)
Water/ICP-MS



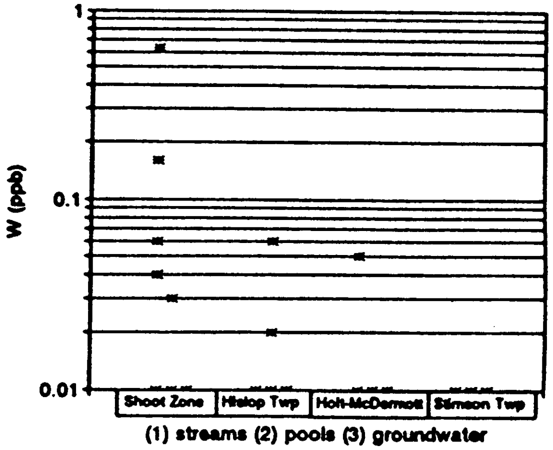
Tin (ppb)
Water/ICP-MS



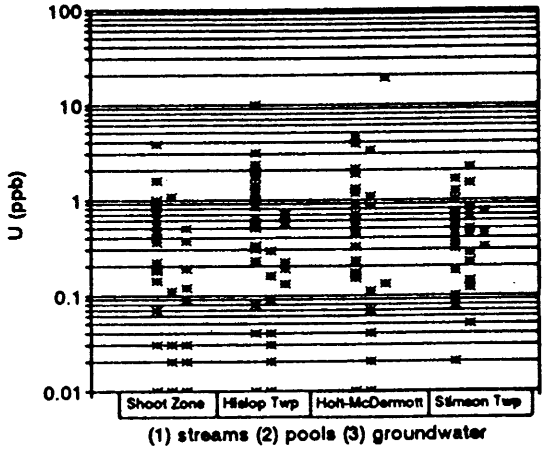
Titanium (ppb)
Water/ICP-MS



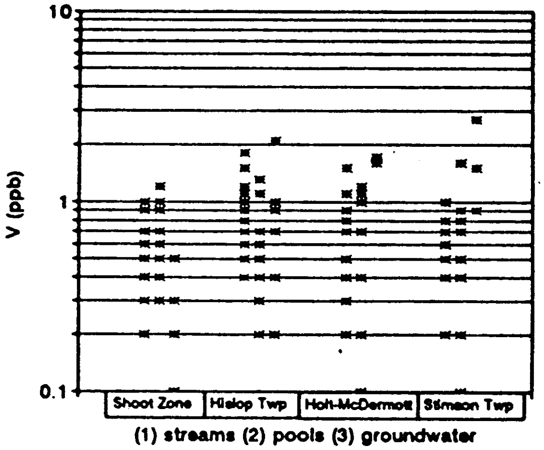
Tungsten (ppb)
Water/ICP-MS

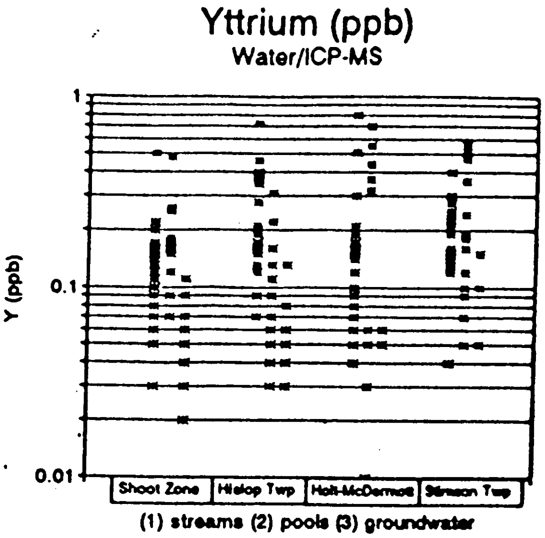


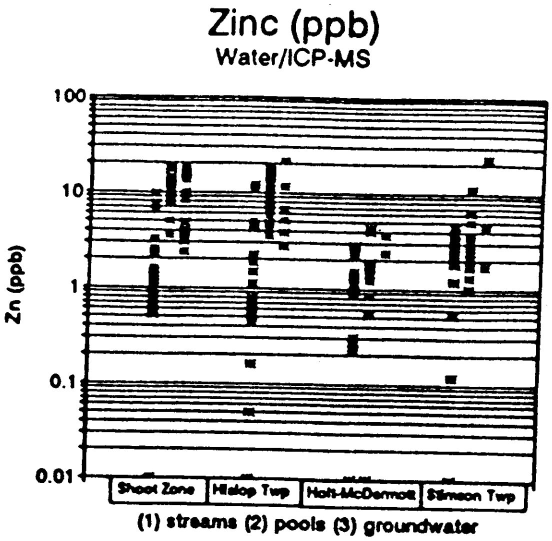
Uranium (ppb)
Water/ICP-MS



Vanadium (ppb)
Water/ICP-MS

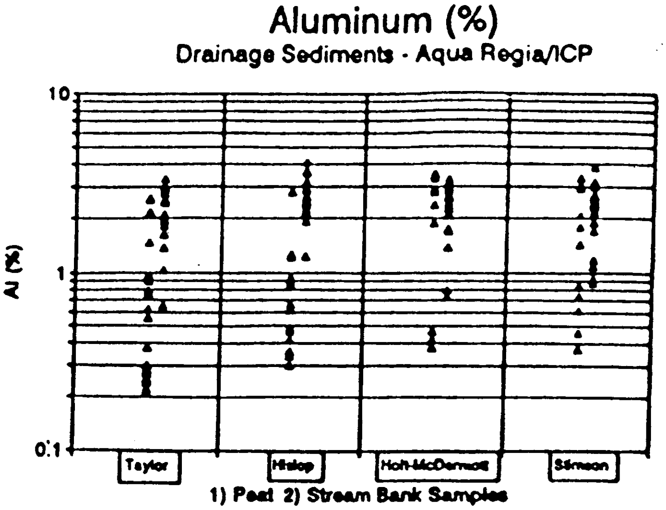


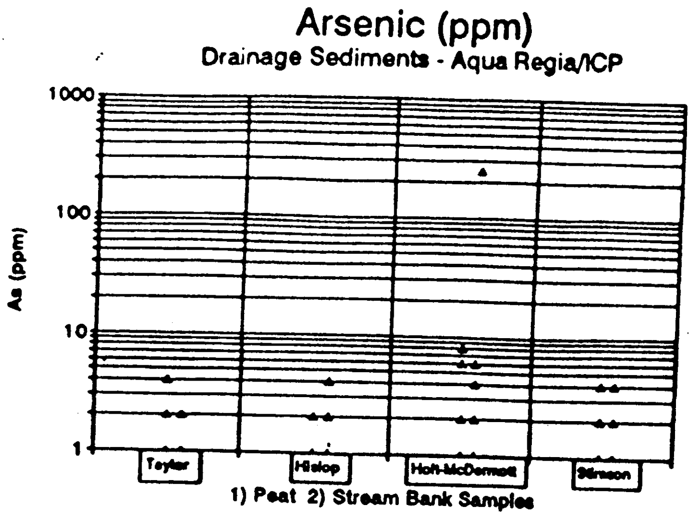

Yttrium (ppb)
Water/ICP-MS
Y (ppb)
1
0.1
0.01
Shoot Zone
Hislop Twp
Holt-McDermott
Stimson Twp
(1) streams (2) pools (3) groundwater

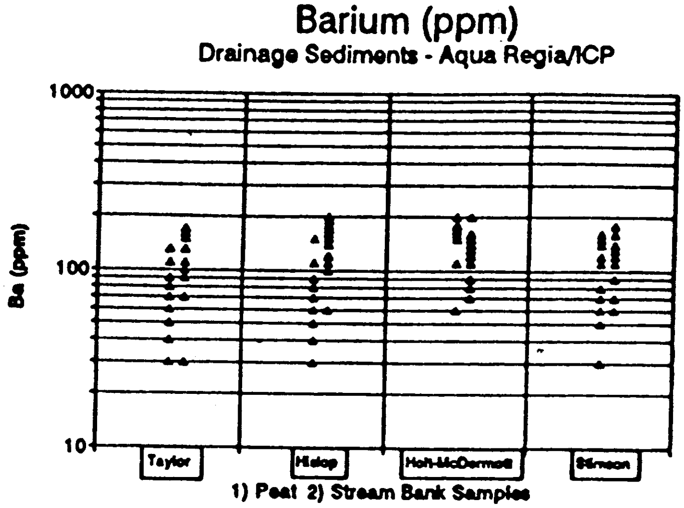

Zinc (ppb)
Water/ICP-MS
Zn (ppb)
100
10
1
0.1
0.01
Shoot Zone
Hislop Twp
Holt-McDermott
Stimson Twp
(1) streams (2) pools (3) groundwater

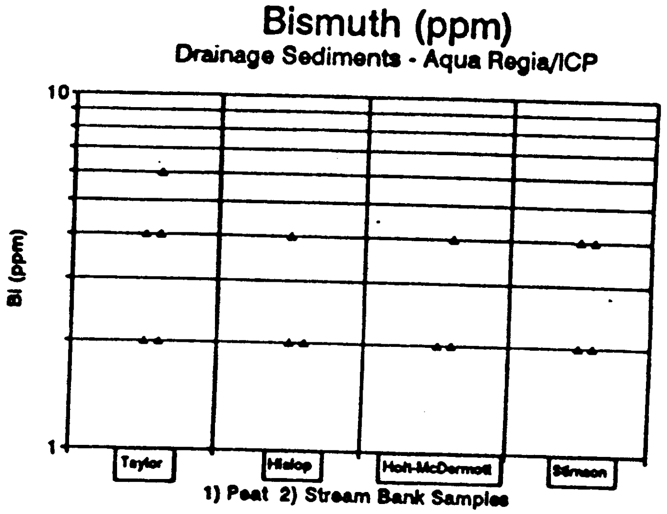
APPENDIX III

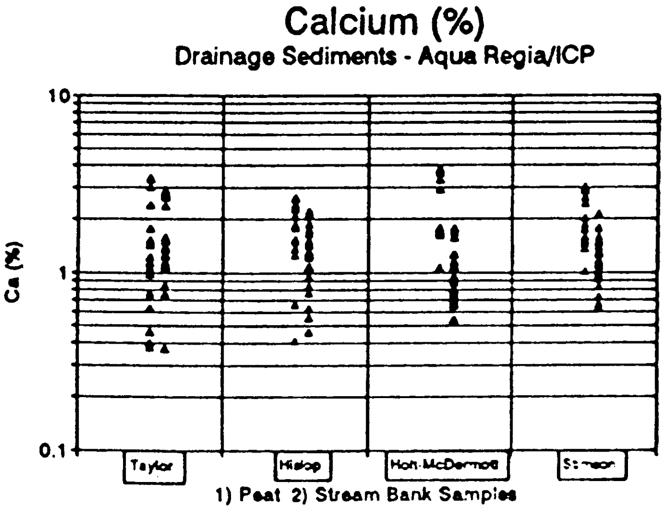
ELEMENT FREQUENCY DISTRIBUTIONS FOR DRAINAGE SEDIMENTS BY AREA

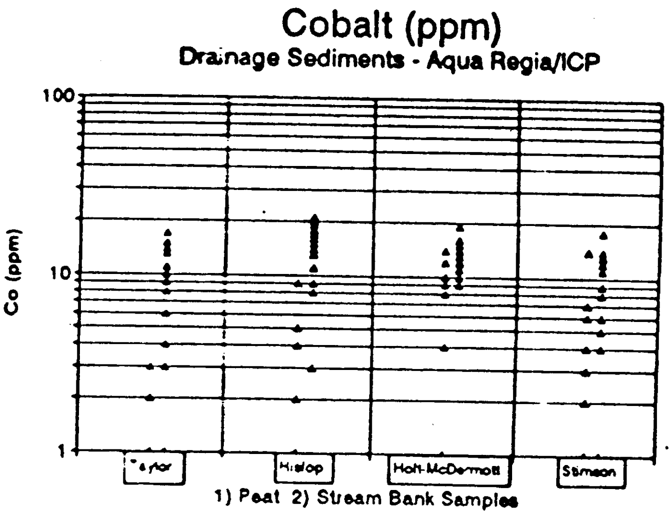

Aluminum (%)
Drainage Sediments - Aqua Regia/ICP
Al (%)
10
1
0.1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Arsenic (ppm)
Drainage Sediments - Aqua Regia/ICP
As (ppm)
1000
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Barium (ppm)
Drainage Sediments - Aqua Regia/ICP
Ba (ppm)
1000
100
10
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

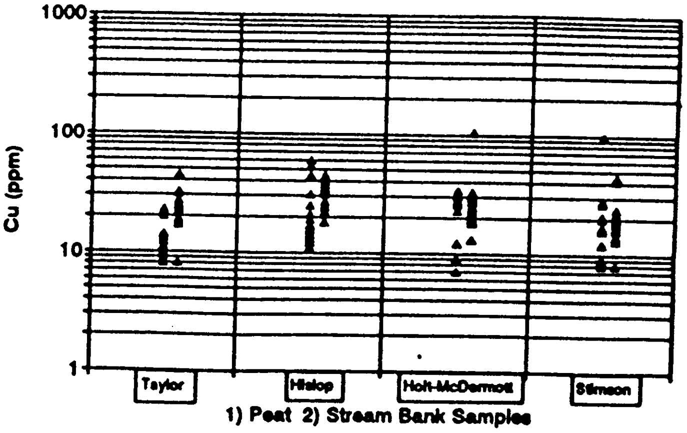

Bismuth (ppm)
Drainage Sediments - Aqua Regia/ICP
Bi (ppm)
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Calcium (%)
Drainage Sediments - Aqua Regia/ICP
Ca (%)
10
1
0.1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Cobalt (ppm)
Drainage Sediments - Aqua Regia/ICP
Co (ppm)
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

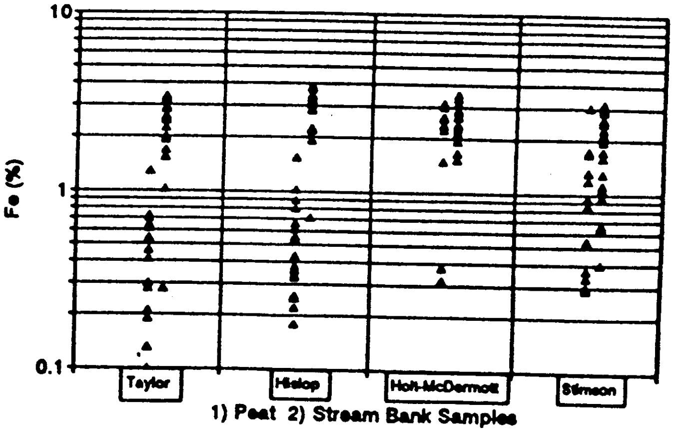
Copper (ppm)

