Open File 1089

SUDBURY TIMMINS ALGOMA MINERAL PROGRAM

PROJECT 3

LITHOGEOCHEMISTRY OF HURONIAN SUPERGROUP, BRUCE MINES AND WHITEFISH FALLS AREAS, NORTHERN ONTARIO

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$7.00

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SUDBURY, TIMMINS, ALGOMA MINERALS PROGRAM (STAMP)

The Sudbury, Timmins, Algoma Minerals Program was announced in Sudbury September 17, 1983, with the objective of stimulating mineral exploration and economic development in the region. It was initiated by the Department of Energy, Mines and Resources and supported by Employment and Immigration Canada. The program was designed and implemented by the Geological Survey of Canada in collaboration with Mineral Policy Sector. The individual projects were managed by the Department of Geology, Laurentian University, Sudbury, under the Chairman, Dr. A.E. Beswick. Field operations began in early October and continued into December. Following an eight-week extension, the Program terminated on May 25, 1984.

The Program comprised four projects with the following objectives:

Project 1 - Mineral Data Base (CANMINDEX)

- to collect, code and enter basic information on mineral occurrences in north-central Ontario into the Geological Survey of Canada data bank (CANMINDEX file); to provide information on these occurrences to the Ontario Geological Survey in their file format, and update information for the EMR (Mineral Policy Sector) National Mineral Inventory System; and to compile available rock geochemical data.

Project 2 - Swayze Belt Overburden Geochemistry

- to identify target areas for mineral exploration by geochemical sampling and analyses of overburden materials (eskers) in the Chapleau-Foyleyet-Gogama area.

Project 3 - Huronian Supergroup Geochemistry

- to define target areas with anomalous metal concentrations in Huronian sedimentary rocks in the Sault Ste. Marie-Sudbury region.

Project 4 - Rock Chemical Mineral Exploration Criteria

4A: to identify lithogeochemical criteria useful for mineral exploration in the Onaping Formation of the Sudbury Basin.

4B: to determine variations in rock geochemistry of major units of the Temagami Greenstone Belt and their relationships with mineralization.

The numbers and titles of the Geological Survey of Canda Open Files reporting results of these projects are listed on the back cover of this report. A description of the STAMP program, which includes overall co-ordination and administrative support, will be published in Current Research, Part A, GSC Paper 85-1A in January 1985.

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INTRODUCTION

Project 3 of the Sudbury-Timmins-Algoma Mineral Program was initiated to identify and define potential target areas with anomalous metal concentrations in the upper Huronian sedimentary rocks between Sault Ste. Marie and Sudbury (Figure 1). In particular, we were interested in the possibility that placer and diagenetic gold concentrations could occur in the Lorrain Formation. The Lorrain bears some resemblance to gold-bearing strata of the Welcom Gold Field in South Africa and is known to contain placer-related gold concentrations in the area northeast of Sudbury (Colvine, 1981; Long, Leslie and Colvine, 1982). The boundary between the Lorrain Formation and the stratigraphically overlying Gordon Lake Formation is known to contain sedimentary-hosted, stratabound, copper mineralization between Elliot Lake and Sault Ste. Marie (Pearson, 1980).

The main objectives of the project were a) to analyse and interpret trace element data from the Lorrain Formation in terms of regional variations, stratigraphic control, and relationship to easily recognized lithological characteristics such as heavy mineral and pebble beds; b) to evaluate the trace element variations across the Lorrain-Gordon Lake Formation boundary and compare them with geochemical data from a known area of copper mineralization at Stag Lake; and c) to delineate any anomalous concentrations of trace metals, particularly gold and copper, which might provide target areas for follow-up.

Rocks of the Lorrain and Gordon Lake Formations have extensive areal distribution; the regional lithogeochemical survey was restricted to the area outside the Cobalt Embayment (figure 1) as the latter area is currently being investigated by A. C. Colvine and D. G. F. Long. The regional sampling program was divided into two main parts, one covering the rocks between Sault Ste. Marie and Thessalon based out of Bruce Mines; the other covered the North Channel area from the Spanish River Indian Reserve to Killarney Park based out of Whitefish Falls. Several traverses were completed on the southeast portion of Killarney Park, and on the Long Lake Outlier.

Although the sampling programs were completed within the areas mentioned, several outliers north and east of Sault Ste. Marie and north of Sudbury were not sampled due to the approach of winter conditions. In the areas north of Elliot Lake, the Ontario Geological Survey had completed some preliminary stratigraphic sampling of the Lorrain Formation for gold; for this reason and the limited time available for the S.T.A.M.P. field program, this area was not included in the present study. However, samples of the Stag Lake copper prospect (figure 1) were obtained from diamond drill core stored at the Oontario Geological Survey Core Library in Sault Ste. Marie.

Previous Work

In a reconnaissance survey of the Lorrain Formation in the Cobalt Embayment, Colvine (1981) found values of gold of up to 1200 parts per billion (ppb) in the hematitic middle members of the formation. Background concentrations were consistently less than 2 ppb. Colvine attributed the high values of gold to possible placer concentrations of gold. He noted that the areal distribution of the unit and the conditions of sediment deposition bore a resemblance to Precambrian placer-gold deposits of similar-age in South Africa. In a sampled stratigraphic section through the Lorrain Formation north of Elliot Lake, Colvine (1983) found only low concentrations of gold. He attributed these low concentrations to the low levels of gold in the granitic provinance north of the area.

Aside from the present study, there have been no other published surveys to date on placer gold in this portion of the Huronian Supergroup, in the Sudbury-Sault Ste. Marie area. However, in the stratigraphically lower "Mississagi" Formation, Long (1981 and in press) attempted to determine if placer-gold concentrations could be related to specific sedimentary environments. This study indicated an association between median grain size (in the pebble conglomerate facies) and gold concentrations in the order of 100 to 300 ppb. Long found no other systematic relationships between gold and any of the other 23 elements and oxides analyzed. Long and Lloyd (1983) and Meyer (1983) examined the placer gold potential of the Elliot Lake Group (basal Huronian) between Sudbury and Sault Ste. Marie; while values of up to 4 parts per million (ppm) have been reported in the conglomerates of the Thessalon Formation (Colvine, 1983), the results of the regional studies are not yet available. The Gowganda Formation does not appear to contain any placer-related gold mineralization (Long and Lloyd, 1983).

A number of authors, including Clemmey (1981), Clemmey and Badham (1982), Long (1981 and in press), Mossman and Harron (1983), Long and Lloyd (1983) and Meyer (1983) have suggested that either diagenetic or metamorphic modification or remobilization of paleo-placers may be important mechanisms for reconcentrating gold in basal Huronian strata. Evidence cited is the presence of diagenetic pyrite (with disseminated gold), the presence of brannerite in conglomeratic zones, and the lack of magnetite and ilmenite in heavy mineral beds. Hematite-rich layers in the Lorrain Formation may likewise represent diagenetic alteration products of magnetite-ilmenite placers.

In summary, based on the previous work, it appeared that heavy mineral beds, pebble conglomeratic facies, and red beds were the most likely candidates for gold concentrations in the Lorrain Formation - either as detrital gold, or from later diagenetic modification.

A concise summary of the sedimentary-hosted copper mineralization at the Lorrain-Gordon Lake Formation transition is given by Pearson (1980). Pearson's study focused on sedimentary copper mineralization in the Desbarats area near Sault Ste. Marie, and the Stag Lake prospect north of Elliot Lake. At Stag Lake, up to 0.34% copper over 2.77 m was intersected in diamond drill holes by Sutherland and Associates (1965); in general it is of low grade but very extensive. Further along strike to the west in the Cobre Lake area, a similar type of mineralization has been intersected by Golden Shields Resources (Northern Miner, October 27, 1984), with chalcopyrite and pyrite occurring in a grey quartz arenite interbedded with red cherty mudstone of the Gordon Lake Formation. Some samples have returned anomalous values of gold up to 270 ppb.

Pearson (1980) noted that finely disseminated chalcopyrite and pyrite occurs in small sandstone lenses within the Gordon Lake Formation. However, most of the mineralization occurs finely disseminated within the upper 50-150 metres of the Lorrain Formation. He suggested that upward migrating, oxidized, copper-bearing solutions moved through the sandstones and were reduced as they neared the less permeable, overlying Gordon Lake rocks. He also suggested that the extensive strike length of the mineralization might be an indication that there was sufficient copper in the mineralizing solution, but insufficient reductants in the Lorrain and Gordon Lake Formations to form a higher grade deposit.

Chandler (1984) in a study of the macro-environment which hosts the sedimentary copper mineralization in the upper Huronian rocks, suggested that the mineralization occurs at the transition between fluvial (upper Lorrain Formation) and tidal marine (Gordon Lake Formation) conditions. Similar types of environments have been suggested for sedimentary copper deposits occuring in late Proterozoic rocks in the MacKenzie Mountains N.W.T. (the Redstone deposit), and early Proterozoic rocks of the Zambian Copper Belt in Africa.

GEOLOGICAL OVERVIEW AND SETTING

Geological mapping for the Espanola-Whitefish Falls section, the McGregor Bay - Bay of Islands area, and for the Sudbury - Manitoulin area were completed by Card (1976a, 1976b, 1976c). The Bruce Mines area was mapped by Frarey (1977), and additional mapping to the east of Sault Ste. Marie was completed by Bennett (1982) and by Chandler (1973). North of Elliot Lake, in the Wakomata lake and Rawhide Lake area, geological mapping was completed by Siemiatkowska (1977-78), and by Wood (1975).

The sedimentary rocks of the Huronian Supergroup have been generally interpreted in terms of a series of glacial - sedimentary cycles consisting of basal paraconglomerates and tillites, followed by marine sedimentary facies, and topped by sandstones (figures 2 and 3). Frarey and Roscoe (1970) believed that these cycles represent periods of glacial advance followed by retreat, marine transgression, and uplift with concomitant continental sedimentation resulting from isostatic rebound and exposure of cratonic source areas. The Lorrain Formation would reflect the closing of one such cycle represented by the Cobalt Group. More recently, the Huronian Supergroup together with other Proterozoic sedimentary and volcanic rocks in the Lake Superior region have been tentatively interpreted in terms of an aulacogen (Young, 1983).

Following sedimentation and lithification, the rocks underwent periods of igneous, metamorphic and tectonic activity, which Card (1978) has subdivided into a period of pre-Nippissing deformation and low-grade metamorphism thought to be concurrent with the emplacement of the Creighton and Murray plutons (ca. 2200 Ma). This was later followed by intrusion of Nipissing diabase at about 2150 Ma., and later by the main metamorphic - tectonic event (Penokean Orogeny, ca. 1900 Ma.) which resulted in isoclinal folding of the strata and up to low amphibolite grade metamorphism in the Whitefish Falls - Killarney area. In the Bruce mines area, this event was characterized by sub-greenschist to greenschist facies metamorphism accompanied by gentle, open folding. In the Sudbury-Manitoulin area, further deformation and low grade metamorphism occurred after the emplacement of the Sudbury Irruptive (ca. 1840 Ma.) which resulted in some retrogressive metamorphism of the earlier-metamorphosed Huronian rocks. This event is thought to have occurred between 1600 and 1800 Ma. and correlates well with the emplacement of the Grenville Front Plutons (ca. 1730-1800 Ma) and the Cutler Batholith (ca. 1750 Ma).

LOCAL GEOLOGY

Bruce Mines Area

The structure of the Huronian rocks in the Bruce Mines area is dominated by the Thessalon Anticline (figure 2, Maps 2 and 3), which is an upright, concentric fold plunging gently westward. The Murray Fault, trending west northwest through the area, separates the rocks encompassed by the Thessalon Anticline from the Echo Lake homocline north of the fault. The homoclinal strata strike west-northwest and dip south to southwest at less than 45 degrees. In general, the Huronian rocks north of the fault have been dropped down by up to 1500 metres relative to those on the south side, bringing into juxtaposition either the Lorrain and Gordon Lake Formations, or the Lorrain and Gordon Lake Formations with the Gowganda Formation.

The Lorrain Formation has been subdivided by Frarey (1977) into six lithstratigraphic members (figure 4). A basal arkose member (14a) is characteristically pink, massive, and medium-to fine-grained, with few sedimentary structures. The unit appears to become more mafic-rich towards the base, and in the upper portion it has conspicuous rusty disseminated spots within the Desbarats area. Disseminated chalcopyrite and specular hematite were also observed within this area. Overlying the arkose just within the Desbarats area is a purple ripple-marked siltstone which constitutes the second member (14b).

The lower red quartzite member (14c) is pink to red, coarse-grained, and pebbly to conglomeratic with abundant cross-bedding (both planar and trough cross-beds). Pebble conglomerate beds occur throughout the unit and are generally less than 15 cm thick extending up to 30 metres over the exposed length of outcrop. Pebbles consist of jasper and white quartz less than 2 cm in size and contained in a poorly sorted quartz matrix (photo 5) which in places is dark due to disseminated hematite or specular hematite. Dark, thin beds of specular hematite and hematite (photo 1) extend over a distance of up to 30 metres in outcrop. These thin beds contain zircon interspersed within specular hematite (photo 6). It may be that the hematite represents an alteration of magnetite or ilmenite from what were originally heavy mineral 'black sands'.

The jasper pebble conglomerate member (14d) consists of pebble beds ranging from 5 centimetres to 2 metres thick and extending up to 30 metres over the exposed outcrop (photo 2). The pebbles beds are interbedded with coarse-grained white quartzite. Pebbles of jasper, chert, and white quartz comprise from 20 to 40% of the conglomerate beds and are contained in a coarse-grained white quartz matrix. Locally the matrix is dark due to disseminated hematite or specular hematite.

The upper red quartzite member (14e) is medium-to coarse-grained, pebbly, and characterized by planar and trough cross-bedding. Beds containing up to 60% jasper and quartz pebbles, range from 5 to 25 cm in thickness and extend from 5 to 10 metres. A more prominent characteristic of the member is the presence of dark, hematitic and pebbly beds up to 8 cm thick, which extend up to 10 metres over exposed outcrop. Thin specular hematite laminations occur at the tops of foresets and at the base of trough cross-beds (photo 3). The quartzite in places is discolored grey to purple by disseminated specular hematite.

The upper white quartzite member (14f) consists predominantly of medium-to coarse-grained, white quartzite, in places grey and purple from disseminated specular hematite and hematite. Pebble beds are most common in the lower portion and contain a few small red jasper pebbles. Purple to grey hematitic beds 2-10 cm thick extend over 60 metres, and hematized pebbly quartzite beds up to 30 cm thick extend up to 25 metres. In some areas, the bedding surface of the upper member contains concentric sedimentary features resembling ´stromatoforms´ (photo 4) which occur at the same stratigraphic position as ripple marked quartzite. Similiar features have been noted in the hematitic sandstone member of the Lorrain Formation in the Wakomata Lake area by Siemiatkoska (1977).

The transition between the Lorrain and Gordon Lake Formation is almost completely hidden by overburden in the Bruce Mines area with the exception of a rock cut on highway 638 near Leeburn. Generally, the basal part of the Gordon Lake formation consists of closely interbedded purple to brown siltstone, fine-grained quartzite, and buff, grey and light-green chert (photo 7). Intraformational conglomerate consisting of chert fragments is common. Beds of siltstone and chert range from less than 2 cm up to 30 cm and are continuous over long distances. Disseminated pyrite is interspersed in the rocks. The road cut on highway 638 exposes a ´lens´ of Gordon Lake ´sandwiched´ between beds of white quartzite (photo 8) which suggests an interfingering relationship between the two formations in this area and not a distinct contact. A white quartzite bed immediately below the interbedded chert and siltstone appears bleached and contains disseminated purple spots of hematite. Above normal metal values were encountered in this bed.

Whitefish Falls - Killarney Area

In the Whitefish Falls - Killarney area, Huronian sedimentary rocks have undergone penetrative deformation, folding, and metamorphism up to amphibolite grade. The rocks form the tightly folded, east-west trending La Cloche syncline (figure 2) which is refolded about an east-west fold axis forming the MacGregor Bay anticlinorium. The Gordon Lake formation occurs at the axis of the La Cloche syncline and is generally poorly exposed, occupying the valley between resistant hills of Lorrain.

The Lorrain Formation has been subdivided into six lithostratigraphic members by Card (1978), (figure 5). During the course of the present survey, the basal silty sandstone member was not clearly distinguished from the overlying feldspathic sandstone member.

The feldspathic sandstone member (15e) is characteristically pink to red, massive, and medium-grained with numerous coarse-grained sections of graded beds. The unit also contains sections with scattered, well-rounded quartz pebbles, and narrow pebble beds with quartz pebbles up to 1 cm in size. Cross-beds, ripple marks, narrow heavy mineral bands, and disseminated pyrite were observed throughout the unit.

The green micaceous sandstone member (15d) is light-green, medium to coarse-grained, and contains numerous pebble beds ranging in thickness from 4 to 24 cm. the round to sub-round pebbles consist mainly of quartz with an average long axis of about 2 cm and commonly exhibit elongation and stretching parallel to the bedding. Graded beds and cross-beds occur infrequently. Some sections contain disseminated pyrite, disseminated specular hematite, heavy mineral bands, and hematitic banding and spotting.

The hematitic (ferruginous) sandstone member (15c) is characteristically pink to red with numerous pebble beds and lenses up to 1.2 metres thick. The angular to rounded pebbles are commonly elongate with a length to width ratio of about 2:1. The pebbles are predominantly quartz with the occasional jasper and chert pebble. Generally the pebbles are tightly packed and contained within a dark matrix (photo 9). Heavy mineral beds and cross-beds with heavy mineral concentrations along with disseminated specular hematite and hematitic banding occur throughout the unit (photo 10). A penetrative fabric is well-developed in the unit, and kyanite is common in the rocks (photos 11 and 12).

The white aluminous sandstone member (15b) is a medium-grained, white sandstone displaying graded beds, ripple marks, and cross-bedding. Pebble beds composed mainly of quartz and some chert have an average thickness of about 3 cm. Some sections contain disseminated pyrite or are stained by hematite occurring as spots and bands.

The upper orthoquartzite (cherty) member (15a) is a monotonous, fine-grained, almost pure white quartzite containing infrequent cross-beds and ripple marks. Some sections have scattered pebbles and disseminated pyrite.

The Gordon Lake Formation (16) is a closely interbedded, commonly finely-laminated rock consisting of sandstone, siltstone, and chert. It is generally brown with some medium to dark grey and green sections. Ripple-marked bedding and disseminated pyrite are common throughout the unit. Disseminated specular hematite, hematitic patches, and magnetite were also observed. As in the Bruce Mines area, the rocks weather recessively resulting in poor exposure of the Lorrain Formation boundary.

SAMPLING AND ANALYSIS

Sampling

Field work consisted of sampling the rocks of the Lorrain and Gordon Lake Formations along traverses cutting across the stratigraphic sequence. Hand-size samples were collected from heavy mineral beds and pebble beds, as well as from representative background samples of the formations. An effort was made to sample at least two traverses per township. In the less accessible areas of Whitefish Falls and Killarney the sample spacing along traverses ranged from a few metres up to 75 metres. This resulted in a distribution of the data which emphasises stratigraphic control. In the Bruce Mines area where access is good and the strata dip gently, the sampling was done at a spacing ranging from 20 up to 200 metres. The more homogeneous sampling density results in a distribution of the data which reflects both a stratigraphic and facies influence.

In the Bruce Mines area, sample locations were plotted on 1:20,000 and 1:63,360 airphotos in the field, and a brief description of the rock was logged for future reference. A 1:50,000 location base map was kept up-to-date on a daily basis. In the Whitefish Falls area, sample locations were plotted on 1":1/4 mile O.G.S. preliminary maps and similar field procedures were maintained.

Several drill holes from the Stag Lake copper prospect were sampled at the Geological Core Library in Sault Ste. Marie. Core samples of the mineralized Lorrain and Gordon Lake formation were taken on both sides of the contact at a spacing of about 1.5 metres. A rock-cut on highway 638 near Leeburn, which exposes the Lorrain-Gordon Lake formation boundary (figure 1), was sampled along three detailed sections spaced about 50 metres apart, with a sample spacing of about 30 centimetres.

All samples were split using a hydraulic rock splitter and a portion was retained for crushing. The other portion is temporarily stored at the Department of Geology Laurentian University, and will be available for future investigation. The first part of the sample preparation consisted of crushing the samples to a 1-3 centimetre size using a rock crusher with steel plates. In the second part, the crushed material was milled to minus 200 mesh using a tungsten carbide "shatter box". Drill core samples fron the Stag Lake prospect were split into two groups consisting of sulfides and silicates and crushed seperately in order to avoid inter-sample contamination. Use of the tungsten-carbide shatter box resulted in cobalt contamination of the samples.

Analysis

Samples were analysed for Cu, Ni, Zn, Pb, Au, Mn, and Fe by atomic absorption spectrophotometry at the Department of Geology, Laurentian University. Analytical procedures are detailed in a separate report by P. Lavoie (Appendix 3). Samples from the Stag Lake prospect and from the stratigraphic section and highway 638 road cut in the Bruce Mines area were analysed by atomic absorption spectrophotometry on partially digested samples at the Department of Geology, Queen´s University.

Aside from the analytical controls maintained by the lab further checks were imposed on the analyses by inserting a series of duplicates into each batch at regular intervals. As well, 17 samples straddling the range of concentration of the elements were sent to X-ray Labs for analysis using the Double Coupled Plasma Emission Spectrophotometric technique. Gold was analysed by neutron activation. Results show excellent correlation between DCP and AA for all elements except gold which showed poor correlation between NAA and AA (Table 1), and iron was not diluted and re-analysed by X-ray labs resulting in a lower assay.

The poor correlation between analytical techniques for gold and as well, between duplicates, reflects the fact that the adequacy of the analytical approach is dependent on the collection of a representative sample and the subsequent analysis of a representative subsample (Nichol, 1984). If the gold is fine-grained, and is distributed homogeneously throughout the rock, then a small sample will likely reflect that of the whole outcrop. However, if the gold particles are large and their distribution is heterogeneous - as might be expected from machanical dispersion, this would result in a "nugget effect", and gold values may range from nil to extremely high. A large sample then would be required to adequately represent the gold content of the rock. This has been quantitatively summarized by Tourtelot (1968). The selection of heavy mineral beds and pebble beds was intended to circumvent this problem somewhat, since these beds would in effect act as pre-concentrators for gold. However, based on the lack of correlation between duplicate analyses of gold, it would appear that in many cases a hand-size sample does not provide enough "sample representivity" and in future a larger proportion of the rock should be sampled and analysed.

TABLE 1: Correlation Coefficients between elements analysed by Double Coupled Plasma Emission Spectroscopy (DCP) and Neutron Activation Analysis (NAA) at X-ray Labs, Toronto, and Atomic Absorption (AA) at the Department of Geology, Laurentian University.

Element	Correlation Coefficient	Analysis X-Ray Labs	Analysis Laurentian
Copper	0.968	DCP	AA
Nickel	0.908	DCP	AA
Zinc	0.994	DCP	AA
Gold	0.213	NAA	AA
Manganese	0.992	DCP	AA
Iron	0.632	DCP (undiluted sample)	AA

Data Presentation

Anomalous geochemical values for the elements analysed are plotted on both 1"=1/4 mile base maps and as computer plots on approximately 1:250,000 maps showing the U.T.M. co-ordinate grid (Appendix 1). The detailed maps are useful for future field work and in identifying specific anomalous samples, whereas the computer plotted maps are useful in displaying regional trends or patterns, and can also be used to represent transformed data, element ratios, etc., which would otherwise be extremely time consuming.

The trace element concentrations for each sample are listed in Appendix 4. Included in the data are four variables (V1,V2,V3,V4) which represent selected field information which has been numerically coded in order to perform various selections on the data set. Locations for each sample point are given in U.T.M. co-ordinates along with a ´color-code´. Statistical analysis of the data were carried-out on the DEC-20 computer at Laurentian University using the Statistical Package for the Social Sciences (S.P.S.S.). Computer plots were made using the Tektronix 4247 system. The geochemical data from Stag Lake, and that from the stratigraphic section and road cut on highway 638 in the Bruce Mines area were statistically processed at Queen´s University using Q´G.A.S. (Queen´s Geochemical Analysis System) and the data set is listed in Appendix 4.

RESULTS AND DISCUSSION

Background and Threshold Determinations

Cummulative percent versus probability plots of log-transformed trace element data indicate that all the elements analysed can be subdivided into several populations (figures 6 and 7). In all cases there is a "background" population, and either one or more above background populations. In defining the class intervals for each element (lithogeochemical anomaly maps 1 to 5, separate map folder), an effort was made to stay above the "background" population. As well, only those samples with values greater than X + 2S (the mean + two standard deviations from the mean) are considered to be significantly anomalous. The lowest class intervals generally represent a high background for the second population.

Gold and Copper

The average gold content of the rocks in the Bruce Mines and Whitefish Falls areas is 4.5 and 5.3 ppb respectively. The range of values observed fall within the same general range as those from other sections of the Huronian Supergroup (ie. "Mississagi" Formation, Table 2). In a large proportion of the samples from the region, gold is not detectable. Of those samples containing greater than 0 ppb, the frequency distributions indicate a "background" population ranging from 1 to 25 ppb and above background populations greater than 25 ppb (figure 6), and in both the Bruce Mines and Whitefish Falls areas the population distribution patterns are similar.

TABLE 2: DESCRIPTIVE STATISTICS FOR PROJECT III

TOTAL DATA FILE: 2189 SAMPLES

	RANGE	MEAN	STANDARD DEVIATION
CU	0-5605 PPM	14.3	140.7
NI	0-428 PPM	16.3	23.3
ZN	0-149 PPM	4.1	11.3
AU	0-250 PPB	4.5	15.9
MN	0-1997 PPM	43.7	160.2
FE	0-44.9 %	0.59	1.8

BRUCE MINES DATA: 972 SAMPLES

	RANGE	MEAN	STANDARD DEVIATION
CU	0-5605 PPM	23.9	202.2
NI	0-160 PPM	14.7	17.9
ZN	0-149 PPM	4.6	12.9
AU	0-197 PPB	3.5	14.3
MN	0-1997 PPM	47.6	165.9
FE	0-44.9 %	0.7	2.1

WHITEFISH FALLS DATA: 1217 SAMPLES

	RANGE	MEAN	STANDARD DEVIATION
CU	0-1820 PPM	6.7	53.2
NI	0-428 PPM	17.6	26.8
ZN	0-123 PPM	3.7	9.8
AU	0-250 PPB	5.3	17.0
MN	0-1801 PPM	40.7	155.4
FE	0-42 %	0.5	1.6

MISSISSAGGI FORMATION: 71 SAMPLES
(Statistics based on data from Long, in press)

	RANGE	MEAN	STANDARD DEVIATION
AU	0-350 PPB	39.2	66.9

The average copper content of rocks from the Bruce Mines and Whitefish Falls areas is 23.9 and 6.7 ppm respectively. In both areas the data comprise two main populations with similar frequency distributions but displaced due to the higher average copper values for the Bruce Mines area (figure 6).

