A Report on Glacial Geology and Geochemical Dispersion in the Chibougamau Area Quebec

by

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INTRODUCTION

General Statement

While working for the Quebec Department of Mines (Mineral Resources Branch) during the summers of 1955 and 1956, the writer was assigned the problem of investigating the possibility of applying geochemical prospecting methods by soil sampling in a heavily glaciated part of the Province.

The present distribution of base metals in glacial soils has been brought about by the following processes:

a) Mechanical dispersion by glaciers of rock material, unconsolidated surface deposits and soil cover of pre-glacial origin. This transported and mixed material forms the present overburden.

b) Post-glacial redistribution of the metals contained in the bedrocks and the glacial deposits by ordinary processes of mechanical and chemical weathering and transportation.

Together, these processes have produced the so-called secondary dispersion of elements from their bedrock source.

A review of the literature soon revealed that little has been written on geochemical prospecting in recently glaciated areas. There is also little information available on the composition of the fine fractions of till, which is the most abundant type of surficial deposit covering recently glaciated regions. For the purpose of prospecting, in a given district, by soil sampling, therefore, it was decided that the following investigations would provide a suitable background.

a) Study on a regional and local scale of the bedrock geology of the district, including a detailed examination of known base-metals occurrences.

b) Study on a regional and local scale of the glacial geology and surficial deposits, including the processes of soil formation.

c) General study of the mechanical dispersion by glaciers of bedrock materials in the fine fraction of tills.

d) Investigation of the secondary haloes and trains of dispersion in the vicinity of known base-metals occurrences.

Concerning the third point of this program, the author felt that a mechanical and mineralogical study of the fine fraction of tills would yield more information regarding the dispersion processes by glaciers than would a chemical analysis of the base-metal content of the same material. This type of investigation has been called sediment-petrographic study by Scandinavian geologists.

The present report deals mostly with the study of the mechanical and chemical dispersion phenomena in the fine fraction of tills.

Choice of the Area

The selection of a suitable location for experimenting with geochemical prospecting methods was dependent on the following requirements.

The area had to be heavily glaciated and show evidence that the ice moved in a single and well-defined direction during the last period of the Pleistocene glaciation. Indeed, it was advisable to completely avoid the complications caused by multiple directions of ice movement.

It was also desirable that the regional and local geology be well known, so that only a compilation of geological data would be necessary. Mineralization in the district had to be fairly abundant; yet the mineral deposits had to be relatively untouched by human activity to avoid contamination of the soils and waters by development, mining and smelting activities.

The Chibougamau Copper District fulfills these conditions satisfactorily. It is located 320 miles north of Montreal, in Abitibi-East County. The closest base metal smelter is at Noranda, some 200 miles southwest. Geological mapping and prospecting in the area started in the early years of the century; it has increased sharply in the recent years since the district has been linked with Lake St. John by an

(~~all weather gravel road.~~) At the ~~present~~ time, only one mine ~~is~~ operating ~~within~~ the area ~~surveyed~~. It was inferred (~~from a few general studies on the glacial geology of Northwestern Quebec that~~) the late Pleistocene history of the area was rather simple, and that the ice moved steadily across it ~~from a stable center of accumulation.~~ in a northeasterly direction.

Field Work and Laboratory Techniques

Geology of Surficial Deposits

~~Field~~ Information on the nature of surficial deposits was gathered while sampling the soils and unweathered tills. (~~as described below.~~) Roadcuts and gravel pits were examined in some detail. (~~No traversing was done with the particular purpose of mapping surficial deposits.~~)

Field observations were extended (~~on the basis of~~) a thorough examination of aerial photographs (~~taken at~~) a scale of one mile to the inch. Larger scale photographs, (~~were only available for~~ small areas about Dore and Antoinette ~~Lakes,~~) ~~therefore~~ Interpretations are broad, and the map of surficial deposits shows only approximate boundaries, especially in parts where little or no sampling was done.

Sediment-Mineralogical Study of Tills

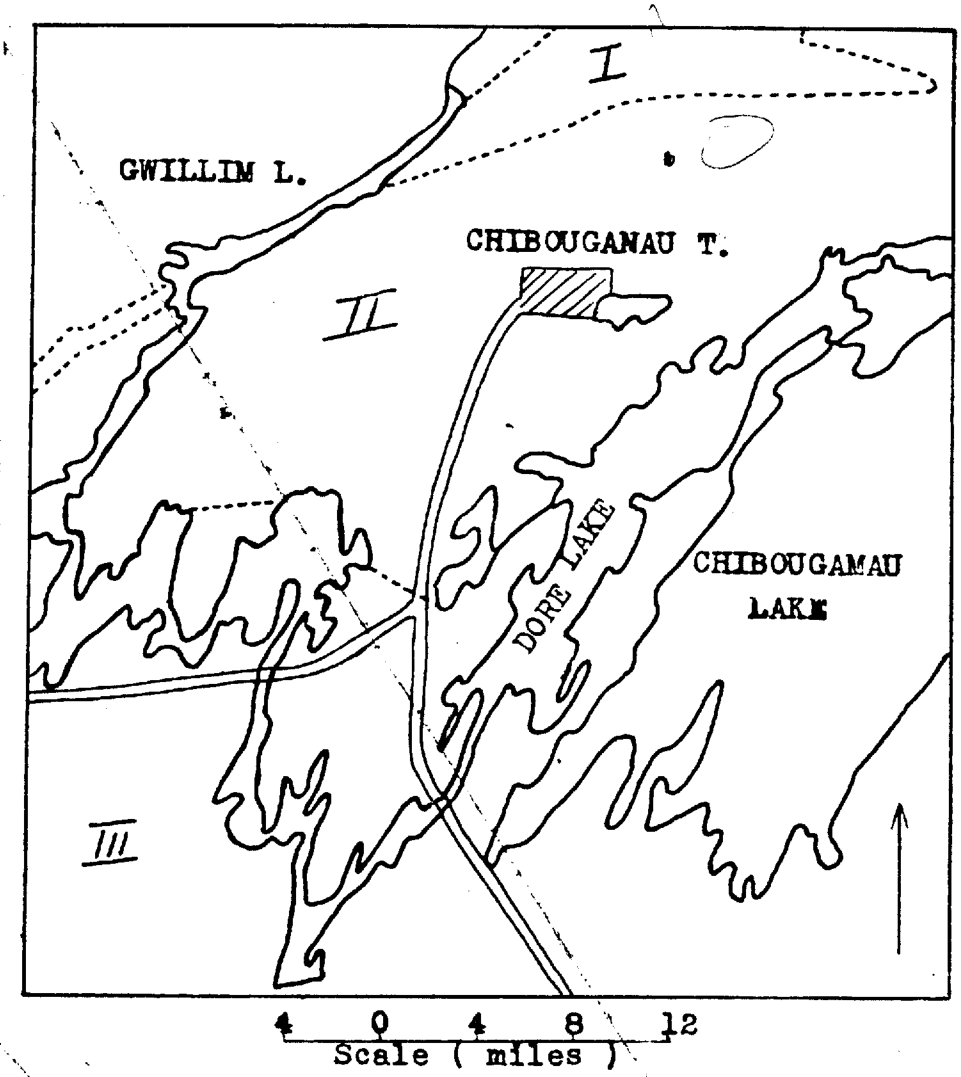
(~~Gathering of Samples.~~)

Twenty samples of the fine fraction of boulder till were collected along two traverse lines approximately parallel to the direction of ice movement. One line followed the Chibougamau highway from the Townsite to the bridge across Chibougamau River, the other followed the northwest shore of Dore Lake (See Figure No. 1). These traverses transect the geological boundaries at a high angle. The spacing between the samples was normally about one mile, but larger gaps were left where till was absent or where no suitable location could be found.

All ~~the~~ samples were ~~taken from shallow gravel pits or exploration trenches, immediately beneath~~ the soil ~~or deeper.~~ About 500 gm of fine material (granule size or finer) were collected from each location ~~along the face of the excavation, after the face had been cleaned of its water-washed surface.~~ ~~The~~ samples so taken ~~were considered~~ to represent the matrix of undisturbed tills.

Mechanical analysis ~~of tills.~~

In the laboratory, the twenty samples of the fine fraction of tills were quartered to 50 to 100 gms and a completely mechanical analysis was made. Material below 9 mesh (2mm) only was studied; the coarser fraction was discarded by sieving. The procedure followed in the preparation of the samples was essentially that proposed by Krumbein and Pettijohn (1938). ~~No difficulty was met in dispersing the particles~~ because of the low content of clay in the samples. Strong treatment such as boiling was not considered necessary,



1. Outwash sands and gravels.

11. Ground moraine (hilly ground)

111. Drumlinoid ridges field.

Fig. 1

~~because no~~ as coagulation of the clay particles ~~was observed~~ did not occur after soaking the samples in a dilute sodium oxalate solution for 24 hours.

The samples were wet-sieved through a 200 mesh screen to separate the finest fraction. The plus 200 - minus 9 mesh material was then dried and sieved through a set of Tyler screens on a Ro-Tap machine for 20 minutes. The minus 200 mesh fraction obtained was added to the fines previously separated by wet sieving.

The minus 200 mesh material was separated by sieving and was sized in a settling column. ~~The plus 200 mesh was sized~~ Two samples were studied by the pipette method (see Krumbein and Pettijohn). All the samples were then studied by the hydrometer method (see Bouyoucos - 1930) which is much faster but less accurate. The results obtained by the two methods were found to be fairly comparable, hence mechanical analyses by the hydrometer method are considered to meet the requirements of the present study.
The plus 200 mesh fraction was sized in a set of Tyler screens.

Mineralogical study of tills:

The purpose of this study was ~~not to obtain the complete mineralogical composition of the matrix of tills, but rather~~ to identify and determine the relative proportions of the most abundant minerals ~~and measure the variations in their content~~ in the suite of samples. ~~Survey~~ These determinations were carried out using ~~Statistical work was done on~~ the minus 100 - plus 150 mesh fraction of the till, ~~for three reasons: (1) It is the~~ which coarsest fraction in which most grains are monomineralic, exception made of fine grained alteration products; (2) Separation by heavy liquids is readily obtained; and (3) The particles can be easily identified under the microscope. This size range is classified as very fine sand in the Wentworth scale.

A first separation (by gravity) into a light and a heavy fraction was made using a Tetrabromoethane + Carbon tetrachloride mixture (density 2.85).

The light fraction was then washed for a short time with a 15% hydrochloric acid solution containing 10 percent of stannous chloride, to remove any surface coating of the grains with iron oxides. An examination under the petrographic microscope revealed that the light fraction was mostly composed of fresh looking, colourless minerals, the determinations of which by ordinary microscopic methods would involve tedious and lengthy optical work. It was therefore decided to group the minerals composing the light fraction into the following four categories: quartz, potash feldspar (microcline, orthoclase), plagioclases (of any composition), and undetermined grains including light alteration products, a few floated flakes of biolite, etc. To recognize these different groups easily, selective staining methods described by Keith (1939) were used. The material was generously spread

~~on a glass plate covered with a thin layer of rubber cement,~~ etched ~~for three minutes~~ in hydrofluoric acid fumes, and stained with a solution of sodium cobalti-nitrite. The plates were ~~washed, dried and~~ examined under a binocular microscope. Quartz was left untouched; potash feldspars were covered with a bright yellow stain of potassium cobalti-nitrite; and the plagioclases displayed a white etched surface. Two hundred grains from each slide were counted and results were recorded in percent/volume.

The heavy fraction was examined under the petrographic microscope after removing ~~the~~ magnetite with a hand magnet. A separation of the main minerals with the isodynamic separator proved to be inefficient because of the abundance of alteration products such as saussurite, uralite, etc. Here again the minerals were grouped into four categories, namely: amphibole-pyroxenes, biotite, epidote (saussurite) and undetermined. The percentage of each mineral group in the samples was again obtained by counting 200 grains.

Postglacial Secondary Dispersion of Base Metals

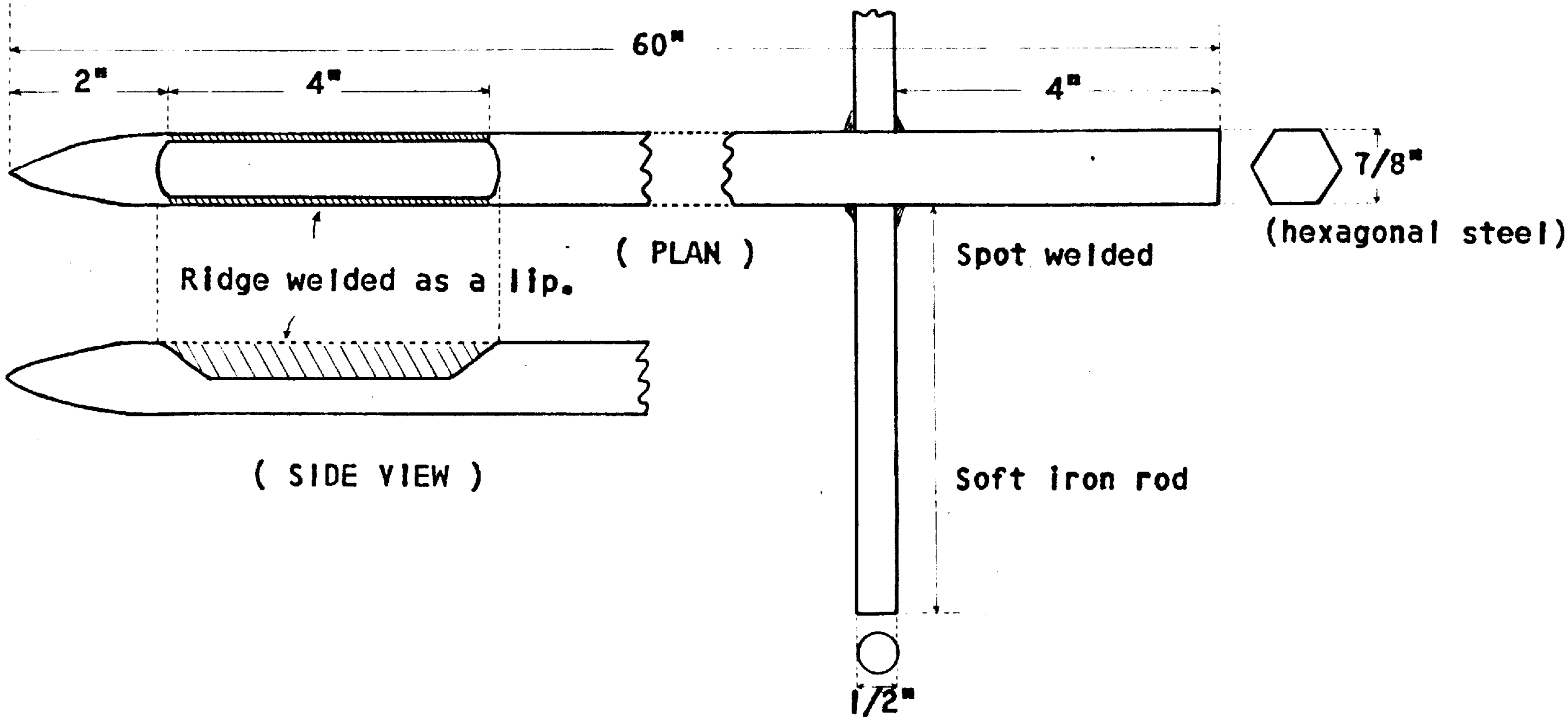
Soil Sampling Tools and Sample Containers:

Most of the samples collected for base metal analysis were taken ~~in~~ from the top five feet of the unconsolidated cover, ~~often within the solum.~~ ~~In a few locations~~ where it was essential to investigate the vertical distribution of metals to a greater depth, samples were collected from as deep as 15 feet below the surface.