Drainage Sediments - Aqua Regia/ICP



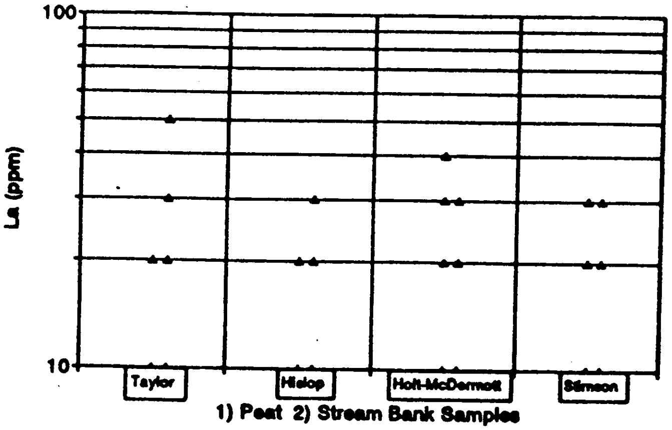
Iron (%)

Drainage Sediments - Aqua Regia/ICP



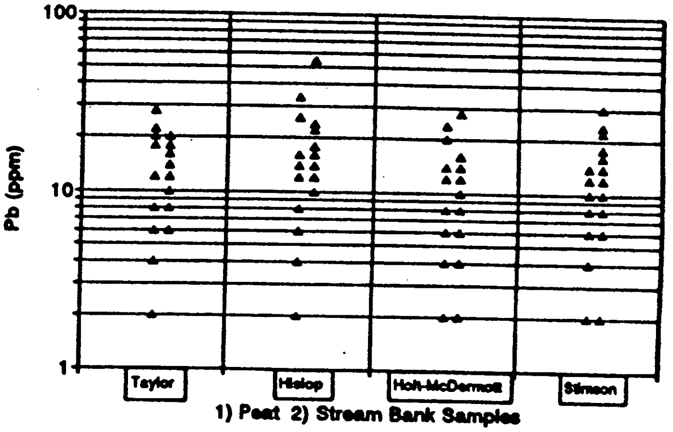
Lanthanum (ppm)

Drainage Sediments - Aqua Regia/ICP



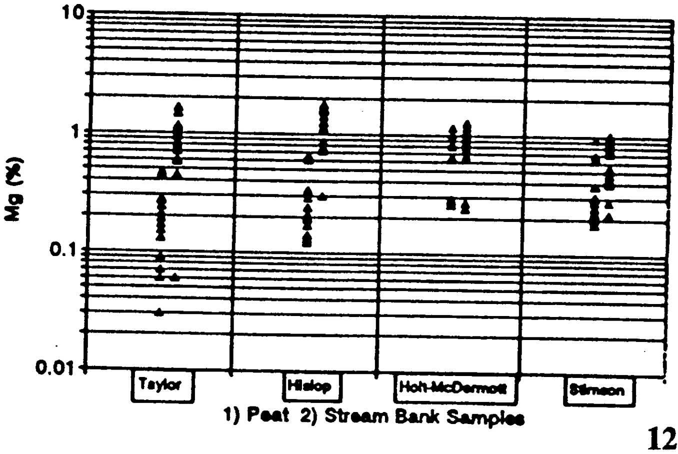
Lead (ppm)

Drainage Sediments - Aqua Regia/ICP



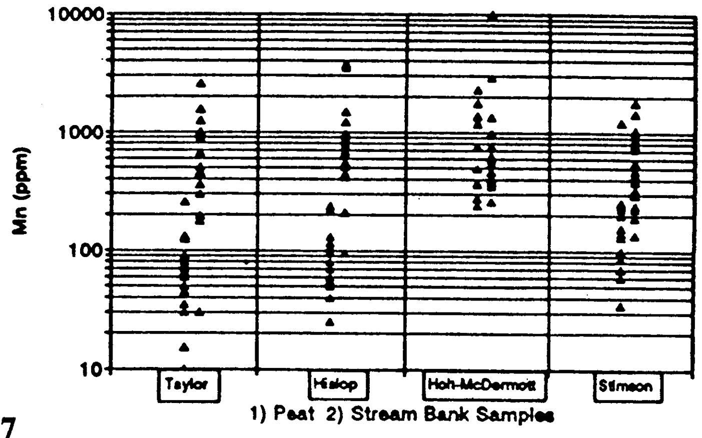
Magnesium (%)

Drainage Sediments - Aqua Regia/ICP



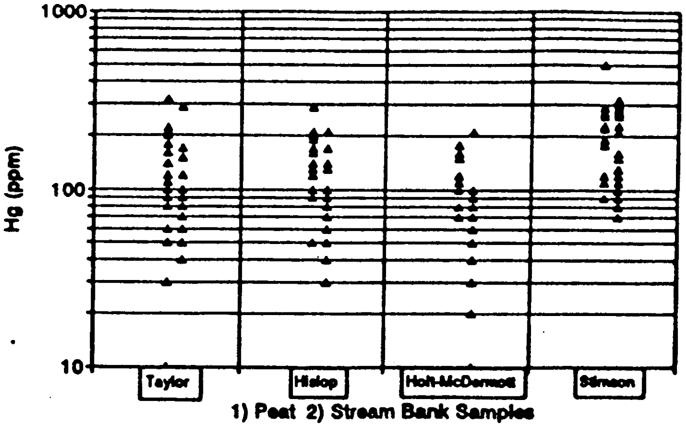
Manganese (ppm)

Drainage Sediments - Aqua Regia/ICP



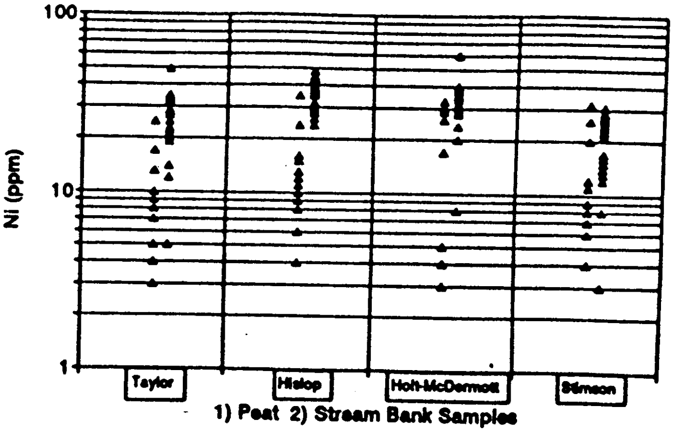
Mercury (ppm)

Drainage Sediments - Aqua Regia/ICP



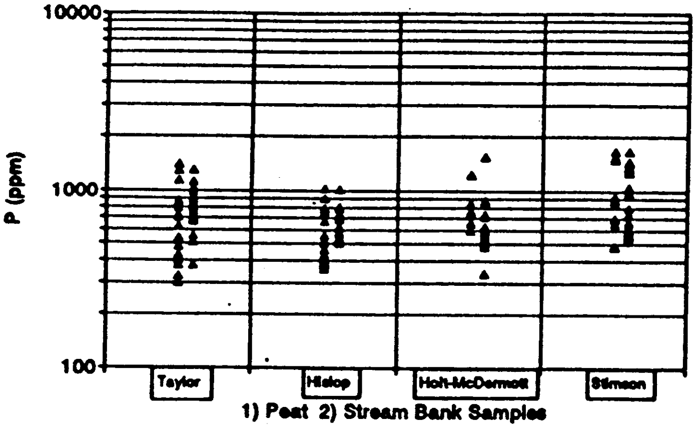
Nickel (ppm)

Drainage Sediments - Aqua Regia/ICP



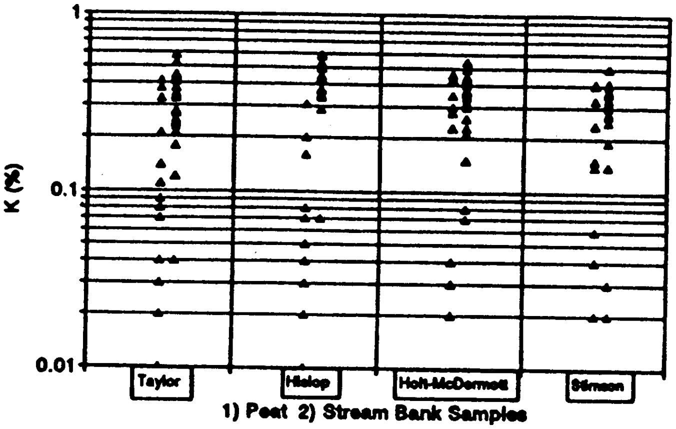
Phosphorus (ppm)

Drainage Sediments - Aqua Regia/ICP



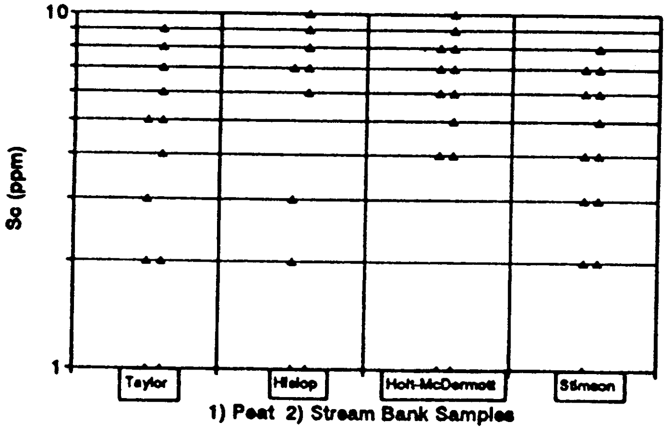
Potassium (%)

Drainage Sediments - Aqua Regia/ICP



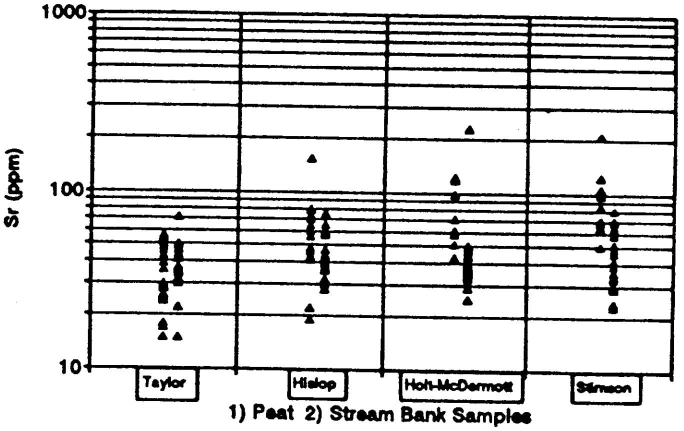
Scandium (ppm)

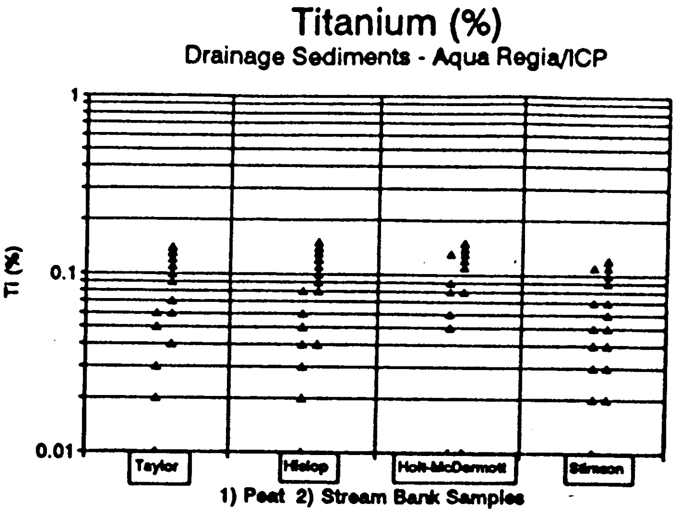
Drainage Sediments - Aqua Regia/ICP

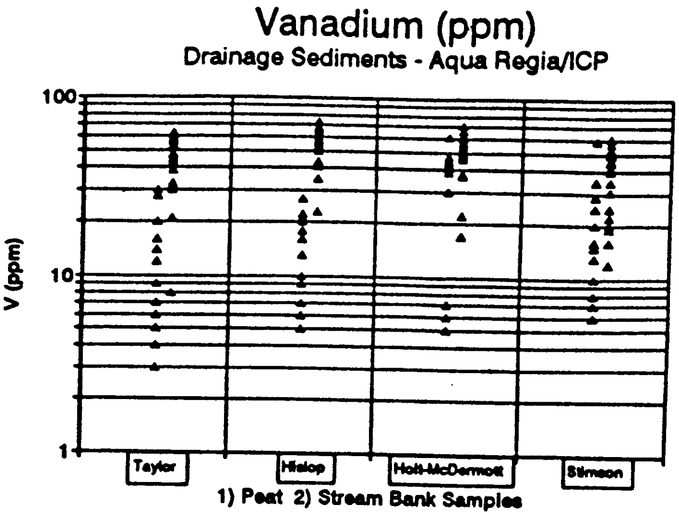


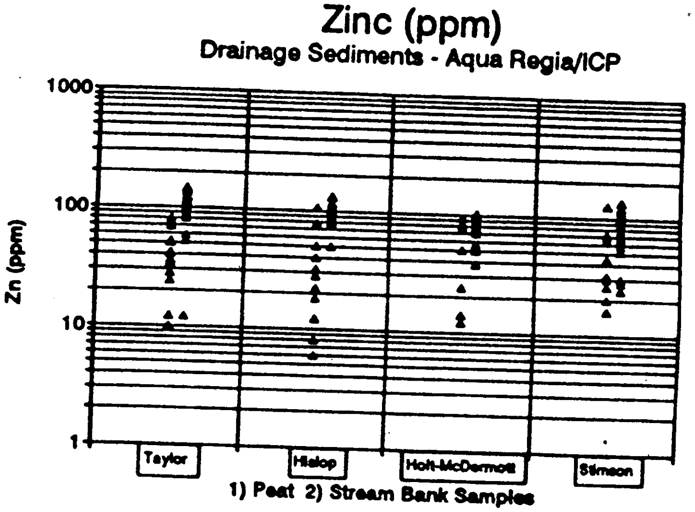
Strontium (ppm)