Stratigraphic Control on the Distribution of Gold and Copper

The average gold content of the rocks is highest in the upper red quartzite member of the Lorrain Formation in the Bruce Mines area (figure 8, Table 3). The distribution of anomalous gold values and their continuity within this member (see Map E, Appendix 1, and the lithogeochemical anomaly maps 1-5 in separate folder), may reflect the presence of numerous heavy mineral beds which it contains. The heavy mineral beds have the highest average gold content of the lithologies sampled (see Lithologic Control on the Distribution of Gold and Copper). The other members of the formation have lower average gold with the exception of the lower arkose member. The high average gold content of the arkose could signify that, being the basal member of the formation, it represents a "source" rock for gold higher-up in the sequence. In the Whitefish Falls area, the variations in the average gold content between members of the Lorrain formation are not large and appear to be irregular.

The average copper content is greatest in the lower arkose member of the Lorrain Formation in the Bruce Mines area, and can be attributed to disseminated chalcopyrite in this member in and around Desbarats

TABLE 3: DESCRIPTIVE STATISTICS FOR GOLD AND COPPER

BRUCE MINES DATA: 972 samples

MEMBER	ELEMENT	RANGE		MEAN	STANDARD DEVIATION
LOWER ARKOSE	AU	0-160	ppb	6.9	22.4
(102 Samples)	CU	0-5605	ppm	108.1	580.1
LOWER RED QUARTZITE	AU	0-60	ppb	2.4	8.0
(248 Samples)	CU	0-315	ppm	9.3	25.8
JASPER PEBBLE CONGL.	AU	0-20	ppm	1.4	3.3
(74 Samples)	CU	0-370	ppm	14.5	50.3
UPPER RED QUARTZITE	AU	0-197	ppb	10.6	26.4
(103 Samples)	CU	0-60	ppm	4.1	9.2
UPPER WHITE QUARTZITE	AU	0-192	ppb	1.5	11.8
(331 Samples)	CU	0-200	ppm	6.9	19.1

HEAVY MINERAL BEDS (94 Samples)	AU	0-192	ppb	7.4	25.0
	CU	0-192	ppm	13.8	32.4
PEBBLE BEDS (191 Samples)	AU	0-87	ppb	2.2	8.2
	CU	0-370	ppm	8.4	32.2
PEBBLE BEDS WITH HEAVY MINERALS (94 Samples)	AU	0-62	ppb	4.4	12.0
	CU	0-49	ppm	3.6	6.5
UNCLASSIFIED SAMPLES (500 Samples)	AU	0-197	ppb	3.3	4.7
	CU	0-1650	ppm	19.1	93.6
GORDON LAKE FORMATION (111 Samples)	AU	0-43	ppb	2.7	19.1
	CU	0-1650	ppm	54.5	195.2
WHITEFISH FALLS DATA: 1217 Samples					
LOWER FELDSPATHIC--QUARTZITE (74 Samples)	AU	0-250	ppb	8.4	30.4
	CU	0-1820	ppm	33.2	211.1
GREEN MICACEOUS--SANDSTONE (230 Samples)	AU	0-88	ppb	4.8	11.2
	CU	0-69	ppm	4.5	6.8
HEMATITIC SANDSTONE (374 Samples)	AU	0-176	ppb	7.1	16.1
	CU	0-50	ppm	3.5	6.6
WHITE QUARTZITE (185 Samples)	AU	0-233	ppb	4.3	22.6
	CU	0-30	ppm	3.6	3.8
CHERTY QUARTZITE (218 Samples)	AU	0-203	ppb	1.9	14.2
	CU	0-50	ppm	4.1	7.6
HEAVY MINERAL BEDS (29 Samples)	AU	0-176	ppb	12.3	33.7
	CU	0-60	ppm	5.6	12.2
PEBBLE BEDS (441 Samples)	AU	0-74	ppb	5.0	11.9
	CU	0-69	ppm	4.0	6.9
PEBBLE BEDS WITH HEAVY MINERALS (70 Samples)	AU	0-250	ppb	11.2	32.2
	CU	0-30	ppm	3.7	6.0
UNCLASSIFIED SAMPLES (625 Samples)	AU	0-203	ppb	3.8	11.9
	CU	0-1820	ppm	8.7	73.6
GORDON LAKE FORMATION (109 Samples)	AU	0-70	ppb	6.5	11.5
	CU	0-120	ppm	10.1	18.7

(figure 8; Map B, Appendix 1). The high average copper content for the Gordon Lake Formation reflects the association of copper mineralization with the Gordon Lake Formation and with the Gordon Lake-Lorrain Formation boundary.

Lithologic Controls on the Distribution of Gold and Copper

Of the easily recognizable lithologic characteristics noted in the field, the highest average gold concentrations occur in the heavy mineral beds from both the Bruce Mines and Whitefish Falls areas (figure 8, Table 3). This is consistent with the original contention that "black sands" or heavy mineral concentrations were the most likely candidates to contain gold. The pebble beds from both areas, however, are unexpectedly quite low in their average gold content. Notably, pebble beds with heavy minerals have the second highest average gold content. It would appear that the pebble conglomerate facies does not represent as favourable an environment for concentrating gold as heavy mineral beds and pebble beds with heavy minerals.

No clear lithologic control is apparent on the localization of copper. The high mean copper content for unclassified samples (figure 8) simply reflects those values attributable to the Gordon Lake Formation in the Bruce Mines and Whitefish Falls areas. It remains unclear why the heavy mineral beds in the Bruce Mines area have an unusually high average copper content.

Nickel, Zinc, Manganese, and Iron

The high average manganese content of the rocks (figure 8, Table 2) reflects the fact that manganese, like iron, tends to occur in greater than "trace" amounts in most rocks (average abundance in the earth's crust is 950 ppm, Levinson, 1974). This is particularly true of the Gordon Lake Formation which was deposited in a marine to tidal marine environment and is well displayed in the regional distribution map for manganese in the Bruce Mines area (Map F, Appendix 1).

Three populations are evident in the iron data for both areas (figure 7). These appear to reflect the differences between red-bed and non-red bed members of the Lorrain Formation, as well as the heavy mineral beds and pebble beds with heavy minerals. The greater iron content in the rocks from the Bruce Mines area likely reflects the wider distribution of red bed lithologies and a greater number of exposed heavy mineral beds compared to the Whitefish Falls area.

Nickel data for both areas subdivides into two populations, with the "background" population in the Bruce Mines area having the greater mean. The second population is essentially the same for both areas. The average zinc content in the rocks in both areas is quite close, and this is also reflected in the frequency distribution pattern of the populations (figure 6). On the regional anomaly maps (Appendix 1), nickel, copper, and to some extent zinc have a similar distribution pattern and the anomalous values tend to concentrate in the Gordon Lake Formation.

Trace Elements across the Lorrain-Gordon Lake Formation Boundary

Analysis of the Stag Lake drill core samples indicates the expected anomalous concentrations of copper in the upper 100 to 150 metres of the upper white quartzite member of the Lorrain Formation (figures 9 and 10, photo 13). Above background gold values occur in some of the mineralized portions of the drill holes. Preliminary petrographic work indicates the presence of thin, graded, pyrite beds contained within the mineralized quartzites of the Stag Lake core (Photo 14), and may represent the "sulphidization" of ilmenite or magnetite "black sands". Replacement of ilmenite or magnetite by sulphides is a characteristic which has been cited in the literature as a possible fixing mechanism for gold (Mossman and Harron, 1983) and is one explanation for the gold distribution in these rocks.

At a road cut on highway 638 in the Bruce Mines area, anomalous concentrations of trace metals occur in the upper white quartzite member of the Lorrain Formation below a lense of interbedded siltstone, chert, and quartzite of the Gordon Lake Formation (Photo 8, figures 11 and 12). The anomalous metal content in these rocks are also significant in that they occur in the only good exposure of the contact that we found in the area; elsewhere the contact is covered by overburden. The close similarity in the geochemical profiles from Sections 1 and 2 (which are separated by about 50 metres), with those from the Stag Lake area indicates that there is potential for further mineralization along the Lorrain-Gordon Lake contact in the Bruce Mines area.

The quartzite exposed in the highway 638 road cut is uncharacteristic of the upper white quartzite member nearby, in that there is localized hematization and carbonatization of the rock. Furthermore, a widespread ´argillic´ alteration bleaches and overprints the earlier hematization, and is characterized by the replacement of matrix quartz by kaolinite. Neither of these alterations can be attributed to any obvious local source such as Nippissing diabase, although a large sill does occur about 1-2 kilometres to the northeast.

CONCLUSIONS AND RECOMMENDATIONS

The lithologic control of gold is evident in the heavy mineral bed data and to some extent in the data from pebble beds which contain heavy minerals. The high average gold content in the upper red quartzite member of the Lorrain Formation in the Bruce Mines area together with the presence of numerous heavy mineral beds in this member, indicate that stratigraphic control also plays a significant role on the localization of gold. However, this conclusion must be tempered by the fact that the maximum recorded values for gold from both areas are less than 250 ppb (0.007 oz/ton or 0.25 ug/g) which suggests that the sediments, being distal facies (figure 13), are not as conducive to placer-type gold concentrations as the more proximal facies represented by the outliers north of Sault Ste. Marie and Sudbury, and the Lorrain Formation in the Rawhide Lake-Wakomata Lake areas. The continuity displayed by anomalous concentrations of gold in the Bruce Mines area along traverses cutting across stratigraphic sections of the Echo Lake Homocline, signify the important influence which exposure of the red bed members and heavy mineral beds, particularly in the upper red quartzite of the Lorrain Formation, have on the gold distribution in the area.

Many isolated anomalies in both the Bruce Mines and Whitefish Falls areas can be attributed to diabase dikes or fracturing and shearing in the rocks (Appendix 2). However, in areas where a number of anomalous samples occur in close proximity, such as the anomalous metal values in the Desbarats area, they reflect the presence of mineralization (Pearson, 1980). This is particularly true in and around the road cut on highway 638, where not only were anomalous concentrations of trace metals encountered at the Lorrain-Gordon Lake Formation boundary, but as well, the stratigraphically overlying Gordon Lake Formation immediately to the south displays a significant concentration of trace metal anomalies.

An unexpected, but nevertheless significant, finding of our lithogeochemical orientation survey of the Stag Lake copper mineralization, has been the above normal background gold distribution in some portions of the mineralized upper quartzite member of the Lorrain Formation. The confirmation of high gold associated with sulphides leads one to have greater confidence in the possibility that chemical processes involving the "sulphidization" of magnetite or ilmenite ´black sands´ by hydrothermal solutions, result in the concentration of gold in pyrite and other sulphides (Mossman and Harron, 1983). The Lorrain-Gordon Lake boundary may therefore be a good target not only for copper mineralization, but also for diagenetic gold accumulations.

Further study is necessary in order to properly evaluate the effects of increased metamorphism on the trace elements in the rocks sampled, based on limited analysis of the data. It appears that the changes in average trace element content in the rocks from one area to another are not significant enough to be singularly attributable to an increase in the grade of metamorphism towards the east, and that the trace element concentrations reflect, for the most part, the original pre-metamorphic distribution.

Recommendations:

The recommended areas for follow-up are summarized in Table 4 and indicated on figure 1.

1) Follow-up detailed rock sampling and geological mapping is recommended for the mineralized Lorrain-Gordon Lake formation boundary exposed in a rock-cut on Highway 638 in the Bruce Mines area, and should include a two mile square area around the rock-cut. This would allow us to outline the limits of the known area of mineralization and provide us with a better understanding of the nature of the lithologic boundary in this area. The field work would require 2-3 weeks and employ a geologist and junior geologist/geotechnical assistant.

2) Exposure of the Lorrain-Gordon Lake formation boundary in the Bruce Mines area is poor, however, anomalous trace metal values are present at the one available exposure which was sampled. We therefore recommend that consideration be given to a study of the overburden geochemistry across selected areas of the boundary which are covered. In order to determine the characteristics of the overburden which best

TABLE 4: SUMMARY OF PROPOSED FIELD WORK, 1984

BRUCE MINES-SAULT STE. MARIE AREA	TIME (WEEKS)	MANPOWER REQUIREMENTS
1) Detailed lithologic sampling and geologic mapping, rock-cut Hwy. 638, near Leeburn.	2-3	1 Geologist 1 Junior geologist/geotechnical assistant
2) Overburden/soil geochemistry, Bruce Mines area.	6-8	1 Party Leader/Geologist 1 Senior geological/geotechnical assistant 2 Junior geological/geotechnical assistant
3) Lithologic sampling of Lorrain formation outliers north and east of Sault Ste. Marie.	2	1 Geologist 1 Junior geologist/geotechnical assistant
Requirements:	10-13	1 Party Leader/Geologist 1 Senior geological/geotechnical assistant 2 Junior geological/geotechnical assistants

ELLIOT LAKE-WHITEFISH FALLS-SUDBURY	TIME (WEEKS)	MANPOWER REQUIREMENTS
1) Regional lithologic sampling, Lorrain formation and Lorrain-Gordon Lake formation boundary, north of Elliot Lake.	8	1 Party Leader/Geologist 1 Senior geological/geotechnical assistant 2 Junior geological/geotechnical assistant
2) Lithologic sampling of the Lorrain -Gordon Lake formation boundary,	2-3	1 Geologist 1 Junior geological/geotechnical

Narrow Bay, Whitefish Falls area.		assistant
3) Lithologic sampling of the Lorrain formation outliers north of Sudbury.	2-3	1 Geologist 1 Junior geological/geotechnical assistant
Requirements:	12-14	1 Party Leader/Geologist 1 Senior geologist/geotechnical assistant 2 Junior geological/geotechnical
Total requirements for both areas:	10-14	2 Party Leaders/Geologists 2 Senior geologist/geotechnical assistants 4 Junior geologists/geotechnical assistants 1 Project Co-ordinator/Geologist

reflect the possible underlying mineralization, an overburden geochemical orientation survey should first be completed across or near-to overburden-covered, copper mineralization in the Cobre Lake and Stag Lake areas north of Elliot Lake. This could best be achieved with the co-operation of the exploration companies already prospecting in the area, and would also provide useful information to those companies which they could incorporate into their exploration strategies. The orientation survey would require at least 2 weeks, and the overburden sampling in the Bruce Mines area would require 4-6 weeks with a crew of 4 consisting of a party leader, a senior geological/geotechnical assistant, and two junior geological/ geotechnical assistants.

3) Completion of the regional lithogeochemical sampling of the Lorrain formation and the Lorrain-Gordon Lake formation boundary in the Rawhide Lake and Wakomata Lake areas. These areas were left incomplete during S.T.A.M.P. due to the onset of winter conditions. The gold potential of the Lorrain formation in these areas is still of interest since they may represent a proximal facies, and certainly, the results of the orientation survey on the copper mineralization in the area indicate that the Lorrain-Gordon Lake formation boundary is a good candidate for both sedimentary-hosted copper, and possibly for diagenetically introduced gold. The field sampling would require a minimum of four weeks for each area with a field crew of 4 consisting of one party leader, a senior geological/geotechnical assistant, and two junior geological/geotechnical assistants.

4) Good exposures of the Lorrain-Gordon Lake formation boundary which occur along Narrow Bay in the Whitefish Falls-Killarney area were not sampled during S.T.A.M.P. due to deteriorating weather conditions and remain to be completed. Field sampling would require 1-2 weeks with a field crew consisting of one geologist and one junior geologist/geotechnical assistant.

5) In addition to a sampling program in the Rawhide Lake - Wakomata Lake areas, outliers of Lorrain formation north and east of Sault Ste. Marie, and north of Sudbury, represent proximal facies of the Lorrain formation which we think stand a better chance of containing heavy mineral beds and pebble beds with higher gold content than those in the distal facies. Each of these areas appears to be characterized by paleo-valleys with fluvial systems closer to the source areas (the Wawa and Batchewana greenstone belts for the outliers north of Sault Ste. Marie, and the Swayze, Benny, and Abitibi greenstone belts for the outliers north of Sudbury, figure 13). Sampling of these areas could be completed by a geologist and geological/geotechnical assistant over a period of 2-3 weeks in each area.

6) It would also be of considerable interest to resample the upper red quartzite member of the Lorrain Formation in greater detail than previously attempted in order to reconfirm its´ above average gold content, and to delineate any significantly anomalous heavy mineral beds. Such a survey should be accompanied by a detailed sedimentological study of this member in order to focus on the sedimentary micro-environments most likely to contain concentrations of gold. This type of comprehensive survey would require a party leader-geologist, a sedimentologist, one senior geological assistant, and two junior geological or geotechnical assistants, who would complete the work over a period of 8 to 10 weeks. If financial support is limited, detailed lithogeochemical sampling of the upper red quartzite member of the Lorrain Formation in the Bruce Mines area should take precedence over the overburden geochemistry program previously mentioned, and if necessary, over the detailed lithogeochemical sampling of the rock-cut on Hwy. 638, and the "fill-in" sampling for several areas left incomplete during S.T.A.M.P. due to the onset of winter conditions.

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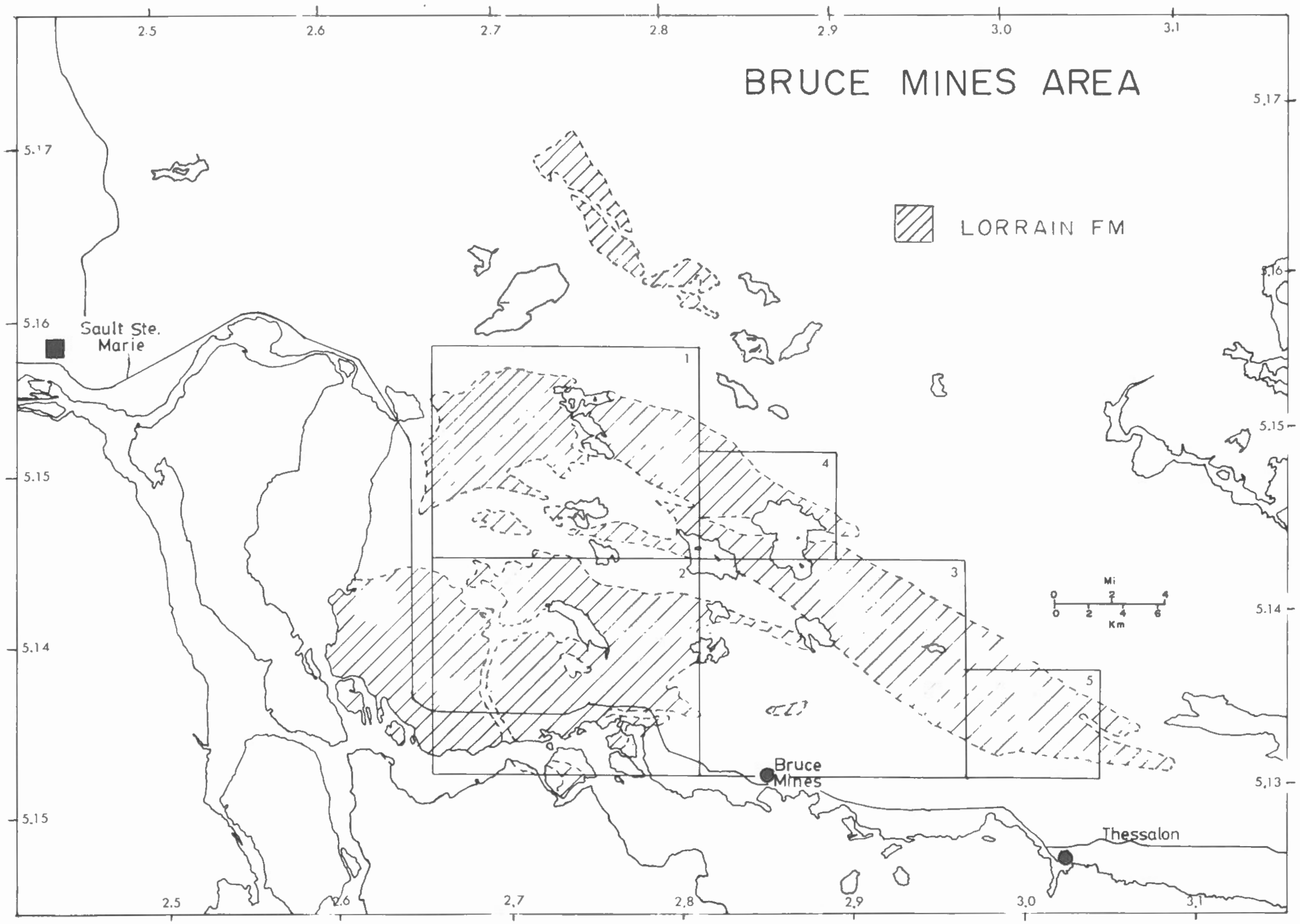
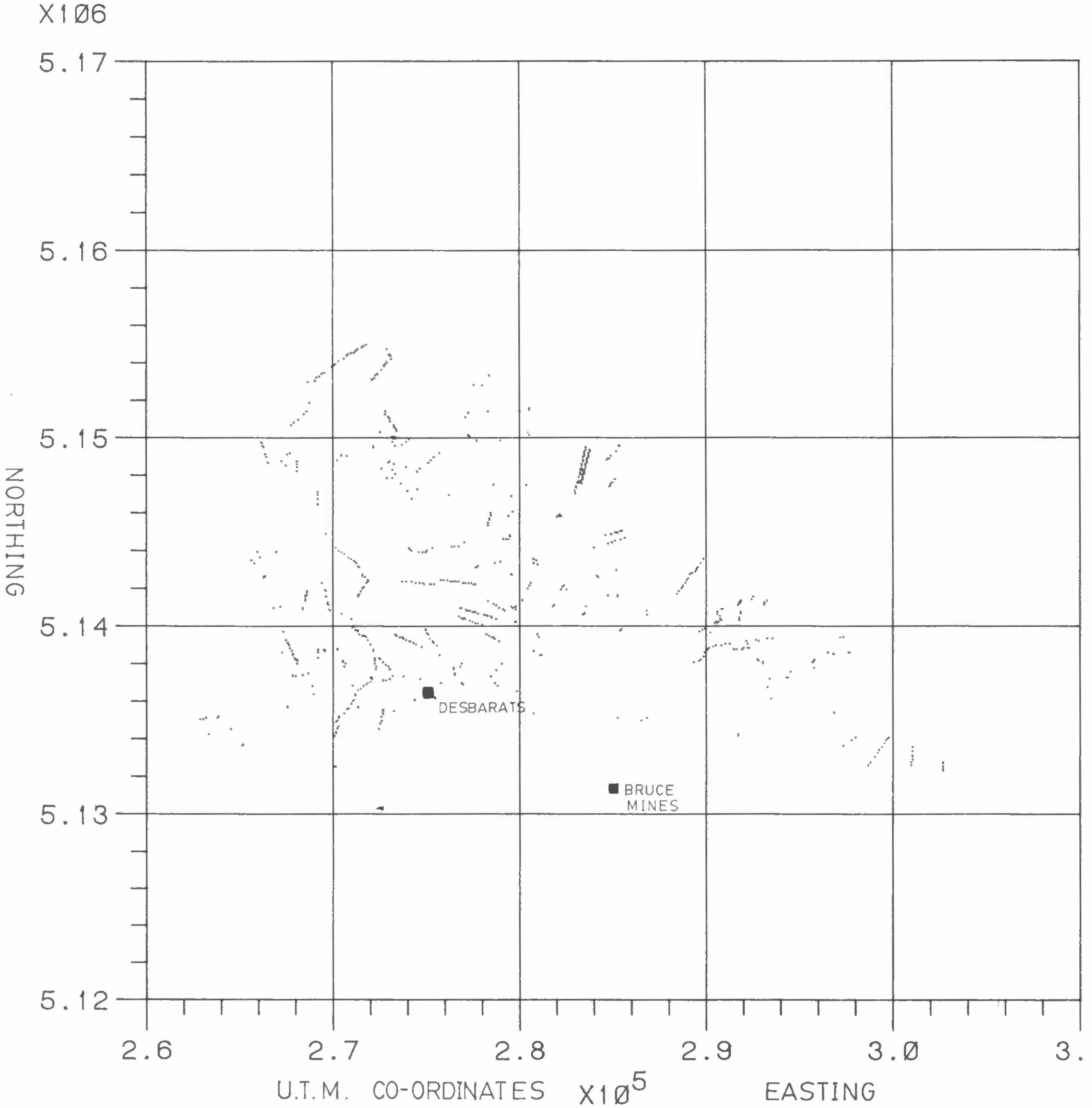
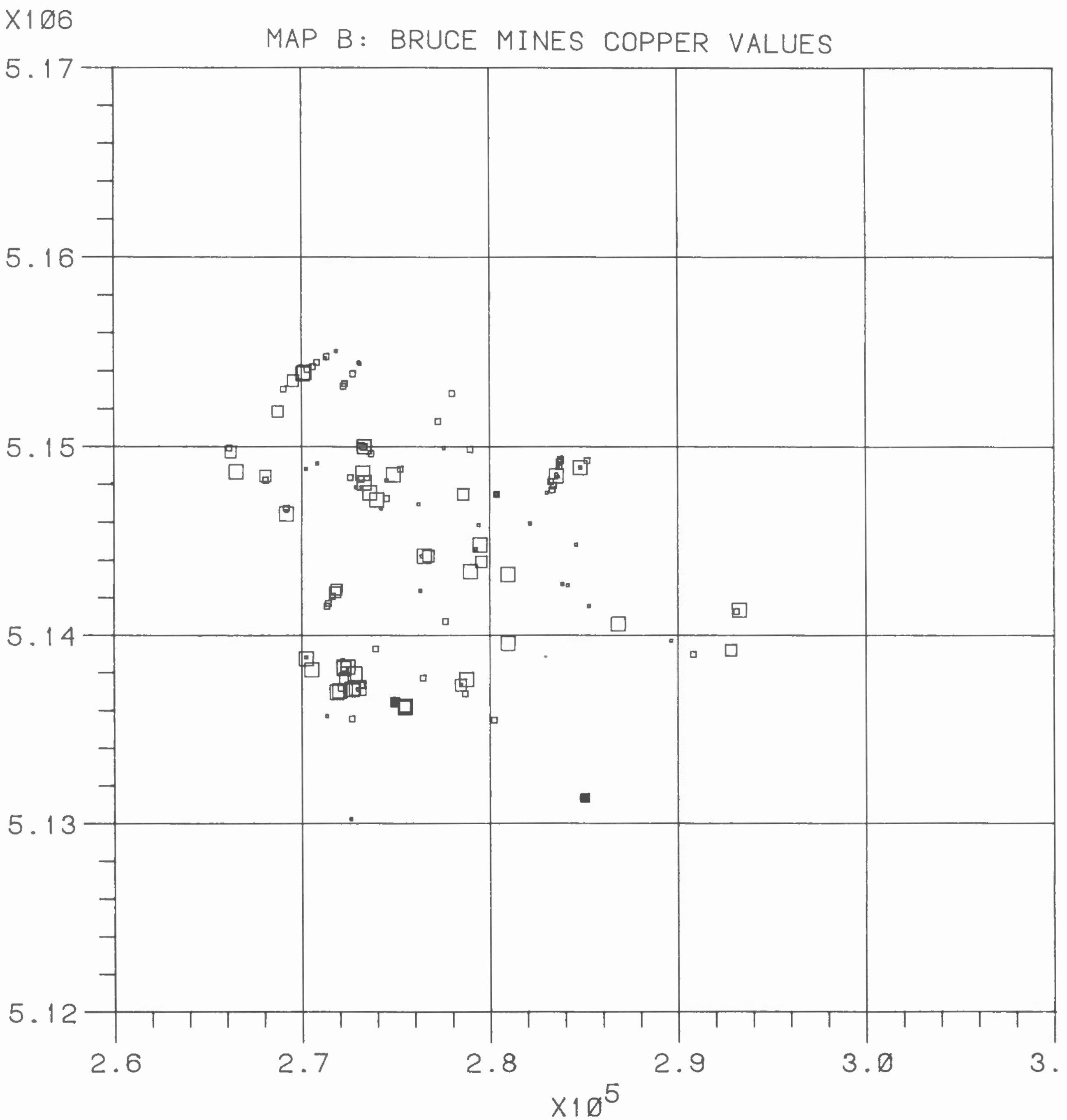
APPENDIX 1