The heavily wooded Chibougamau district is mostly covered by boulder till which is in places very rocky; however, shallow depressions filled with swamp material are abundant. A suitable soil sampling tool must be adapted to these conditions.

For shallow soil sampling, an instrument devised by Ogden (1954) was adopted with a few modifications. It is represented by Figure No. 2. The tool, which has an over-all length of 60 inches, is driven to the necessary depth with a six pound sledge-hammer. If the surface is very rocky, the tool is used as a bar to explore the ground through the moss and humus cover. It is hammered down to the required depth, pulled out, cleaned and placed back into the sampling hole; the sample is then collected by rotating the instrument several times. The whole operation is very rapid under normal conditions.

~~There is another~~ The instrument ~~built~~ for deeper sampling ~~. It~~ is designed so that the soil filling the head will be continuously evacuated under the pressure of newly introduced material, as the instrument is hammered down; consequently, the sample recovered when the instrument is pulled out represents the bottom few inches of the traversed



SOIL SAMPLING TOOL.
Fig.2.

soil. (~~Photograph No. shows how the instrument is operated.~~) The steel rod is driven down with a sledge hammer, as in shallow sampling and additional four-foot ~~steel~~ sections, threaded at each end, are attached with special couplings whenever necessary. To pull the instrument out, a tripod is erected and the rods are lifted by means of a 1-1/2 ton aluminum rack and pinion device. This lifting tool is required even for relatively shallow depths of sampling, especially when the sampling tool curves after hitting the side of a boulder. Whenever a large boulder is encountered, the hole is necessarily abandoned.

Peat samples were collected to a maximum depth of 15 feet using an ordinary hand piston sampler. The tool is driven to the required depth with the piston down in the sampling tube. The piston is then lifted by pulling up the instrument about one half foot; the instrument is rotated to lock the piston in the "up" position and the sample is collected by driving the instrument down a few inches below the depth initially reached.

~~Experience showed that~~ The most practical container for keeping soil samples ~~(about one half ounce of fine material)~~ is a 3½" x 6" ~~three and one half by six inch~~ heavy paper envelope sealed with waterproof glue. Handling and contamination of the sample are reduced to a minimum by drying it before opening the envelope. Aluminum tins were also used occasionally but were found less convenient.

Sampling Pattern

In the present study, a single sample of about half an ounce was collected from each sampling site. Studies by the U.S. Geological Survey (Hawkes - 1953) have shown that in most residual soils, such a sample represents the metal content within a radius of about five feet.

The reproducibility of analyses of spot samples in glacial soils has been tested by the following experiments.

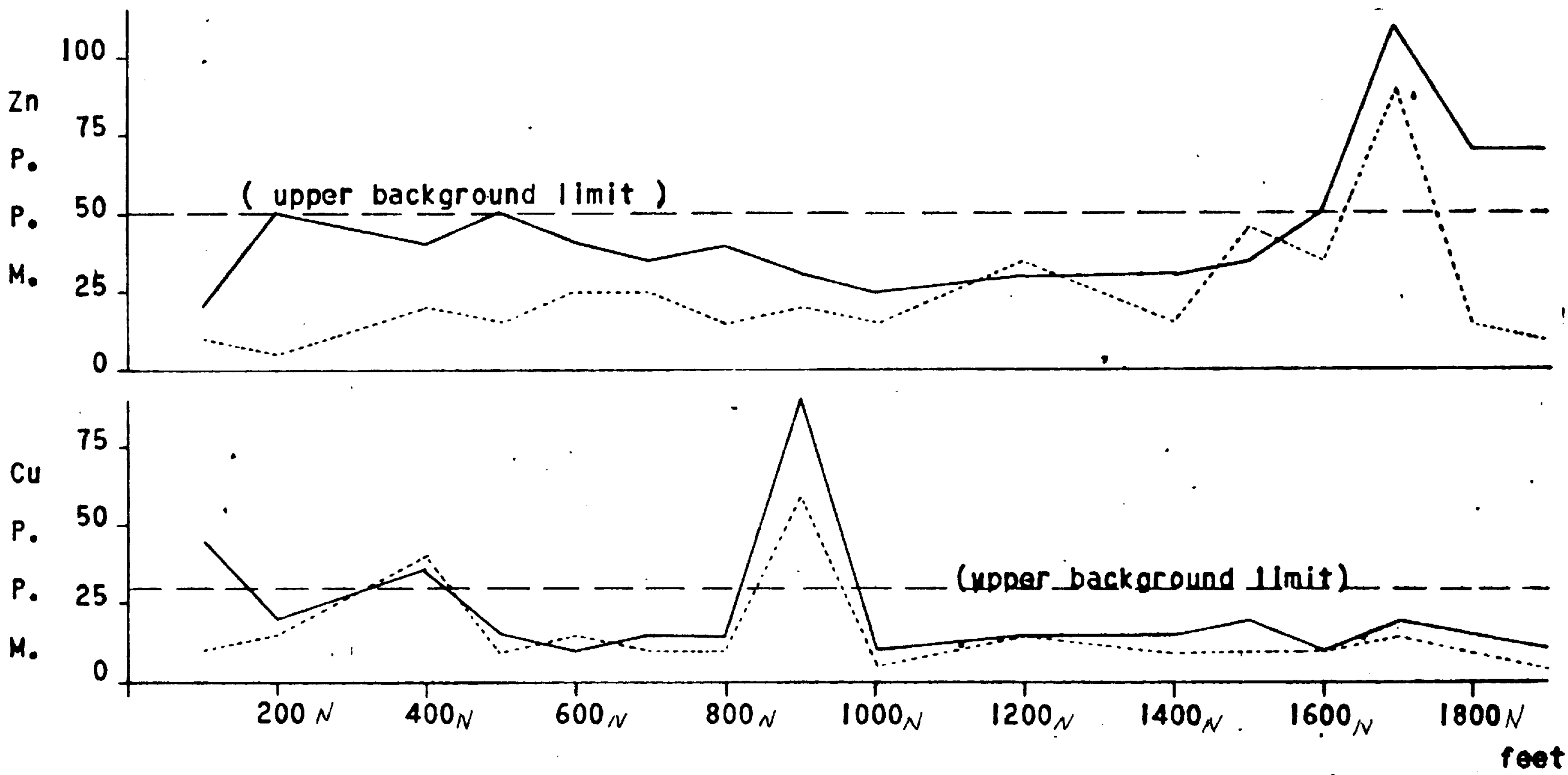
Figure No. 3 shows the analyses in copper and zinc of two sets of samples taken approximately at the same location (i.e., within one or two feet) within an interval of one year. Analyses were made by two different persons. The copper assays for the two sets are very similar, and the slight variations fall within the range of accuracy of the analytical methods. The only serious discrepancy was found in the southernmost pair of samples; it is very likely caused by surface contamination of the richest sample, which was collected in swampy ground in the immediate proximity of a diamond drilling site. The correspondence between the zinc analyses may seem rather poor. The zinc values of the second year in the south half are much higher than the first year results, although they remain within the background range. Such systematic differences will be discussed later; they are probably inherent in the analytical technique used. Both analytical series show a similarly located peak above the background value.

Figure No. 4 shows the analytical results of two sets of samples, taken 15 feet apart. Results check fairly well in the south half of the traverse, but to the north the sample taken at location 600 + 15 feet N is much higher in zinc than the one taken at location 600 N.

Sampling Pattern:

Detailed soil sampling and a limited amount of water testing were first carried out near several of the ~~main~~ known ~~occurrences~~ deposits of base metals. The purpose was to investigate the shape and intensity of secondary halos of dispersion developed about these deposits. The sampling usually followed picket lines at right angles to ore-bearing structures that were cut by mining companies for their geological and geophysical work, ~~mostly at right angles to the ore-bearing structures~~. Sampling traverses were normally spaced 200 to 300 feet apart, and samples along the traverse lines were taken every hundred feet or closer. ~~At the same time~~ The background values of copper, zinc, and lead in the soils of the district were also established ~~at the same time~~ by this work

Soil sampling was then extended to the ground separating the main mineral deposits, and to the area southwest of the known belt of mineralization, ~~in~~ being the direction in which the ice moved during late Pleistocene time. The purpose

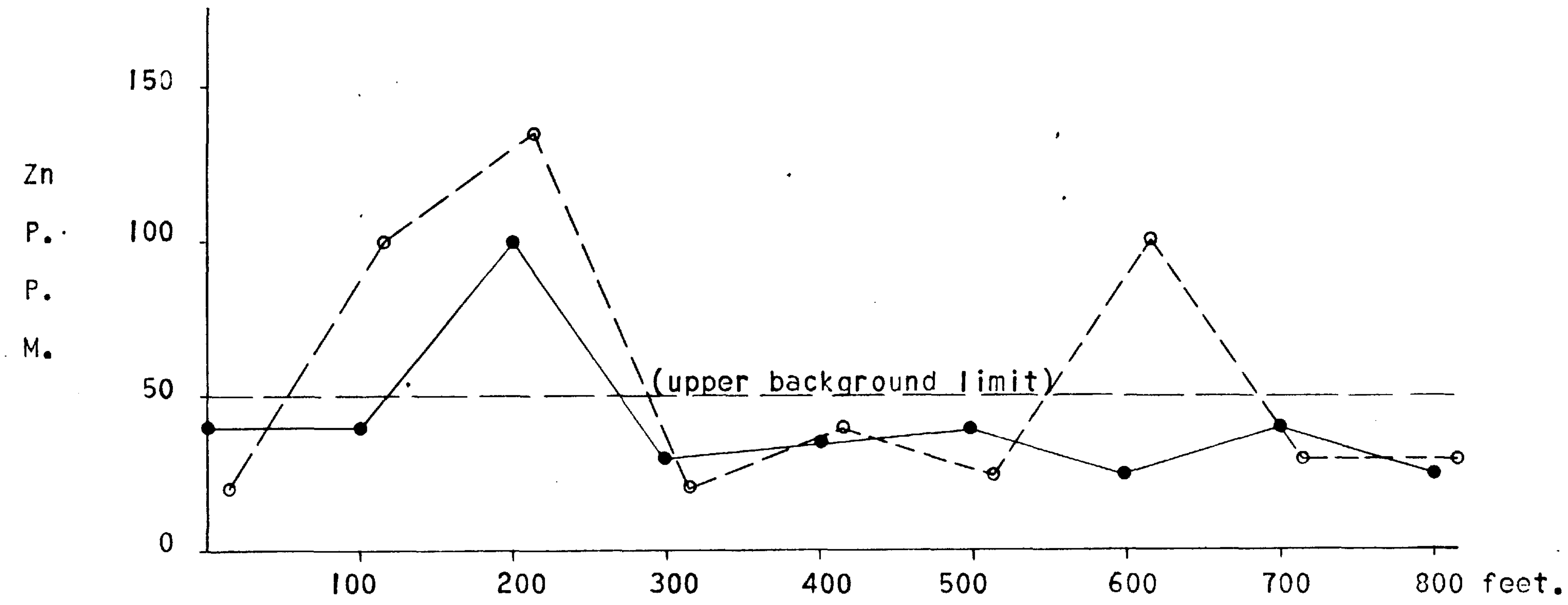


.... Analyses of samples collected in 1955.

——— Analyses of samples collected in 1956.

Comparison of zinc and copper values obtained for two sets of samples collected at the same locations.

Fig 3



Comparison of zinc values obtained for two sets of soil samples collected at 15 feet intervals..

Figure 4.

Out (

was to determine whether or not there was an increase in the background values of base metals in the till because of the integration ~~(in the till)~~ of mineralized material from deposits located up-source. ~~upstream.~~ In this case, soil sampling traverses were located approximately one thousand feet apart and oriented at right angles to the direction of ice flow. Sampling points along the traverses were spaced 200 feet apart or more.

A total of 4,300 soil samples were collected, each weighing approximately one ounce.

Analytical Technique:

Warren and Delavault (1956) divide the total metal content of a soil as follows:

a) Metal present as free ions. Easily extractable by water. Forms a small percentage of the total metal content.

b) Metal ions loosely bound to the surface of mineral particles and organic matter. Can be extracted with a cold solution containing a high concentration of exchangeable ions.

c) Metal ions tightly bound by chelating (formation of certain types of organic complexes), or by entering the clay particles. Mostly extractable with strong acids.

d) Metal present as sulphides, secondary oxides and carbonates (hydrothermal and epigenic). Extractable with mild to strong acids.

e) Metal contained in primary silicate and oxide minerals. Can only be extracted by destroying the mineral lattice with hydrofluoric acid, potassium bisulphate fusion, etc.

The total content of a given metal in the material sampled is seldom sought in geochemical prospecting. The sample is, ~~rather~~, digested in such a way that most silicate minerals are undamaged and only part of the metal present is analysed; moreover, a great accuracy is not required, because the intensity of the anomaly sought is ordinarily equal to several times the background value.

Two different analytical techniques were used in the present work. With the cold extraction method of Bloom (1955) the samples were treated with a cold solution of ammonium citrate, and metals belonging to groups (a) and (b) only were dissolved. With the hot nitric acid extraction method of Bloom and Crowe (1953), metals belonging to groups (c) and (d) were also brought into solution.

In both methods, the base metals dissolved during the preliminary treatment of the sample are removed by a dilute dithizone (diphenyl thiocarbazone) organic solution; coloured metal dithizonates are formed and the metal content is estimated colorimetrically.

The analytical methods mentioned above were developed by the U.S. Geological Survey primarily for the study of residual soils and alluvium. (~~The Chibougamau district residual soils are very scarce or completely absent.~~) The secondary halos of dispersion in the transported overburden of the Chibougamau district, ~~mainly~~ formed mainly by chemical weathering, are geologically very recent and consequently the anomalies are fairly weak. The original analytical techniques were thus slightly modified to meet the local requirements.