Drainage Sediments - Aqua Regia/ICP



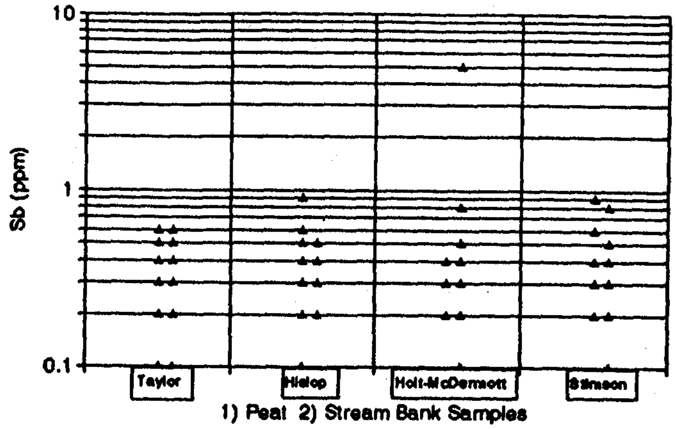

Titanium (%)
Drainage Sediments - Aqua Regia/ICP
Ti (%)
1
0.1
0.01
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Vanadium (ppm)
Drainage Sediments - Aqua Regia/ICP
V (ppm)
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Zinc (ppm)
Drainage Sediments - Aqua Regia/ICP
Zn (ppm)
1000
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

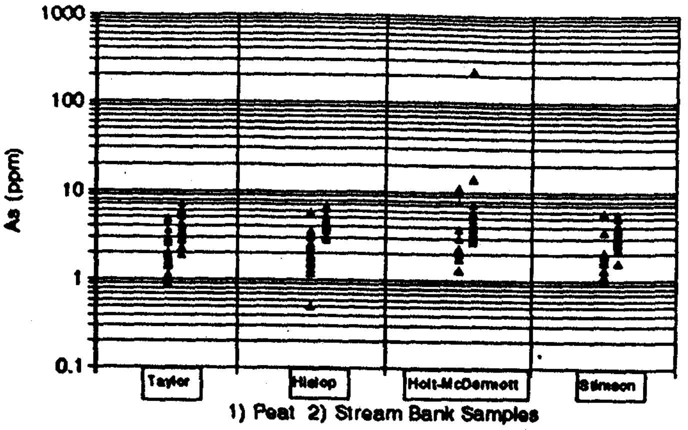
Antimony (ppm)

Drainage Sediments - INAA



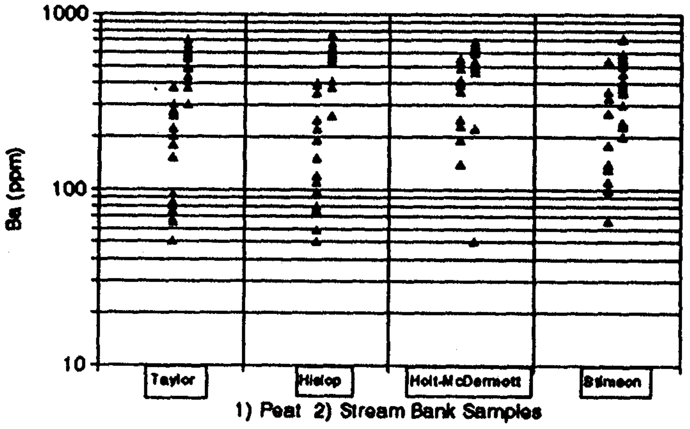
Arsenic (ppm)

Drainage Sediments - INAA



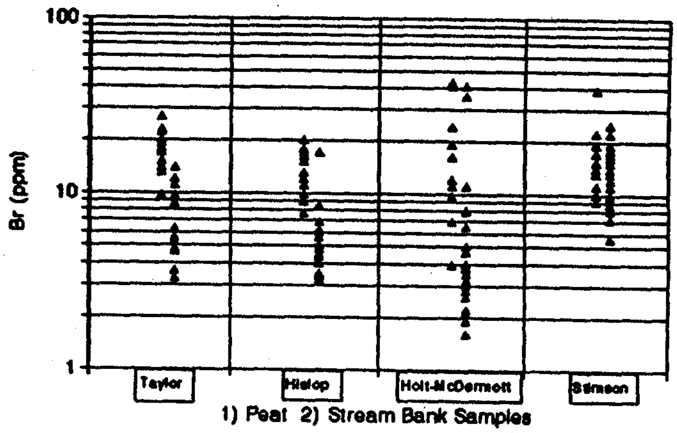
Barium (ppm)

Drainage Sediments - INAA



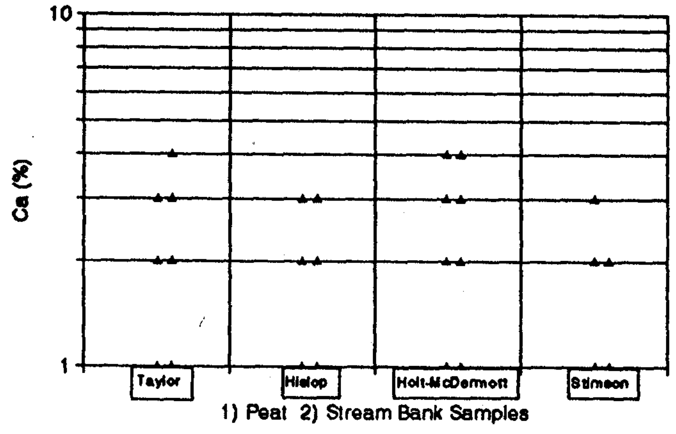
Bromide (ppm)

Drainage Sediments - INAA



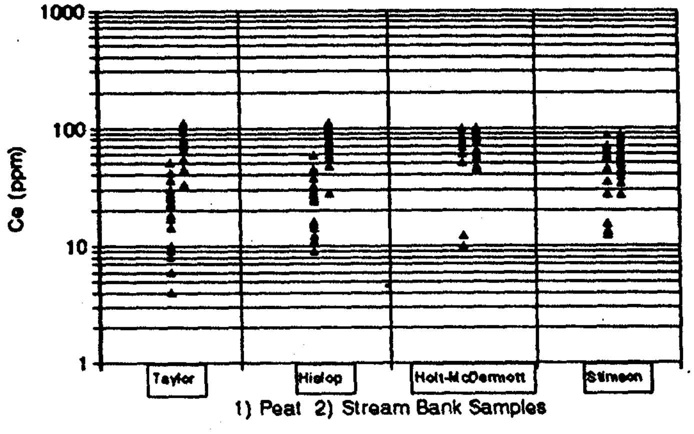
Calcium (%)

Drainage Sediments - INAA



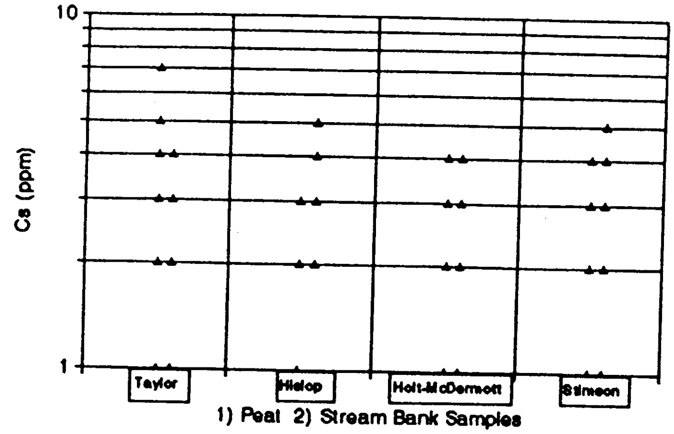
Cerium (ppm)

Drainage Sediments - INAA



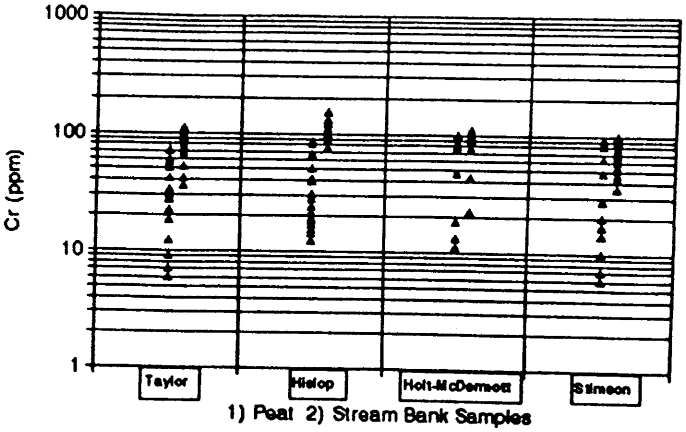
Cesium (ppm)

Drainage Sediments - INAA



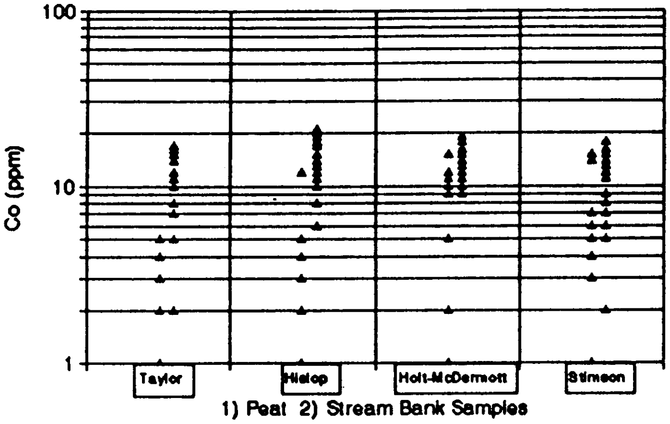
Chromium (ppm)

Drainage Sediments - INAA



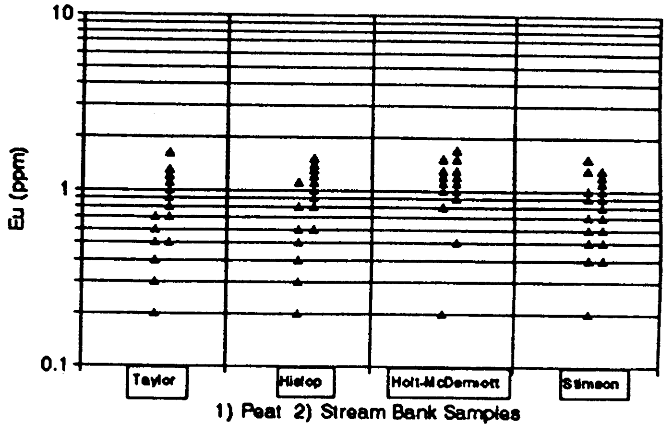
Cobalt (ppm)

Drainage Sediments - INAA



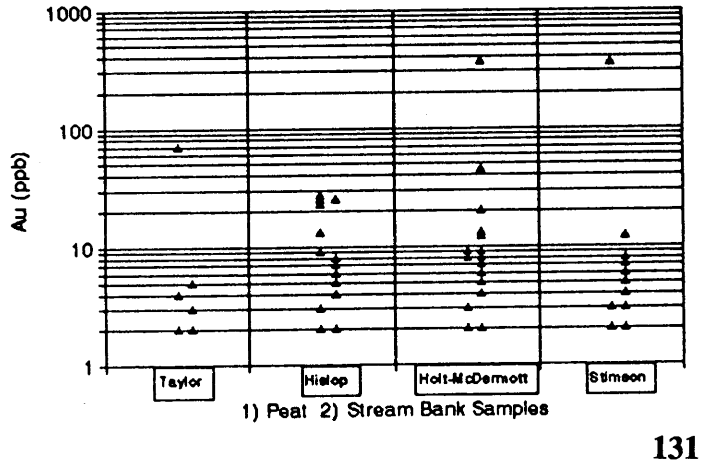
Europium (ppm)

Drainage Sediments - INAA



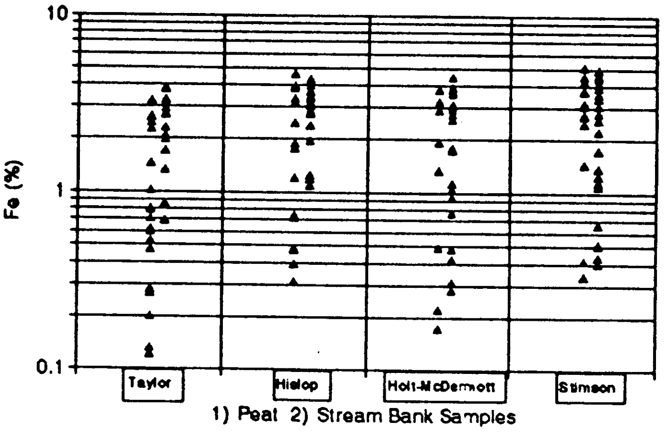
Gold (ppb)