Map	
-	Distribution of the Lorrain Formation in the Bruce Mineas area
A	Bruce Mines: Sample Locations
B	Bruce Mines: Copper
C	Bruce Mines: Nickel
D	Bruce Mines: Zinc
E	Bruce Mines: Gold
F	Bruce Mines: Manganese
G	Bruce Mines: Iron
-	Distribution of the Lorrain Formation in the Whitefish Falls area
H	Whitefish Falls: Sample Locations
I	Whitefish Falls: Copper
J	Whitefish Falls: Nickel
K	Whitefish Falls: Zinc
L	Whitefish Falls: Gold
M	Whitefish Falls: Manganese
N	Whitefish Falls: Iron


BRUCE MINES AREA
LORRAIN FM
Sault Ste. Marie
Bruce Mines
Thessalon
Mi
0 2 4
0 2 4 6
Km
1
2
3
4
5
2.5
2.6
2.7
2.8
2.9
3.0
3.1
5.17
5.16
5.15
5.14
5.13

MAP A: BRUCE MINES SAMPLE LOCATIONS



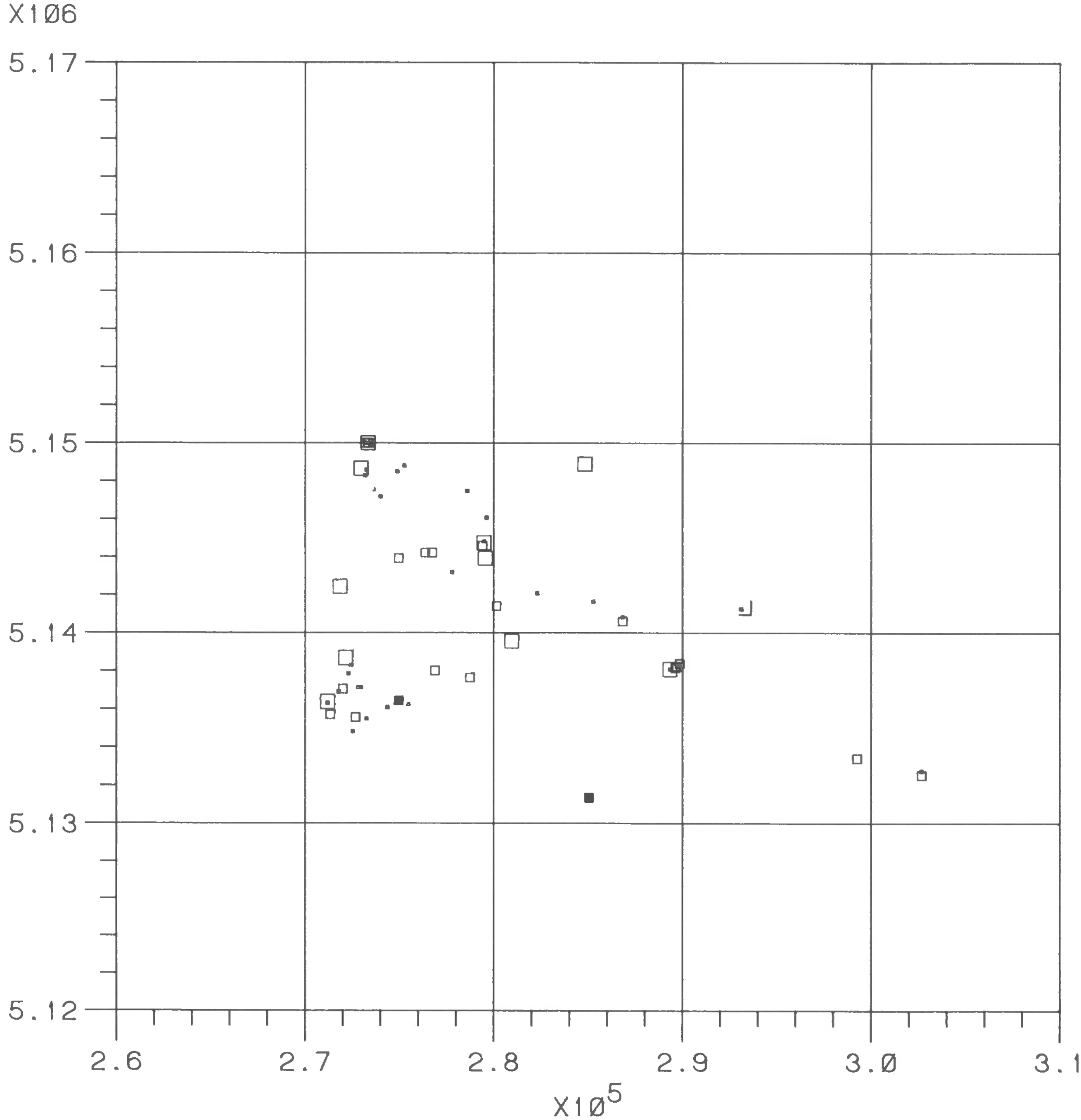


CLASS INTERVALS

10	25	ppm	(high background)
25	50	ppm	(possibly anomalous)
50	75	ppm	(probably anomalous)
	75	ppm	(definitely anomalous)

66 ppm = X + 2 S

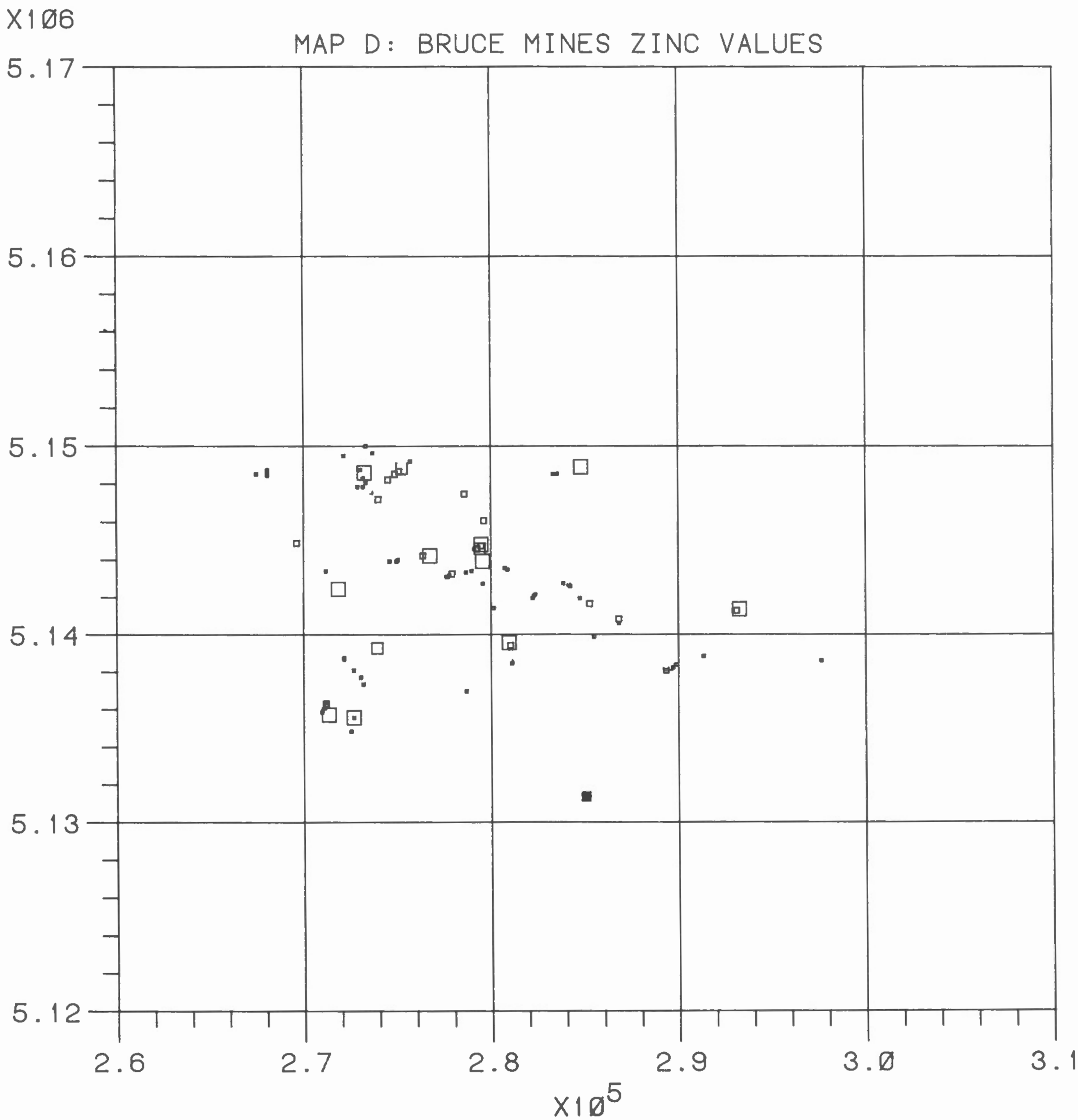
MAP C: BRUCE MINES NICKEL VALUES



CLASS INTERVALS

44 ppm = X + 2 S

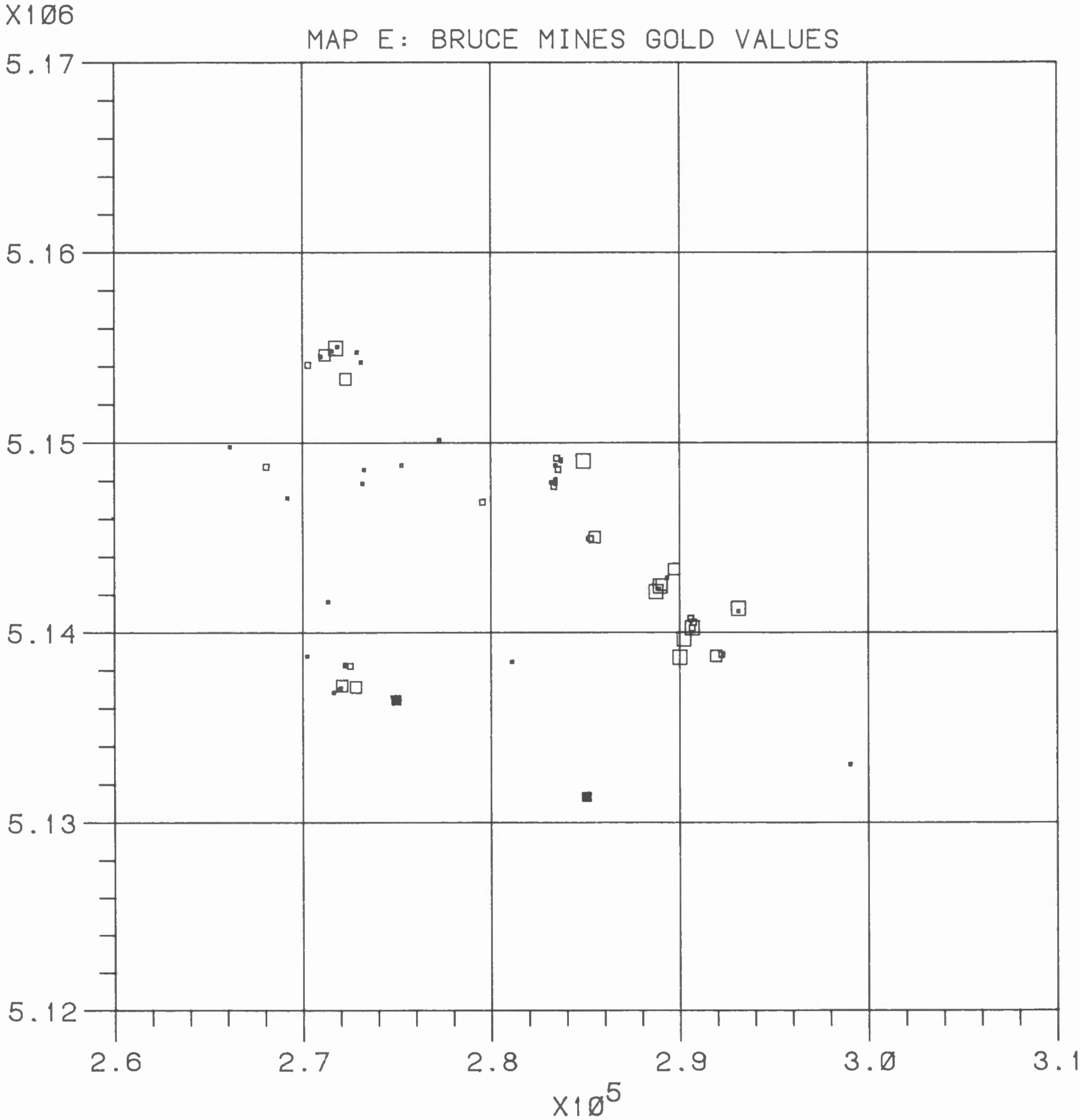
□	40	60 ppm	(high background)
□	60	80 ppm	(possibly anomalous)
□		80 ppm	(definitely anomalous)



CLASS INTERVALS

18 ppm = X + 2S

▫	10	25 ppm	(high background)
▫	25	50 ppm	(possibly anomalous)
□	50	75 ppm	(probably anomalous)
□		75 ppm	(definitely anomalous)

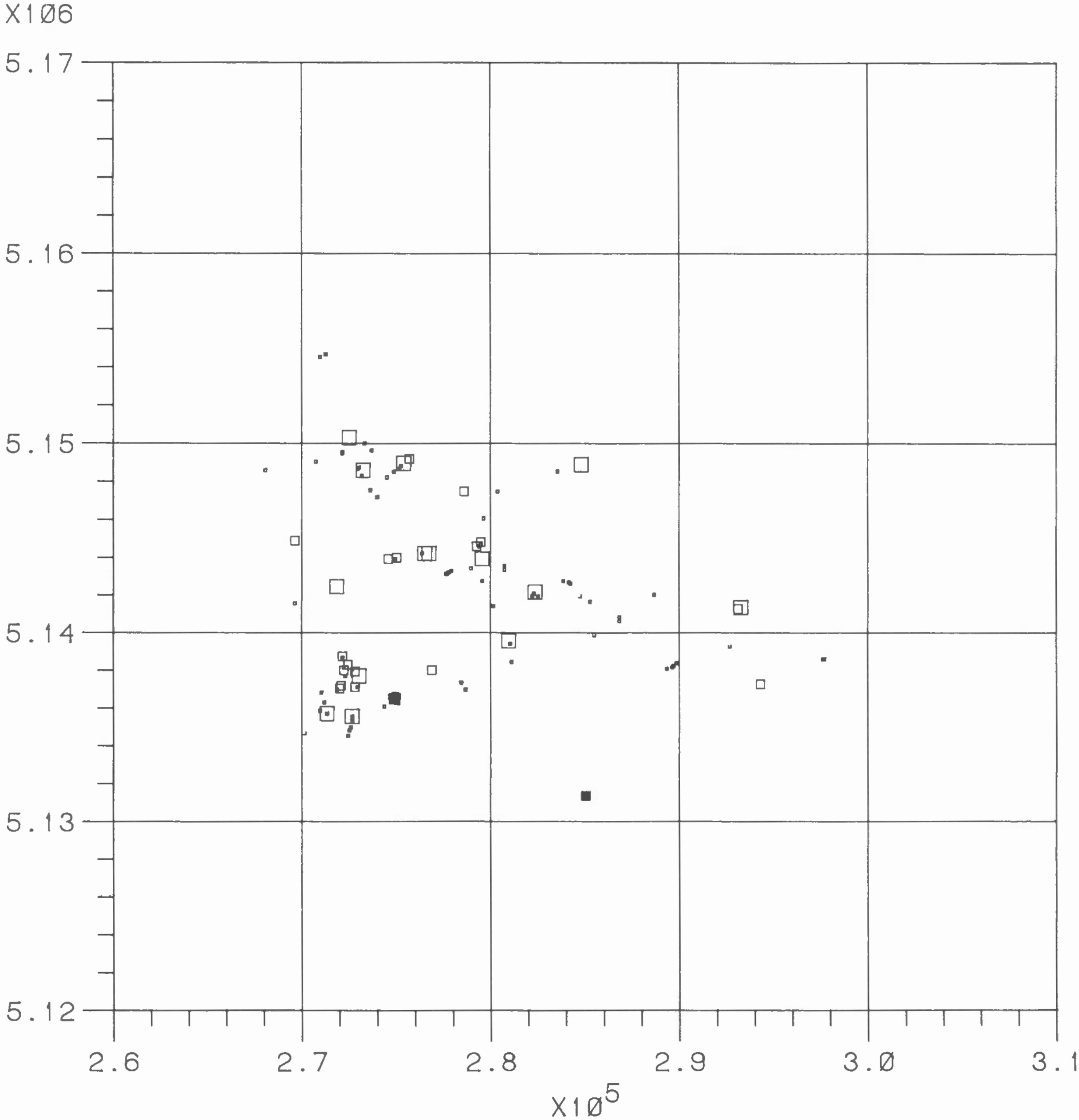


CLASS INTERVALS

17 ppb = X + 2S

▫	10	25 ppb	(high background)
□	25	50 ppb	(possibly anomalous)
□	50	75 ppb	(probably anomalous)
□		75 ppb	(definitely anomalous)

MAP F: BRUCE MINES MANGANESE VALUES

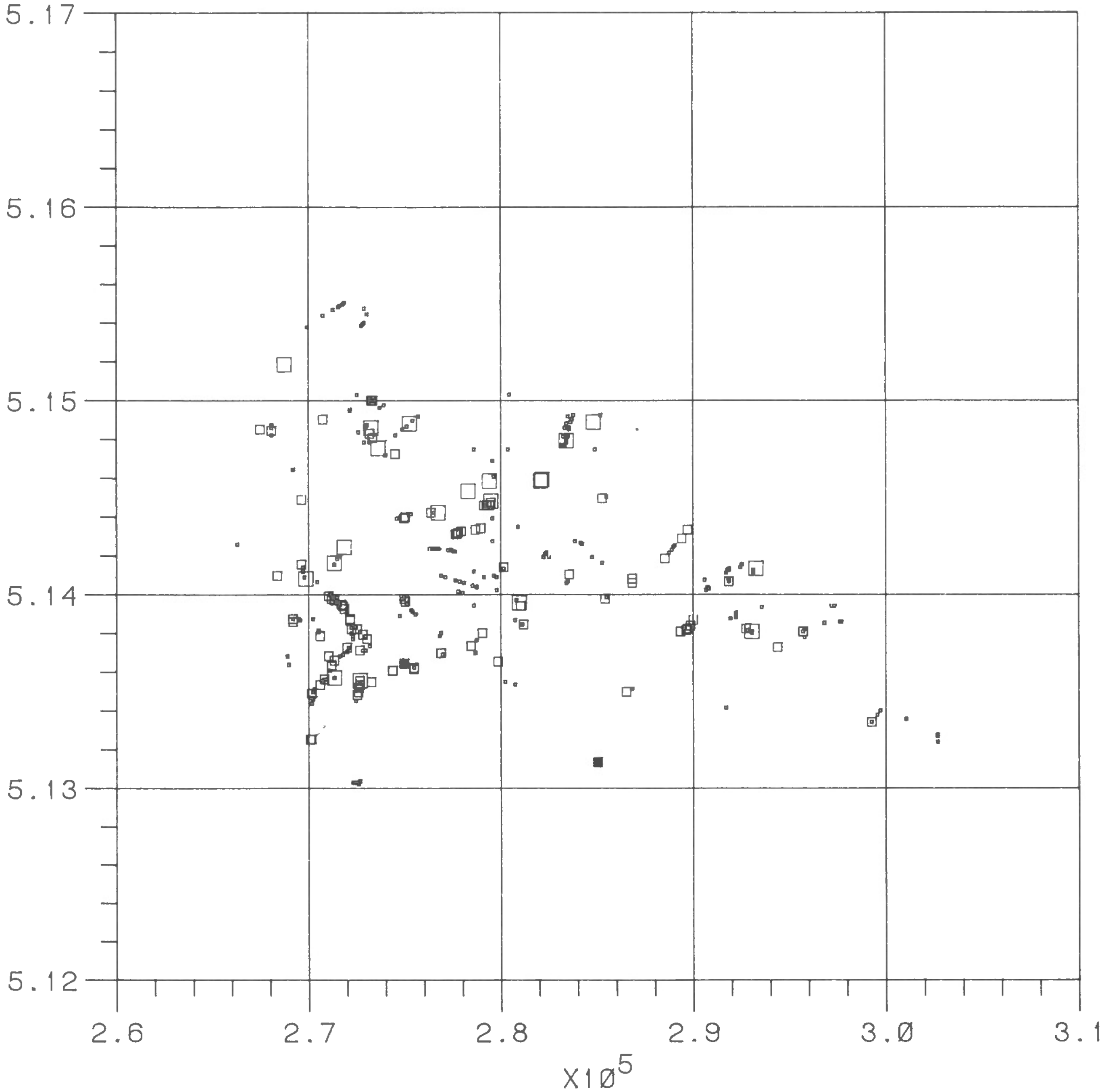


CLASS INTERVALS

140 ppm = X + 2 S

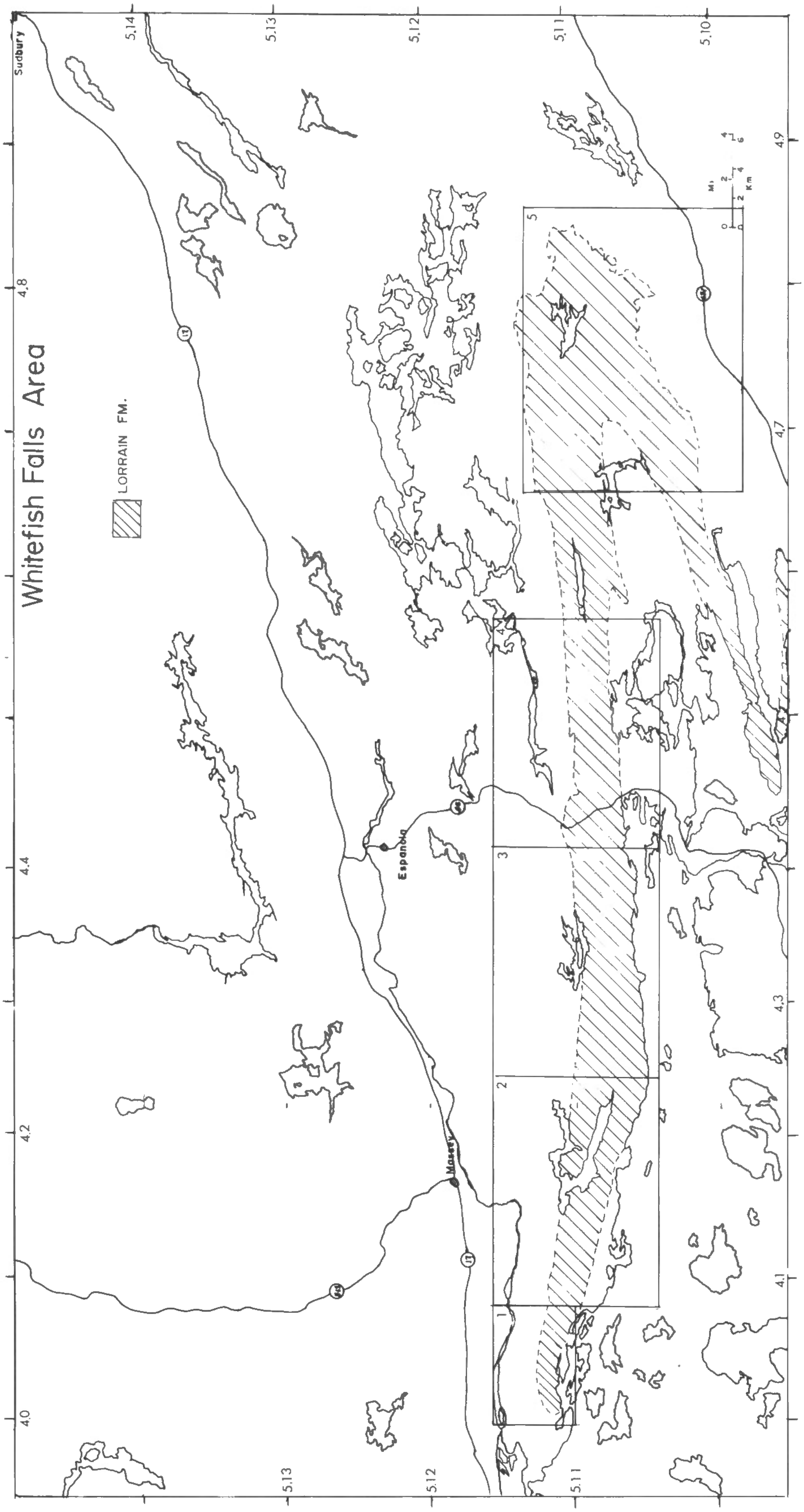
▫	100 300	ppm	(high background)
□	300 500	ppm	(probably anomalous)
□	500	ppm	(anomalous)