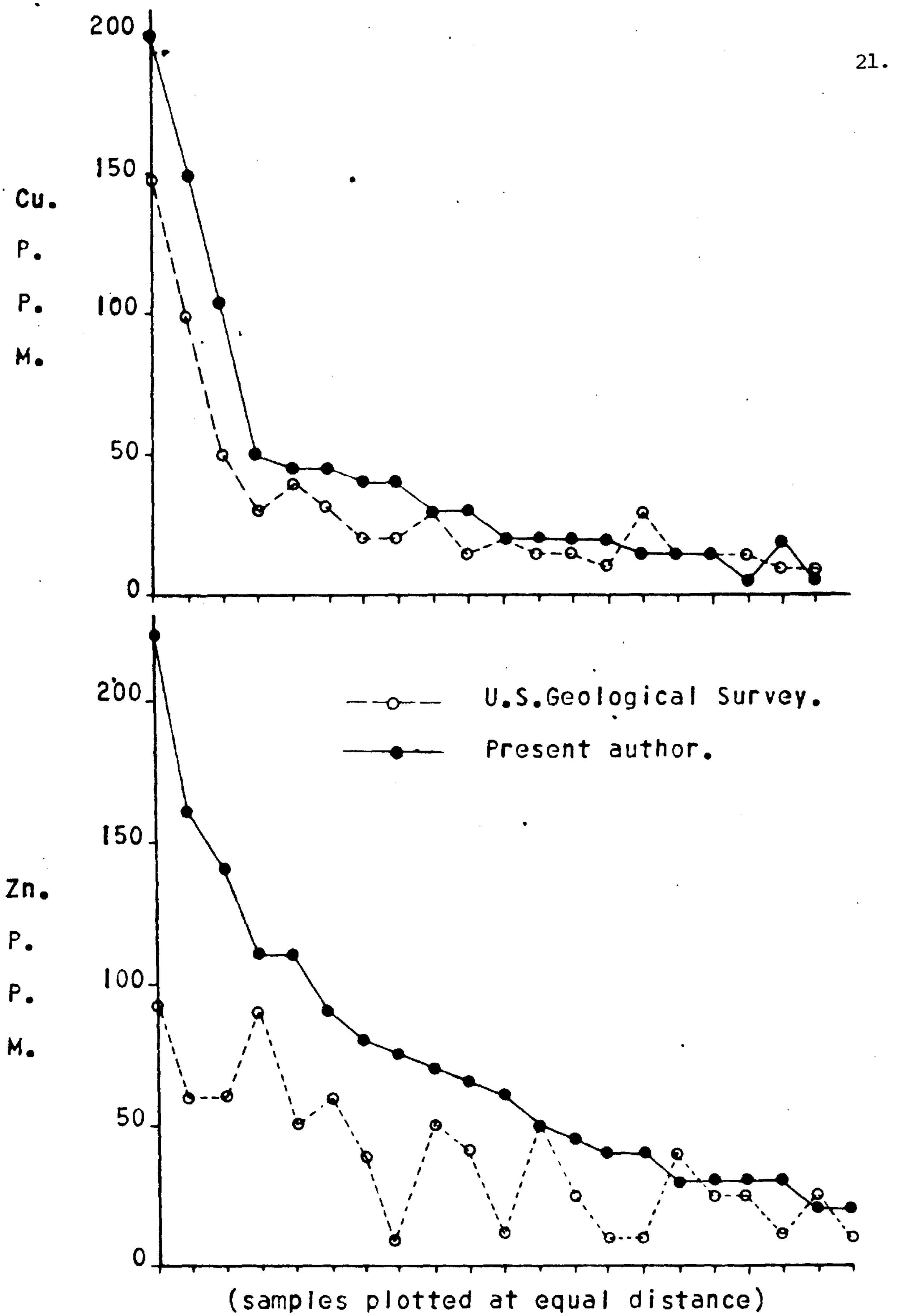
Hot Nitric Acid Extraction.

All the till samples were analysed by the hot nitric acid extraction method. In this way, the base metals removed by the ice from mineralised bedrock and dispersed mechanically in the till in the form of primary and secondary sulphides and oxides ~~could~~ can be detected. The results of these analyses for each metal are expressed in parts per million (p.p.m.) of the sample. For a matter of convenience, the metals so analysed will be called readily soluble metals in further parts of this ~~thesis~~ report.

The sensitivity of the nitric acid digestion method was increased by using 0.25 to 0.50 gm. of minus 80 mesh material instead of 0.1 gm. With this modification, the smallest amount of metal detectable was 5 p.p.m. The sample was digested for two hours in 5 ml. of 1:3 nitric acid in a boiling water bath. In this way, losses by bumping out of the tube during boiling were completely eliminated, and the extraction was complete. It was observed that by using larger amounts of nitric acid, the buffer solution used in the zinc test became ineffective.

The reproducability is evaluated by Dehn (1957) to be plus or minus 50% of the amount present for values above 20 p.p.m. Such a correspondence, or better, was usually obtained between the field laboratory assays and assays obtained at the Geochemical Laboratory of McGill University. At times, however, both laboratories experienced difficulties with abnormally high values in the low range, especially for zinc. Subsequent verifications would reveal variations reaching 100 percent of the amount present. The discrepancy between two sets of samples shown on Figure No. 5, illustrates such a situation. The reason for these variations is not known.

Figure No. 5 compares the assay results obtained in the field laboratory with those reported by the Geochemical Laboratory of the U.S. Geological Survey, for a suite of 21 samples of mineral soils. Samples are plotted according to decreasing copper and zinc values as determined by the writer and his assistants. At the U.S. Laboratory, samples were fused with potassium bisulphate prior to the determination of copper and zinc, so that the total metal content was brought into



Comparison of zinc and copper values obtained for the same soil samples by the U.S.G.S. and the author.

Fig 5

solution. Nevertheless, the results obtained by the Laboratory are systematically lower (for above background values) than those of the writer. The shape of the two curves for copper is very similar. There is also a general correspondence of the zinc results.

Unsatisfactory results were obtained when using the hot nitric acid extraction method for the analysis of copper in humus samples. The background values did not exceed 5 p.p.m., and in many samples no copper at all could be detected. Results obtained by the U.S. Geological Survey Laboratory for a few samples of humus, after fusion with potassium bisulphate, were markedly higher. A series of 26 humus samples was then submitted to the Geochemical Laboratory of McGill University for analysis of copper after $KHSO_4$ fusion; the assay results are given in Table No. 1. Values obtained by this method are considerably higher than those found after the hot nitric acid digestion, but there is no systematic relation between the two sets of values. It is probable that when the sample is digested in hot nitric acid, part of the copper becomes fixed in particularly stable organic complexes and does not form copper dithizonates.

About one half of the chemical analyses were done in a field laboratory by the writer and other members of the field parties during the summers of 1955 and 1956. The remaining part was done at the Geochemical Laboratory at McGill University.

Ammonium Citrate Extraction.

The ammonium citrate extraction method was also used, mainly as an "on the spot" guide to the field work. The results are semi-quantitative and are expressed as cc. of dithizone solution used to obtain a blue-purple end colour. They represent the cold extractable total base metal content.

For equal amounts of metals present, the reaction obtained is strongest for zinc, followed by copper and lead. The predominance of either zinc, copper or lead in soils may be detected by additional tests.

In Chibougamau, copper is the most widespread base metal, and a specific field test for copper would therefore be more convenient. At the time the writer made the survey, there was no description of such a test in the literature. Specific methods for field determinations of copper in soils have since been developed by Holman (1956) and Warren and Delqvault (personal communication).

The amount of soil to be tested was measured in a leucite scoop designed to contain 0.1 gm. of dry sandy material. During the field work, this measure was used for soils of widely different composition and water content, so that the actual weight of material analysed varied widely.

The sensitivity of the ammonium citrate extraction method was also increased, by using a more dilute working solution of dithizone (0.001% weight/volume) than the one ordinarily used by Bloom (0.003% weight/volume). Unfortunately, very diluted dithizone is so unstable that it is difficult to use in the field. For this reason, many determinations were made at the base camp.

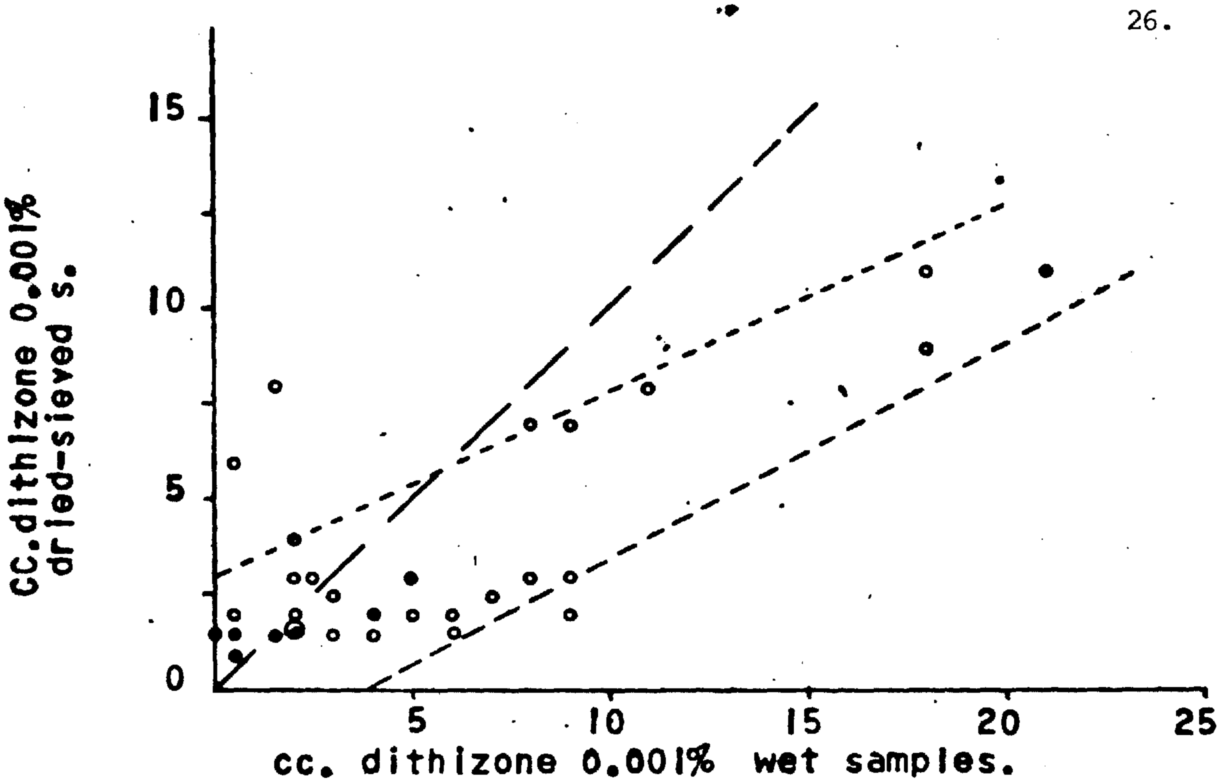
Two large soil samples, one containing background amounts of cold extractable metal and the other one containing anomalous amounts, were collected in the beginning of the field season. Their homogeneity was achieved by thorough mixing. Chemicals used in the field test were regularly checked for deterioration or contamination with these two samples. The results were as a rule very constant.

The results obtained by cold extraction with dried and sieved soils are expected to be more uniform than with unprepared samples. The variable amount of water which may be present in the natural soils, particularly in humus, is eliminated, and for the same type of material the differences in weight of samples assayed are attenuated. The variation in the grain size of the samples is decreased by discarding material above a certain size (greater than 80 mesh). This is particularly important for mineral soils because the largest part of the metal analysed by the ammonium citrate extraction method is loosely bound by adsorption to the surface of mineral particles, hence the amount of extractable metal is a function of the surface area (see McPhar, 1956 and Hawkes and Bloom, 1956).

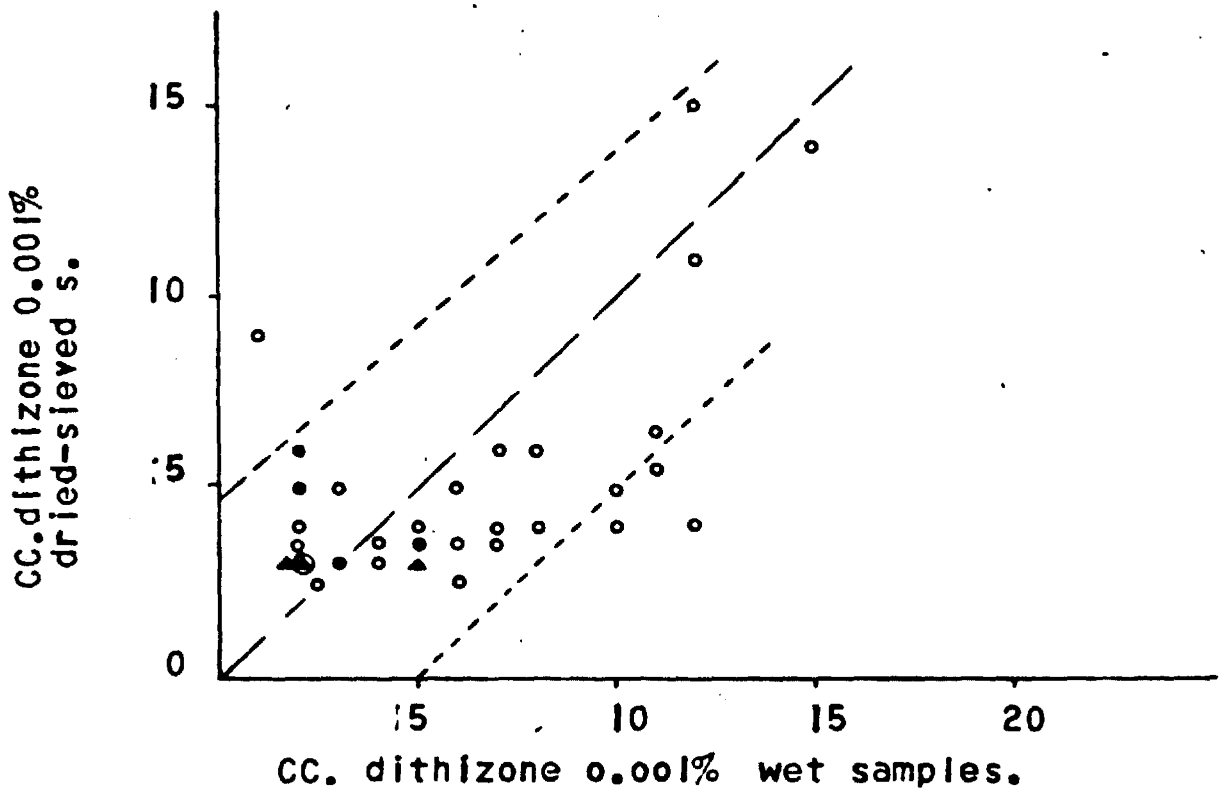
The relation between assay results obtained in the field with wet samples and values found in the laboratory for the same samples after drying and sieving is shown in Figure No. 6. The same volume of soil was used in both series of analyses so that more mineral and organic material was analyzed in the laboratory test. For the reasons outlined above, there is a considerable variation between the values obtained. For soils predominantly of inorganic composition (B and C soil horizons), there is a marked decrease of the "cold extractable" metal content with drying and sieving. The values found for predominantly organic soils (mostly Ao horizon of podsols) for the two series of tests are statistically comparable. This is in accordance with results obtained by Berrange (1957) in organic soils of the Kenora district of Ontario. In the latter case, it should be remembered that by drying and sieving the sample the organic material contained in the same volume is increased by two times or more. The conclusion is that in all types of soils, drying decreases the amount of base metals extractable by mild treatment.

Water Testing (McPhar Method)
~~McPhar Method (Water Testing).~~

A commercial McPhar water testing kit was used



MINERAL SOIL SAMPLES.



ORGANIC SOIL SAMPLES.

o one reading.
• two readings.
▲ three readings.
● four readings.

Comparison of cold extraction results with wet and dried-sieved samples.