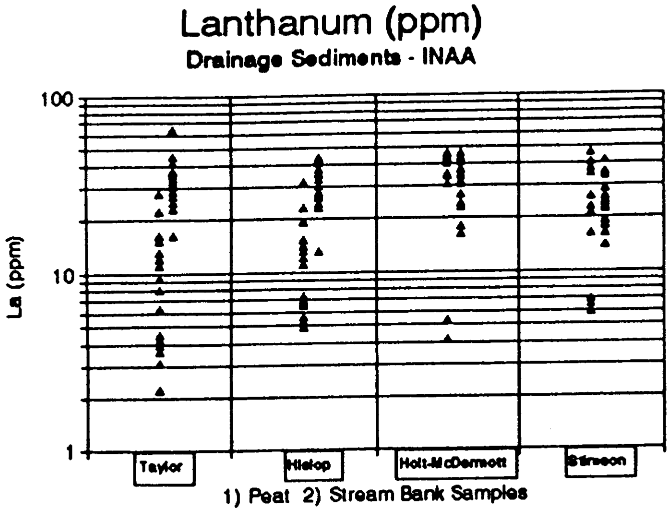
Drainage Sediments - INAA

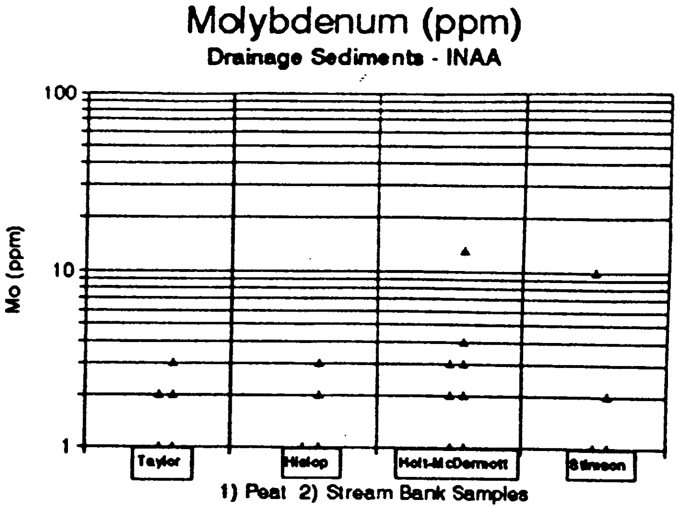


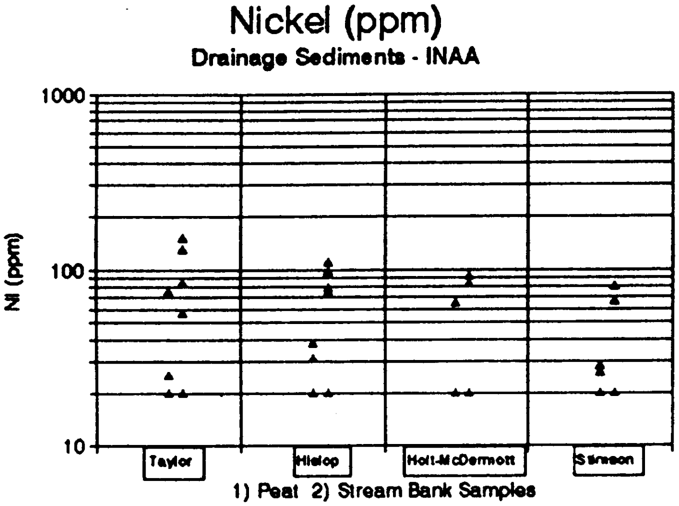
Iron (%)

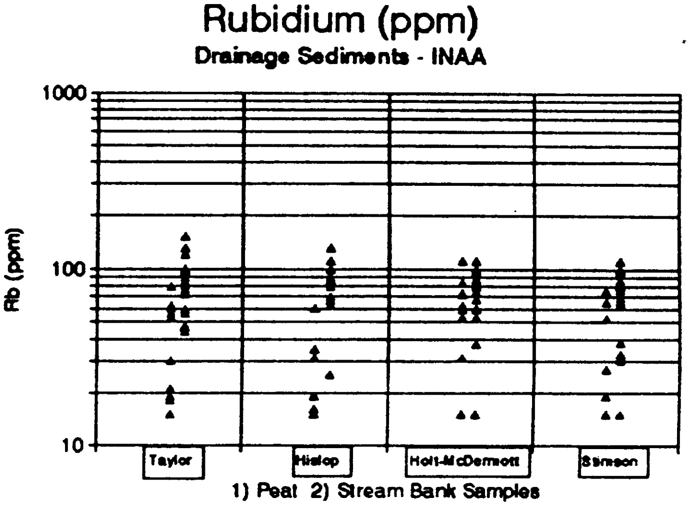
Drainage Sediments - INAA

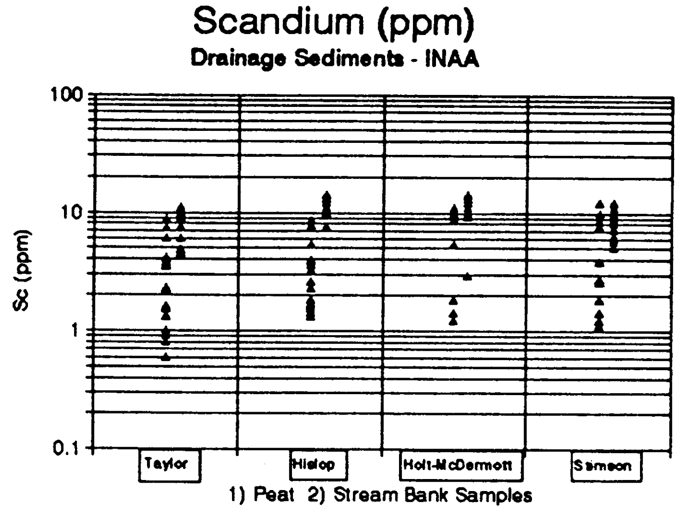


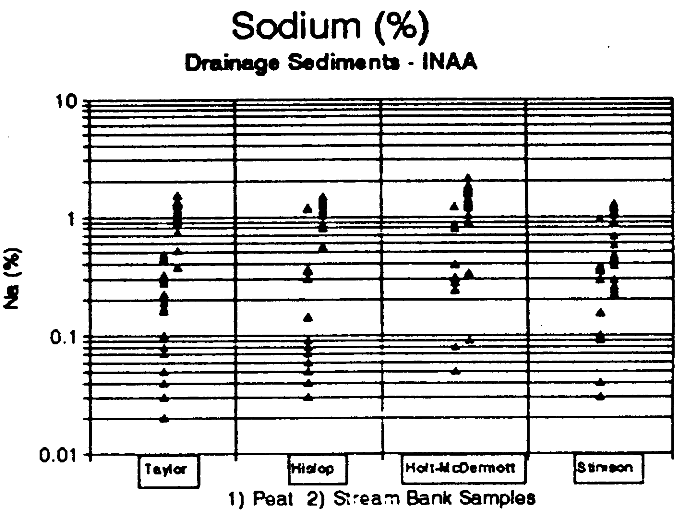

Lanthanum (ppm)
Drainage Sediments - INAA
La (ppm)
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

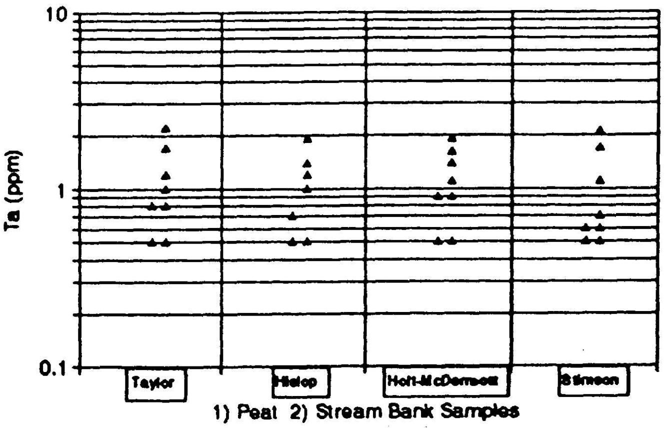

Molybdenum (ppm)
Drainage Sediments - INAA
Mo (ppm)
100
10
1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

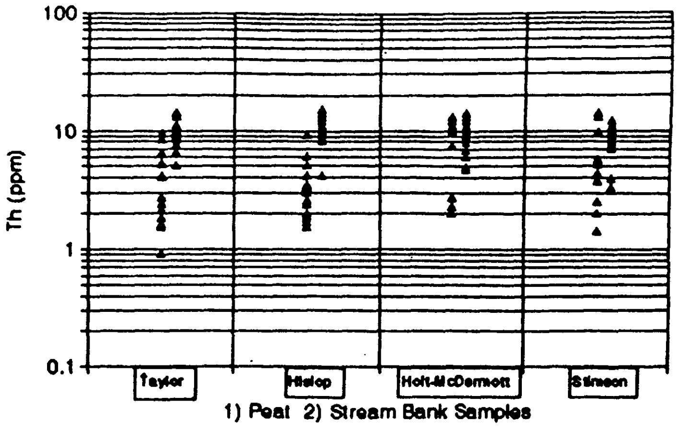

Nickel (ppm)
Drainage Sediments - INAA
Ni (ppm)
1000
100
10
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

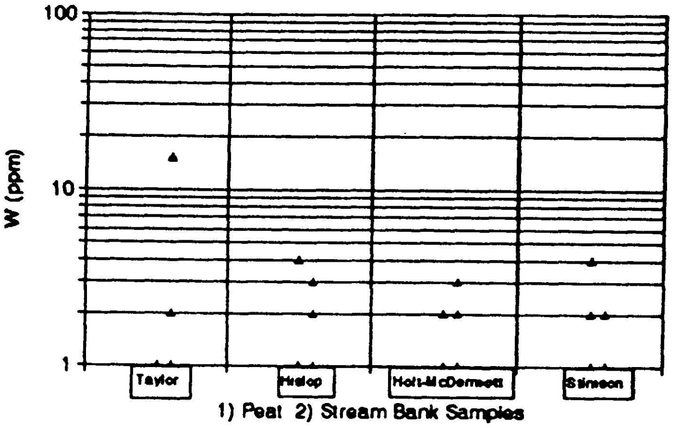

Rubidium (ppm)
Drainage Sediments - INAA
Rb (ppm)
1000
100
10
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

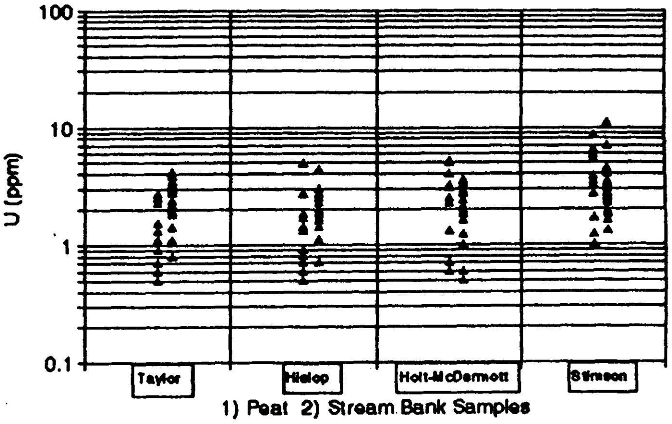

Scandium (ppm)
Drainage Sediments - INAA
Sc (ppm)
100
10
1
0.1
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples

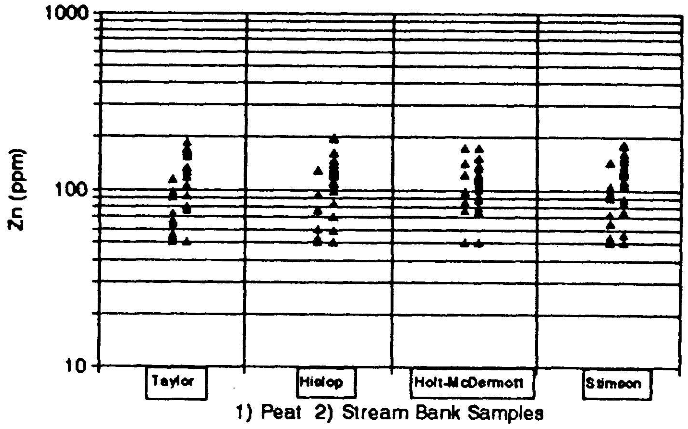

Sodium (%)
Drainage Sediments - INAA
Na (%)
10
1
0.1
0.01
Taylor
Hislop
Holt-McDermott
Stimson
1) Peat 2) Stream Bank Samples


Tantalum (ppm)
Drainage Sediments - INAA


Thorium (ppm)
Drainage Sediments - INAA

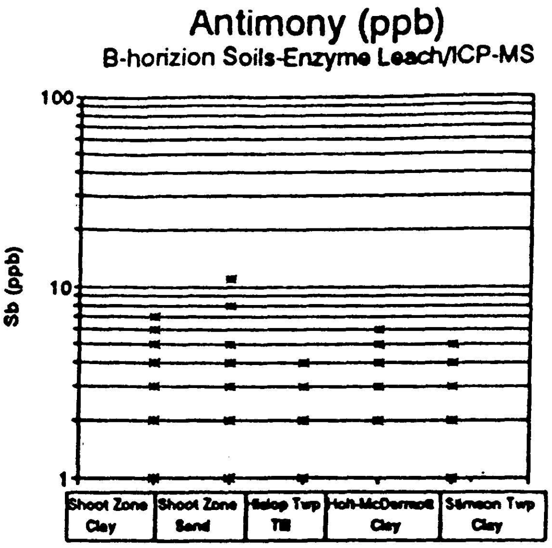

Tungsten (ppm)
Drainage Sediments - INAA

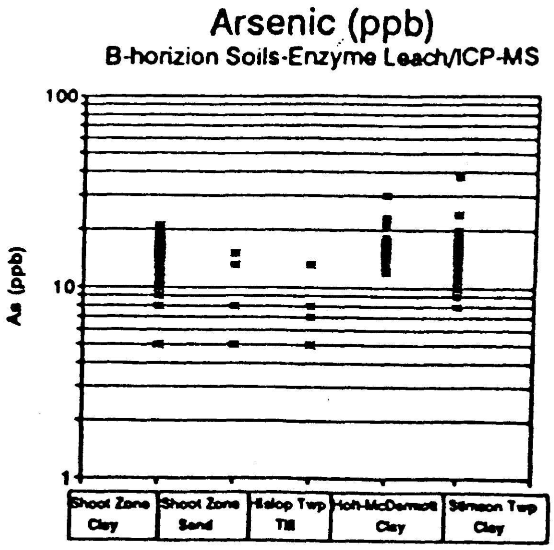

Uranium (ppm)
Drainage Sediments - INAA

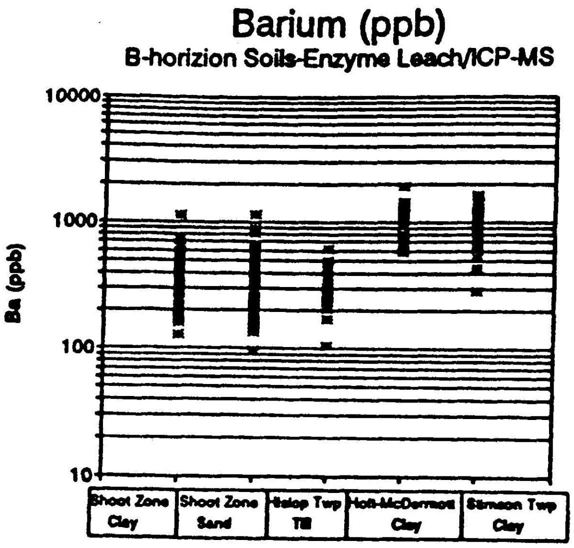

Zinc (ppm)
Drainage Sediments - INAA

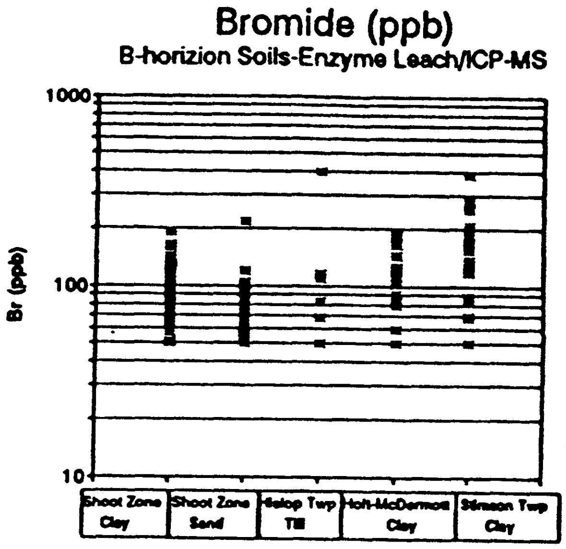
APPENDIX IV

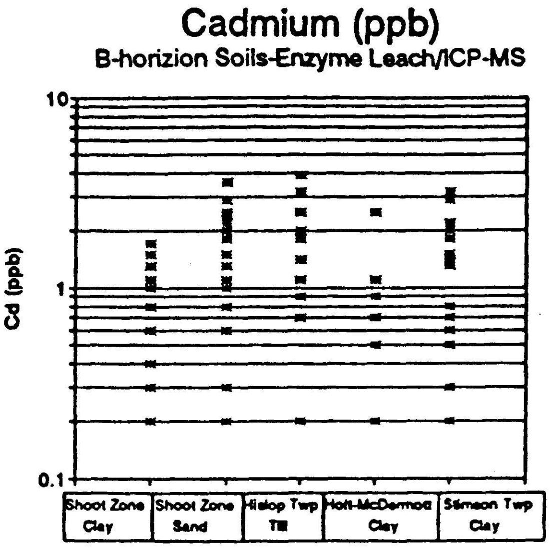
ELEMENT FREQUENCY DISTRIBUTIONS FOR B HORIZON SOIL (ENZYME LEACH/ICP-MS) BY AREA