MAP G: BRUCE MINES IRON VALUES

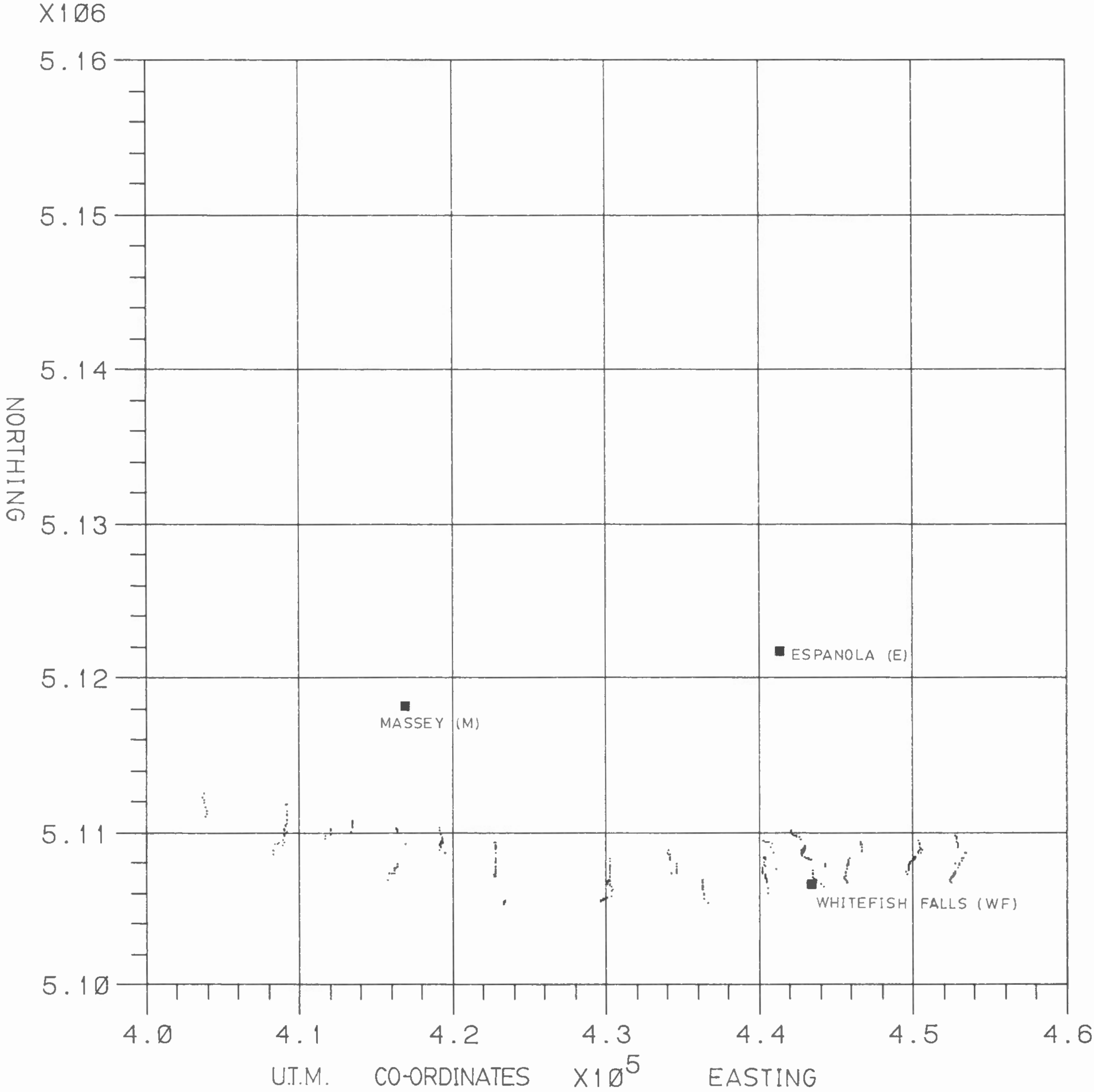


CLASS INTERVALS

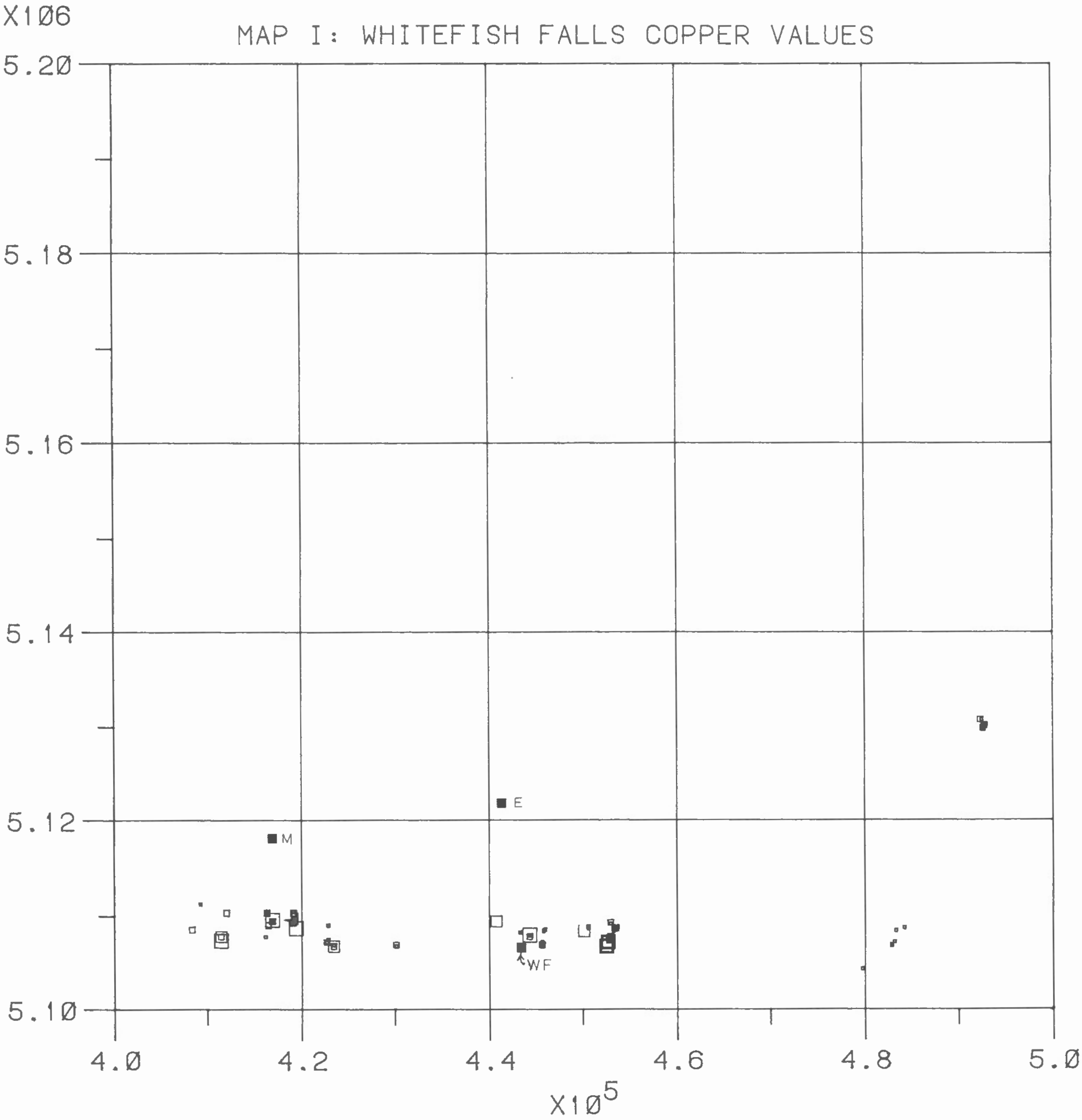
▫	5000 10000	ppm	(possibly anomalous)
			16500 ppm = X + 2 S
◻	10000 50000	ppm	(probably anomalous)
□	50000	ppm	(definitely anomalous)


Whitefish Falls Area
LORRAIN FM.
Sudbury
Espanola
Massey
5.14
5.13
5.12
5.11
5.10
4.9
4.8
4.7
4.4
4.3
4.2
4.1
4.0
Mi
Km
1
2
3
4
5

MAP H: WHITEFISH FALLS SAMPLE LOCATIONS



MAP I: WHITEFISH FALLS COPPER VALUES

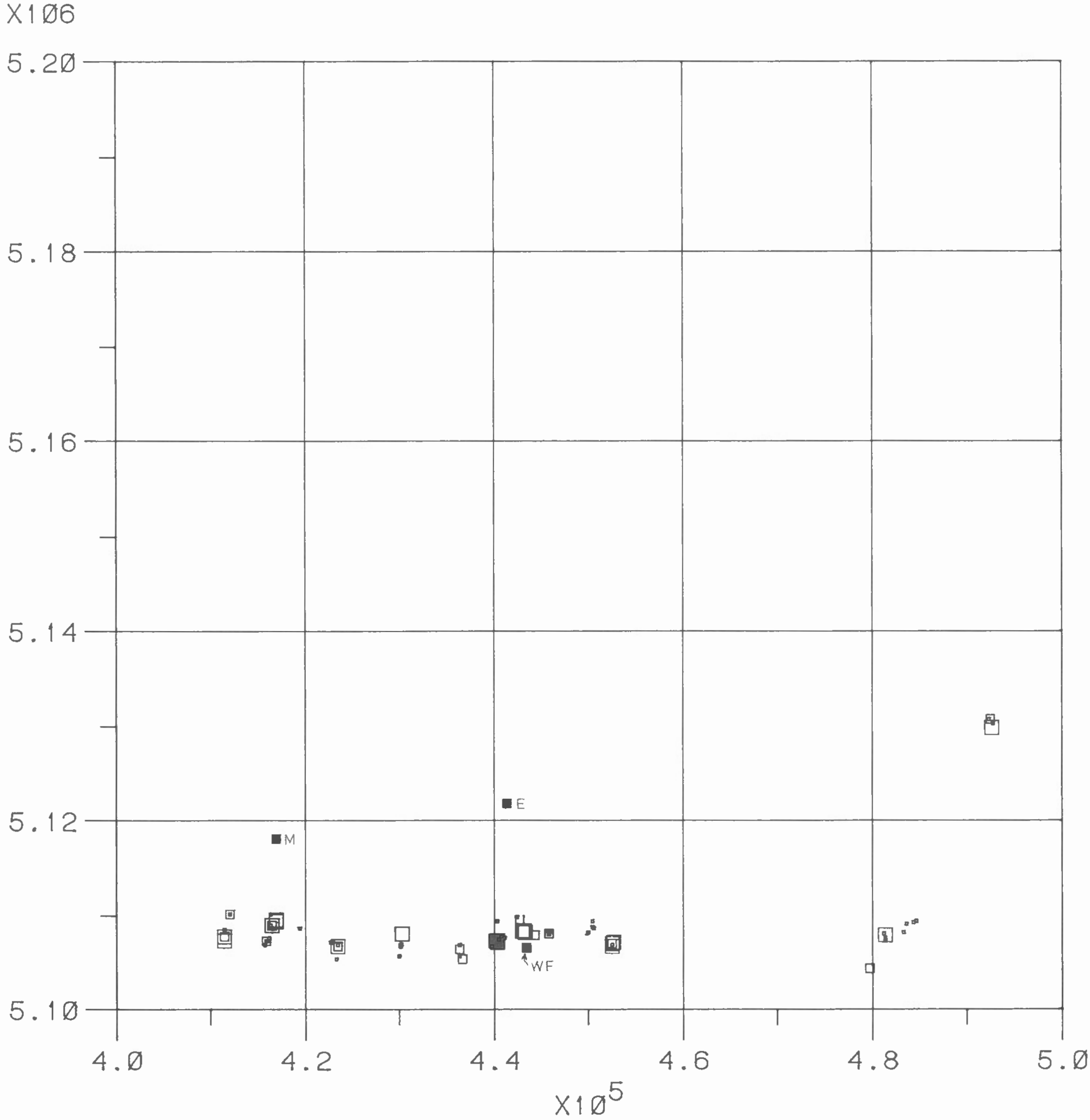


CLASS INTERVALS

18 ppm = X + 2S

▫	10	25 ppm	(high background)
▫	25	50 ppm	(possibly anomalous)
□	50	75 ppm	(probably anomalous)
□		75 ppm	(definitely anomalous)

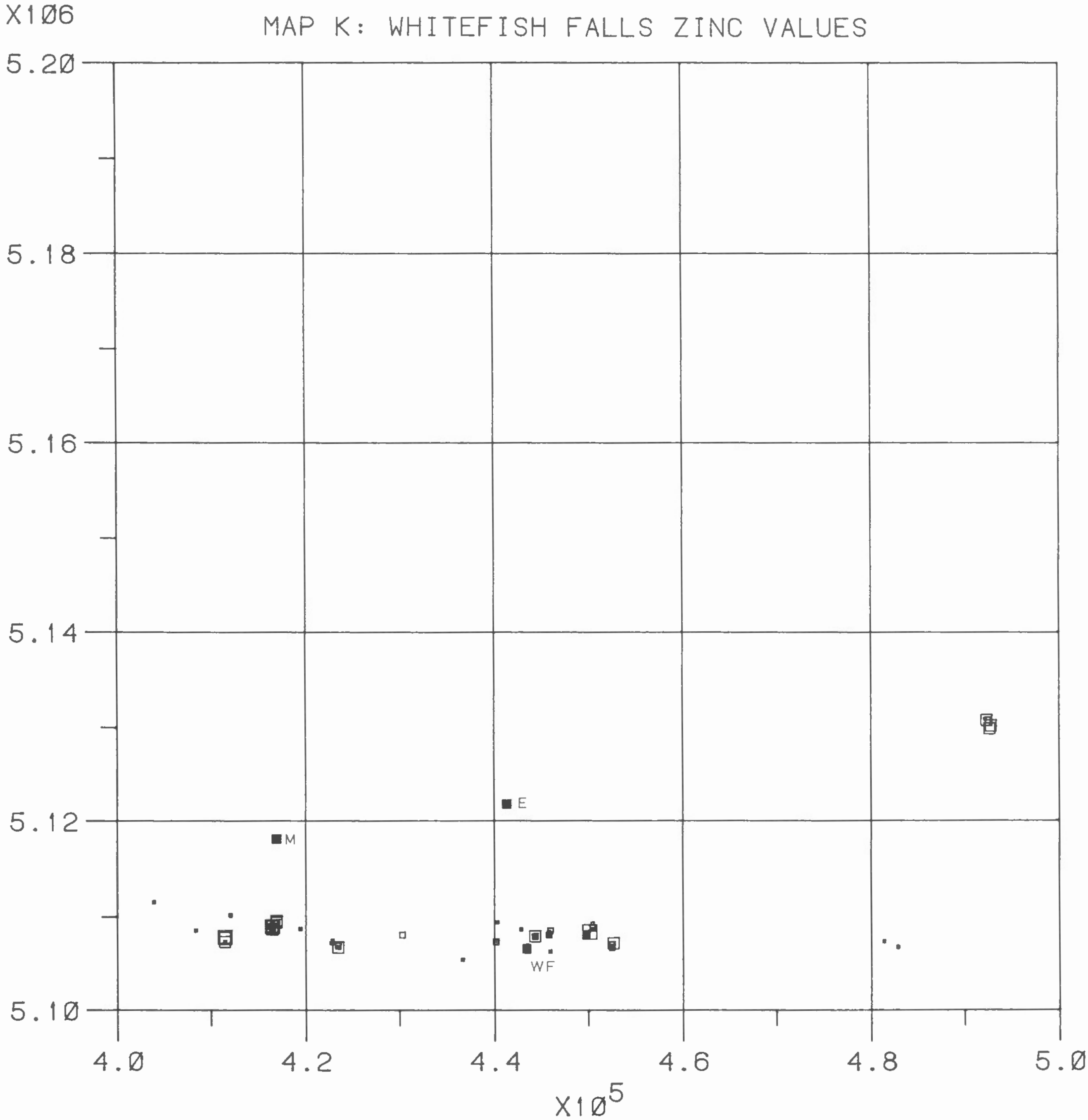
MAP J: WHITEFISH FALLS NICKEL VALUES



CLASS INTERVALS

46 ppm = X + 2 S

▫	40	60 ppm	(high background)
□	60	80 ppm	(possibly anomalous)
☐		80 ppm	(definitely anomalous)

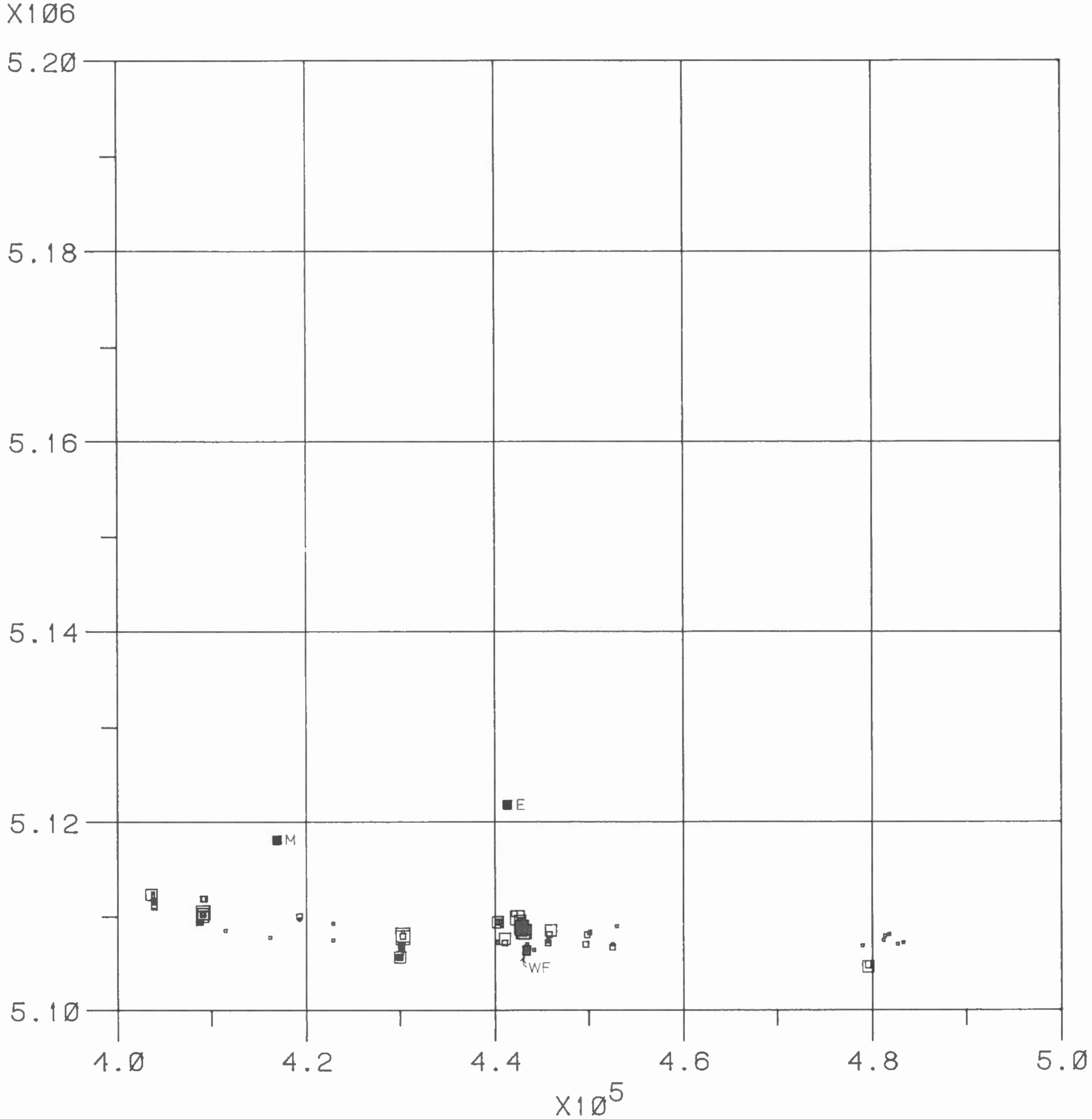


CLASS INTERVALS

16 ppm = X + 2S

▫	10	25 ppm	(high background)
□	25	50 ppm	(possibly anomalous)
□	50	75 ppm	(probably anomalous)
☐		75 ppm	(definitely anomalous)

MAP L: WHITEFISH FALLS GOLD VALUES

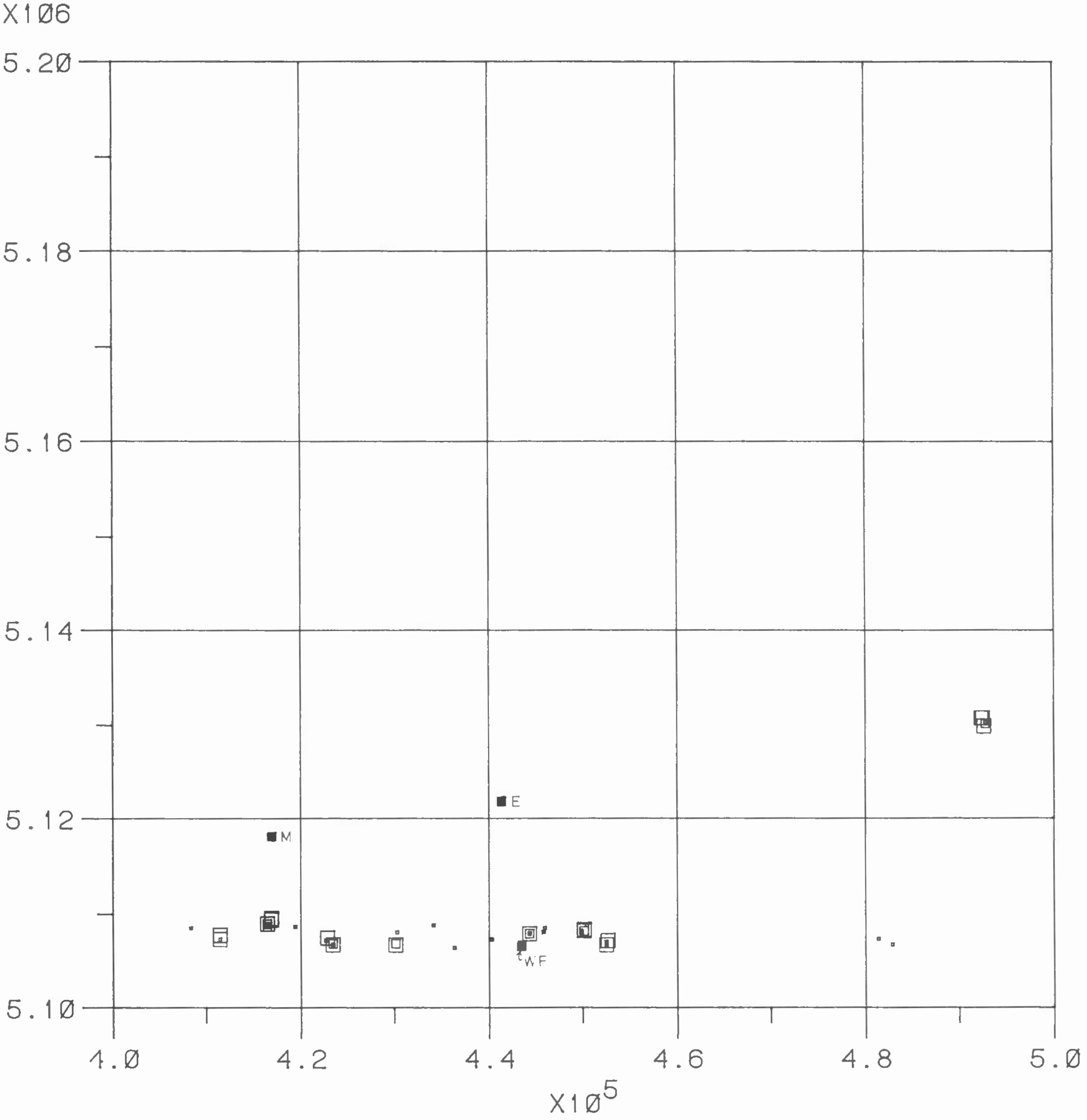


CLASS INTERVALS

▫	10	25 ppb	(high background)
□	25	50 ppb	(possibly anomalous)
□	50	75 ppb	(probably anomalous)
□		75 ppb	(definitely anomalous)