Fig. 6.

in the field for water analyses. In this method, heavy metals, i.e., zinc, copper, lead, nickel, cobalt, tin and silver are extracted from a buffered water sample by a dilute solution of dithizone in chloroform. A pH of 5.5 is obtained when using the buffer provided with the kit. At this ph, the unused portion of dithizone, if any, remains in the organic layer and the colour produced is a mixture of that of the unused dithizone (green) and that of the heavy metals dithisonates (red). In the McPhar analytical procedure, 1 ml. of dilute dithizone in chloroform is first added to the water sample. After shaking, the colour of the organic droplets is observed. If the droplets are red, more dithizone is added until the mixed purple shade indicating that all the heavy metals have been transformed into dithizonates is reached. The total volume of dithizone solution added is recorded; using a diagram provided with the kit, this volume can be translated into parts per million of total heavy metal in water as zinc equivalent. If, after addition of the first ml. of dithizone solution a purple colour is already obtained, the amount of heavy metals present may be determined more accurately by adding a few drops of amonia to the water sample. At a basic pH (approximately 9) the unused portion of dithizone is soluble in the aqueous layer, and the organic layer then shows the true colour of the mixture of dithizonates present.

In the present study, the results of water tests will be indicated as ml. of dithizone solution (prepared as per instructions of the McPhar Geophysical Co.) used to obtain the purple end point at a pH of 5.5 with a water sample of 50 ml.

pH Measurements.

The procedure outlined by the association of Official Agricultural Chemists (1950, p. 44) was followed. All the measurements were made in the laboratory with a Beckman model N pH-meter. For measurements oh mineral soils, distilled water was added until a soil-water ratio of approximately 1:1 was reached; the mixture was then stirred vigorously and allowed to stand for 30 minutes. For organic soils, the soil-water ratio adopted was 1:5 and the mixture was left to stand for 2 hours. Several readings were taken with each sample; after each measurement, the electrodes were withdrawn from the soil mass. The initial reading was often found inaccurate because equilibrium had not been obtained between the electrodes and the soil mass.

The material used had been previously air-dried for sieving and chemical analysis. ~~Reed and Cummings (1945)~~ consider that this treatment should not change the pH of the soil by more than 0.1.

BEDROCK GEOLOGY

Regional Geology.

All the consolidated rocks in the Chibougamau district are of pre-cambrian age.

The general distribution of the main rock types, as compiled from maps published by several authors, is shown in Figure No. 6. The mineralogical composition of these rocks, which is of special interest to this study, will be described in detail. The results are summarized in Table No. 2.

Granites and Gneisses:

The continuous belt of granites and gneisses which underly the easternmost part of the area is believed to belong to the rocks of the Grenville Subprovince (Norman, 1940). In the Chibougamau-Mistassini district, these rocks have been mapped by Longley (1951), Gilbert (1951) and Deland (1951). A detailed description of the rocks is given by Wahl (1953) and Neilson (1953) who worked northeast of the area covered by Figures Nos. 6 and 7. These authors distinguish a belt of granitic rocks and orthogneisses several miles wide immediately east of the line of contact with the volcanic and sedimentary rocks.

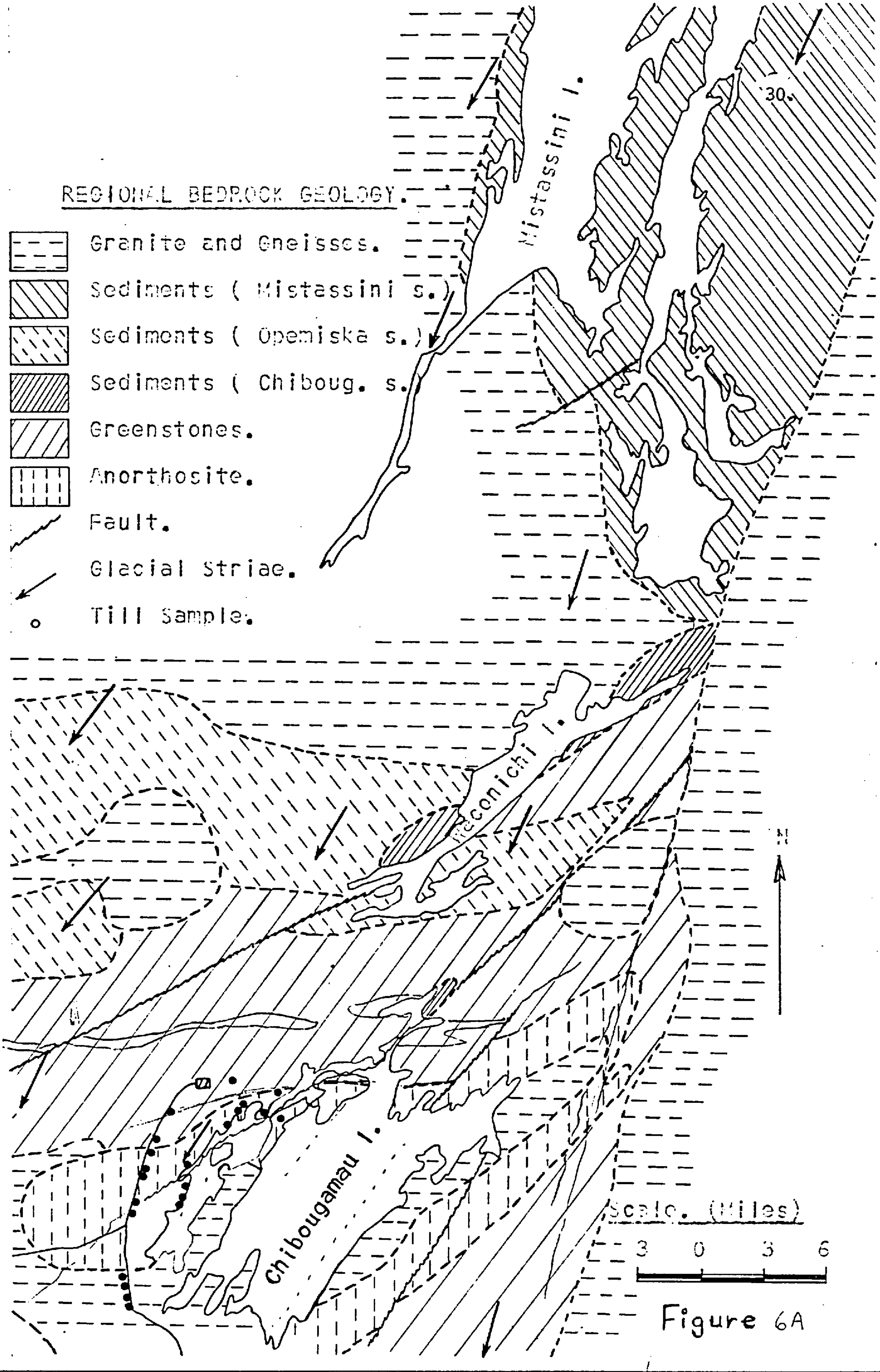

REGIONAL BEDROCK GEOLOGY.
Granite and Gneisses.
Sediments (Mistassini s.)
Sediments (Opemiska s.)
Sediments (Chiboug. s.)
Greenstones.
Anorthosite.
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Figure 6A

TABLE NO. 2

MINERALOGICAL COMPOSITION OF THE MAIN ROCK-TYPES CHIBOUGAMAU AND MISTASSINI REGION.

ROCK TYPE	LIGHT MINERALS	HEAVY MINERALS
Granites and Gneisses (Grenville)	Quartz- Microcline (fresh) Plagioclase (fresh)	Biotite - Minor Hornblende and Muscovite.
Granites and Gneisses (West of Mistassini)	Quartz- Microcline (fresh) Plagioclase (fresh)	Biotite - Some Minor Hornblende.
Same. South border phase.	Potash Feldspar (fresh) Plagioclase (fresh)	Hornblende.
Granite Batholiths (w. and e. Waconichi)	Quartz - Potash Feldspar (fresh) Plagioclase (fresh)	Biotite - Minor Hornblende.
Chibougamau Lake granite.	Quartz (up to 40%) - Plagioclase (altered) Secondary albite.	Chlorite (alteration of biotite) Saussurite (alteration of plagioclase)
Mistassini sediments.	Dolomite - Calcite - Clay minerals.	
Anorthosite-Gabbro Complex	~~Same~~ Secondary albite; minor original plagioclase	sericite actinolite saussurite; chlorite; magnetite-ilmenite
Opemiska sediments.	Plagioclase - Quartz (fairly abundant).	Amphiboles - Micas.
Greenstones, ~~Cache Lake~~ gabbro; etc. ultra basics	Plagioclase (mostly secondary albite) Very minor quartz.	Uralite - Remnants of Diopside Saussurite - Actinolite - serpentine Chlorite Magnetite - Ilmenite etc.

Further east, paragneisses are predominant. The grade of metamorphism is described as medium to high. The typical mineral assemblage is quartz, potash feldspar (predominently microcline), plagioclase (predominently obligoclase) and biotite. Hornblende is usually present only as a minor mafic constituent, except in hornblende schiest bands where it may form up to 70 percent of the rock; muscovite is found as a minor constituent of biotite gneisses.

The large region of granites and gneisses located in the north central and west part of the areas illustrated by Figure No. 6 has been mapped and described in general terms by Kindle (1942). More detailed studies of its south and east fringes have been made by Sabourin (1956), Shaw (1941), Gilbert (1951) and Deland (1951).

The southern part of this area is characterized by an abundance of gneissic hornblende syenite. Pink potash feldspar, sodic plagioclase and hornblende are the main minerals; quartz is only a minor constituent. In numerous places, a metamorphic gradation from feldspathic gneiss to amphibole gneiss and finally to a typical and only slightly metamorphosed graywacke has been observed from north to south. Apart from this southern belt, the area is underlain by a complex of gneisses, granites (fine to medium grained), and pegmatitic granite. The mineralogical composition is quartz, microcline, albite, oligoclose, biotite, or hornblende (minor. All of these minerals are comparatively fresh and unaltered.

Threes important granitic intrusive masses should be mentioned:

1. The Lac Frances grey-pink granite rock (Gilbert, 1951) covers an area of approximately 20 square miles east of Waconichi Lake. Its mineralogical composition is 50 to 70 percent pale feldspars (not specified), 10 to 30 percent quartz and 20 percent partly chloritized biotite.

2. The instrusive stock located some 15 miles west of Waconichi Lake is a porphyritic granite (Sabourin, 1956) containing potash feldspars phenocrysts, sodic plagioclase, quartz, biotite, and minor hornblende.

3. The granitic batholith which appears partly in the southwest corner of the area illustrated by Figure No. 6 is, according to Norman and Mawdsley (1935), composed mostly of a grey quartz, oligoclase, biotite (and minor hornblende) granite. Both mafic minerals are intensily altered to chlorite and saussuritization of the plagioclase is widespread. A dioritic border phase between the granite and the anorthosite is composed mainly of saussuritized andesine, biotite, and chlorite derived from biotite.

Sedimentary rocks:

The sediments of the Mistassini series are largely represented in the northeast corner of the area illustrated by Figure No. 6. The most abundant rock types are pure crystalline dolomite and sandy dolomite. (Deland, 1957). Dolomitic shales are also rather common.

A belt of sedimentary rocks covers the central part of the area, as shown on Figure No. 6. They have been described by Shaw (1941) and Lebourin (1956) as a thick formation of greywacke, composed of fragments of quartz-feldspars, amphibole and micas. Minor amounts of tuff and conglomerates are also mentioned. These rocks belong to the Opemiska series.

Sedimentary rocks belonging to the Chibougamau series are found in synclinal remnants and downfaulted blocks in the vicinity of Waconichi and Chibougamau Lakes. They constitute only a minor part of the regional rock assemblage. Coarse detrital rock types such as conglomerates, greywacke and arkoses predominate.

"Greenstone" belt:

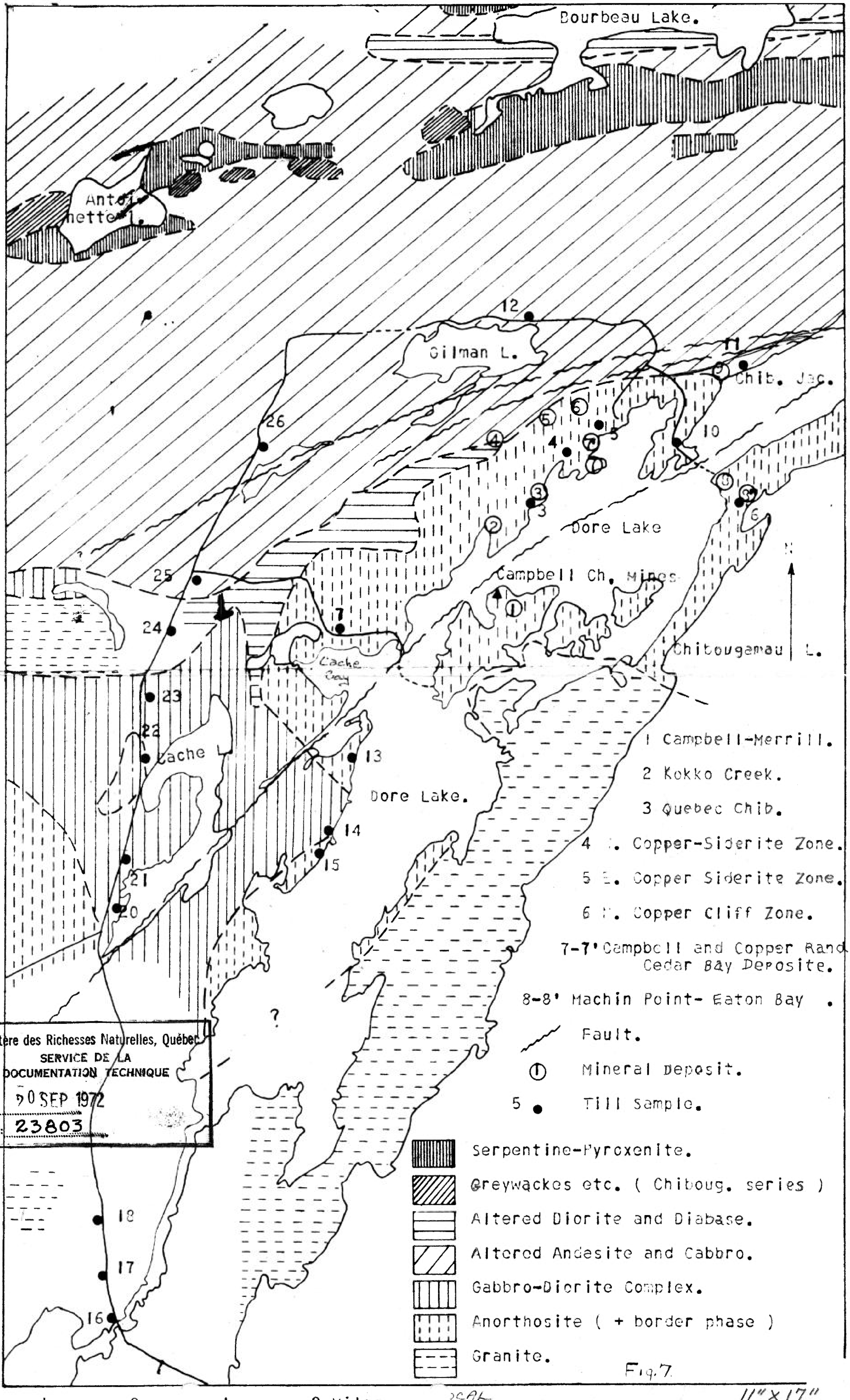
According to Norman and Mawdsley (1935) and Shaw (1941) the "greenstone" belt which has a broard V-shaped outcrop pattern, is mainly composed of pale to dark green, massive to schitose, andesitic and basaltic lava flows. The rocks are thoroughly saussuritized and uralitized Epidote, albite, secondary hornblende, and chlorite are the products of alteration; the most abundant accessory minerals are magnetite and ilmenite.