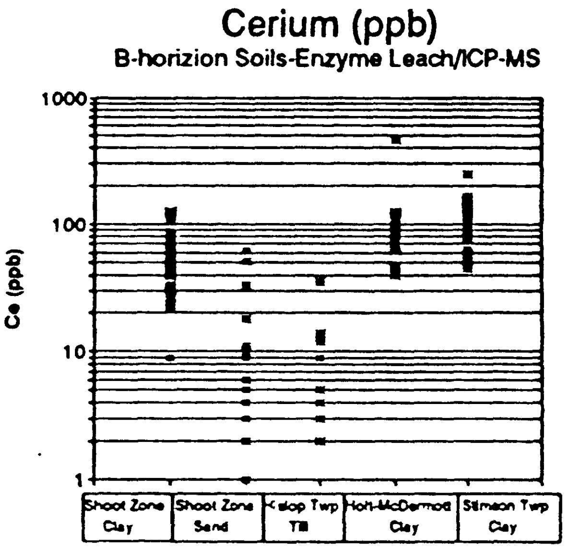

Antimony (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Sb (ppb)
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay

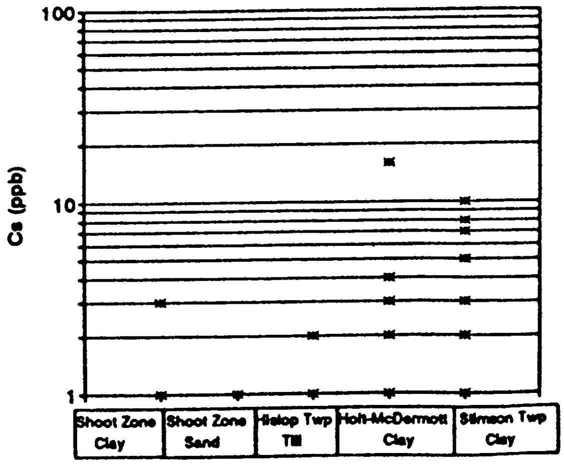

Arsenic (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
As (ppb)
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Barium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Ba (ppb)
10000
1000
100
10
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Bromide (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Br (ppb)
1000
100
10
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay

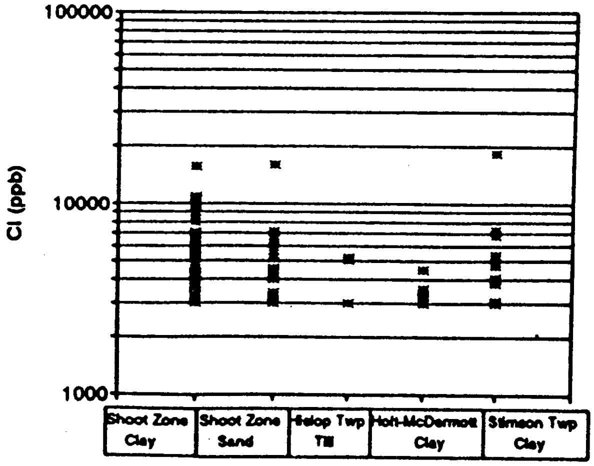

Cadmium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Cd (ppb)
10
1
0.1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Cerium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Ce (ppb)
1000
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay



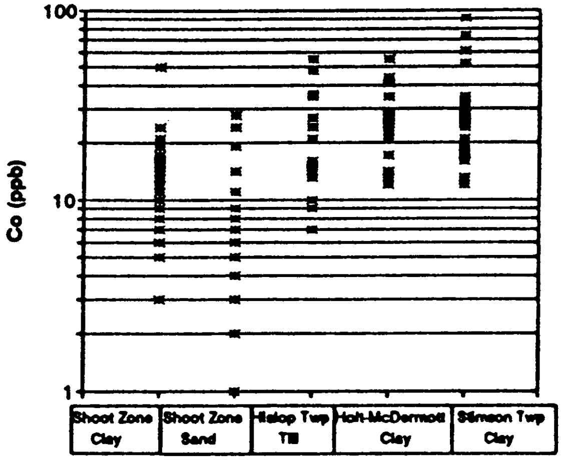
Cesium (ppb)

B-horizion Soils Enzyme Leach/ICP-MS



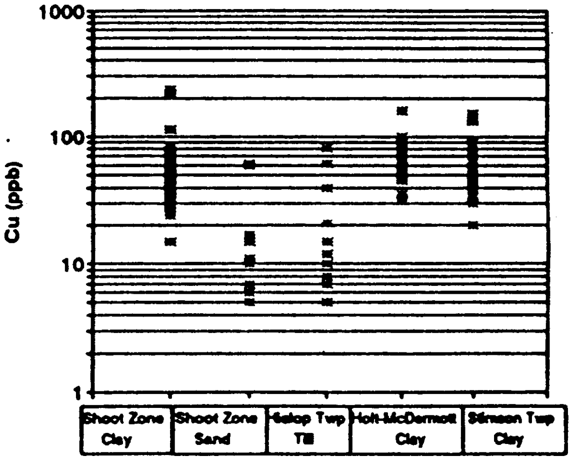
Chloride (ppb)

B-horizion Soil-Enzyme Leach/ICP-MS



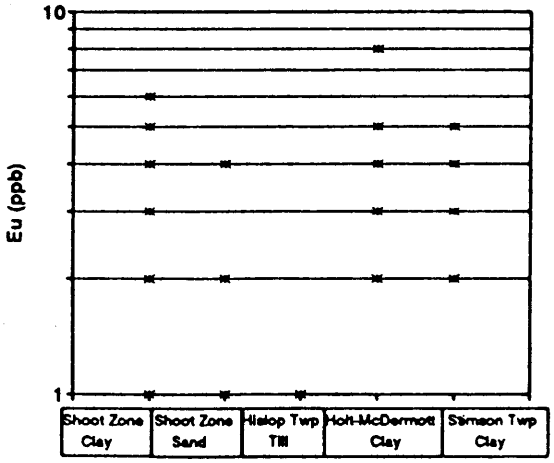
Cobalt (ppb)

B-horizion Soils-Enzyme Leach/ICP-MS



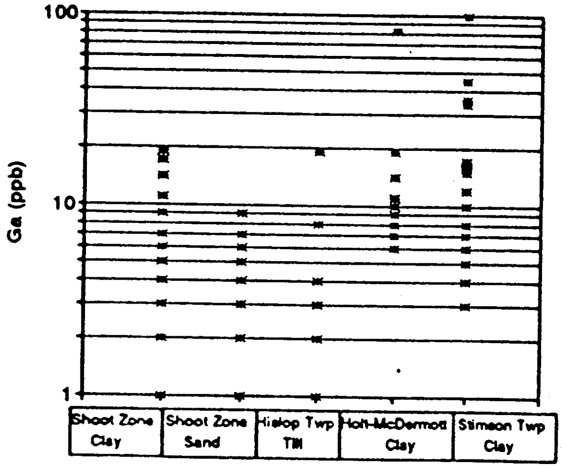
Copper (ppb)

B-horizion Soils-Enzyme Leach/ICP-MS



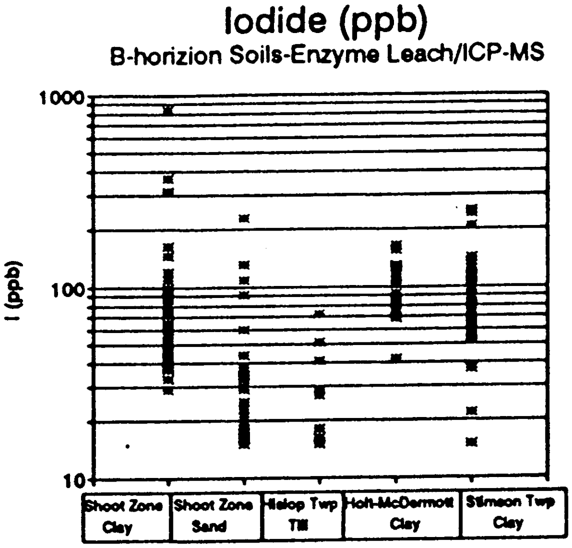
Europium (ppb)

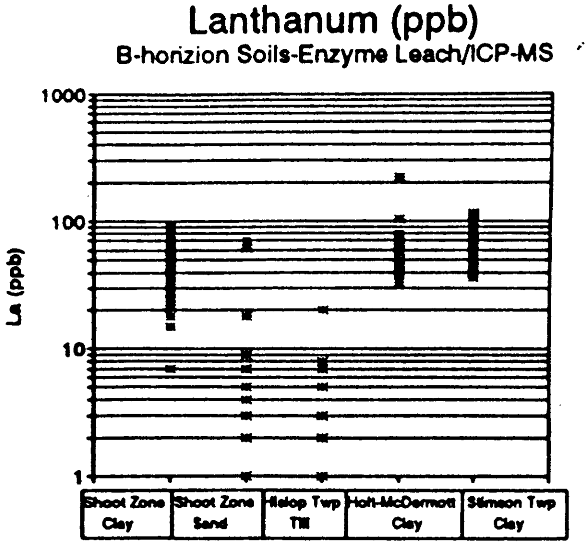
B-horizion Soils-Enzyme Leach/ICP-MS

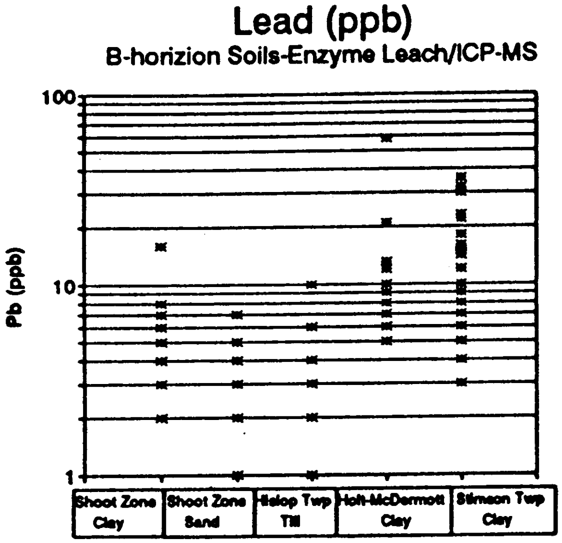


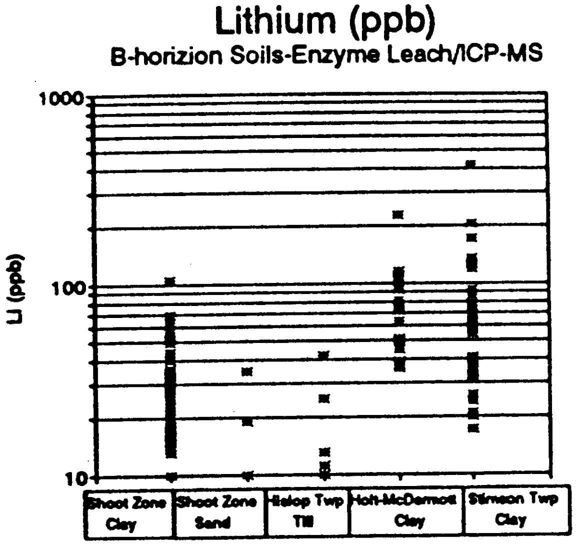
Gallium (ppm)

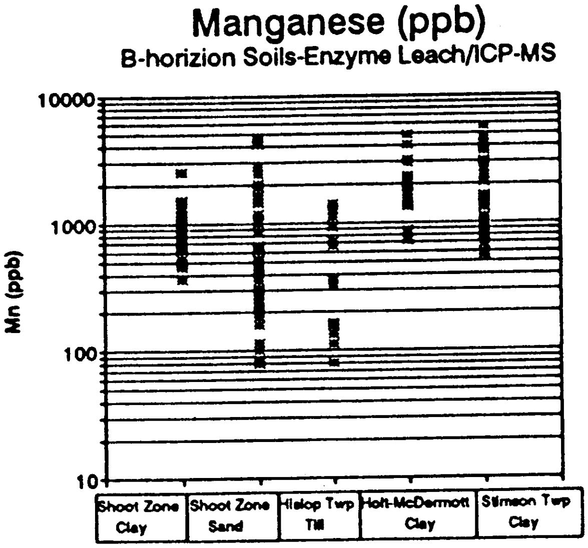
B-horizion Soils-Enzyme Leach/ICP-MS

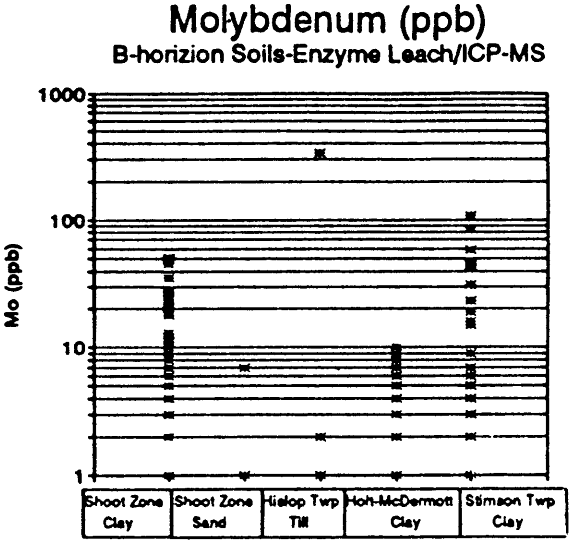

Iodide (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
I (ppb)
1000
100
10
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Lanthanum (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
La (ppb)
1000
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay

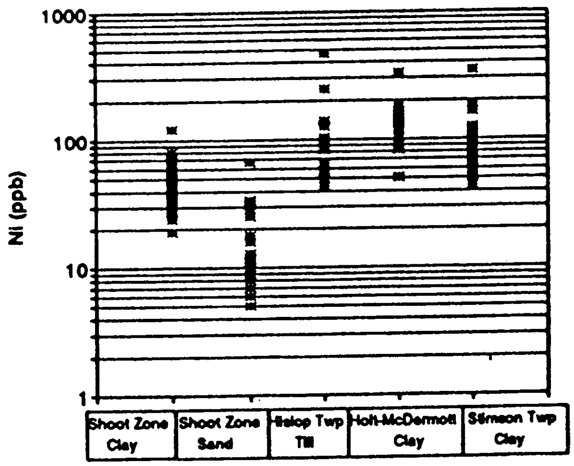

Lead (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Pb (ppb)
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Lithium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Li (ppb)
1000
100
10
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay

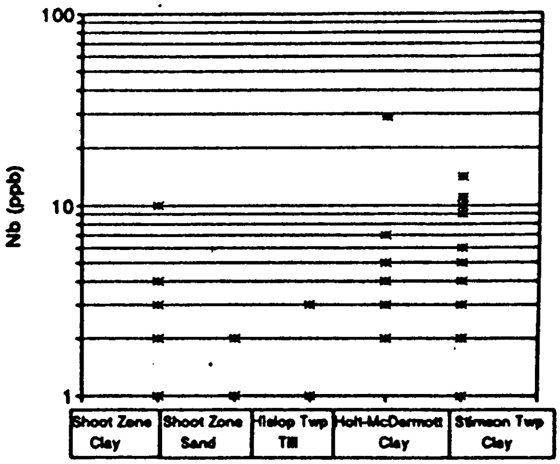

Manganese (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Mn (ppb)
10000
1000
100
10
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay


Molybdenum (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS
Mo (ppb)
1000
100
10
1
Shoot Zone Clay
Shoot Zone Sand
Hislop Twp Till
Holt-McDermott Clay
Stimson Twp Clay

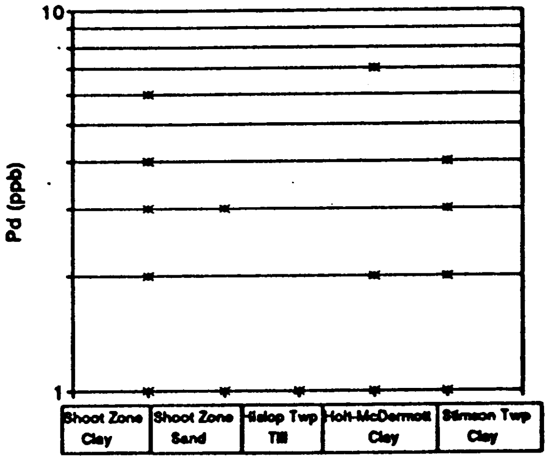
Nickel (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



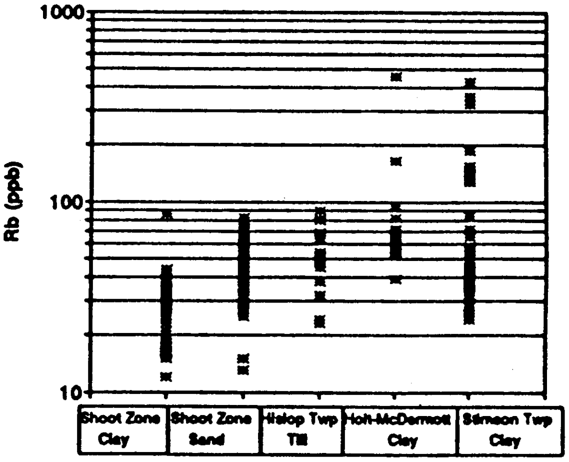
Niobium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



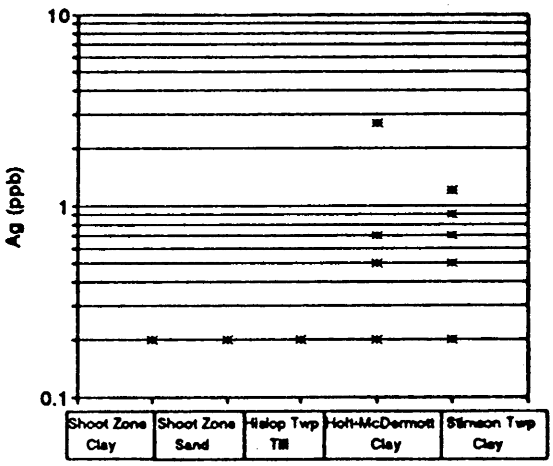
Palladium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



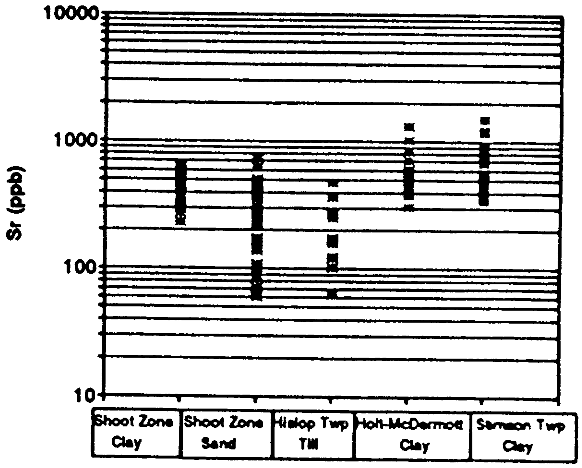
Rubidium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS

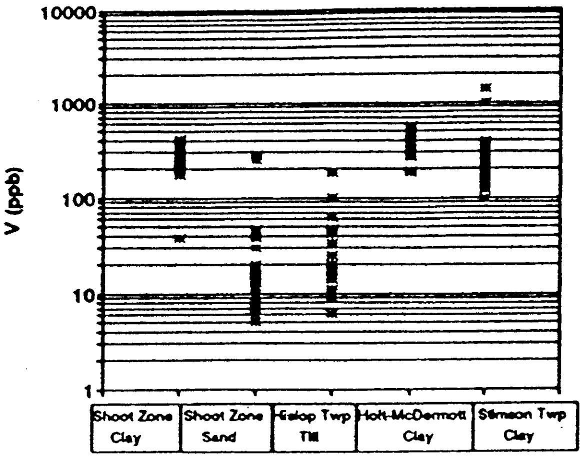


Silver (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS

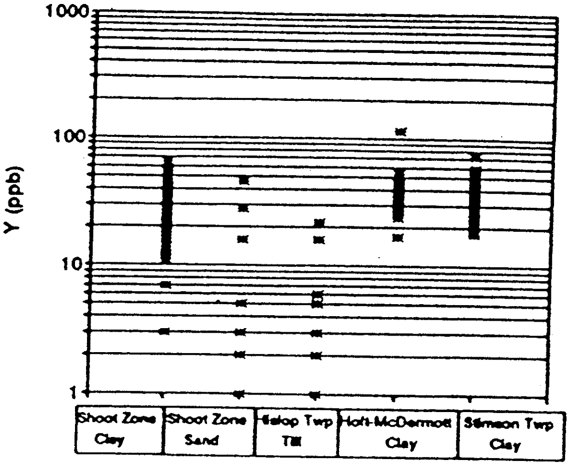


Strontium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS

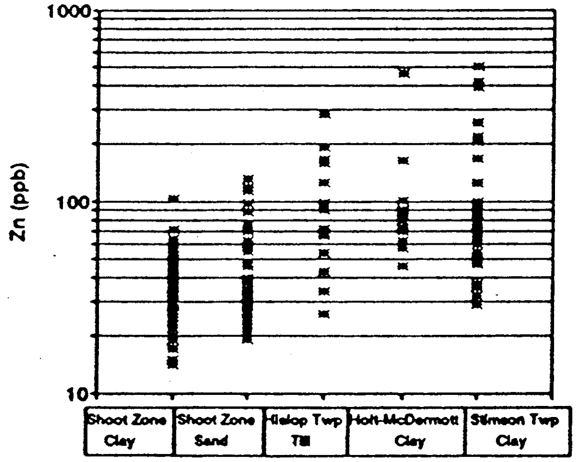




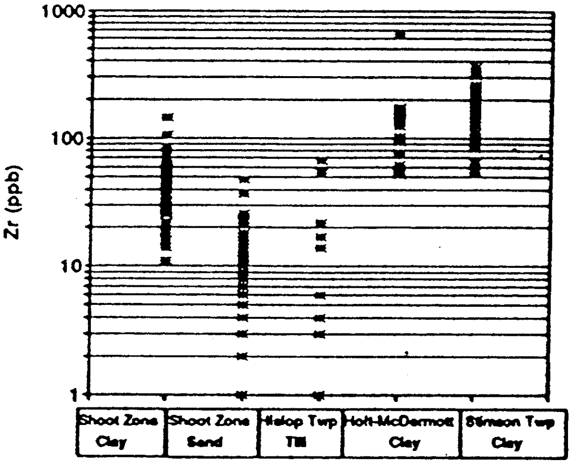
Vanadium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



Yttrium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



Zinc (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS



Zirconium (ppb)
B-horizion Soils-Enzyme Leach/ICP-MS

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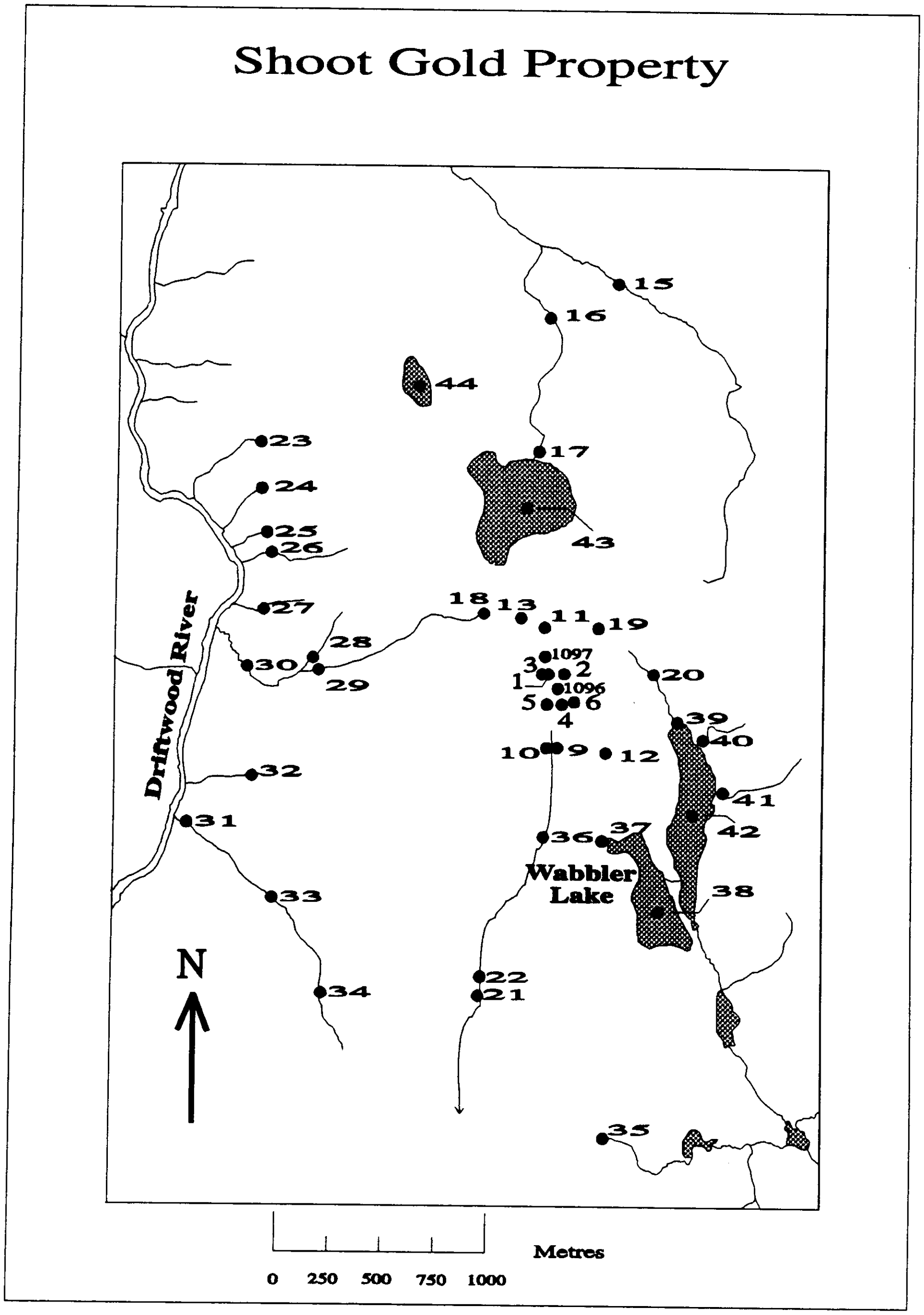
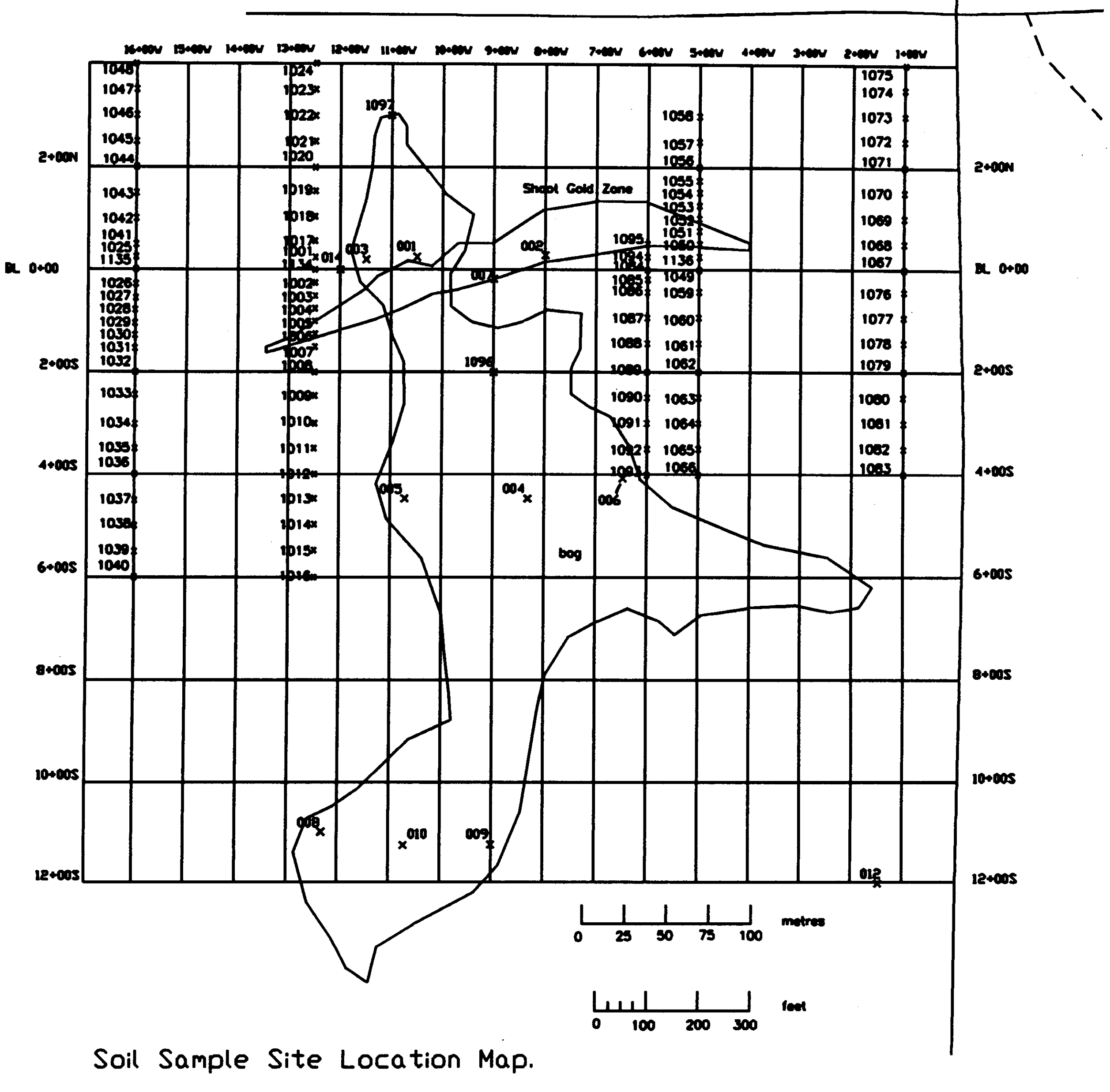
APPENDIX V