27 ppb = X + 2 S

MAP M: WHITEFISH FALLS MANGANESE VALUES



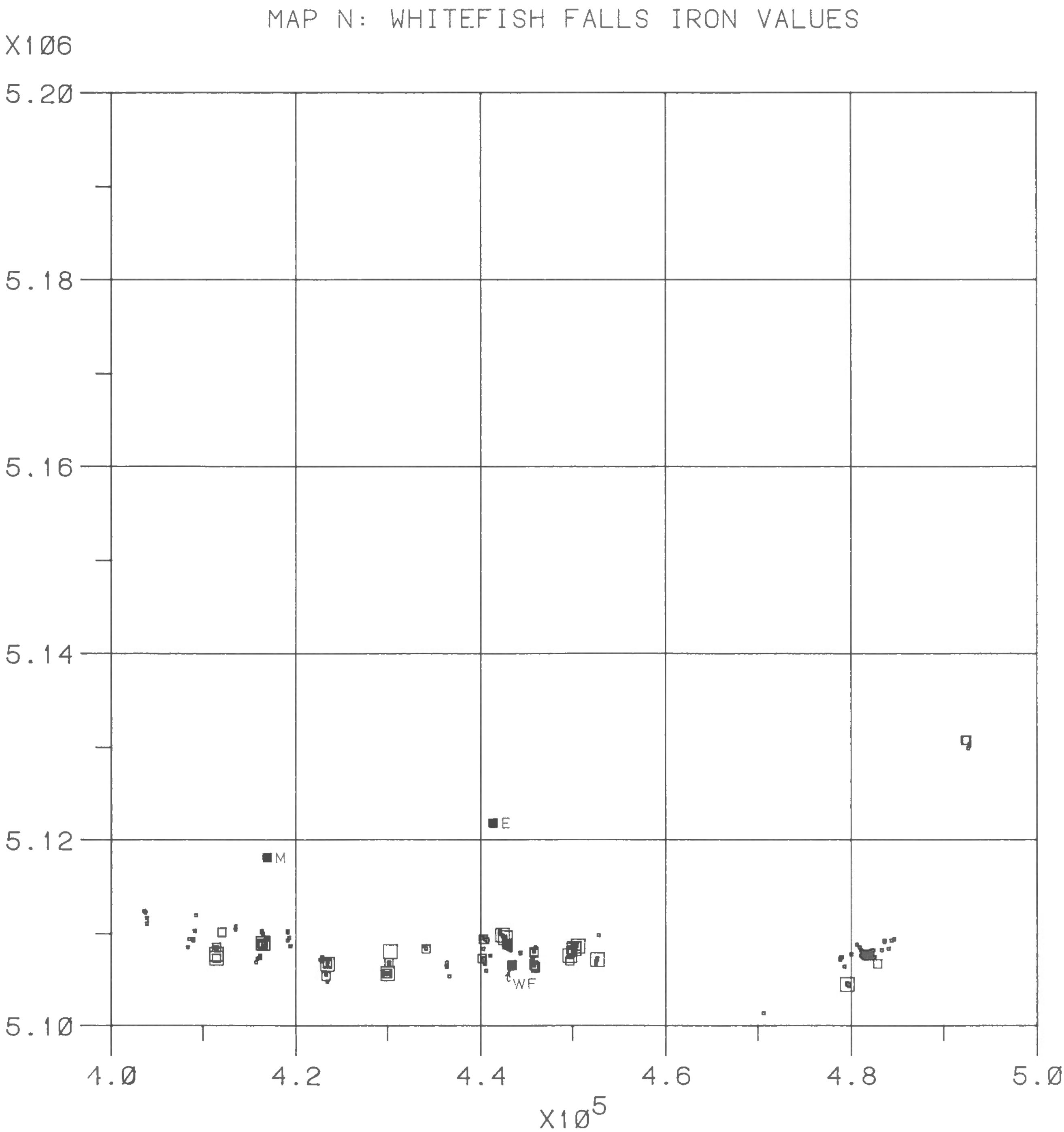
CLASS INTERVALS

130 ppm = X + 2 S

▫ 100 300 ppm (high background)

□ 300 500 ppm (probably anomalous)

☐ 500 ppm (anomalous)



CLASS INTERVALS

8900 ppm = X + 2 S

▫	5000	10000	ppm	(possibly anomalous)
▫	10000	50000	ppm	(probably anomalous)
□	50000		ppm	(definitely anomalous)

Appendix 2

A Partial List of Anomalous Values
from the Lithogeochemical Anomaly Maps
Whitefish Falls and Bruce Mines areas

Note: numbers refer to the relative level of the anomaly ie:

1 = high background to possibly anomalous
2 = probably anomalous
3 = definitely anomalous

APPENDIX 2: PARTIAL LIST OF ANOMALOUS VALUES, WHITEFISH FALLS AREA

MAP	TRAVERSE	SAMPLE	ANOMALOUS ELEMENTS CU	NI	ZN	AU	FE	MN	ROCK CODE	REMARKS
1	RR-1 (07)	0324				2			15e	Fe stain,qtz veins
		0325				2			15e	Fe stain,qtz veins
		0327				2			15d	scattered pebbles
		0328				2			15d	scattered pebbles
		0330				2			15d	scattered pebbles
		0331				2			15d	graded bedding
		0332				2			15d	graded bedding
2	9CT-1 (06)	0360				2			15a	pebble beds
	9LV-1 (29)	4218-21	3	3	3		3	3	17,18	diabase
	4LV-1 (27)	4186-90	3	3	3			3	17,18	diabase
		4205-11		3	3		3	3	16a	near 15/16 contact
	13LV-1 (18)	4237-40	2	2	2		2	2	16a	near 15/16 contact
		4262	2	2	2		2	2	16a	near 15/16 contact
3	27CT-1 (03)	0237				3			15b	scattered pebbles
		0243				2			15c	pebble bed
		0246		3	3	3	3	3	15c,d	close to diabase
		0248				1			15d	
		0221-24	1	2		1			16a	15/16 boundary
		0183-89				1			15c	pebble beds
4	7CT-1 (05)	0302				1			15d	
		0303				1	2		15d	
		0304		2	2				15d	heavy mineral bed
		0305				1			15c	graded beds
		0306				1			15c	graded beds
		0307				1	2		15c	
	RT-8 (02)	0052				3		3	15d	heavy mineral bed
		0123				3			15c	heavy mineral bed
		0259		3		3			15b	sulphides
		0262		3		3			15b	sulphides
	27LV-1 ( )	4038	2			1		1	13	near amphibolite
		4039	3	3	3			3	17,18	amphibolite
		4040		2	2			2	13	near amphibolite
		4041		2	2			2	13	near amphibolite
		4042		2	2	2		2	13	near amphibolite
		4046	3	3	3		3	3	15e	
5	(No significant anomalies)									

APPENDIX 2: PARTIAL LIST OF ANOMALOUS VALUES, BRUCE MINES AREA

MAP	TRAVERSE	SAMPLE	ANOMALOUS ELEMENTS CU	NI	ZN	AU	FE	MN	ROCK CODE	REMARKS
1	DT-05-053 (23)	6214-15	3						14d	jasper conglomerate
		6216-24	1			2			14c	pebbly in places
		6228-30	1			2			14a	
	DT-06-NW (24)	6234				2			14c	pebbly bed
	BM-15-045 (15)	6164	1				3		14f	spec. hem. showing
	BM-13-160 (13)	6144				1			14f	pebbly
		6151	3						14f	
	BM-14-360 (14)	6155	2		1		2		15	bleached fractures
		6157			1	1			15	
	DT-07-180 (25)	6251	3						20	boulder conglomerate
	FT-SCTN-1 (97)	8432	3	2	1			1	14f	road cut hwy. 638
	FT-SCTN-2 (98)	8455	1	2			2		14f	road cut hwy. 638
	FT-SCTN-3 (99)	8482	1	1			2		15?	road cut hwy. 638
	BM-17-230 (17)	6173	1		1			1	15	yellow bleaching
	BM-18-180 (18)	6174	3	1	3	1	3	3	15	
		6175	1	1	1		2	1	15	
		6176	3		1		2		15	
	BM-19-050 (19)	6179	3	1	1			1	15	diss. pyrite
		6181	1	1	2	1	3	1	15	diss. pyrite
	BM-21-RD (21)	6188	1		1	1			15	
		6189	3	1	1		3	1	15	hematite stain
	BM-11-RD (11)	6124-25				1			14f	spec. hematite
	FT-12-W (85)	8371	3	1	3		3	2	15	sulphide grains
		8370		3	1		2	1	15	spec. hematite
		8372		2	2		2	1	15	spec. hematite

APPENDIX 2: PARTIAL LIST OF ANOMALOUS VALUES, BRUCE MINES AREA

MAP	TRAVERSE	SAMPLE	ANOMALOUS ELEMENTS CU	NI	ZN	AU	FE	MN	ROCK CODE	REMARKS
2	DR-20-SW (62)	8153	3					3	15	siltstone
		8184	2	2	3		3	3	17,18	diabase
	BM-12-RD (12)	6138	2	3	3			3	15	near diabase
	DT-15-RD (33)	6319	3						15	near diabase
	FT-Mc-RD (86)	8376	3				3		15	diss. pyrite
	DR-09-SE (50)	8047	3	3	3		3	3	17,18	diabase
	DR-25-NW (67)	8192	2	3	3		3	3	14f	pebbly bed
	BM-22-260 (22)	6196	2						14c	
	FT-06-SE (74)	8281					3		14c	heavy mineral layer
	FT-07-NW ( )	8306-18					3		14c	heavy mineral layers
	FT-RD-A9 (75)	8284	3						14b	near diabase
		8287	3			1			14c	diss. chalcopyrite
		8294-97					3		14c	heavy minerals
	FT-01-N (69)	8228	3					1	14a	fractured
		8229	3			1	2		14a	diss. chalcopyrite
		8230	3			1			14a	diss. chalcopyrite
		8231	1	3	1		2	1	14b	
	FT-02-SE (70)	8233	3	1				1	14a	diss. chalcopyrite
		8234				1	2		14a	
		8236	3				2	2	14a	specular hematite
	DR-21-E (63)	8164	3				2		14a	pyrite on fractures
		8165	2	1		2		1	14a	diss. pyrite
	FT-03-SW (71)	8239	1			2		1	14a	rusty spots
		8240	3	2		1		2	14a	diss. sulphides
		8241	3			1		1	14a	diss. sulphides
		8243					1		14a	pyrite,rusty spots
		8250		3	1		2		14b	diss. spec. hematite
	FT-11-SW (84)	8363-66					2	1	14a	rusty fractures
	DR-14-HWY (56)	8083	1	2	3		3	3	14a	diss. pyrite
		8081	1	2	3		3	3	14a	nearby diabase
		8079		2	1		2	1	14a	chloritized fractures
		8072	3				2		14c	fractured
		8073	3						14c	fractured
		8074	2	1			2		14c	fractured
		8075-77		1			2		14a	bleached fractures
	DT-RD-1 (68)	8215-18	2				2	1	14(a?)	qtz. veins & diss.py.

APPENDIX 2: PARTIAL LIST OF ANOMALOUS VALUES, BRUCE MINES AREA

MAP	TRAVERSE	SAMPLE	ANOMALOUS ELEMENTS CU	NI	ZN	AU	FE	MN	ROCK CODE	REMARKS
3	BM-05-030 (05)	6050-56				2			14e	heavy mineral and pebble beds
		6067				2	2		14c	purple hematite stain
	BM-03-240 (03)	6027-31				1			14e	heavy mineral beds
		6036				3			14e	spec. hem.; X-beds
		6040				3			14e	pebble bed
	BM-02-080 (02)	6014				2			14e	pebbles+heavy minerals
		6016-17				1			14e	heavy mineral beds
	BM-04-220 (04)	6047				3	2		14f	heavy mineral bed
	BM-01-NE (01)	6002	1	1	1	3		2	14a	
		6003	3	3	3		3	3	14a	near diabase contact
	DT-01-SW (40)	8001-6		2	1		2	1	15	
	FT-RD-6 (81)	8347	3	2	1		2	1	15	diss. pyrite
4	BM-06-190 (06)	6073				1			14c	pebble bed
	DT-09-185 (27)	6079				1			14d	heavy mineral bed
		6090				1			14e	heavy mineral bed
	BM-07-225 (07)	6098				3			14a	diss. pyrite
		6099	3	2	3		3		14a	
	DT-15-RD (33)	6332	1				3		14f	"stromatoforms"
		6334					3		14f	"stromatoforms"
		6335					3		14f	"stromatoforms"
	BM-09-070 (09)	6110				1			14e	
		6112				1	3		14e	pebble bed with heavy minerals
		6114				2			14e	pebbly dark bed
5	DR-05-NE (46)	8027				1			14f	pebble bed

APPENDIX 3

Analytical Procedures for Projects of the

Sudbury-Timmins-Algoma Mineral Program

by

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Laurentian University

ANALYTICAL METHODS

Sample Preparation:

A total of 3,910 samples were analyzed for various elements. All of these were catalogued and stored once a subsample was taken for analysis. Project 3 and Project 4 subsamples were crushed using a Bico Jaw crusher then ground to ~ 200 mesh in a tungsten carbide dish on a shatterbox grinder. The resulting powders were stored in polystyrene vials. Project 2 esker samples were dried and sieved to < 2 µm and stored in plastic sample bags. The coarser fraction of these was also stored for future reference. The following analyses were done at Laurentian University.

Gold Analysis:

Project 2 esker powders were analyzed for gold following a partial acid digestion. A 2 gm weight was transferred to a 50 ml capacity test tube and digested with 15 ml of aqua regia for 1 hr. at low heat. Rock powders from the other projects were totally digested prior to gold analysis. A 2 gm weight was digested in a teflon beaker with a 30 ml HF/15 ml $HClO_4$ mixture to dryness. The residue was then dissolved in 25 ml aqua regia. Gold was then extracted from the agua regia solutions into a 3 ml aliguot of methyl iso-butyl ketone (MIBK). Project 2 samples required centrifugation at this stage. Once the layers had separated a 0.5 ml aliguot of the gold bearing MIBK was removed for analysis. Gold determinations were done using a Model 703 Perkin-Elmer Atomic Absorption spectrophotometer with graphite furnace and HGA 500 programmer. The analysis program for gold is outlined in Table 1. The instrument was calibrated using standards prepared from the appropriate dilution of a stock solution of 'Fisher purified' gold metal, which was then extracted into MIBK as for the samples.

All analyses were done with a deuterium lamp background corrector to minimize any matrix enhancement effects. Highly anomalous samples were reanalyzed as often as four times. Due to the inherent nature of gold it is very difficult to obtain a homogeneous sample distribution. Ideally a larger sample size would have been preferable however not economical in view of the large number of samples. The large majority of samples analyzed were near the detection limits (ie. 2 ppb).

Table 1
Gold Analysis Program

Step 1 (drying)	150°c Temperature 70 sec. Ramp 15 sec. Hold Baseline
Step 2 (charring)	800°c Temperature 55 sec. Ramp 15 sec. Hold 40 sec. Recorder
Step 3 (atomization)	2700°c Temperature 3 sec. Ramp 7 sec. Hold 5 sec. Read Recorder 40 Internal Flow
Step 4	2750°c Temperature 1 sec. Ramp 3 sec. Hold Recorder
Step 5	30°c Temperature 10 sec. Ramp 5 sec. Hold 10 sec. Read

Note: 20 µl sample volume

Traces by Atomic Absorption Spectrophotometry:

All project 3 and project 4 samples were analyzed for Cu, Ni, Zn and Pb following a total digestion (ie.HF/$HClO_4$). The digestion residue from a 0.5 gm sample was then dissolved in 5% HCl and analyzed by flame atomic absorption spectrophotometry using a Perkin-Elmer Model 5000 with an AS50 autosampler in conjunction with a Model 3600 Data Station. Project 3 samples were also analyzed for Fe and Mn by this method. All flame atomic absorption spectrophotometry standard solutions were prepared by the appropriate dilution of Fisher 'Certified A.A. Standard' 1000 ppm stock solution with 5% HCl. Single element electrodeless discharge lamps were used for Pb and Zn while all other analyses were done with single element hollow cathode lamps. All anlyses were done with flow spoiler option.

Detection limits for each element are shown in Table 2. Precision was determined by repeated analysis of random samples as shown in Table 3.

Project 2 esker samples were analyzed for a number of traces by atomic absorption spectrophotometry at Queen's University following an aqua regia digestion.

Table 2
A.A. Detection Limits

Element	D.L. (ppm)
Cu	.16
Ni	.06
Zn	.03
Pb	.68
Fe	.03
Mn	.09

Table 3
Results of Repeated Analyses

Sample	Content (ppm ± S.D.[A])					
	Cu	Ni	Zn	Pb	Mn	Fe
6067	4 ± 1	16 ± 12	2.5 ± .6	ND	-	9431 ± 952
6099	172 ± 12	117 ± 38	117 ± 13	ND	1945 ± 147	119,525 ± 3,521
6176	58 ± 6	36 ± 11	13 ± 1	ND	92 ± 32	12,786 ± 2,949
6181	7 ± 3	60 ± 15	57 ± 7	ND	306 ± 46	231,425 ± 21,885

A) standard deviation based on 4 separate analyses.

Traces by X-ray Fluorescence Spectrometry:

A Philips Model 1220 Semi-Automatic Spectrometer was used to determine Y, Rb, Sr, Zr and As levels. Samples were analyzed as 4 gm loose powders in spectro cups on mylar film. The instrument conditions are shown in Table 4.

The XRF data were processed on a PDP11/03 (Digital Equip. Co.). Matrix correction for these elements was based on the total mass absorption coefficient as determined by comparing their Mo - K_{α} compton peak intensity to that of several standards of known absorption coefficients. Duplicate sample powders were also prepared and analyzed, one in every 20 samples. Accuracy and precision were determined by analyzing international rock standards with each sample batch. Table 5 shows these results along with the published values for these standards.

Table 4
Operating Conditions for X-ray Fluroescence

Element	Tube	Excitation		Crystal	Counter
Si	Cr	50kv	40 mA	PE	Flow
Ti	Cr	50kv	35 mA	LiF200	Flow
Al	Cr	50kv	40 mA	PE	Flow
Fe	W	35kv	10 mA	LiF200	Flow
Mn	W	50kv	40 mA	LiF200	Flow
Mg	Cr	50kv	40 mA	TLAP	Flow
Ca	Cr	40kv	30 mA	LiF200	Flow
K	Cr	50kv	40 mA	PE	Flow
P	Cr	50kv	40 mA	PE	Flow
Na	Cr	50kv	40 mA	TLAP	Flow
Y[A]	Mo	95kv	20 mA	LiF200	Scintillation
Rb	Mo	95kv	20 mA	LiF200	Scintillation
Zr[B]	Mo	95kv	20 mA	LiF200	Scintillation
Sr	Mo	95kv	20 mA	LiF200	Scintillation
As	Mo	60kv	40 mA	LiF200	Scintillation

A) Y and Rb were determined simultaneously in order to correct for the enhancement of Y by Rb directly.

B) Zr and Sr were determined simultaneously in order to correct for Sr enhancement of Zr.

Table 5
Comparison of Published Values to Experimental Values for International Standards.[A]

Element	W-1 Published Value(Abbey)	W-1 L.U. Value	GSP-1 Published Value	GSP-1 L.U. Value	BCR1 Pub. Value	BCR1 L.U. Value
Sr	190	190 ± 4			330	328 ± 6
Zr	105	90 ± 11			185	177 ± 7
Y	25	28 ± 2	29	34 ± 2		
Rb	21	21 ± 1	250	260 ± 8		

A) based on at least 6 analyses.

Whole Rock Analysis by X-ray Fluorescence Spectrometry

The ten major oxides were determined on sample beads by a Philips PW 1220 semi-automatic X-ray spectrometer. The sample beads were prepared by adding 4.2 gm of lithium tetraborate and 1 gm of ammonium nitrate to 1.4 gm of roasted sample powder. Loss on ignition was determined from the roasting data. This dry mixture was then mechanically mixed and transferred to a non-wetting platinum crucible of the Claisse Automatic Fluxer. The sample was fused and cast in a platinum mould to form the bead.

Matrix correction for the major elements was based on mass absorption comparisons between samples and international standards. Approximately one in every twenty samples was a duplicate bead. The accuracy of these results is shown in Table 6. Table 7 shows the results of our analyses of the international standards and their published values. Also shown are the results of a basalt rock powder (BAS) run as an internal check with each sample batch, a total of 17 separate analyses. The instrument conditions for these analyses are listed in Table 4.

Table 6
Results for Duplicate Beads

CODE	NA	MG	AL	SI	P	K	CA	TI	MN	FE
0063A)	4.42	1.43	16.74	67.64	0.06	2.44	3.04	0.43	0.07	3.75
B)	4.38	1.37	16.67	67.87	0.06	2.45	3.02	0.43	0.06	3.69
2003A)	3.38	6.15	12.58	51.52	0.01	0.60	10.60	0.96	0.17	14.03
B)	3.62	6.15	12.76	51.23	0.01	0.60	10.59	0.95	0.16	13.9
4015A)	3.86	7.22	17.32	49.34	0.08	0.12	1.85	1.57	0.20	18.44
B)	3.92	7.25	17.45	49.34	0.07	0.12	1.89	1.60	0.21	18.14
4101A)	2.87	2.96	20.19	63.17	0.12	1.57	1.70	0.86	0.07	6.49
B)	3.01	2.97	20.17	62.97	0.12	1.57	1.70	0.85	0.07	6.56
4165A)	2.84	1.22	15.41	73.12	0.12	2.54	2.37	0.39	0.03	1.97
B)	2.31	1.16	15.49	73.56	0.11	2.53	2.43	0.40	0.03	1.99
C)	2.69	1.21	14.91	73.47	0.12	2.92	2.41	0.39	0.03	1.85
4284A)	0.05	3.09	13.81	63.75	0.12	3.37	7.91	0.75	0.17	6.98
B)	0.07	3.04	13.84	63.77	0.14	3.39	7.94	0.73	0.18	6.90
4070A)	3.19	8.09	15.03	49.03	0.08	0.25	9.87	1.06	0.21	13.20
B)	3.14	8.09	15.09	49.20	0.08	0.26	9.78	1.04	0.21	13.10
4096A)	5.14	4.75	15.20	62.28	0.13	1.13	5.43	0.55	0.09	5.30
B)	4.88	4.91	15.51	62.24	0.14	1.11	5.38	0.53	0.08	5.22
0205A)	2.22	3.65	13.25	56.46	0.16	1.84	5.28	1.99	0.26	14.89
B)	2.88	3.62	13.18	56.02	0.16	1.86	5.26	1.98	0.27	14.76
0236A)	0.11	6.27	16.08	54.46	0.21	1.86	7.95	1.18	0.15	11.71
B)	0.09	6.34	16.13	54.41	0.22	1.86	7.83	1.17	0.15	11.79
0144A)	2.86	0.34	14.63	73.88	0.02	4.18	1.56	0.24	0.02	2.27
B)	2.70	0.22	14.55	73.94	0.02	4.28	1.65	0.25	0.02	2.36
0194A)	1.17	16.54	21.24	30.42	0.64	1.55	15.24	1.07	0.35	11.78
B)	1.85	16.51	21.16	30.19	0.65	1.56	15.08	1.07	0.35	11.58
0244A)	5.24	4.28	15.46	60.31	0.10	0.83	6.30	0.50	0.12	6.86
B)	5.40	4.19	15.47	60.20	0.09	0.84	6.28	0.49	0.13	6.89
2100A)	0.33	1.57	17.04	65.65	0.26	4.38	2.11	0.68	0.06	7.92
B)	0.36	1.51	17.04	65.78	0.26	4.36	2.08	0.68	0.06	7.87
4101A)	2.87	2.96	20.19	63.17	0.12	1.57	1.70	0.86	0.07	6.49
B)	3.01	2.97	20.17	62.97	0.12	1.57	1.70	0.85	0.07	6.56
4165A)	2.84	1.22	15.41	73.12	0.12	2.54	2.37	0.39	0.03	1.97
B)	2.31	1.16	15.49	73.56	0.11	2.53	2.43	0.40	0.03	1.99
4284A)	0.05	3.09	13.81	63.75	0.12	3.37	7.91	0.75	0.17	6.98
B)	0.07	3.04	13.84	63.77	0.14	3.39	7.94	0.73	0.18	6.90
4070A)	3.19	8.09	15.03	49.03	0.08	0.25	9.87	1.06	0.21	13.20
B)	3.14	8.09	15.09	49.20	0.08	0.26	9.78	1.04	0.21	13.10

Table 7

Results for International Standards Compared to Their Published Values

Element Content (%)

Standard	Na	Mg
GSP1[A]	2.76 ± .25	0.96 ± .03
published	2.82	0.97
BCR1[A]	3.48 ± .28	3.49 ± .09
published	3.28	3.48
BAS	4.71 ± .32	4.93 ± .13
Standard	**AL**	**Si**
GSP1[A]	15.10 ± .53	68.12 ± 1.5
published	15.32	67.91
BCR1[A]	13.40 ± .19	54.58 ± .38
published	13.65	54.72
BAS	15.92 ± .46	49.8 ± .8
Standard	**P**	**K**
GSP1[A]	0.21 ± .01	5.06 ± .34
published	0.28	5.58
BCR1[A]	0.34 ± .005	1.56 ± .08
published	0.33	1.68
BAS	0.5 ± .03	1.11 ± .06
Standard	**Ca**	**Ti**
GSP1[A]	1.98 ± .09	0.66 ± .02
published	2.04	0.66
BCR1[A]	6.97 ± .04	2.30 ± .33
published	6.96	2.21
BAS	5.80 ± .09	3.09 ± .25
Standard	**Mn**	**Fe**
GSP1[A]	0.04 ± .003	4.34 ± .05
published	0.04	4.37
BCR1[A]	0.18 ± .006	13.70 ± .27
published	0.19	13.70 ± .27
BAS	.20 ± .008	14.01 ± .38

A) based on 10 analyses

APPENDIX 4

a) Total trace element data for Cu, Ni, Zn, Au, Mn, Fe for the Whitefish Falls and Bruce Mines areas.

b) Selected samples with anomalous trace elements for the Bruce Mines and Whitefish Falls areas.

c) Cu, Ni, Zn, Au, Mn, Fe, Co, Ag data for:
- Stag Lake drill core
- Stratigraphic section, Bruce Mines area
- Highway 638 road cut

d) Descriptive statistics for the total data file, the Bruce Mines area, and the Whitefish Falls area.

e) Frequency distributions for normal and log-transformed data from the total data set, the Bruce Mines area, and the Whitefish Falls area.