Gabbro sills of similar mineralogical composition are abundant. Light coloured acid flows, with or without quartz phenocrysts, are only locally important.

A belt of ultrabasic rocks, from 1/2 to 1-1/2 miles wide, extends across the greenstones, in a south 60° west direction passing through the northernmost bay of Chibougamau Lake. It is composed of rather discontinuous sill-like masses of serpentine and pyroxenite. In the latter rock type, fresh diopside is very abundant. Immediately north of this belt lies a zone of dioritic and quartz dioritic instrusive rocks containing the products of saussuritization and uralitization and having an average of 5 percent quartz. It is only about 1/4 of a mile wide west of Chibougamau Lake, but reaches a width of one mile east of it. The distribution of the last two rock types has not been indicated on the accompanying map, as they have a rather limited outcrop area.

Anorthosite. (Figure No. 6)

The anorthosite, together with its related gabbros, forms a canoe-shaped intrusive body in the Chibougamau Lake area. The typical anorthosite is altered, according to Norman and Mawdsley (1935) and Allard (1956) to a mass of secondary minerals that entirely obscure its original composition. The saussuritization of plagioclases and the chloritization of the original ferromagnesian minerals is so complete that the rock consists now of abundant zoisite



1 0 1 2 Miles

~~REGIONAL~~ LOCAL BEDROCK GEOLOGY.

11" x 17"

and clinozoisite, albite, chlorite, and carbonates.

Along the north edge of the anorthosite (which has been best studied), a border gabbro phase up to 1,000 feet wide has been found. Here again all the primary minerals are thoroughly altered and the mineralogy is quite similar to that of the altered anorthosite except for a much larger percentage of chlorite. Concentrations of magnetite and titaniferous magnetite have been reported from scattered localities within this border phase.

Local Geology.

General Geology:

The detailed bedrock geology of the area which has been surveyed by the author is shown on Figure No. 7, after Mawdsley and Norman (1935).

The large mass of altered gabbroidal and dioritic rocks surrounding Cache Lake described by Mawdsley and Norman has been studied in detail by Graham (1956); he includes them in his Dore Lake intrusive complex, which also includes the anorthosite and its border differentiates. The predominant rock type is a coarse grained gabbro, but fine grained phases and porphyritic types have also been recognized. The rocks are composed of saussuritized plagioclase (up to 30 percent), pleochroic yellowish green to bluish green hornblende, and 5 to 10 percent titaniferous magnetite as individual crystals or as inclusions in the other minerals. Dioritic rocks belonging to the same complex have a similar mineralogical composition, but the amount of altered plagioclase reaches 50 percent.

Altered dioritic and diabasic rocks outcrop between the anorthosite and the "greenstones", northeast of the gabbros described above; their nature is more obscure. Mawdsley and Norman consider them as a basic phase of the granite underlying Chibougamau Lake. Graham groups them also with these acid intrusives, but he believes that they represent gabbros of the Dore Lake complex which have been metasomatically modified by the introduction of quartz. Excepting the 25 to 35 percent of quartz present as grains, 1/16 to 1/8 inch in diameter, these rocks are made up of saussuritized andesine and hornblende-chlorites which are minerals characteristic of the gabbros.

The attitude of compositional banding within the anorthositegabbro complex suggests that there is an anticlinal axis passing through the granite-invaded zone underlain by Chibougamau Lake. The belt of ultrabasic intrusives in the northern part of the area studied may well represent a synclinal zone.

The faults indicated on Figure No. 7 have been drawn from geological maps by Graham (1956) and Allard (1956).

The McKenzie Narrows fault, which has been encountered in underground workings at the Campbell Chibougamau Mines and is indicated farther northeast by diamond drilling beneath Dore Lake, is one of a set of major northeast-trending breaks transsecting the region. The same structure has been traced beyond the area studied here by Mawdsley and Norman. Its role in the emplacement of copper-gold mineralization will be mentioned later. The Savage Lake fault seems to limit on the north the extension of copper-gold bearing structures.

Economic Geology:

To the present, all the base-metal deposits of economic value have been found in the Dore Lake section, within the gabbro-anorthosite complex. The mineralization has taken place along northwest-to west-trending zones of fracturing and shearing which lie on either side of the McKenzie Narrows fault and are probably associated structurally with it.

Campbell Chibougamau Mines, the only base metal producer in this part of the Chibougamau mining camp, is exploiting copper-gold deposits. Several zones of mineralization which were found are presently being developed for production. During recent years, modern geophysical methods of prospecting have led to the location of similar ore-bearing structures in drift covered ground and under the waters of Dore and Chibougamau Lakes. Numerous mineral occurrences of minor importance have also been reported throughout the area. The most important base-metal occurrences are shown on Figure No. 7 .

Copper-gold deposits in the anorthosite complex:

Assad (1957) distinguishes two main types of base-metal deposits within the anorthosite complex.

The first type is represented by copper-gold deposits located on Merrill Island, and immediately northwest and north of it on the mainland. The deposits occur within narrow dyke-intruded zones of brecciation and shearing which trend northwest across the anorthosite mass. The main sulphide minerals are pyrrhotite, chalcopyrite and pyrite. Wall rock alteration minerals are quartz, chlorite and minor amounts of carbonates. To this group belong the Campbell-Merrill ore zones, the Kokko Creek deposit, and the Quebec Chibougamau Goldfield mineralized zones.

The second type of deposit is found further northeast along the shores and beneath Dore Lake. The northwest-to-west-trending ore bearing structures are wide schist zones composed of variable amounts of sericite, chlorite, chloritoid and carbonates. The schist is impregnated and cut by veinlets of chalcopyrite containing lesser amounts of pyrite. Deposits of present economic value belonging to this category are the Campbell Chibougamau-Copper Rand Cedar Bay deposits, the Machin Point deposits and the Chibougamau

Jaculet ore-zones. The east and west copper-siderite zones on the property of Copper Cliff Consolidated Mining Corp. and the North Copper Cliff zone on the Copper Rand property belong to this group.

The Copper Rand mineralization at Eaton Bay displays features characteristic of both categories, and may be considered as an intermediate type.

It has been suggested by several authors that the copper-gold mineralization of the Doré Lake district is genetically related to the Chibougamau Lake granite batholith. In the opinion of these workers, the presence of minor amounts of molybdenite associated with the copper minerals supported this hypothesis.

Recent diamond drilling by the Yorcan Exploration Company within the anorthosite belt immediately northeast of the area studied has intersected a new zone of mineralization similar to the ones described above, but containing considerable amounts of nickel (up to 1 percent) and some cobalt (up to 0.2 per cent) in addition to the copper. If all the copper deposits of the anorthosite belt have been formed by identical processes, and there is no suggestion of the contrary, then their genetic association with the granite becomes very unlikely. They are more probably genetically related to the basic magmas responsible for the intrusion of the gabbro-anorthosite complex itself; this hypothesis explains better the presence of nickel.

Iron sulphide deposits along faults:

Massive sulphide replacement lenses occur intermittently along the southern branch of the Savage Lake fault. The fault zone, which varies in width from 150 to over 1,000 feet, is essentially composed of a carbonate-chlorite-chloritoid schist. The predominant sulphide within the replacement bodies is pyrite; subordinate amounts of pyrrhotite have also been noticed. Assays up to 0.5 percent zinc have been reported by the Copper Cliff Consolidated Mining Corporation. Similar amounts of copper, over a core length of 50 feet, have been encountered farther east by Chibougamau Jaculet Mines. Massive sulphides have been reported by Mawdsley and Norman farther east at the head of Chibougamau Lake, on the possible extension of the Savage Lake fault. The predominent sulphide there is pyrrhotite.

Weaker mineralization of a similar type has occurred along other zones of faulting and alteration, mainly within the greenstone belt.

Berrigan Lake pyrrhotite-sphalerite deposits:

The Berrigan Lake deposits are located on the property of Tache Lake Mines Ltd., 3,500 feet east of the north tip of Antoinette Lake. According to Smith (1953) sulphides have been found within sepentinized pyroxenites and dunites of the ultra-basic belt. Complex folds and faults have controlled the mineralisation. Two types of occurrences may be distinguished on the basis of the mineralogical assemblage.

The North deposit consists of two joining breccia zones 4 to 10 feet wide. Sulphides are, in order of importance: pyrrhotite, sphalerite, galena, chalcopyrite, pyrite and arsenopyrite. Galena is concentrated in a few high grade lenses. The average zinc content is 4 to 5 percent.

The Berrigan zone follows the north shore of Berrigan Lake for several hundred feet. Pyrrhotite and sphalerite are by far the most abundant sulphide minerals; chalcopyrite is a minor constituent. The main sulphide bearing zone is 40 to 100 feet wide. The average zinc content is 3 to 4 percent. Nickel assays up to 1/2 percent are also reported by the Company.

An intense chlorite-carbonate wallrock alteration is noteworthy around both deposits. Fine grained grey quartz has also been abundantly introduced. Minor amounts of sphalerite have been reported from several similar zones of alteration extending to the east from the main deposits.

The mineral deposits of Berrigan Lake are characterized by an intense surface weathering. It has been noticed that the pyrrhotite is of a type particularly unstable under surface conditions. A heavy gossan often marks the outcrops of mineralized rocks.

SURFICIAL GEOLOGY

Regional Glacial Geology.

Introduction:

The purpose of this section is to give a general idea of the sequence of events related to glaciation which occured during late Pleistocene time in northwestern Quebec. Glacial features having a special significance will be considered in detail.

As a rule, the geologists who have been mapping the Canadian Shield have paid very little attention to the distribution of unconsolidated surficial deposits, therefore the information on the glacial geology of the region is usually scarce and very imprecise. A few studies on the distribution of the morphologically most striking glacial and fluvio-glacial deposits of some districts have been made, using aerial photographs. For the part of northwestern Quebec which will be considered here, a compilation of such studies has been published by Norman (1938), Wilson (1938), and Shaw (1944).

Figure No. 8 shows the distribution of the glacial and fluvio-glacial deposits which will now be described.

Drumlins:

The literature on the glacial geology of northwestern

Quebec does not contain any compilation on the occurrence of drumlins; nevertheless, such deposits are mentioned by several geologists who observed them in the course of regional geological mapping and mapped them to show their actual distribution.

One major field of till ridges, showing a complete gradation from elongated, shallow shapes to typical drumlins, extends from about 10 miles south of Chibougamau and Opemiska lakes to the northeastern corner of the map area. The north and east boundaries of this field are unknown. To the west, drumlins do not extend far into the washboard moraine field.

In the area about Mistassini Lake, the ridges may be as long as 4 miles, and the ratio between length and breadth as little as 1/20. The maximum height recorded there is 400 feet but this is exceptional; the average height is between 100 and 150 feet. These ridges resemble more the "ispatinows" described by Tyrrell (1893) in northern Manitoba, than they do true drumlins. They are described as being composed of boulder clay.

Further southwest, in the Chibougamau Lake area, the ridges are composed more of sandy till. Here they are more typically drumlinoid, with the length-breadth ratio fluctuating between 1/3 and 1/6. The average length is 1.5 miles.

Washboard moraines:

As no mention is made of washboard moraines in most

~~North American textbooks and because they are conspicuous in the area, the writer has described them in detail.~~

A belt of washboard moraines extends from Chibougamau Lake to Evans Lakes in a general northwest direction. The approximate boundaries are given by Shaw (1944) who has compiled most of the data from ~~acrial~~ aerial photographs. Farther southwest, there are indications that similar moraines may be covered by varved clays. Descriptions of washboard moraines in textbooks are rare.

The first description of moraines in this belt was given by Mawdsley (1936) who noticed them in the Opemiska Lake District and named them after their characteristic washboard pattern. Norman (1938) mapped them in detail over a larger area; he pointed out their similarity to moraines mapped as early as 1889 by De Geer in Sweden ~~, who called theirs~~ and termed Winter moraines. Believing as De Geer ~~did~~ does in their cyclic annual significance, Norman called them annual moraines.

The washboard moraines of the Opemiska Lake region are long, narrow ridges composed of unsorted boulder till lying perpendicular to the general direction of ice movement. The average height of the ridges is 10 feet, the distance between successive crests 500 to 1,000 feet, and the average length about one mile, although shorter ones are numerous. The sides of the ridges are fairly steep, with the north-facing side steeper than the south. The crest of the ridge is narrow and large boulders are ~~often~~ commonly perched upon it.

Washboard moraines have now been recognized in many other parts of Canada, such as in the Canadian Prairies ~~(Elson 1953, 1957)~~, the Eastmain River area on the southeast shore of Hudson Bay, ~~(Shaw, 1944)~~ ~~and~~ possibly in Central Labrador ~~(Hughes, 1964)~~. and They have also been found in several places in Northern Europe.

Elson, studying moraines similar to the ones described above, in the Tiger Hills region, Manitoba, has added several important points to previous descriptions. He mentions that washboard moraines curve upstream near large eskers, and that small eskers are often offset by them or may overlie them. He has made several pebble fabric analyses and found that, in most of the ridges, there is a core composed of compact sandy till with a fissile character indicating lodgment deposition. The pebble fabric of the core shows:

> "a statistical preferred orientation of the long axis of individual pebbles parallel to the general direction of ice movement. When the ridges curve into re-entrants caused by thinning of the ice along glaciers drainage channels, . . the pebble fabric is faithful to the general direction of ice movement rather than changing to become perpendicular to the axis of the ridges".

This core is covered by a layer of till showing either a random pebble fabric or a pebble orientation parallel to the axis of the morainic ridge. This surface layer is interpreted as an ablation moraine.

A short historical review of hypotheses which attempt to explain the origin of washboard moraines is given by Elson (1953, p. 95-96). Until recently, all the theories required the presence of deep proglacial lakes in front of the ice margin.

Mawdsley thought that these ridges are composed of morainic material washed into crevasses which formed parallel to the border of a thinning ice sheet floating in a deep water body. De Geer, and Norman (1938) considered that washboard moraines were formed at the front of a retreating ice sheet which terminated in a deep proglacial lake. During the winter, when the ice was stagnant or slightly readvancing, convection currents were set up in the deep water at the ice margin, bringing water above freezing temperature into contact with the ice front. The morainic ridge was produced by liberation and dumping of the morainic material enclosed in the ice.

Washboard moraines have also been interpreted as "push moraines" formed at the front of a readvancing ice sheet and "dump moraines" formed by slumping of superglacial material at the steep front of an ice sheet, ~~(the latter process of formation of small ridges has actually been observed by Goldthwait on Baffin Island)~~.

Elson believes that a satisfactory theory of origin of washboard moraines should not require subaqueous conditions as these ridges undoubtedly exist in regions which were never submerged in water (as in the Tiger Hills, Saskatchewan, and Central Labrador). He also points out the inadequacy of the above theories to explain the pebble fabric which he observed. He offers the following hypothesis:

> "Washboard moraines in the Killarney plain probably originated by subglacial thickening of ground moraine at a zone of thrusting developed where the brittle surface ice of the glacier extended to

> the subglacial floor and pinched out the plastic ice" (Figure No. 9).