SAMPLE SITE LOCATION PLANS

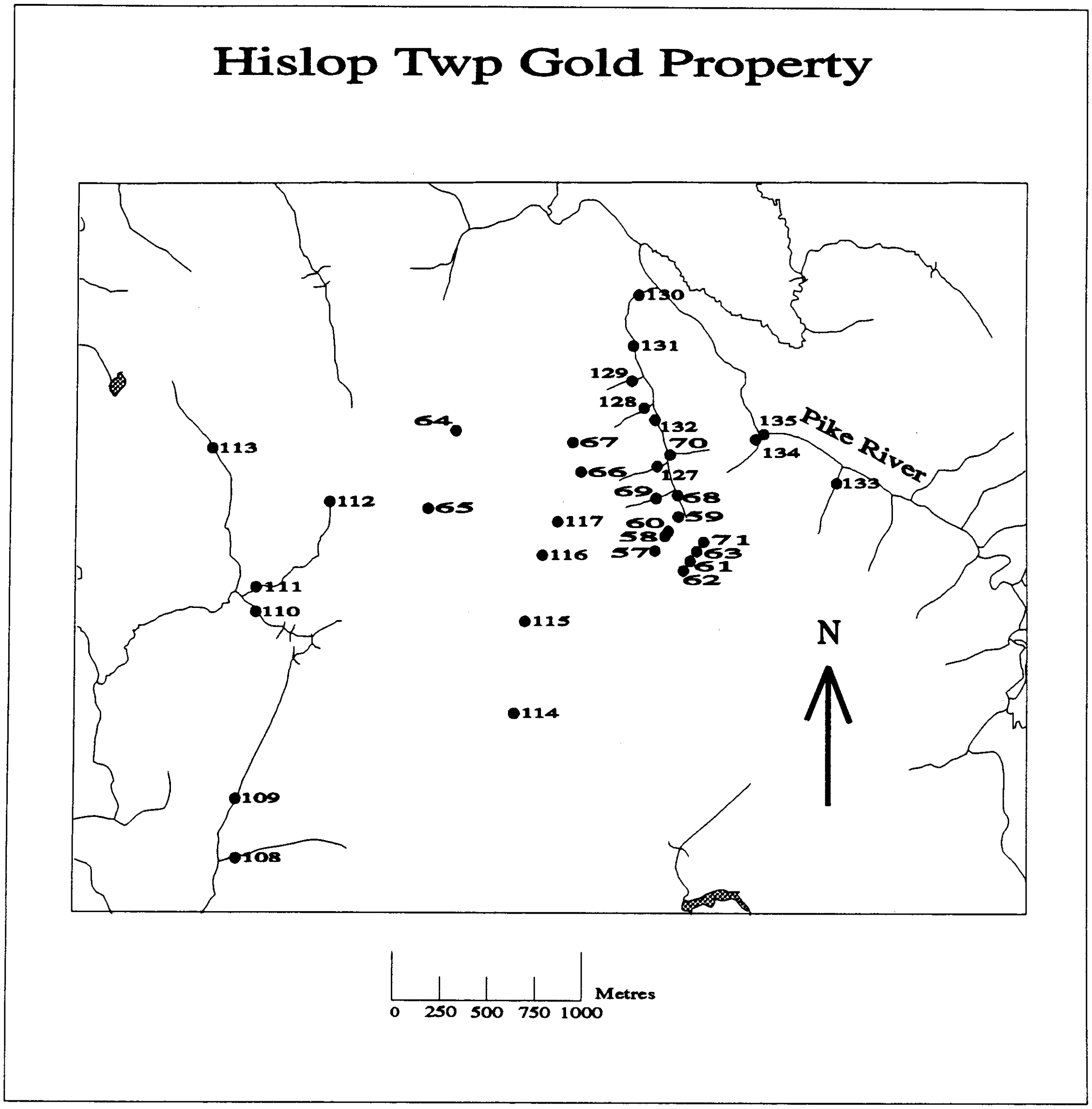


Drainage Sample Site Location Map.

Shoot Zone Grid

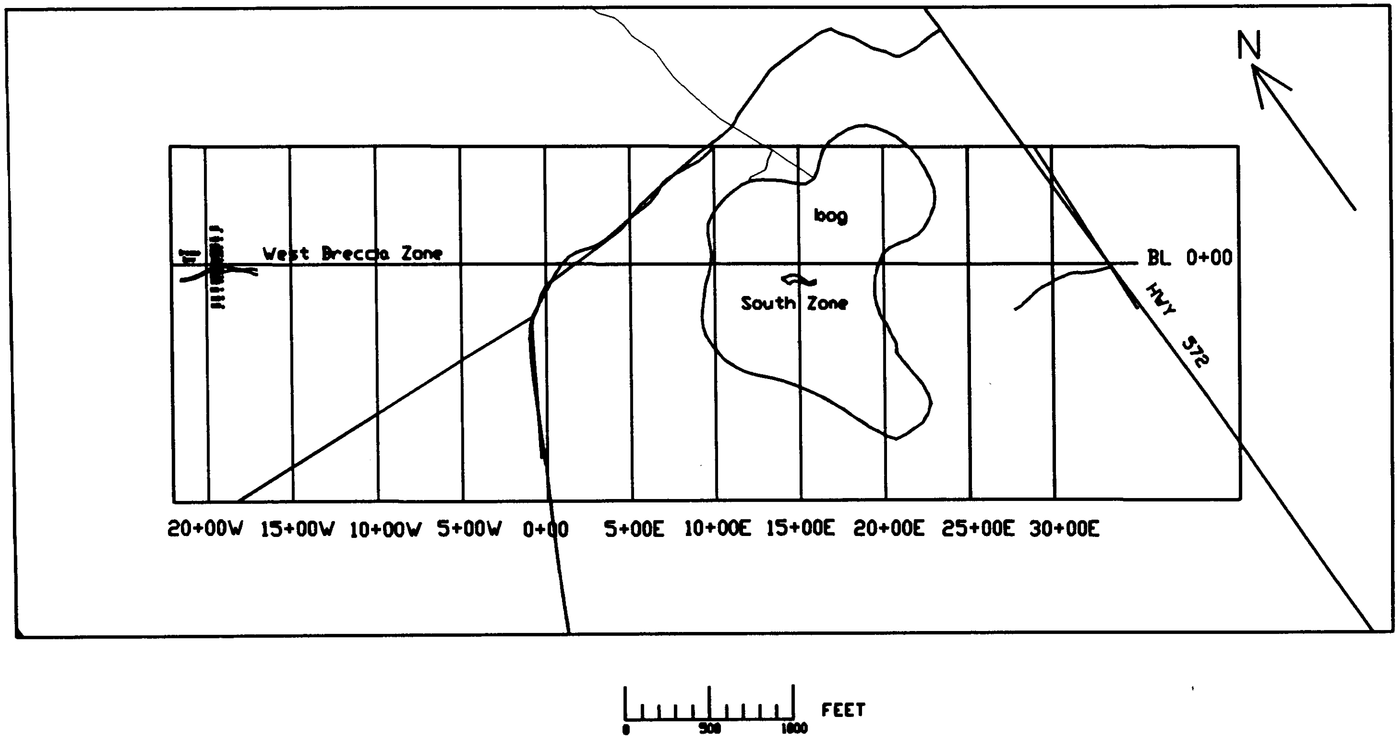


Soil Sample Site Location Map.

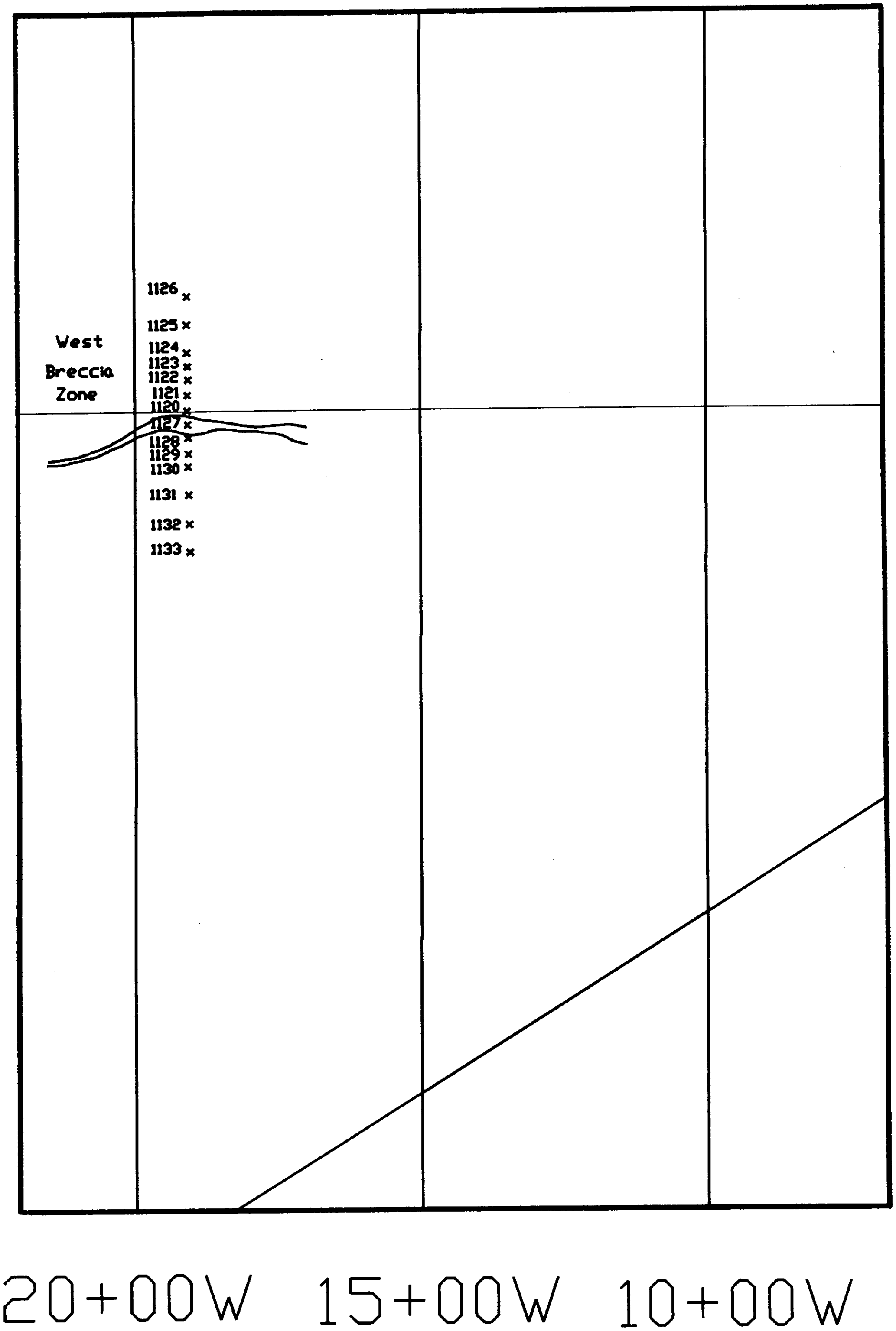


Drainage Sample Site Location Map.