Appendix 4 is available for viewing only at the Science Library, Laurentian University, in Sudbury, Ontario.

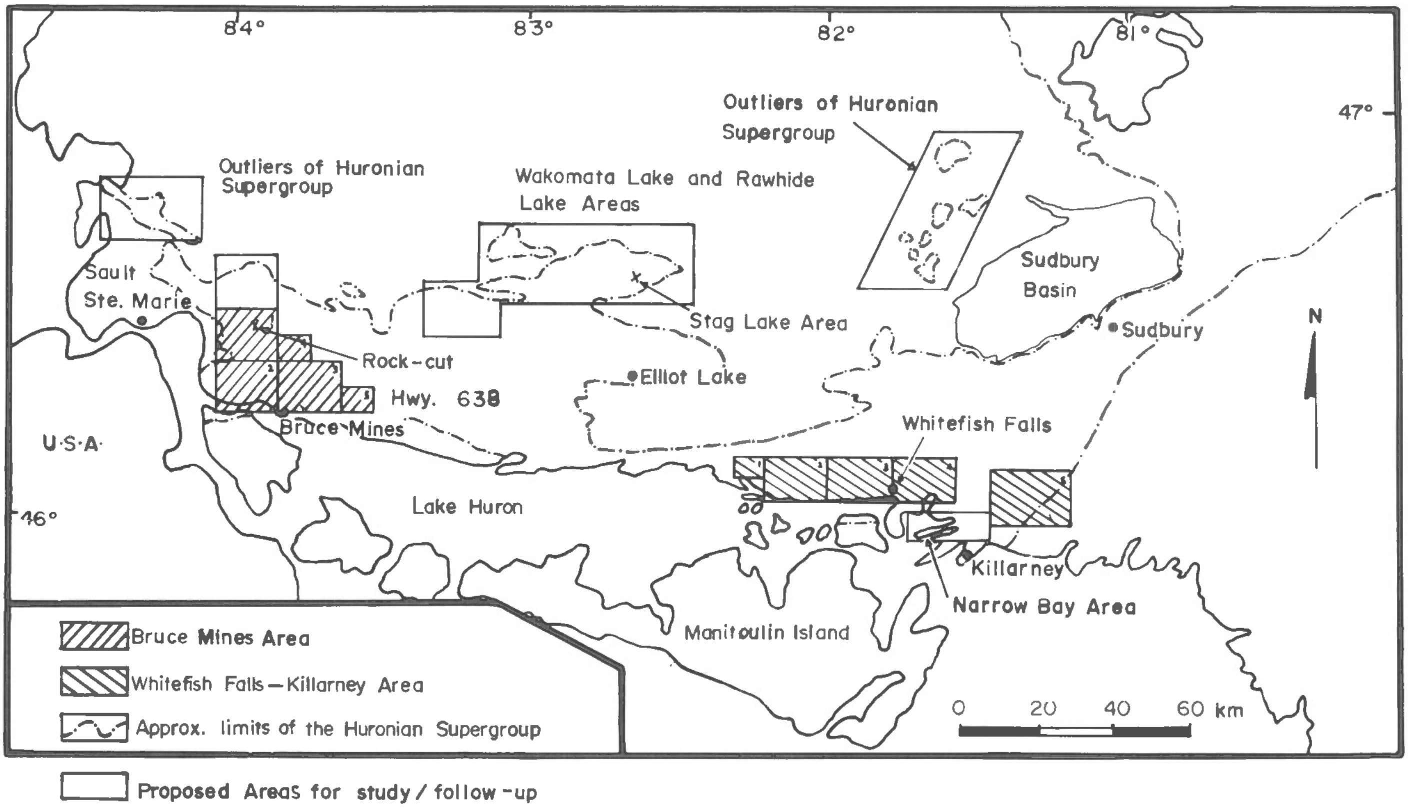


Figure 1. Location map showing study areas (modified after W.N. Pearson, 1980).

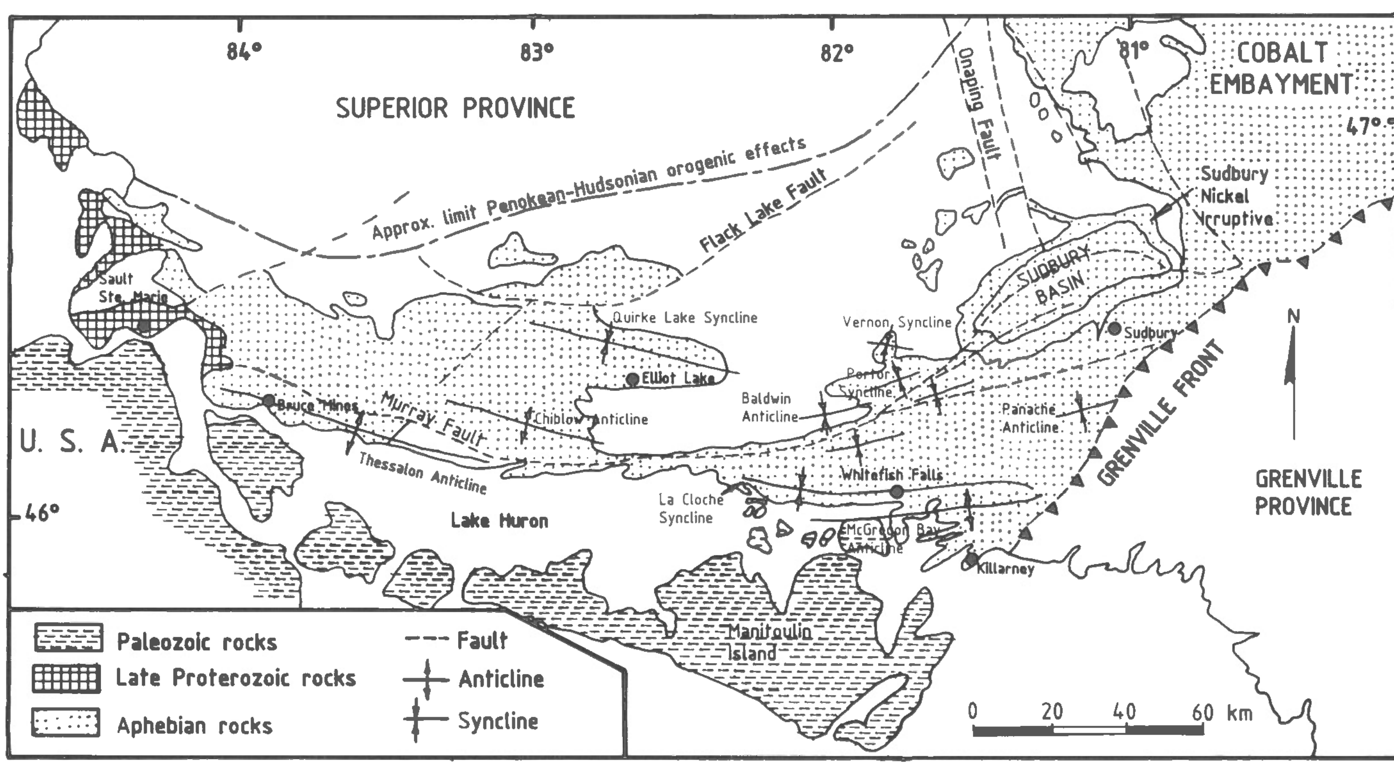
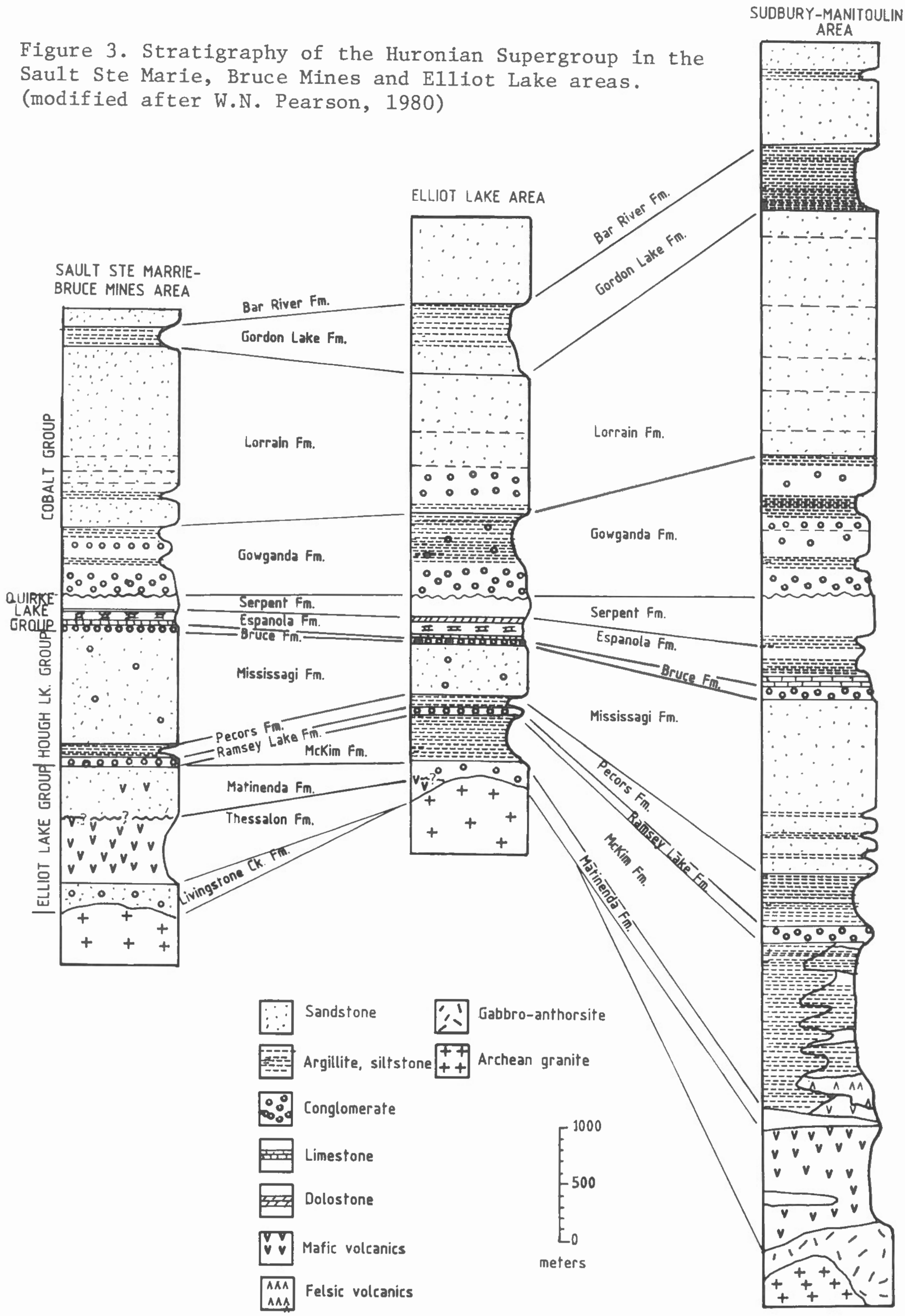


Figure 2. General geology (modified after W.N. Pearson, 1980).

Figure 3. Stratigraphy of the Huronian Supergroup in the Sault Ste Marie, Bruce Mines and Elliot Lake areas. (modified after W.N. Pearson, 1980)



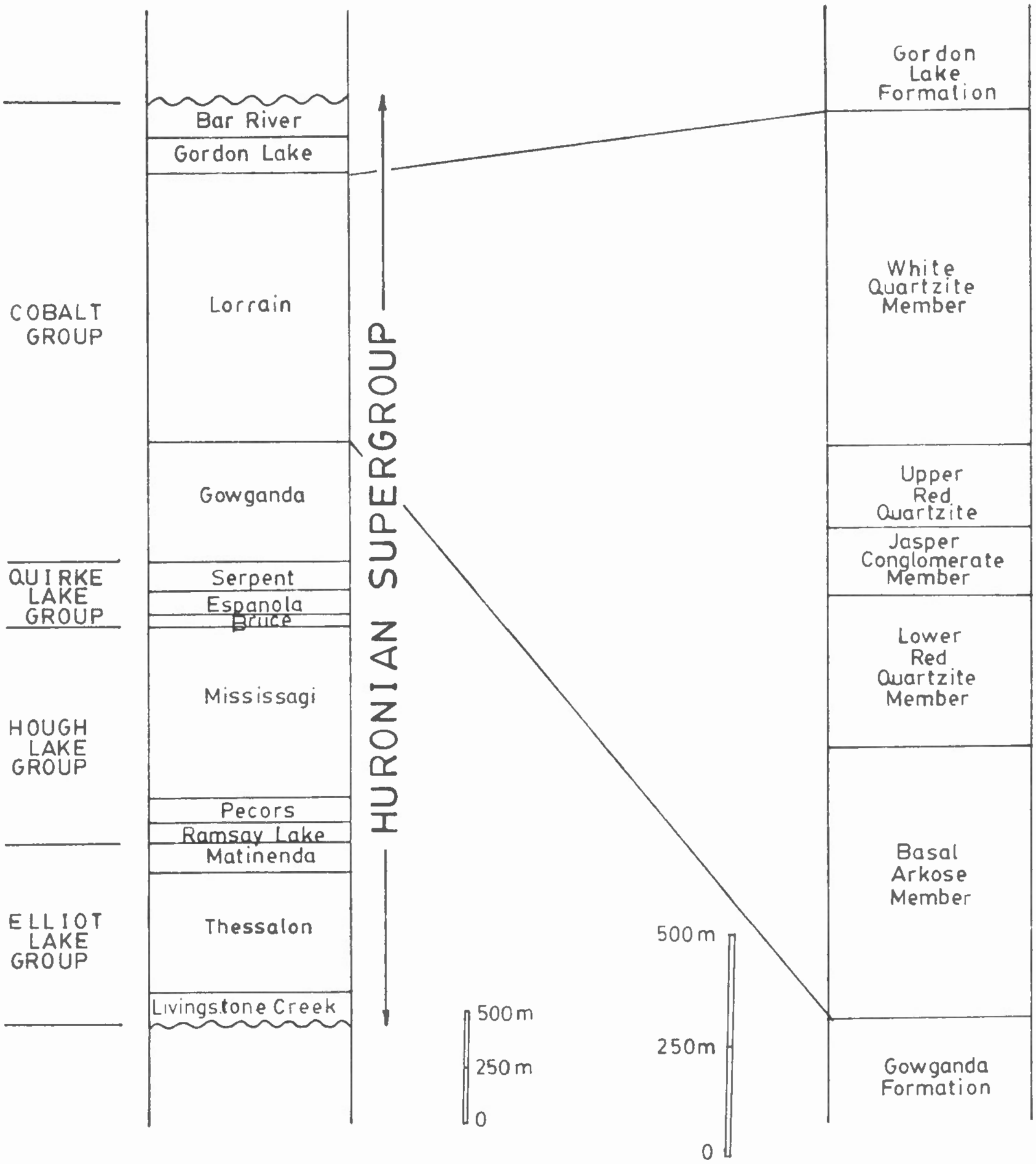


Figure 4. Stratigraphic section of the Huronian Supergroup, Bruce Mines area.

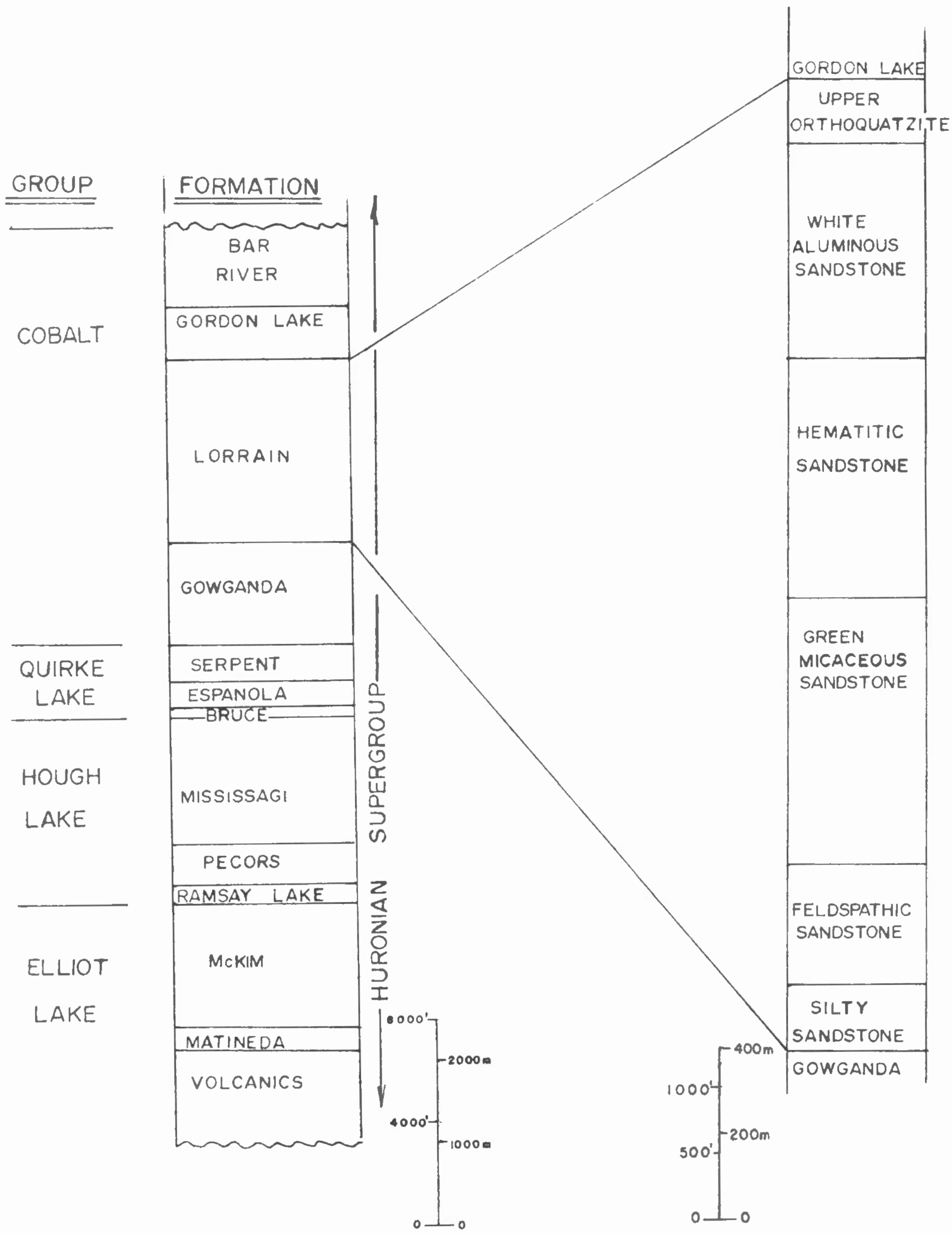


Figure 5. Stratigraphic section of the Huronian Supergroup, Whitefish Falls area.

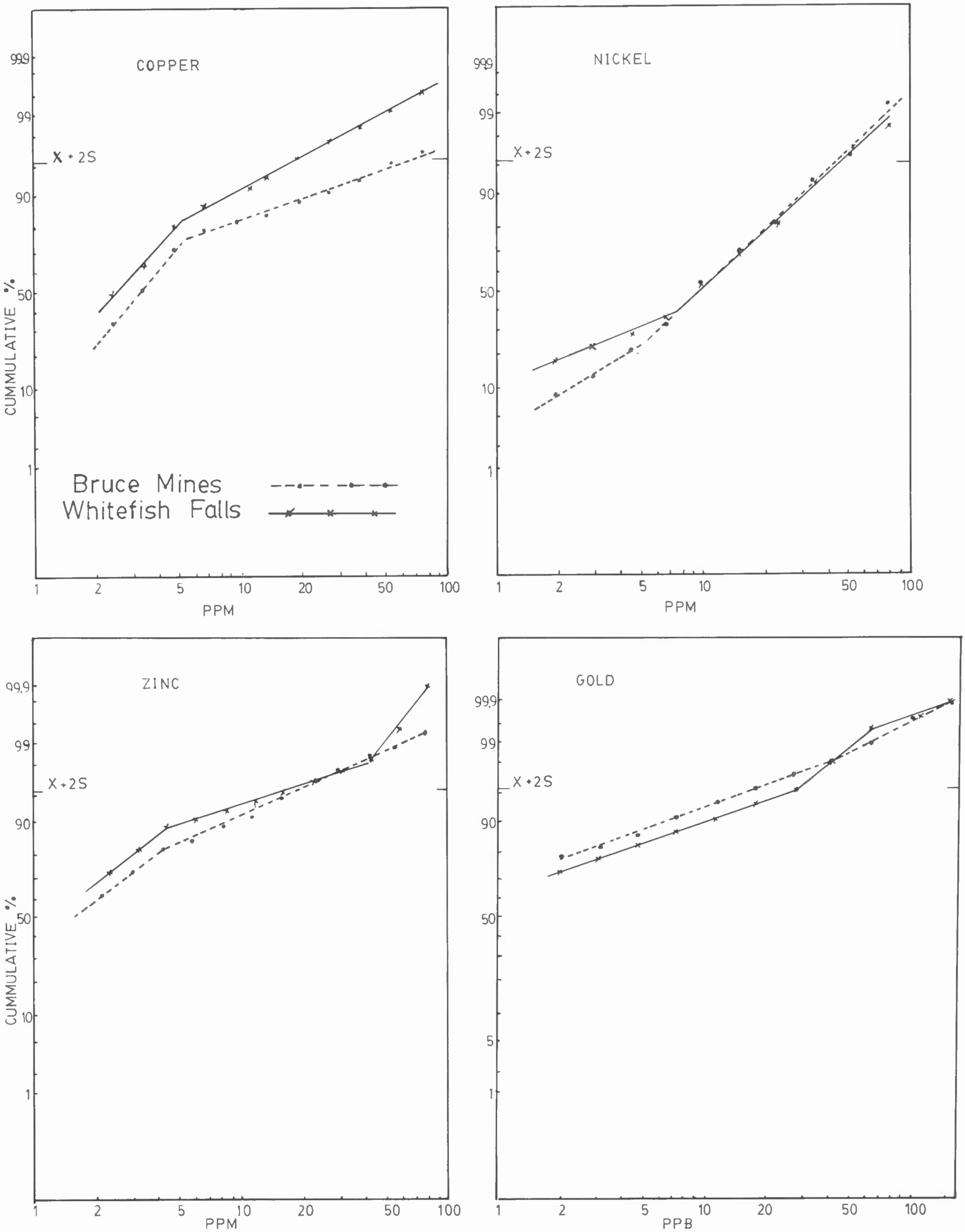


Figure 6. Cummulative % - Probability plots for Cu, Ni, Zn, and Au.

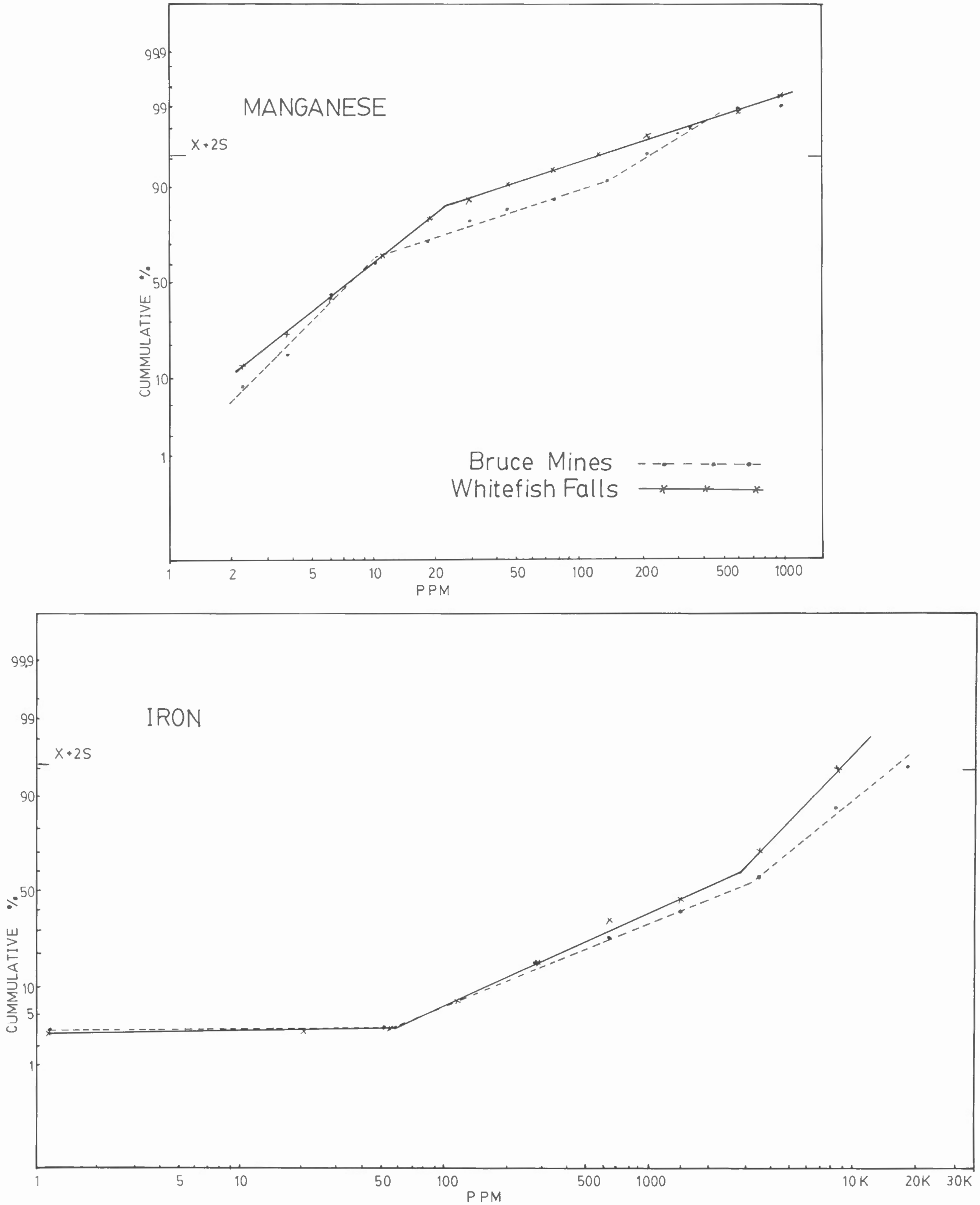


Figure 7. Cummlùative % - Probability plots for Mn and Fe.