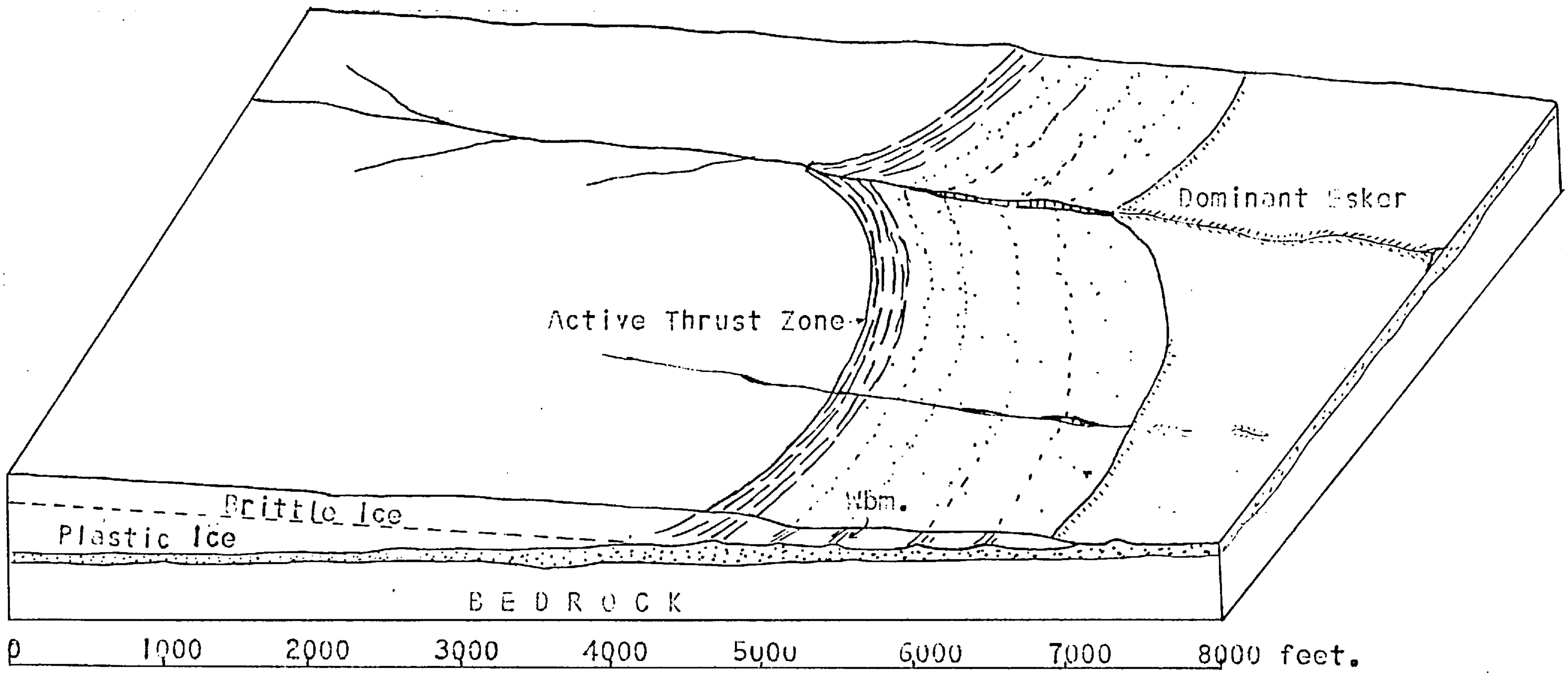
This happens during the winter when the ice-front is stationary, and the line along which the brittle ice layer pinches out the plastic ice is stationary.

> "The availability of subglacial debris to the thrust planes may be a more important control than cyclical climatic phenomena. The amount of ablation moraine derived from thrust planes has a profound effect on the rate of thinning near the glacier margin and hence the recession of the ridge depositing thrust zone."

Widespread occurrences of washboard moraines, as found in northwestern Quebec, suggest a regular retreat of the last ice sheet in the area concerned. Whether or not these moraines have a strictly annual significance is still open to discussion. Norman has noticed that in the Chibougamau district,

> "the interval between the moraines averaging 500 to 700 feet and reaching 1,000 feet in places corresponds perfectly with the intervals 454 to 820 feet between successive yearly fronts of the ice during its retreat in Quebec as calculated from varve measurements by Antevs".

A similar correlation of moraine ridges with varved clays was made by De Geer (1940). Hoppe (1948), on the other hand, found no such correlation in another district and believes that washboard moraines have no periodic significance. The answer to such contradictory conclusions may be that washboard moraines have only an annual significance when conditions for their development are optimum.



ORIGIN OF WASHBOARD MORAINES.

Simplified after Elson (1956)

Figure 9.

Fluvioglacial Deposits:

The only deposits of this category which will be mentioned are large eskers, which Norman (1938) called retrogressive eskers, and extensive outwash deposits associated with them. Smaller features have never been studies systematically in northwestern Quebec, and in any case they are not important in working out the late Pleistocene evolution of the district.

The distribution of these large deposits has been compiled for the extreme northwestern part of the Province of Quebec by Wilson (1938), and for an area extending from Opemiska Lake to Mistassini Lake by Norman (1938, 1939).

Retrogressive eskers are described by Norman as follows:

> "The central part . . . is a fairly uniform sharp-crested ridge with steep slopes, that may extend without change for several miles. The central sharp-crested ridge is bordered on each side by a continuous series of kettle holes and depressions that separate the ridges from lateral outwash apron on the outside parts of these eskers . . . The sandplains . . . resemble the large eskers in having wide lateral aprons of outwashed sand, but instead of a prominent sharp-crested central ridge have a central chain of kettle holes. The sandplains vary in width from 1,500 to 10,000 feet . . . The few measurements made show that they very in height from 60 to at least 180 feet above adjacent level ground".

The eskers spread out to wide flat-topped sand plains with terraced sides. These steep sides are interpreted by most authors as being fore-set beds. The belts of outwash sands and gravels are believed to represent successive and coalescent deltaic deposits formed in front of a regularly retreating ice sheet.

The major eskers of the Opemiska-Mistassini belt are often found along shallow northeasterly trending valleys not occupied by streams and lakes. This means that the ground topography had a marked control on the location of glacial streams beneath the ice.

The major eskers shown on Figure No. 10 in the Opemiska-Mistassini lakes belt have been obtained from compilation by Norman and Shaw; only a part of them are of the giant retrogressive type described above. The two eskers shown at the extreme west side of Figure No. 10 belong to another major belt of retrogressive eskers described by Wilson.

Fluvioglacial deposits of the type described above have been encountered in other parts of North America and Northern Europe. Apparently the first occurrences mentioned were in areas where varved clays are abundant, and consequently all the early theories on the mode of formation of these deposits were based upon the presence of a large proglacial water body where the major subglacial stream emerged from the ice sheet. In this respect, the situation is quite similar to that presented in the study of washboard moraines. It is to be noted that in recent years, retrogressive eskers and sand plains have been described from areas where there is no evidence of the former existence of extensive proglacial water bodies (Fortier, 1949; Wright, 1957). It would appear that when the heavily loaded river which deposited the esker ridge in the subglacial channel reached the ice border, its transporting power decreased rapidly because of the removal of hydrostatic pressure, and its load was dropped. This seems sufficient to explain the deltaic deposits of sand and gravel, and the presence of a proglacial water body is therefore not prerequisite. If there were such a proglacial lake in the Chibougamau region, one would expect to find a gradation from sand and silt to varved clays beyond the outwash sand ridge. The finest material is most likely removed farther by the melt-water of proglacial streams.

Proglacial Lake Deposits:

The boundaries of varved clay and silt deposits believed to have formed on the bottom of the proglacial lake Barlow-Ojibway are shown on Figure No. 8. The sediments represent the easternmost part of an extensive clay belt covering most of Northern Ontario, for a total of approximately 60,000 square miles.

The total thickness of these lacustrine deposits is not very great, generally less than 25 feet but reaching a maximum of 85 feet. The greater part of the deposits consists of interlaminated beds of clay and silt, ranging from 1/4 to 3/4 of an inch in thickness. The contact of the stratified clay and silt with the underlying glacial drift is usually gradational, the stratified clay and silt giving place to stratified sand which in turn passes downward into typical glacial till.

From his study of varved clays and silts of Northern Ontario and northwestern Quebec, Antevs (1925) has concluded that the average annual rate of retreat of the ice during late Pleistocene time has been 630 feet. As already stated, this distance is of the same order of magnitude as the mean distance between successive ridges in the washboard moraines of the district.

Late Pleistocene History:

The direction of flow of the ice during late Pleistocene time is clearly indicated by the distribution of glacial and fluvioglacial deposits, and by the pattern of glacial striations which are shown on Figure No. 8.

Most of the area was covered by the so-called Labradorian ice-sheet whose center, at least at a late stage of glaciation, was located near Shefferville, some 350 miles northeast of the northern tip of Mistassini Lake. The direction of flow varied from south 35° West in the Mistassini Lake region to almost due south near the 49th Parallel.

The extreme west part of the area was covered by ice of the Keewatin sheet, the center of which was probably somewhere in Hudson Bay. Here the direction of flow varied from south 45° East to south 15° East.

The two ice sheets met along a north-southwest line located between longitude 77° and 78° West; they formed as interlobate moraine south of the 50th Parallel (see Wilson, 1938). Farther north, at a late stage, readvancing ice of the Keewatin sheet encroached on the territory previously covered by "Labradorian" ice. This is shown by southeast glacial striae cutting southwest striae. The Keewatin ice deposited an important recessional moraine, the Broadback moraine, which extends for more than one hundred miles in a northeast direction, reaching, according to Shaw, as far east as Evans Lake.

On a regional scale, it has been noticed that till deposited by the Labradorian ice sheet, which spread over extensive areas of granites and gneisses, is essentially sandy; on the other hand the Keewatin ice sheet, which overrode Paleozoic sediments in the James Bay region, deposited abundant boulder clay.

There are strong indications that the retreat of the Labradorian ice sheet during late Pleistocene time has been regular and continuous throughout the area under study. This is shown by the abundence of washboard moraines, and the presence of several eskers of the retrogressive type with their associated sand formations. No end moraine or recessional moraine deposited by this ice sheet has been found. The retreat of the Keewatin ice sheet, on the other hand, was marked by important periods of immobility or even readvances on ground previously abandoned by the Labradorian ice sheet.

These differences in the mode of retreat were probably caused by different climatic conditions over the respective centers of glaciations.

The presence of extensive varved clay and silt deposits indicates that at least part of the area described here has been covered by an extensive proglacial lake. Early authors, for example Coleman and Antevs, considered that the eastern limit of this lake corresponded closely to the limit of outcrop of varves. Norman has challenged their views, and postulated that Lake Ojibway-Barlow extended as far east as a few miles beyond Mistassini Lake, near to the present height of land, although he mentions that varved clays are lacking or very rare in the Chibougamau and Mistassini Districts. In an article dealing with the Opemiska Lake district, Norman described series of wave cut terraces and boulder beaches which he found around several hills at elevations from 120 to 261 feet above the present level of Lake Opemiska. He concluded that the Opemiska district must have been covered by deep waters belonging to the proglacial Lake Ojibway-Barlow. To support these views, he also mentioned the abundance in the district of washboard moraines, and the presence of several eskers of the retrogressive type. It has been shown earlier in this chapter that such deposits do not constitute any additional proof of the presence of deep water. In another article (1939) Norman suggested that Lake Ojibway-Barlow extended much farther east, because the conditions of glacial wastage and deposition (i.e. formation of washboard moraines and retrogressive eskers) appear to have been quite uniform from a point 35 miles southwest of Opemiska Lake to at least as far as Mistassini Lake. Near the upland country east of this lake, he noticed a definite change in the type of glacial deposition and concluded that the eastern limit of Lake Ojibway-Barlow must have been located there. He does not, however, note any wave-cut terraces similar to those described in the Opemiska district. Neilson (1953) and Wahl (1953) have noticed in the Albanel Lake area poorly developed terraces extending to about 50 feet above the present lake level. Similar features have been noticed by Horscroft (1957) and the present author in the Chibougamau Lake area. These terraces, which are more or less parallel to the present shore of these lakes represent former higher levels, and are believed to have a local significance only.

Consequently, there is no available evidence that Lake Ojibway-Barlow extended east beyond the Opemiska Lake area, near the present boundary of the clay belt. It is probable that at the time the ice front passed through this area, a low outlet was open, perhaps towards Hudson Bay, and the lake was rapidly drained. This would explain the absence of wavecut terraces and similar features from the present level of Lake Opemiska to about 120 feet above it.

Local Surficial Geology.

Introduction:

The location of the area which has been surveyed in some detail by the author is shown on Figure No. 8. . Only the largest deposits of recent lake silts are shown.

The direction of movement of the ice during late Pleistocene times is indicated by abundant striae, grooves, "roche moutonnees" and drumlins. Azimuths vary usually between south 35° west to south 50° west, but in some places, the ice flowed in a more westerly direction along pre-glacial valleys.

Physiography:

As a whole, the Chibougamau district displays the slightly undulating platform landscape typical of most of the Canadian Shield peneplain. The topographic surface, which dips gently to the west, is slightly modified by bedrock hills, and recent unconsolidated deposits.

The area which has been covered by this survey may be subdivided into three main parts (see Figure No. 1). Their main physiography features have been described by Mawdsley and Norman (1935).

To the north, a belt of outwash sands and gravels stretches in a northeasterly direction through the northern part of McKenzie township. Farther southwest, in the vicinity of Opemiska Mines, similar sediments are known to reach a thickness greater than 100 feet.

The central area is formed of two belts of ridges separated by lower ground; local relief ranges from 300 to 600 feet. The northern ridges are underlain by ultrabasic rocks and greenstones capped by the younger Chibougamau sediments.

The southern belt, which parallels the northwest shore of Dore Lake as far south as Cache Lake includes the anorthosite intrusive complex and subparallel bands of volcanic rocks and gabbros grouped in the previous chapter under the general name of greenstones. West of Gilman Lake, the two belts join to form a wide tract of high ground.

The southern area is occupied by a field of drumlinoid ridges producing a low, rolling topographic surface.

As it has already been mentioned, the great depression of the Chibougamau-Dore Lake region is occupied by granite, a folded sill-like mass of gabbro-anorthosite, intruded by granite along the axis of the anticlinal fold. Belanger (1955) suggests that the pre-Pleistocene area was already a depression before the beginning of the glaciation, while the ground to the northwest formed the ridges which remnants can still be seen today. Glacial erosion further lowered the ground underlain by the granite and produced the closed basins occupied now by the two lakes.

The hydrographic network developed in each physiographic division is quite characteristic. In the outwash deposits, streams are scarce and flow in the direction of the general land slope. The streams of the hilly belt are controlled by the structure of the underlying rocks, and the main brooks are subsequent. In the southern and western part of the area, streams flow consistently in a southwest direction, following depressions of "corrugated" or drumlinized till; in this part, the drainage system is poorly developed and swamps and ponds are abundant.

The preglacial drainage pattern of the hilly belt has been modified to some extent by glacial erosion and deposition. The main valleys have been moderately deepened; glacial striae indicate that the ice was diverted from its regional direction of flow by some of them. Deposition of till has resulted in the formation of ponds and swamps along these valleys. The southwest drainage of the Bourbeau Lake region was reversed after the valley was partially filled by coarse outwash deposits. The deposition of the sand plain on which the Chibougamau townsite has been built resulted in the blocking of the normal drainage to the southwest and the formation of Gilman Lake. Along the hill slopes, most of the secondary valleys have been filled with glacial deposits and drainage is now accomplished mainly by seepage.