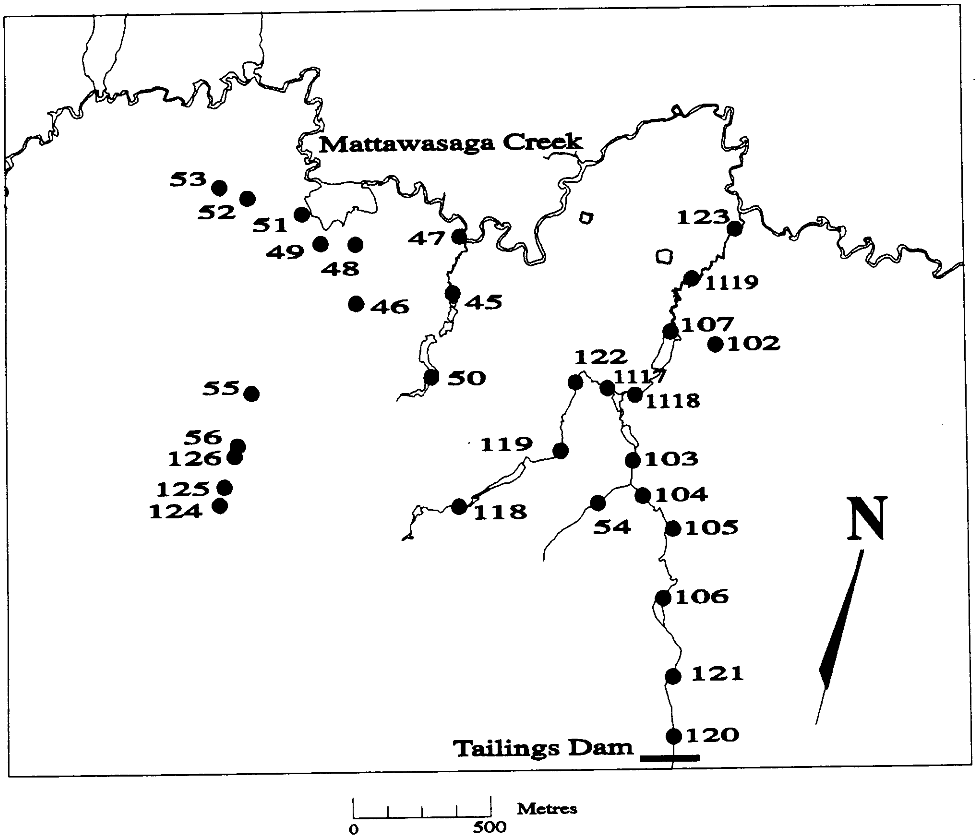
Hislop Grid



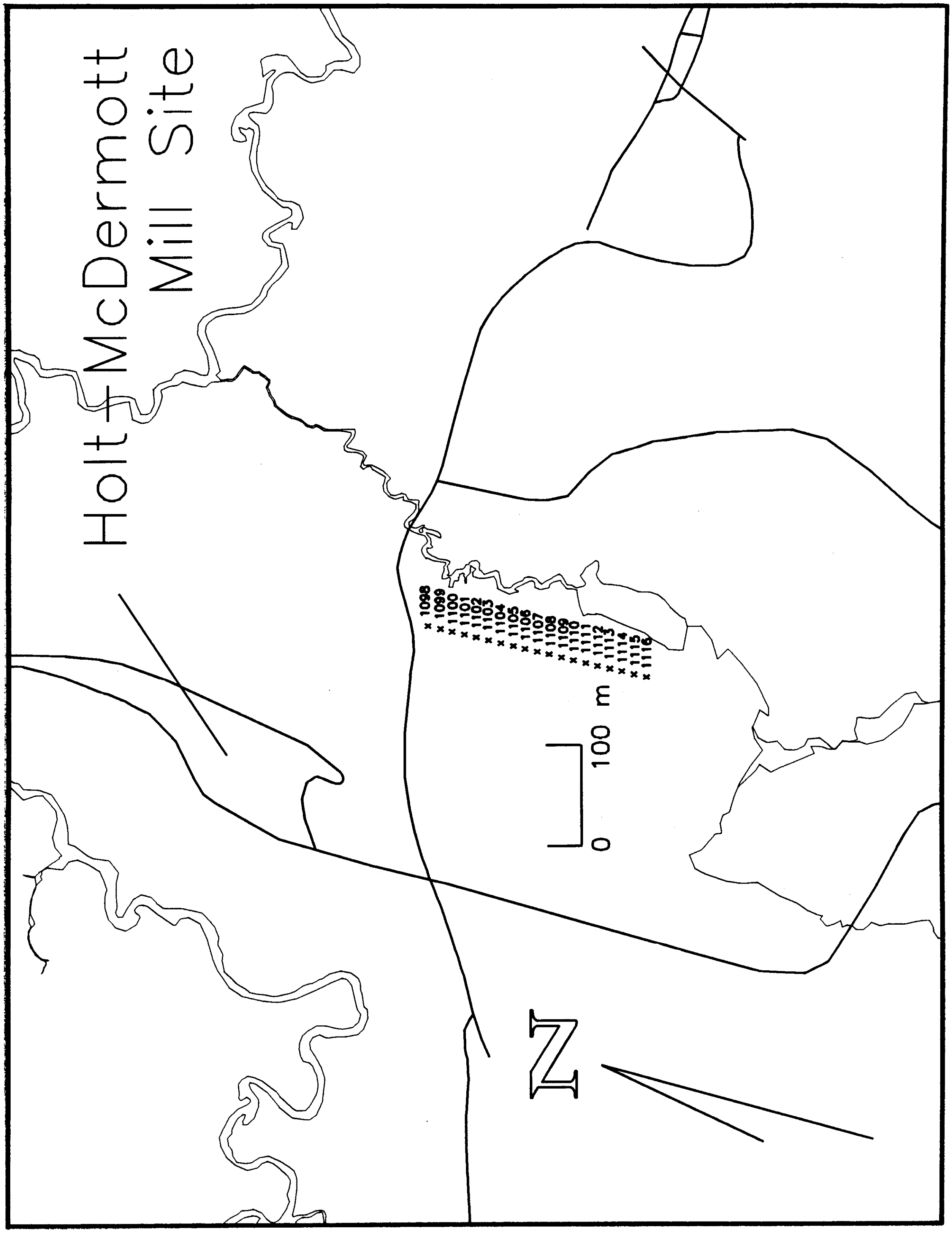
Soil Traverse Location Map


West
Breccia
Zone
1126
1125
1124
1123
1122
1121
1120
1127
1128
1129
1130
1131
1132
1133
20+00W
15+00W
10+00W

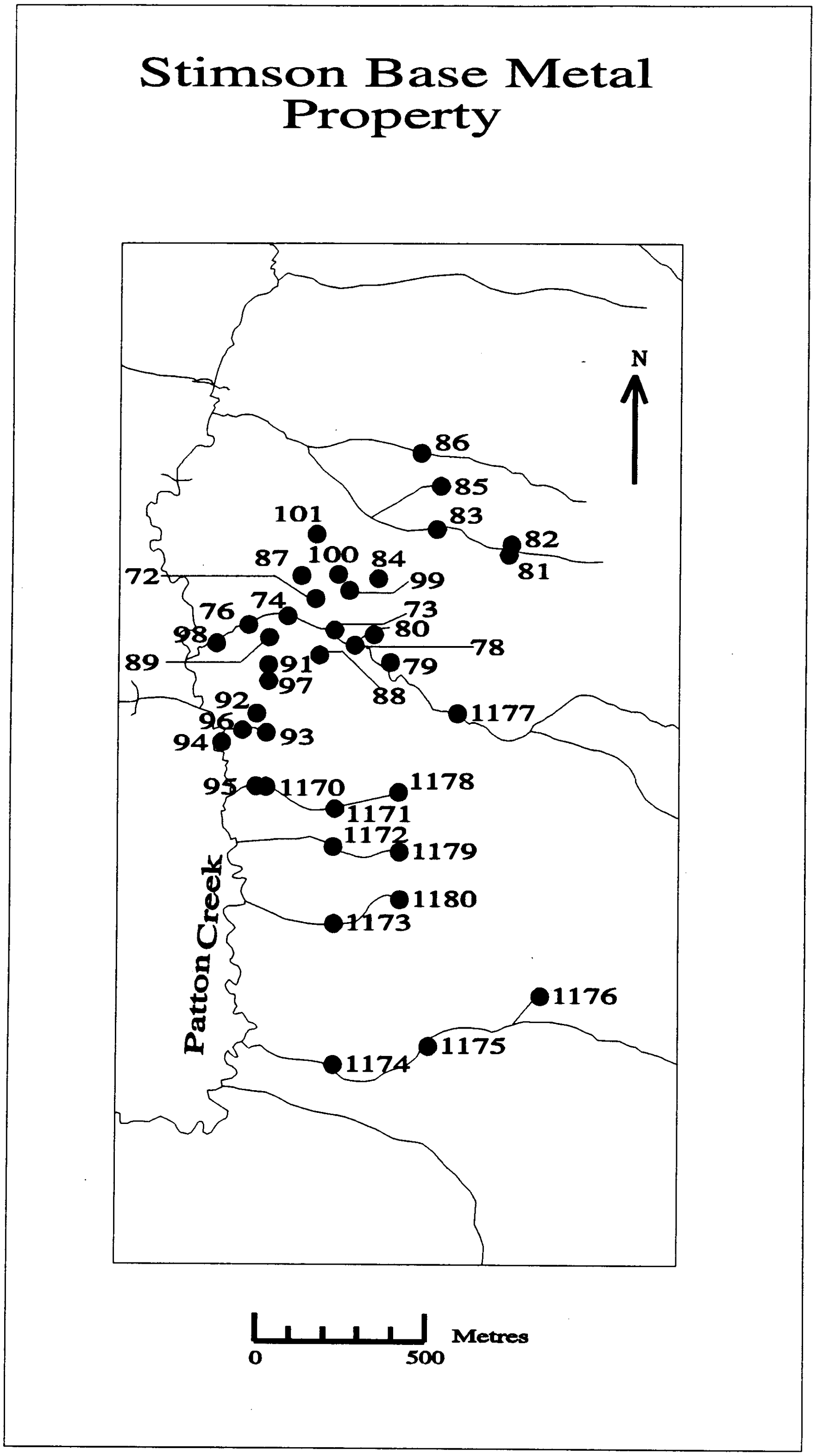
Holt-McDermott Gold Property



Drainage Sample Site Location Map.



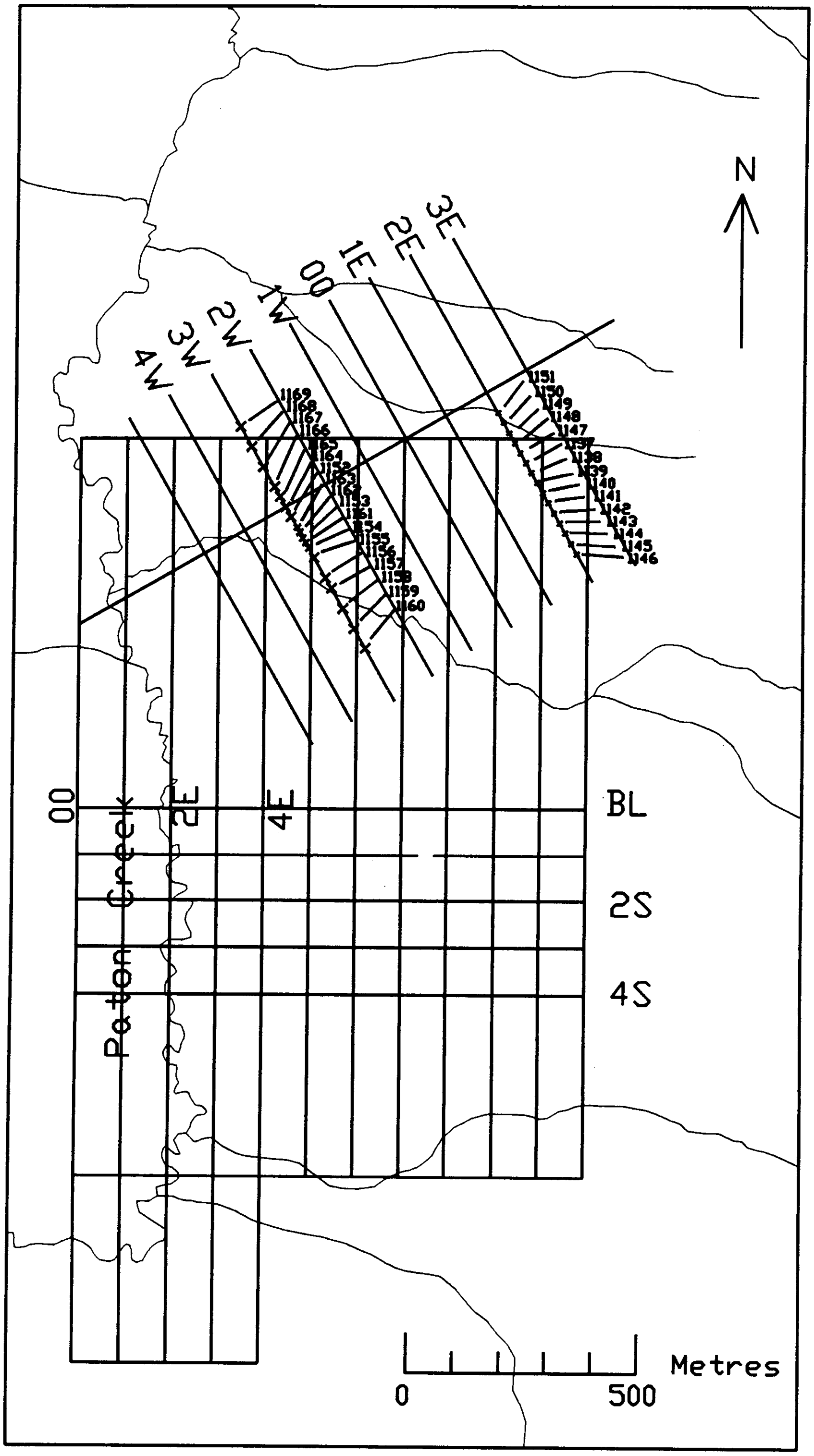
Holt-McDermott Mill Site



Stimson Base Metal Property

Drainage Sample Site Location Map.

Stimson Base Metal Property



Soil Sample Site Location Map

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			**Conversion from Imperial to SI**		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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