MEMBERS OF THE LORRAIN FORMATION: BRUCE MINES
(1) LOWER ARKOSE AND SILTSTONE
(2) LOWER RED QUARTZITE
(3) JASPER PEBBLE CONGLOMERATE
(4) UPPER RED QUARTZITE
(5) WHITE QUARTZITE

MEMBERS OF THE LORRAIN FORMATION: WHITEFISH FALLS
(1) LOWER FELDSPATHIC QUARTZITE
(2) GREEN MICACEOUS SANDSTONE
(3) HEMATITIC SANDSTONE
(4) WHITE QUARTZITE
(5) CHERTY QUARTZITE

GORDON LAKE FORMATION:
(6) INTERBEDDED SILTSTONE AND CHERT

SELECTED LITHOLOGIC CHARACTERISTICS:
(1) HEAVY MINERAL BEDS
(2) PEBBLE BEDS
(3) PEBBLE BEDS WITH HEAVY MINERALS
(4) UNCLASSIFIED

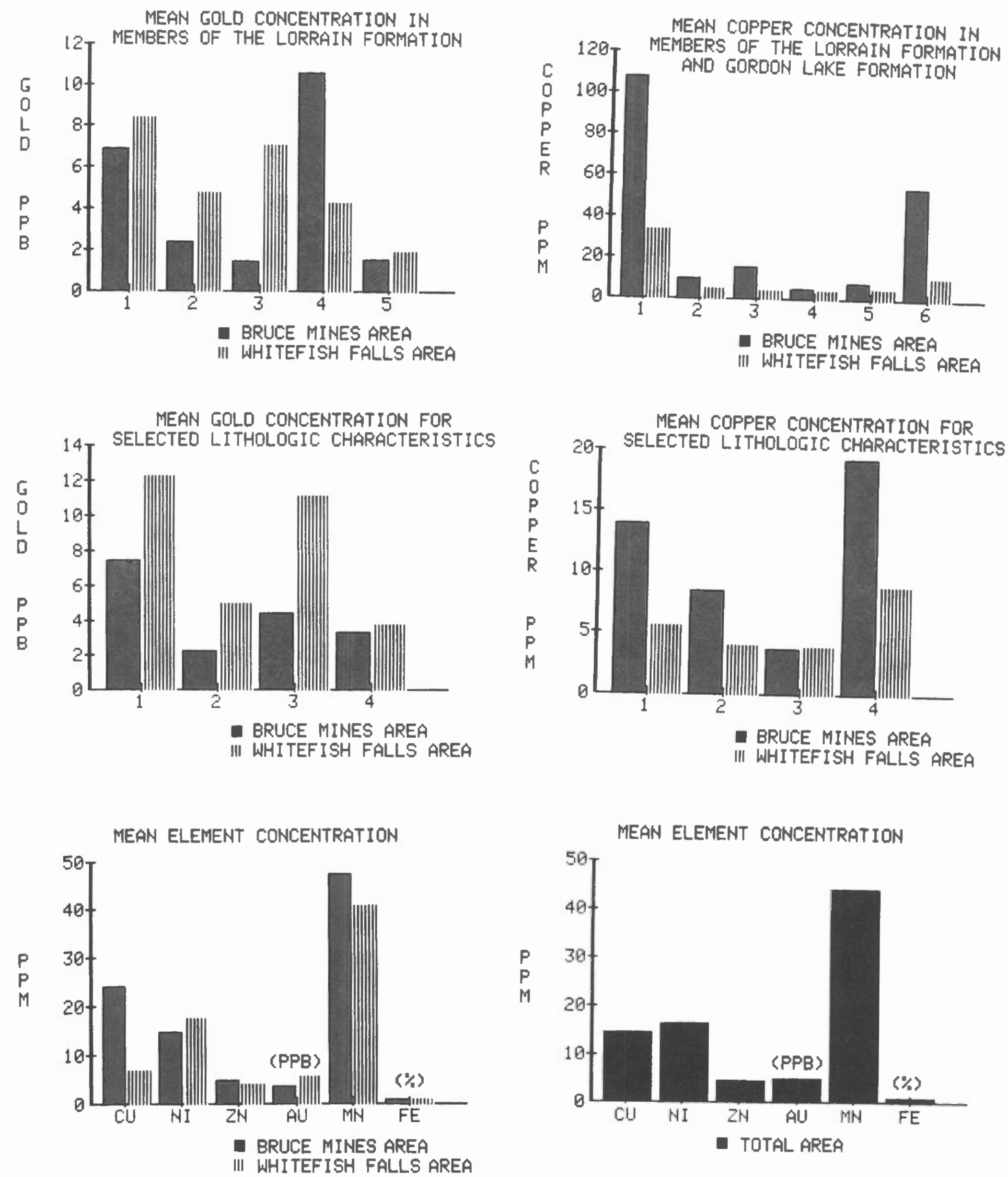


Figure 8. Descriptive statistics for the Bruce Mines, Whitefish Falls and total area.

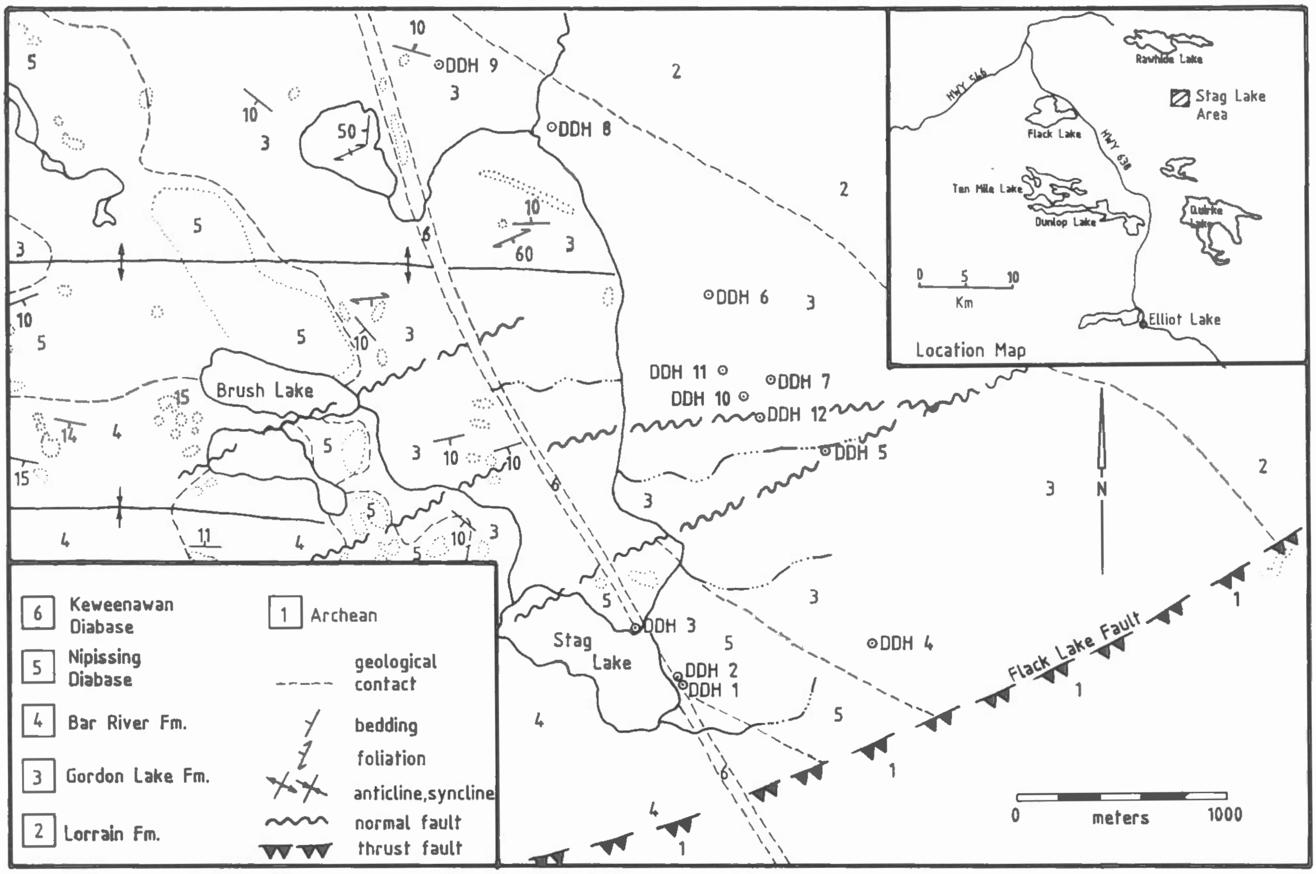


Figure 9. Geology of the Stag Lake area (modified after W.N. Pearson, 1980)

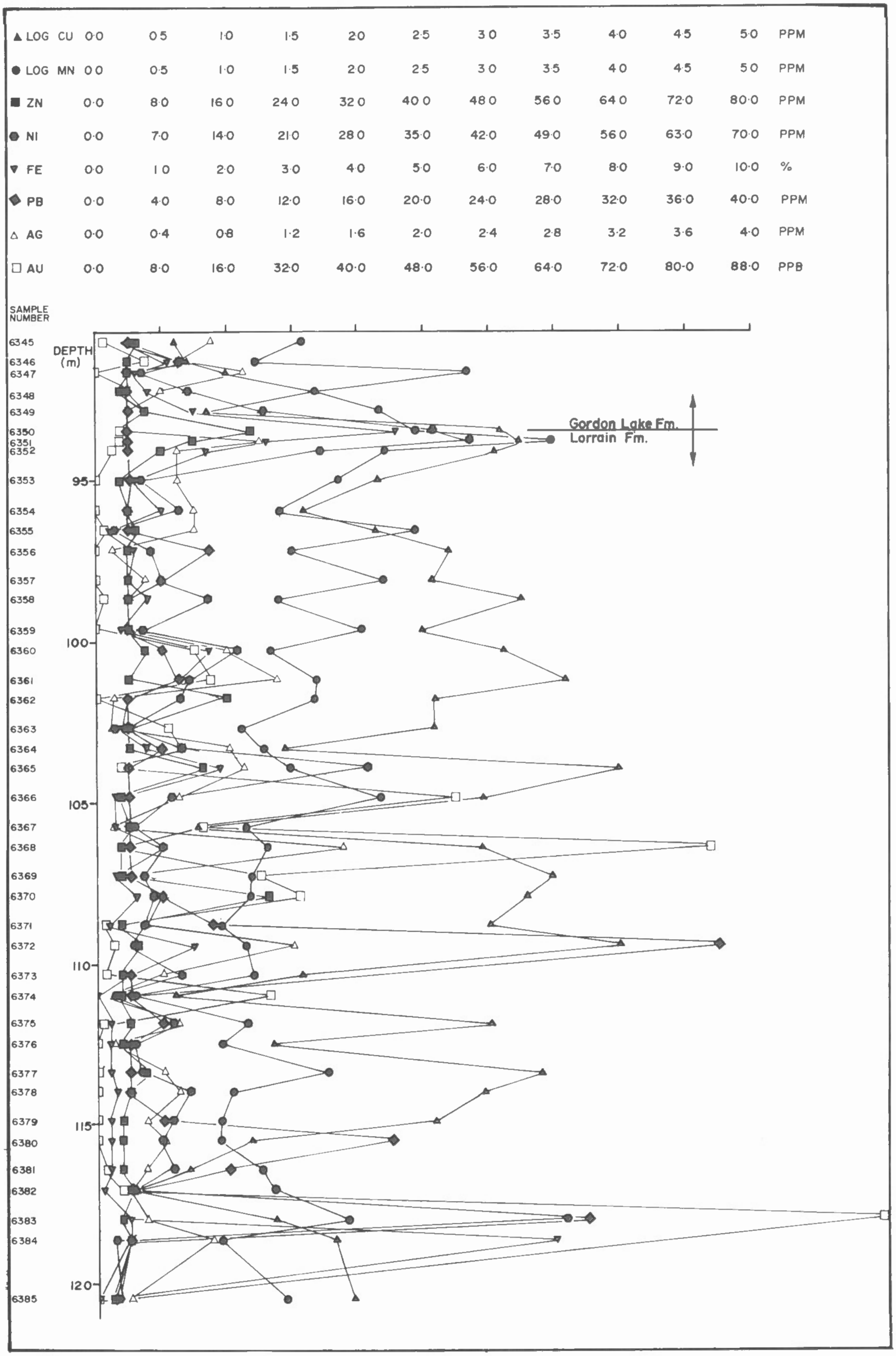


Figure 10. Trace element distribution in D.D.H. 7 from the Stag Lake copper prospect north of Elliot Lake.

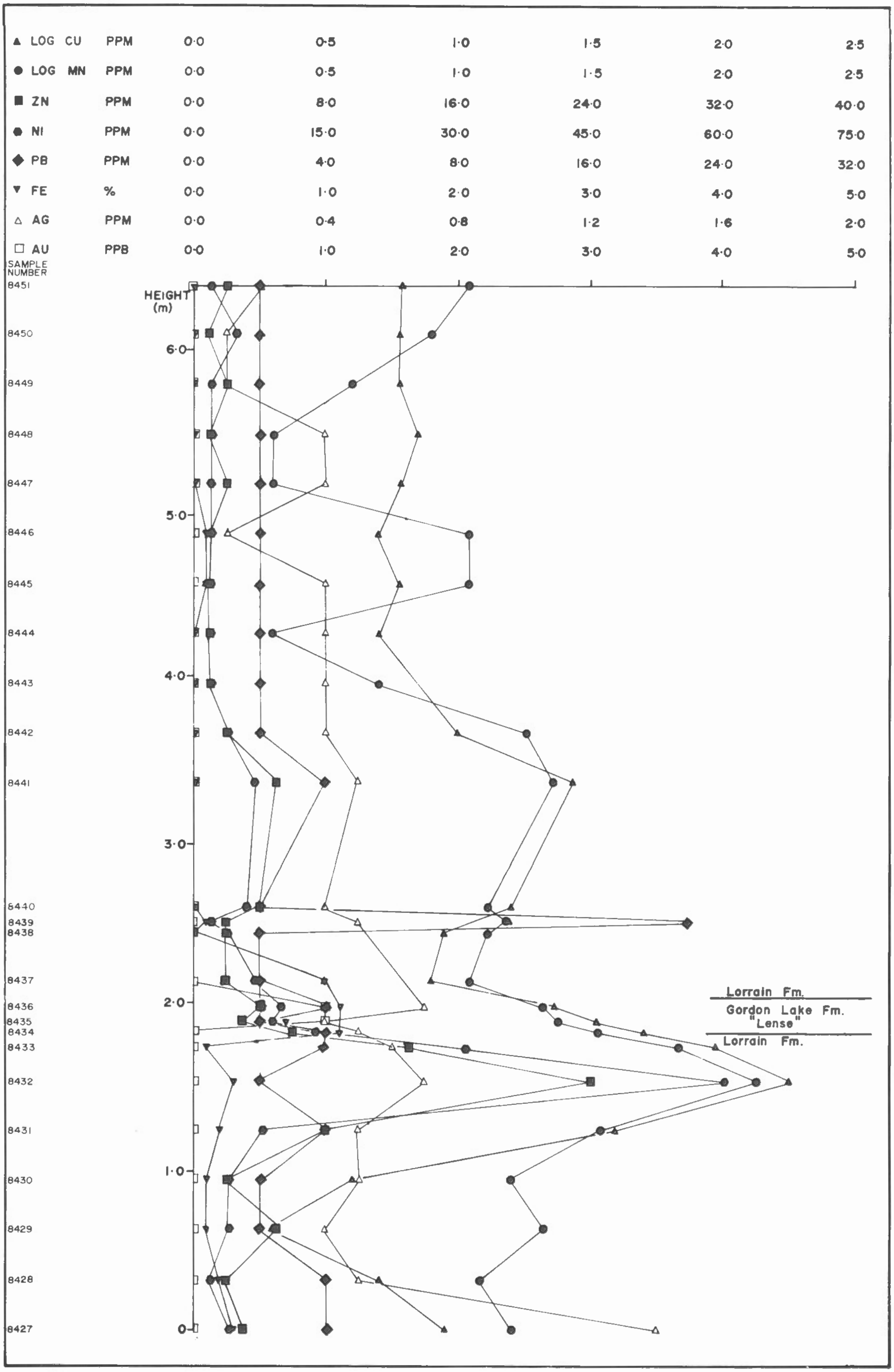


Figure 11. Trace ēlement distribution in Section 1 from a rock cut on Highway 638.

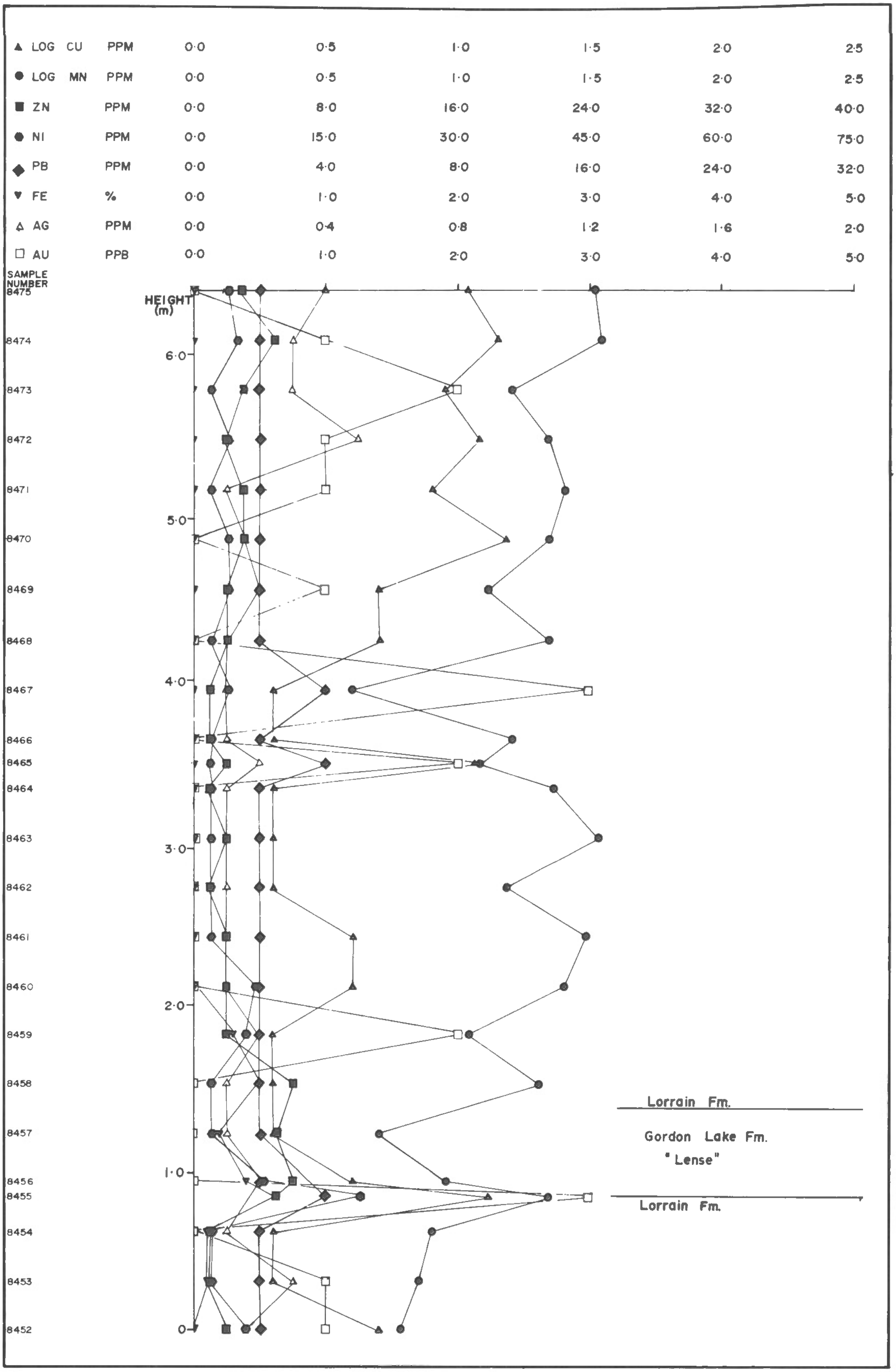


Figure 12. Trace element distribution in Section 2 from a rock cut on Highway 638.

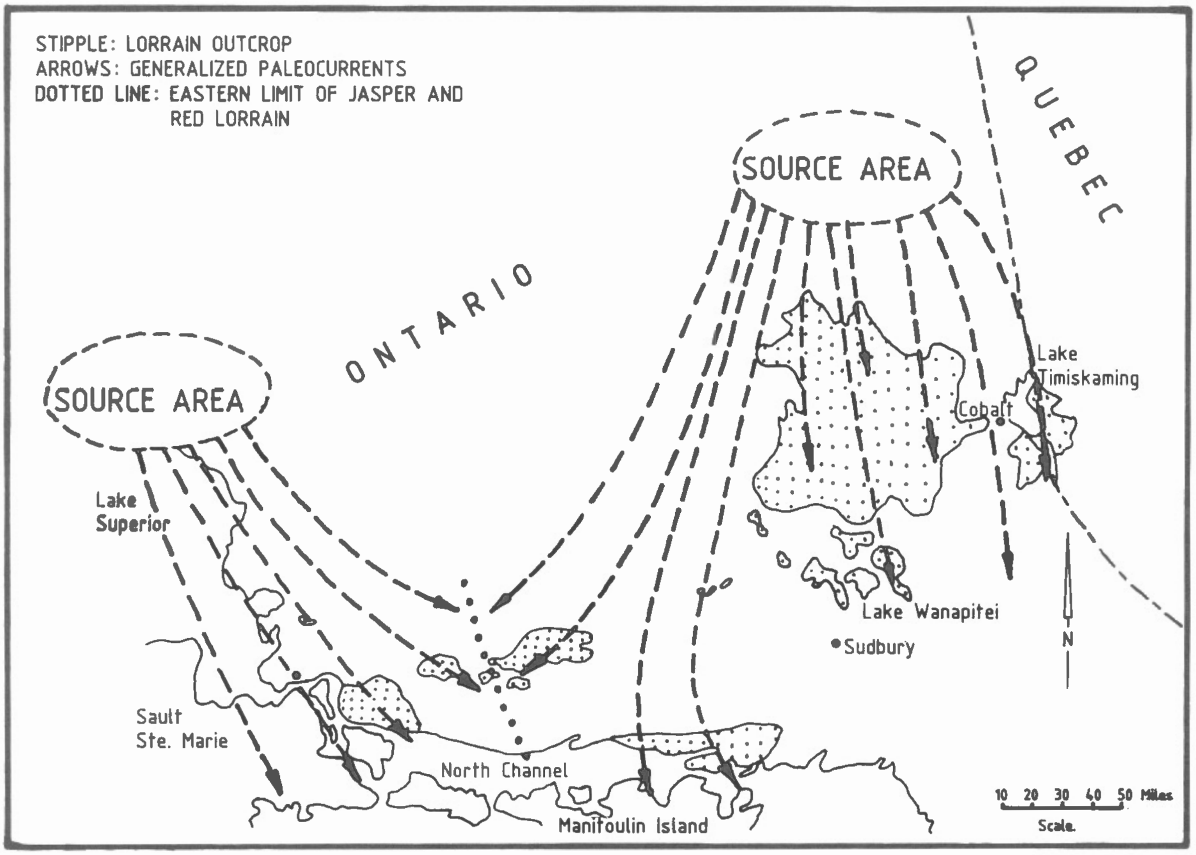
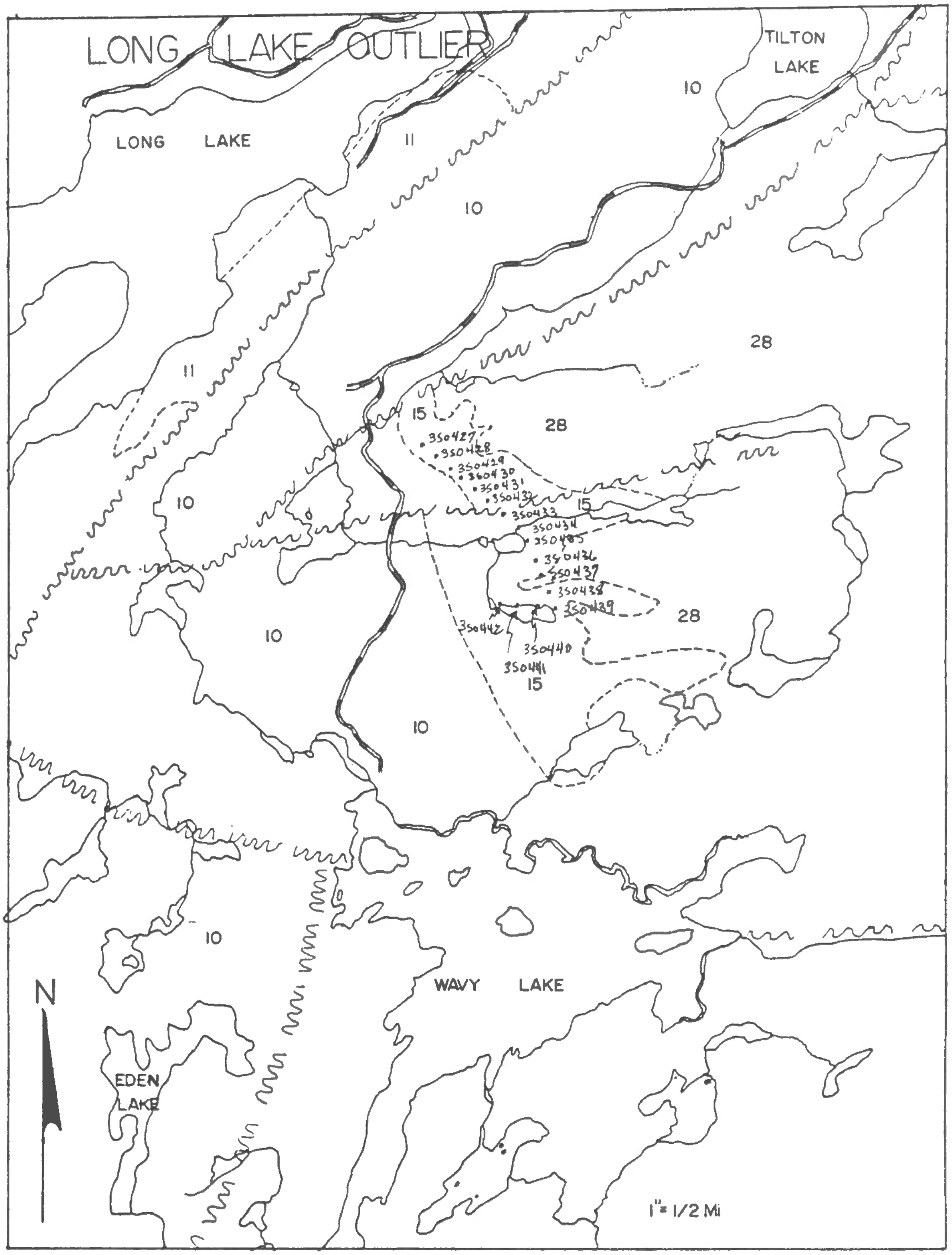


Figure 13. Source areas for the Lorrain Formation (modified after Hadley, 1968)



Samples from the Long Lake outlier.