That the hills were strongly affected by glacial erosion is shown by the high degree of polishing of rocks outcropping in elevated ground; also the hill crests have generally been rounded or even fluted in the direction of ice movement.

Surficial Deposits:

(i) <u>Ground-moraine</u>

Ground moraine is the most common type of glacial deposit in the hilly parts of the Chibougamau district. It forms an irregular mantle varying in thickness from a few inches to several tens of feet over polished and striated bedrock, and is also found between the drumlin ridges where it is often covered by a thin layer of silt washed down from the drumlin slopes. Outwash sands and gravels can be seen in several places overlying ground moraine.

South of Antoinette Lake, and between David and Cache Lakes, ground moraine displays a corrugated surface which represents a gradation to the drumlin ridges found farther south.

Fresh ground moraine is presently exposed along recent roadcuts and other excavations. The sediment is compact and quite homogenous beneath the soil profile; no surface layer of ablation moraine could be recognized. All the sections examined were interpreted as being composed of a single till sheet. A study of the mechanical and mineralogical composition of the tills lead to the same conclusion.

The nature of the matrix of the ground moraine and other glacial deposits will be discussed in detail in Chapter 4.

(2) <u>Drumlins and drumlinoid ridges</u>

Typical drumlins are restricted to the southern part of the area surveyed. Their long axes, oriented approximately south 30° east, vary in length between $\frac{1}{2}$ and $1\frac{1}{2}$ miles; the length-breadth ratio fluctuates from 3 to $3\frac{1}{2}$; their maximum height is estimated at 150 feet.

A few shallow and elongated till ridges are scattered throughout the hilly belt. Only the most important ones are indicated on the accompanying map.

Several drumlins have been opened up during the recent years in the course of road building and in the search of fill for underground workings. A particularly good exposure can be observed near the road leading to Campbell Chibougamau mines (see Photograph No. 1). The core of the drumlin is composed of unsorted, bouldery fine sandy till containing a few small pockets of silty clay. This core is covered by a 4½-foot layer of stratified, water-lain material whose bedding more or less parallels the surface of the drumlin. The same structures have been recognized along the main highway where the exposures are older and partly obscured by slumping. No drumlins having a bedrock core have been noticed within the area.

South of Cache Lake several drumlinoid ridges entirely composed of well-sorted sand and gravel have been exploited for road material. These forms are thought to be re-worked outwash deposits and have been indicated as such on the accompanying map.

"Crag and tail" till deposits are common southwest of bedrock hills. An excellent example is found on the peninsula separating Dore and Chibougamau lakes (see Photograph No. 2 a), where a tongue of till extending southwest from a bedrock hill covers part of the Eaton Bay Copper deposit. Diamond drilling disclosed up to 150 feet of overburden.

(3) <u>Fluvioglacial deposits</u>

The extensive sand and gravel deposits which form the north physiographic division are part of a retrogressive esker-and-delta system which extends intermittently from the northwest end of Lake Albanel to the Opemiska Lake district. Very little work has been done by the writer in this area, therefore the deposits will not be studied here.

Extensive outwash sands and gravels occur in the central hilly area, between the north and south ridges. These sediments apparently originated in the Bourbeau Lake area, and may therefore belong to the "retrogressive outwash system" mentioned above. The coarsest material, composed of coarse to medium gravel, fills partly the valley extending from the southwest bay of Bourbeau Lake, and continues for at least 2½ miles. Sands appear 1½ miles southwest of the lake and forms a broad plain on which the Chibougamau townsite has been built. The sediments are well bedded, and the bedding surfaces dip gently to the south and the southwest, indicating that the sands form a broad alluvial fan. Further southwest, fine outwash occupies low ground in an area of "roches moutonnees".

Another important occurrence of outwash deposits was encountered immediately south of Cache Lake where thick deposits of fine gravel and sand have been quarried during the construction of the Chibougamau highway. The sediments have been reworked by advancing ice and present a drumlinoid surface which makes them very hard to recognize from true glacial sediments on aerial photographs. To the south-west the outwash deposits grade into low, swampy ground.

A few ordinary eskers have been observed and mapped during the sampling work. One of them formed, southwest of Merrill Island, a chain of small islands which have been completely removed by Campbell Chibougamau Mines and used as stope-fill. The esker continues on the mainland, between Cache and Dore lakes, forming in places two closely spaced and parallel ridges. Whether or not it is directly related to the extensive outwash deposits further southwest could not be determined. Excellent sections across this esker were available during the summer of 1955. Photographs No. 3 to 7 show a few typical features.

(4) Recent lake sediments

Sands, silts and clayey silts are often found in low ground surrounding lakes. The top few inches are usually composed of coarse to medium sand, and there is a gradation with depth towards finer material. The sediments are light gray to bluish, which means that they have been deposited in reducing conditions. They are similar to material being accumulated in the bottom of present lakes, and are interpreted as representing previous higher levels of these lakes; this interpretation is supported by the existence of terraces which have been observed by the writer to lie up to a few tens of feet above the present level of the larger lakes. Horscroft (Personal communication) has found terraces along the north shore of Chibougamau Lake.

Somewhat similar sediments have been deposited in depressions separating drumlinoid ridges in the southern part of the area.

Soils and Vegetation.

Introduction:

The most common mineral soils of the southern part of the Canadian Shield are described by Stobbe and Leahey (1943) as typical podzols to typical grey-wooded soils. Hydromorphic soils are also abundant because of the poor degree of integration of the drainage system resulting from the Pleistocene glaciation.

Podzols and grey-wooded soils are both products of podzolization: under suitable conditions of temperature, rainfall and vegetation, abundant organic acids and other substances of great solvent capacity are produced by the decay of surface organic matter. In the podzols, these substances remove from the solum most of the soluble salts, such as carbonates and sulfates, which may be originally present. In grey-wooded soils, which according to Stobbe and Leahey, most often develop over calcareous parent materials, the same salts are removed from the upper soil horizons and more or less concentrated in the lower part of the solum. Grey wooded soils are, therefore, much less acid than true podzols. In both soil types, a layered soil profile is produced in which the surface organic layer (Ao) is underlain by a zone of eluviation (A2) from which most of the iron and aluminum has been leached out; these metals, together with some colloidal organic material, are deposited as sesqui-oxides in a deeper zone of iluviation (B).

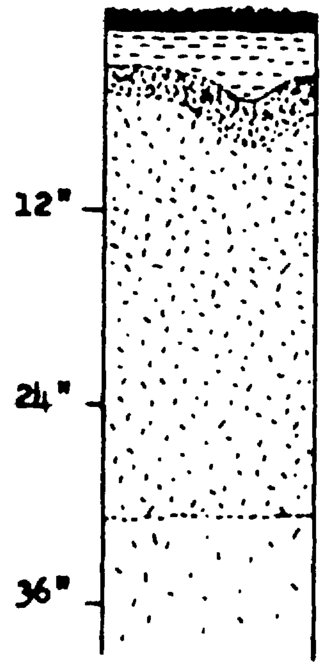
Hydromorphic soils develop when drainage is poor, either for topographic reasons or because the soil profile characteristics prevent normal water filtration. They are intrazonal soils whose major characteristics are determined by local feature rather than by climate. The extreme member of this soil group is the bog soil in which the water table is at or near surface. There is a complete gradation between well drained podsolic soils and bog soils.

In the Chibougamau district, fully developed true podzols are widespread in well drained terrane. Brown podzolic soils , which result from a less intense podzolization, arealso common in some hilly parts. No grey-wooded soils were observed. Typical bog soils, and hydromorphic types such as half bogs and ground water podzols have developed where topographic conditions are favorable.

Podzolic soils:

Two different types of podzolic soils have been recognized by the writer in the Chibougamau district: true podzols and brown podzolic soils. The soil profiles characterizing these two types are shown in Figure No. 11 (after Mailloux and Godbout, 1954).

The podzols predominate in well drained terranes covered by a mantle of overburden exceeding a few feet. Vegetation varies with the types of overburden. Coniferous trees, mostly

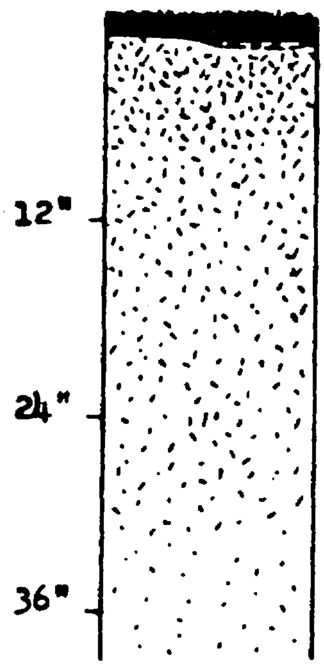


Aoo Undecomposed litter
Ao Partly decomposed organic m., dark.
A2 Eluvial horizon, light grey to white.
B21 Illuvial horizon, dark brown (enriched in humus, Fe and Al.)

B22 Illuvial horizon, yellowish brown, mainly enriched in Fe sesquioxides.

C Parent material.

TYPICAL PODZOL.



Aoo Undecomposed litter.
Ao Partly decomposed organic m., dark.
A1 Mixture of humus and mineral m.
A2 Eluvial horizon, light grey, often absent.
B21 Illuvial horizon, dark reddish brown.

B22 Illuvial horizon, yellowish brown.

C Parent material : light, greyish.

BROWN PODZOLIC SOIL.

Fig 11

balsam and spruce, predominate over compact boulder tills; birch and poplar prefer looser and more sandy ground such as the layer of water-washed sediments covering some drumlins; pine is conspicuous over outwash deposits and eskers.

The A_0 horizon of true podzols consists partially of decayed organic matter showing a fibrous or lamellar structure; there is only a thin sheet of well developed, black humus at the bottom of this layer. The zone of eluviation or A_2 horizon is well developed and sharply defined. It is a white to grey, highly siliceous layer. The B horizon or zone of illuviation may be subdivided into three parts: the $B2_1$ or upper zone is a thin, intensely coloured layer in which colloidal humic material leached out of the surface organic zone is fixed together with some iron and aluminum sesquioxides; the underlying $B2_2$ zone is a compact layer where clay minerals and sesquioxides are accumulated; the B_3 zone marks the transition to the C horizon which is the unmodified parent material.

The depth of the podzolic soil depends on local conditions of drainage and on the nature of the overburden. The deepest soils are found in areas of outwash sands where the combined widths of the B and C horizons may reach 36 inches.

Brown podzolic soils are found in the central hilly belt, in high ground and along fairly steep slopes covered by a thin layer of overburden. The forest cover is composed of a mixture of spruce, balsam, and birch, with abundant mountain maple in the undergrowth.

Several important differences exist between the profiles of brown podsolic soils and true podzols. In the brown podzolic soils, the A_2 horizon is absent or weakly developed. The surface A_0 layer of partly decomposed organic matter is separated from the B horizon by a thin A_1 layer formed of a mixture of organic and inorganic material. The B horizon is characterized by a weak concentration of sesquioxides. Seldom has cementation or clay accumulation taken place, hence brown podzolic soils are generally loose and well drained.

Hydromorphic soils:

Numerous peat bogs are scattered throughout the Chibougamau district in low ground surrounding present lakes and ponds, along valleys which are more or less obstructed by till deposits, and in the depressions between drumlins.

The largest peat-bogs, especially those surrounding present lakes, usually have a bottom layer of sedimentary peat mostly formed of remnants of pond weed, water lilies, etc. Overlying this layer is a variable thickness of fibrous peat which consists largely of partly decomposed mosses and sphagnum. The top of the most mature bogs is commonly formed of a layer of woody peat containing abundant remnants of coniferous trees and undergrowth shrubs.

Variations in the arrangement of profile layers are so common that, as pointed out by Lyon, et al (1952), every peat bed requires a separate investigation.

As a rule, the thickness of peat bogs in Chibougamau does not exceed 5 feet, although local accumulations of 15 feet and more have been observed.

The surface organic layer is commonly underlain by recent lake sediments, which have been previously described. In some bogs of small size, the organic layer immediately overlies boulder till. A typical soil horizon called glei horizon and characterized by the reduction of the iron to the ferrous state, has developed; it has a light grey to bluish colour.

Various mosses and labrador tea form the common undergrowth of Chibougamau bogs. The tree cover, if present, consists of spruce and cedar, the latter being in the vicinity of lakes.

PH of soils:

The pH of 40 soil samples was determined in the laboratory, using the procedure outlined in a previous section. The results vary from 3.4 to 7.0, which in terms of soils means extremely acid to neutral conditions. In all the vertical profiles examined, regardless of the soil type, the pH increases steadily with depth.

The average pH values found for the different horizons of podsolic soils in Chibougamau are given in Table No. 3. Values reported by Lyons et al, (1952) for a well developed podzol in New York State are also tabulated for comparison.

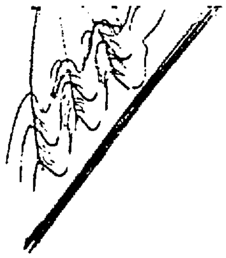
TABLE NO. 3

PH VALUES OF PODZOLIC SOILS

Soil horizon	PH (Chibougamau)	PH (New York)
Ao	3.4	3.48
A2	3.9	4.20
B	4.7	4.50
C	4.8 to 7.0	4.80

Values obtained for the two regions are fairly similar except for the C horizon where, in Chibougamau, the pH increases with depth to values of 6 to 7, as shown in Figure No. , profiles 1 and 2. (For the location of the pH profiles, see map No. 3 in backfolder.) In profile 2, the pH of the C horizon varies with the coarseness of the sediments, reaching the highest values in coarse sandy till. It is interesting to mention that grey wooded soils have a zone of accumulation of calcium carbonate at a depth of 2 to 4 feet (Leahey and Stobbe, 1943). At this depth in Chibougamau, the pH indicates still fairly acid conditions, but high pH values at greater depth may indicate the precipitation of some calcium carbonate. The Chibougamau soils would then represent a transition type between true podzols and grey-wooded soils.

The pH of several soil samples collected above heavily carbonatized bedrock does not differ significantly from the average figures given above. In an area of abundant dissemination of pyrite in the bedrock, on the contrary, pH values of 4.0 to 4.4 were obtained in the B horizon of a podzol developed over a thin cover of boulder till. These values are well below the normal average and probably here, the bedrock composition has a direct bearing on the pH of the overlying soil.



MECHANICAL DISPERSION BY GLACIERS

Introduction and Previous Work.

Many investigators in glacial geology, impressed by the physiographic features displayed by different types of glacial deposits, have studied these deposits exclusively from the morphological point of view, and have neglected to apply in their work the ordinary petrographic methods commonly used in the study of other sediments. As a result, little is known of the petrography and minerology of glacial sediments although they cover extensive areas of North America and Europe.

In recent years, petrographic methods of study of glacial sediments have been increasingly used in cases where the morphological approach had failed to clarify the stratigraphy of Pleistocene deposits. Portmann (1956) gives a detailed review of these methods, which comprise mainly mechanical analyses, fabric studies and petrographic - mineralogical investigations.

Incomplete sediment-petrographic descriptions of tills have been published by authors who used for correlation purposes the grain-size (Krumbein-1933, Shepps, 1953), the nature of boulders and pebbles (MacKintoch, 1944), and the heavy minerals content of the fine fraction (Dreimanis and Reavely, 1953).