Photo 1: Dark heavy mineral bed in pebbly upper red quartzite member of the Lorrain Formation, Bruce Mines area.

Photo 2: Jasper pebble conglomerate bed about 2 metres thick in sharp contact with very fine-grained white quartzite of the Lorrain Formation, Bruce Mines area.

PLATE 2

Photo 3: Trough cross-bedding in upper red quartzite member of the Lorrain Fromation, with dark hematitic foresets outlining the cross-beds, Bruce Mines area.

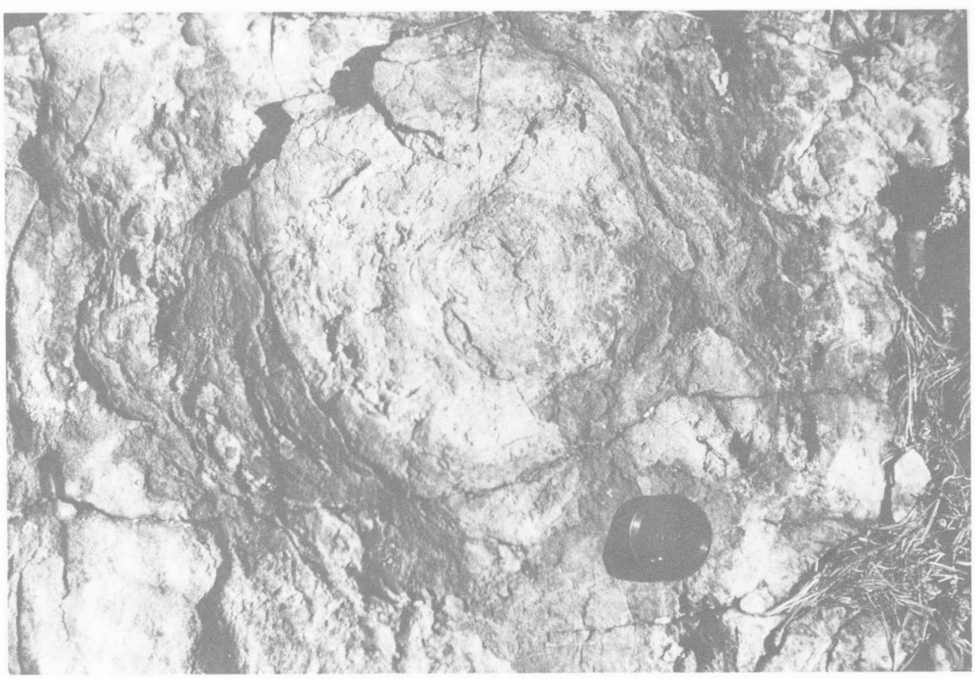


Photo 4: Purple to dark grey "stromatoform" in the upper white quartzite member of the Lorrain Formation, Bruce Mines area.

PLATE 3

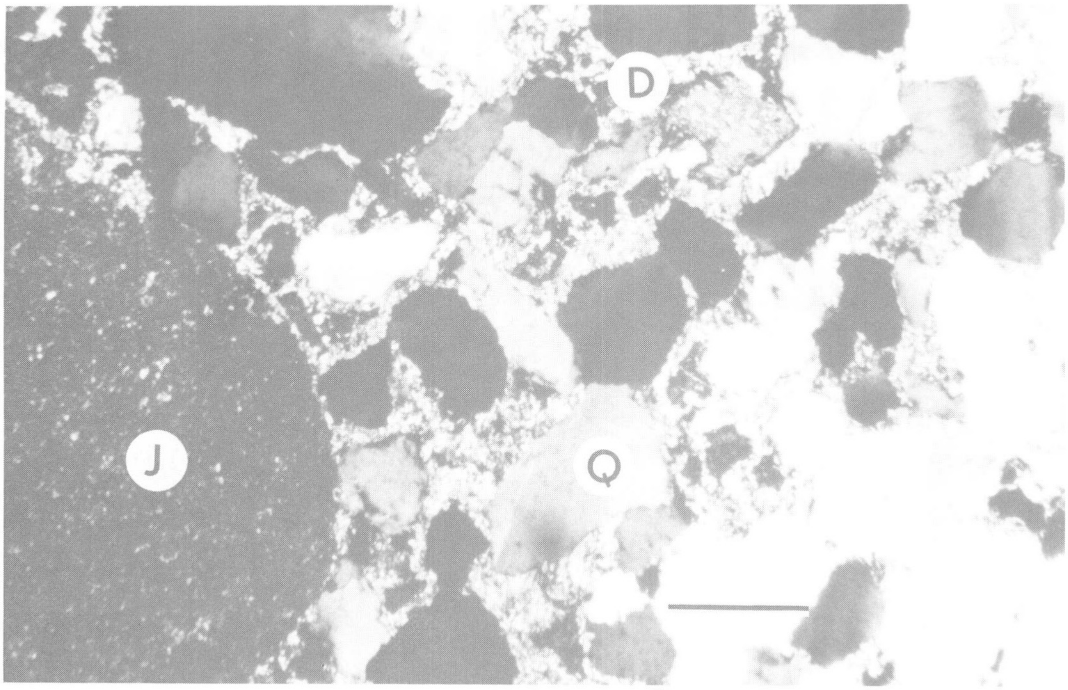


Photo 5: Microphotograph of a pebbly bed in the lower red quartzite member of the Lorrain Formation in the Bruce Mines area. A rounded jasper pebble (J) is surrounded by angular to rounded quartz grains (Q) which are contained in a predominantly sericitic matrix. A ragged plate of diaspore (D) is partly rimmed by kaolinite. Sample No. 3S-6255. Crossed Polars. Bar scale is 0.5mm.

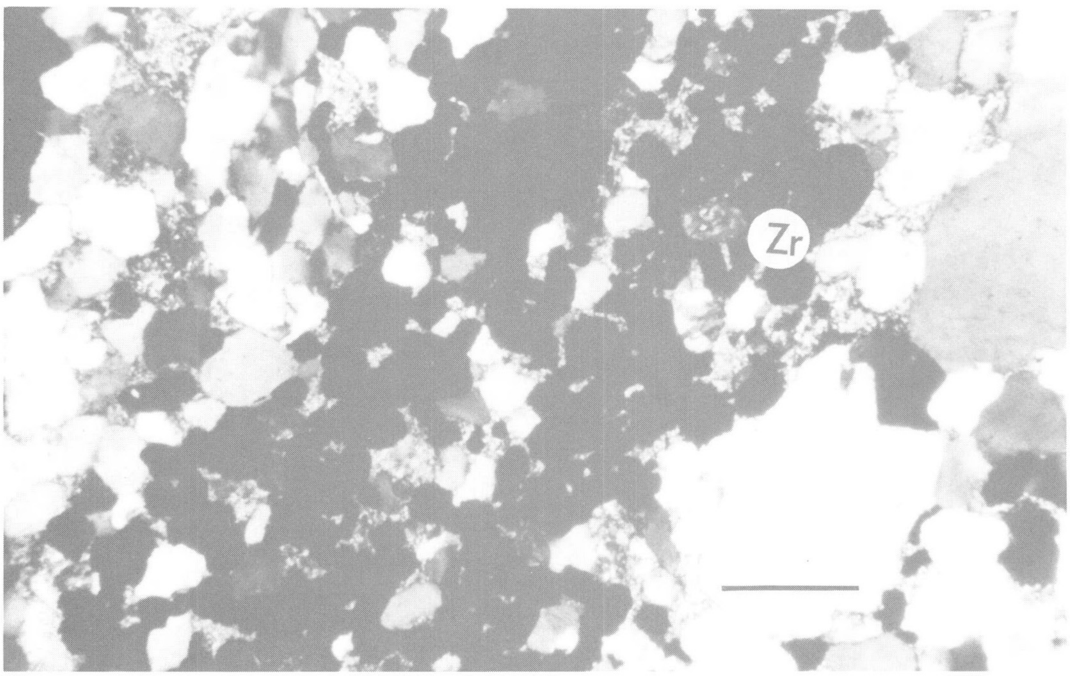


Photo 6: Microphotograph of a portion of a heavy mineral bed in the lower red quartzite member of the Lorrain formation, Bruce Mines area. The bed consists mostly of specular hematite grains (dark) with some scattered zircon grains (Zr). Sample No. 3S-8296. Crossed polars. Bar scale is 0.5mm.

PLATE 4

Photo 7: Alternating, thin beds of chert, quartzite, and siltstone of the Gordon Lake Formation, Bruce Mines area.

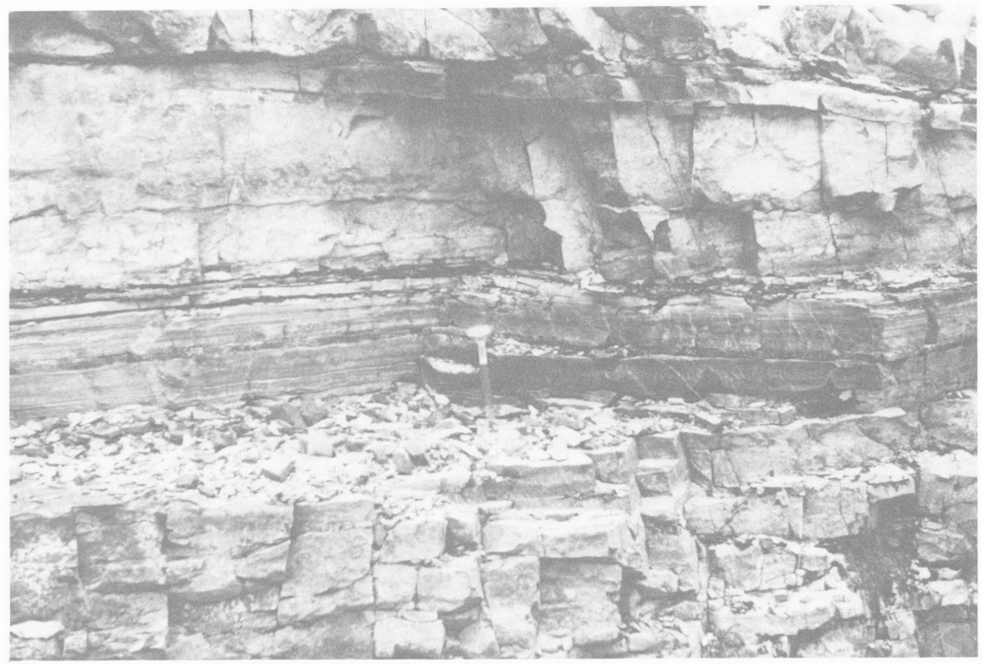


Photo 8: A bed or lense of Gordon Lake lithology "sandwiched" between upper white quartzite of the Lorrain Formation; the rock cut is on highway 638 and cuts through the approximate location of the boundary between the Lorrain and Gordon Lake Formations in the Bruce Mines area.

PLATE 5

Photo 9: Ferruginous quartzite member of the Lorrain Formation containing thin pebble lenses with disseminated specular hematite and heavy minerals, Whitefish Falls area, Highway 6.

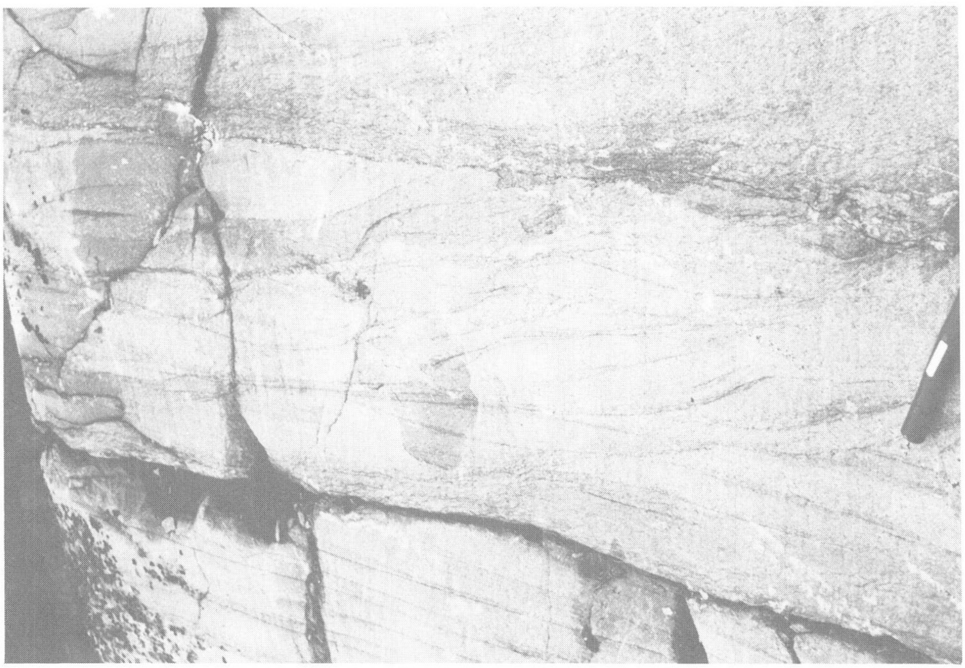


Photo 10: Ferruginous quartzite member of the Lorrain Formation in the Whitefish Falls area, Highway 6; heavy mineral beds outline trough cross-beds (Note the similarity with photo 6 from the Bruce Mines area).

PLATE 6

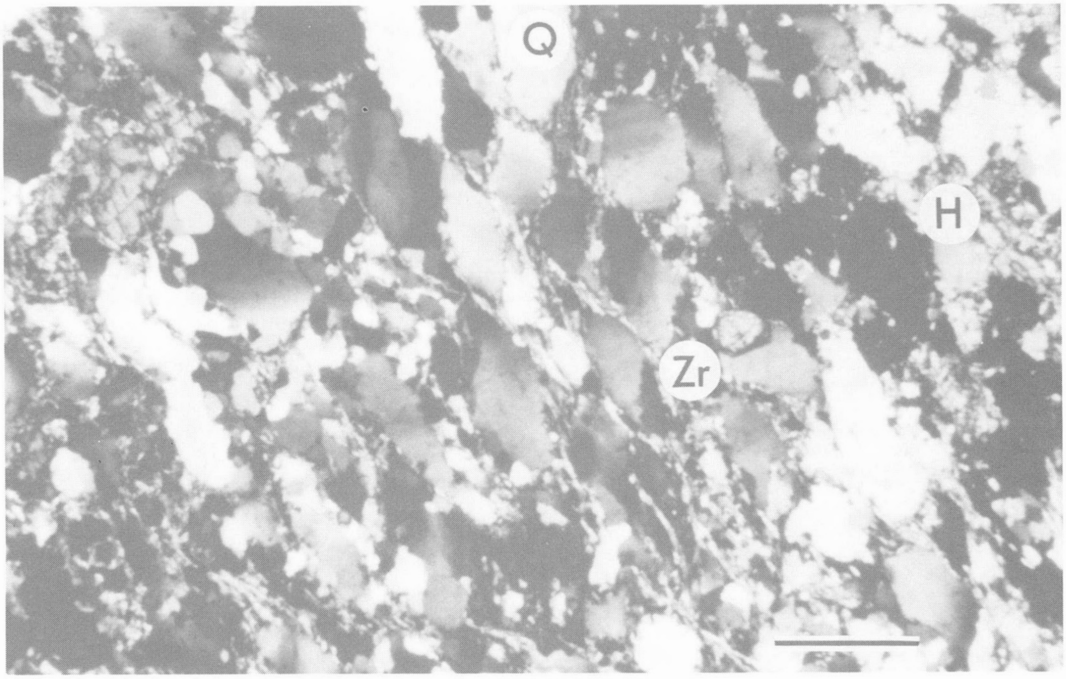


Photo 11: Microphotograph of the ferruginous member of the Lorrain Formation, highway 6, Whitefish Falls area. Elongate quartz grains (Q) and muscovite filaments define a penetrative fabric in the rock. A specular hematite layer (H) containing zircon grains (Zr) occurs parallel to the fabric and many of the grains have a lenticular shape. Sample No. 3s-0084; Crossed polars. Bar scale is 0.5mm.

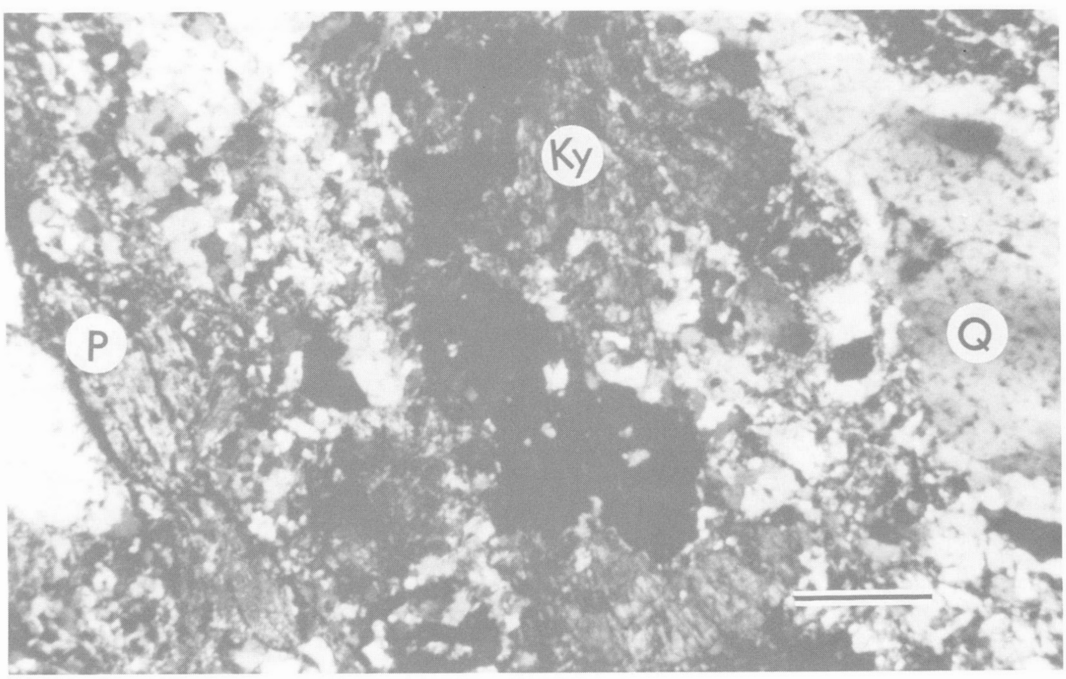


Photo 12: Microphotograph of a portion of a pebbly bed in the ferruginous member of the Lorrain Formation, Hwy. 6, Whitefish Falls area. Large intergrowth of kyanite (Ky) poikiloblastically enclose secondary quartz. Polygonal aggregates of quartz and fine-grained sericite-muscovite form a matrix to large quartz grains (Q), kyanite, and radiating clusters of pyrophyllite (P). Sample No. 3s-0128; Crossed polars; Bar scale is 0.5mm.

PLATE 7

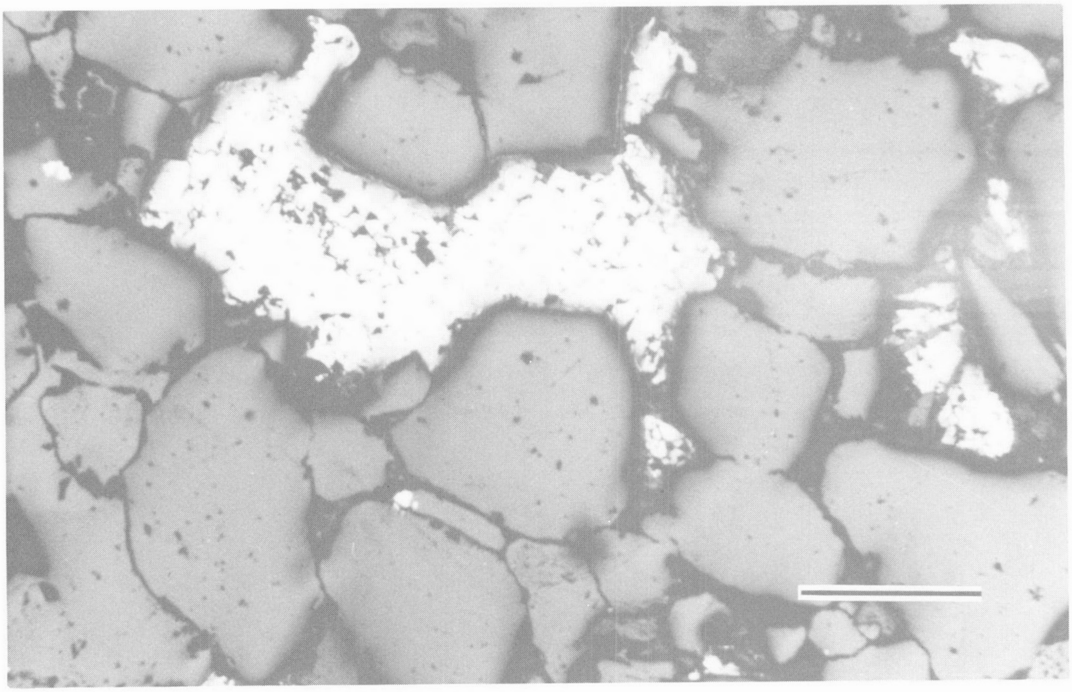


Photo 13: Microphotograph of chalcopyrite from the upper white quartzite member of the Lorrain Formation, Stag Lake area. The chacopyrite (white) occurs in the interstices of rounded quartz grains. Core sample No. 3S-6365 from D.D.H. #7; Reflected plane light; Bar scale is 0.5mm.

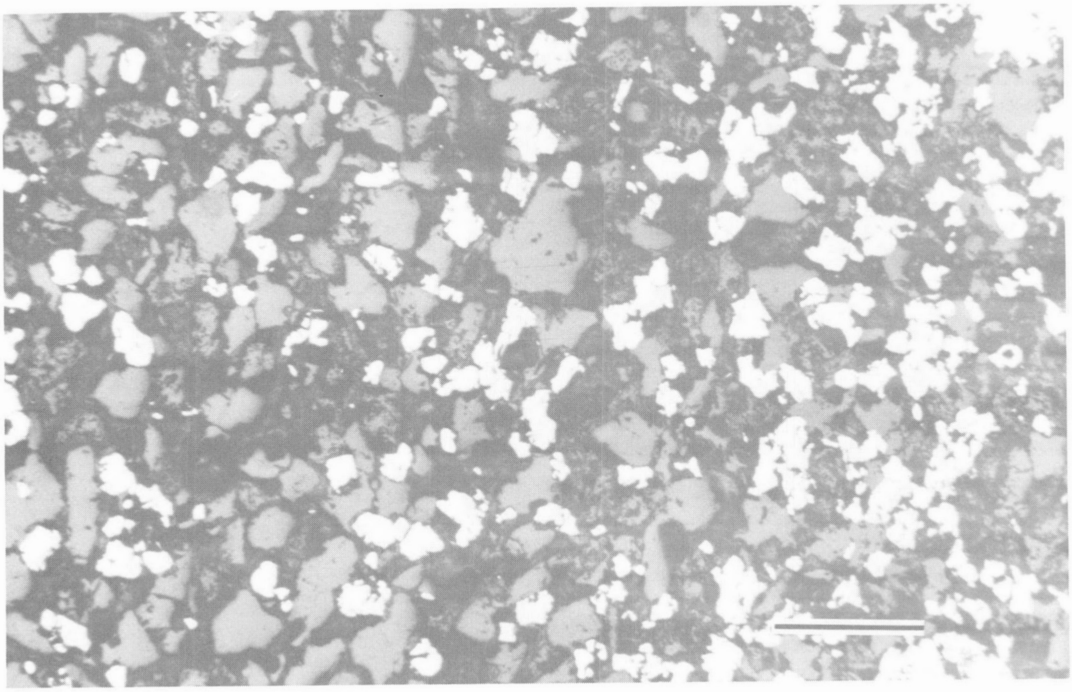


Photo 14: Microphotograph of a portion of a graded pyrite bed in the upper white quartzite member of the Lorrain Formation, Stag Lake area. Anhedral to subhedral pyrite grains (white) decrease in concentration and size, stratigraphically upwards. Core sample 3S-6457 from D.D.H. #5; Reflected plane light; Bar scale is 0.2mm.

Geological Survey of Canada Open File Reports

O.F. 1087*	Mineral inventory of the Sudbury-Timmins-Sault Ste. Marie region, Ontario; D.G. Rose (Project 1)
O.F. 1088*	Geochemistry of Swayze Belt esker, northern Ontario; J.A. Richard (Project 2)
O.F. 1089	Lithogeochemistry of Huronian Supergroup, Bruce Mines and Whitefish Falls areas, northern Ontario; D. Tortosa (Project 3)
O.F. 1090	Mineralization in the Onaping Formation, Sudbury Basin, Ontario; N. Bussolaro, D.H. Rousell, A.E. Beswick (Project 4A)
O.F. 1091	The metamorphic mineralogy and chemical alteration of the Temagami Greenstone Belt, northern Ontario; A.E. Beswick, R.S. James (Project 4B)

* To be released later.

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