Observations on the coarse material of tills are fairly abundant. They deal with the petrographic composition of pebbles and cobbles, their relation to the bedrocks, and the distance this material has been transported by the ice.

Commenting on these studies, Gravenor (1951) writes:

> "Pleistocene geologists have long claimed that till is largely local in origin . . . that is the average distance of transport is only a few miles. This belief is based primarily upon the type of pebbles found in the till, and little attention has been given to the fine fraction".

Studying heavy minerals from the fine fraction of tills from south-western Ontario to evaluate the contribution of the Precambrian rocks of the shield to these tills, Gravenor found that:

> "in all cases but one, there was more crystalline material in the sand and silt sizes than in the gravel sizes. . . The till from Lindsay, Ontario, contains 45% crystalline material, yet a pebble count on the same till yielded only 18 - 20% foreign material".

Excellent studies on the pebble lithology of moraines from the State of New York, Illinois and Montana-North Dakota have been recently published by Holmes (1952), Anderson (1955), and Howard (1956).

Complete general studies of Finnish glacial deposits have been published by Okko (1944) and Kivekäs (1946). These writers have divided tills into several categories depending on the predominant petrographic nature of the source bedrock. They have defined the mechanical, chemical, and mineralogical composition of these different tills.

Kruger (1937) has made a complete mechanical and mineralogical study of the sandy fraction of certain tills in Minnesota with the purpose of confirming the main stratigraphic divisions previously established by other methods. Jaeznefors (1952) has made a complete sediment-petrographic study of the tills from the Pajala District in northern Sweden, with the same purpose in mind. Reference will be made later to several of these publications.

Mechanical analysis of the fine fraction of tills.

Mechanisms of formation of the fine fraction:

Portmann (1956) groups into three categories the factors which influence the grain size distribution:

a) Lithological nature of the bedrock
b) Distance of transport
c) Local genetic conditions

The lithology of the bedrock, the hardness and grain size of the rock-forming minerals, and the degree of fracturing of the rocks are all important factors to consider when determining the effectiveness of glacial erosion. Fine-grained rocks and rocks formed of soft minerals are subject to severe abrasion. Granitic rocks, on the other hand, are eroded mostly by plucking or quarrying, at least until the surface layer of weathered and open jointed material has been completely removed; then abrasion may complete the glacial process of erosion and produce the polished rock surfaces so characteristic of the Canadian shield.

Once the material has been separated from the bedrock and incorporated in the glacier, attrition and crushing become the active processes of mechanical disintegration. Holmes (1952) has shown that the ratio between the distance of transport of pebbles and the rate of size reduction is different for each lithologic type. He has studied the influence of the rock type on its size distribution within the pebble range. Working with an index grain size of $\frac{1}{2}$ to $\frac{1}{4}$ of an inch, he has found that the maximum frequency of quartzite in tills occurs close to the outcrops in the direction of ice movement, while the same maximum for limestone is located 25 miles from the source in the same direction. The reason is that the size of rock fragments detached by plucking from quartzite outcrops is close to the index size studied, whereas glacial erosion of limestone produces large fragments separated from the bedrock by plucking, as well as abundant fine material eroded by abrasion.

From these considerations, it is clear that the bedrock contributes in two ways to the fine fraction of tills: a variable amount of the fine fraction is produced by direct abrasion and the remainder is formed by mechanical disintegration of larger fragments during their transportation by the ice.

It is also important to remember that tills do not necessarily and entirely form by direct erosion of bedrock. Shepps (1953) has found in northeastern Ohio that the upper till, which is much finer grained than the underlying ones, is mostly composed of material derived from loess and lake sediments formed during the preceeding interglacial period. Krumbein (1933) has shown, further, that certain tills of Indiana and Illinois are composed of an appreciable amount of dune sand.

Student of glacial deposits in Scandinavia commonly divide tills into the following four categories, depending on which size group is predominant: gravel-tills, sand-tills, silt-tills and clay-tills.

Kivekäs (1946) has studied the influence of the nature of the bedrock on the mechanical composition of the till matrix in parts of Finland where specific rock-types predominate large areas. He reached the conclusion that, regardless of the bedrock geology, sandy tills are by far the most abundant all over the country. A complete study of the grain-size distribution, however, shows systematic differences do exist, for example: the average clay content of sandy tills derived mostly from basic rocks is twice that of tills formed from granites and gneisses; tills in which fine silt or soarse clay fractions predominate are conspiciously scarce; and fine-clay tills form 22 percent of the unsorted glacial sediments derived from basic rocks.

It is evident then that there is a preferential size to

which rock-material is reduced by glacial erosion, provided it is transported sufficiently far. This is probably explained by the fact that most rocks are structurally heterogeneous; when they are submitted to crushing, the fractures produced tend to pass preferentially through grain boundaries and a large proportion of the material obtained is of the average grain size of the rock. The same situation is commonly observed in the products of artificial crushing devices (see Gandin, 1926). Once this preferential grain size has been attained, crushing follows the normal laws, at least for minerals which have no prominent cleavage, and the work required to crush the material further increases in a geometrical ratio with a decrease in particle size. Most of the fine clay size material is not the result of progressive reduction of larger particles by crushing; rather, it is produced by other processes such as
and contains most probably mineralogically different products.

Topography and amount of water present during the deposition of the till are among the most important genetic factors influencing the grain-size of the matrix. Ablation tills, which forms at a very late stage in the presence of abundant meltwater, are often crudely sorted and the matrix is coarser than that of ground moraine formed from similar rock material.

It has been noticed in central Sweden that till covering high ground and the upper part of hill slopes is generally compact with a fine matrix and has a lamellal structure which indicates that it has been deposited under a heavy ice cover; on the other hand, morainic material covering the lower part of slopes and valley bottoms is coarser and rich in local material (Okko, 1944). An opposite situation is described by Holmes (1952) in the State of New York, where tills are more sandy and loose on high parts than in depressions.

Topography may thus have an important influence on the grain size distribution of moraines, but its influence is difficult to evaluate.

Mechanical composition of the firm fraction of Chibougamau tills:

The Wentworth size classification, which will be used in the following discussion, is given for reference in Table No. 4.

TABLE NO. 4

Part of Wentworth size classification with corresponding Standard Tyler Sieves

Particle Diameter	Wentworth Classification
2mm............. 9 mesh*........) 0.5mm (1/2) ....)	coarse sand
0.417mm......... 35 mesh*.......) 0.295mm......... 48 mesh*.......) 0.25mm (1/4) ....)	medium sand
0.145mm.........100 mesh*.......) 0.125mm (1/8).....................)	fine sand
0.104mm.........150 mesh*.......) 0.074mm.........200 mesh*.......) 0.062mm (1/16)....................)	very fine sand
0.004mm (1/256)...................)	silt
0.004mm...........................)	clay

*screen sizes used in the dry sieving.

Table No. 5 shows the result of the mechanical analyses of nineteen till samples. The same data are represented in Figure No. 12 in the form of cumulative curves. For comparison, two other curves describing sediments deposited by water have been included in the diagram: the first one gives the granulometry of a reworked outwash deposit (curve No. 6) and the second one represents a recent lake silt collected within the same general area (curve No. 27). The tills studied may be grouped into two main types.

The first type of till is represented by all curves lying between curves No. 16 and 12. It shows a wide range of grain size which is characteristic of sediments deposited directly beneath the ice, away from the sorting action of meltwater. Ground moraine, drumlins, etc. are often composed of such material. Most of the curves lie within a narrow range of values. Sample No. 16 is coarser than usual, while samples Nos. 7, 10 and 12 have a particularly fine matrix; nevertheless, the general shape of their cumulative curves is similar to that of the other till samples belonging to the same category and they most probably formed under similar conditions. It is interesting to note that the last three samples are within the deepest collected.

Curves Nos. 4, 24 and 26 represent a second type of till, in which the comparisons are concentrated within a much narrower range; they contain more than 90% of sand particles. They are located between the typical till curves described

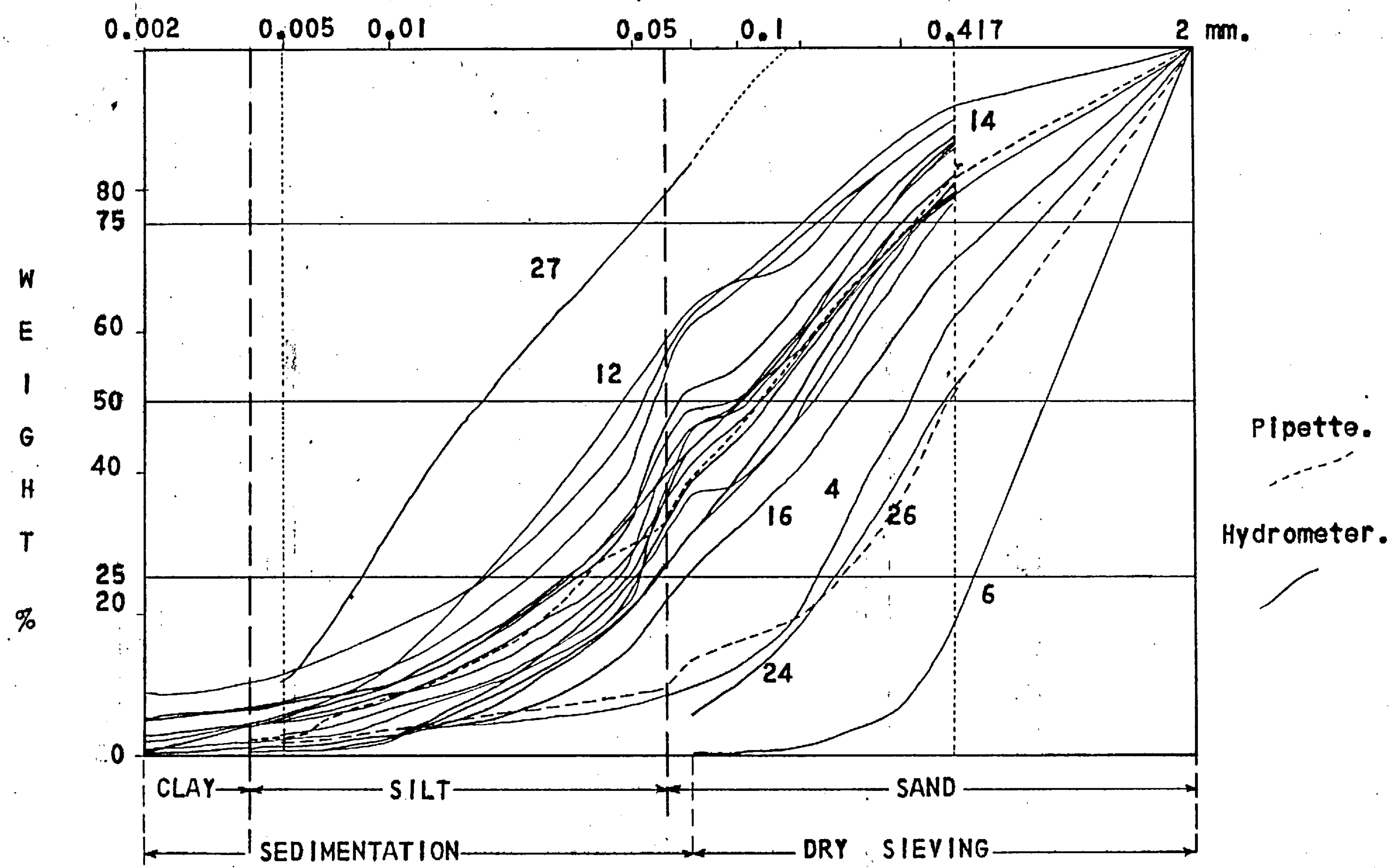
Table No. 5

MECHANICAL ANALYSES OF TILL SAMPLES

Sample	Feet Depth	% Clay	% Silt	% Sand	Grade Sizes in Millimeters: 2.0–0.417	0.417–0.295	0.295–0.149	0.149–0.100	0.100–0.074	0.074–0.05	0.05–0.01	0.01–0.005	0.005–0.002	minus 0.002
3	6	3.0	27.9	69.1	21.5	9.3	21.3	9.7	1.0	12.6	17.9	3.7	3.0	
4	4	1.7	7.9	91.4	38.2	14.4	27.6	7.6	2.5	2.6	3.5	1.7	1.6	
5	4	3.4	42.4	54.2	14.2	6.6	19.1	9.6	1.2	14.1	26.8	4.0	4.4	
6	20	-	-	10.0	81.1	11.7	5.9	0.8	0.2	——— 0.5 ———				
7	10	4.9	52.6	42.5	9.9	4.9	14.7	3.2	3.9	11.8	39.6	6.0	3.3	2.7
10	8	7.1	48.9	44.0	10.5	4.1	12.2	7.2	5.0	19.2	29.7	4.2	2.3	5.6
11	4	1.5	25.8	72.7	21.0	6.5	21.2	12.3	7.5	10.5	18.3	1.2	1.5	
12	10	10.5	47.7	41.8	8.2	4.1	12.6	7.6	4.9	15.5	29.0	6.7	2.6	8.8
13	3	0.3	25.5	74.2	19.7	8.6	21.9	12.1	6.4	11.0	19.1	0.8	0.3	
15	3	4.8	34.0	61.2	18.6	6.3	16.3	9.2	6.0	9.8	24.1	4.9	4.8	
16	5	1.1	19.6	79.3	30.6	9.3	19.9	8.6	5.1	11.7	12.0	1.6	1.1	
17	5	3.7	31.1	65.2	20.5	6.5	16.9	9.4	5.6	12.6	20.7	3.2	2.3	2.2
18	5	1.8	33.0	65.2	19.4	6.8	16.3	7.1	3.7	23.5	18.1	2.8	1.2	0.9
20	10	4.0	32.9	63.1	14.0	7.0	20.5	10.3	1.8	18.8	19.3	3.3	2.7	2.1
21	4.5	0.3	34.5	65.2	14.0	6.6	19.4	10.1	6.1	18.1	23.6	1.8	0.3	
23	3	6.1	36.6	57.3	12.9	6.2	16.8	9.6	2.8	17.9	24.4	2.3	2.5	4.5
24	1.5	--5.6---		94.4	47.8	12.5	22.0	7.3	4.7	——— 5.6 ———				
25	4	0.4	30.6	69.0	18.6	5.7	20.4	10.7	5.8	15.6	20.5	2.2	0.4	

Sample	Feet Depth	% Clay	% Silt	% Sand	2.0–0.417	0.417–0.295	0.295–0.149	0.149–0.100	0.100–0.074	0.074–0.062	0.062–0.042	0.042–0.031	0.031–0.023	0.023–0.016	0.016–0.012	0.012–0.008	0.008–0.006	0.006–0.004	minus 0.004
14*	5	2.3	30.8	66.9	18.2	8.1	18.1	8.7	7.4	5.3	5.3	5.9	5.1	4.7	2.7	2.4	3.0	1.6	2.3
26*	2	1.6	8.1	90.3	48.0	15.3	17.0	3.7	2.5	3.8	1.3	1.4	1.0	1.6	0.5	1.0	0.7	0.7	1.4

* Pipette method for the minus 0.074 mm. fraction.



Cumulative Curves representing the

MECHANICAL COMPOSITION OF THE - 2MM FRACTION OF TILLS.

Figure 12

above , and curve No. 6 which represents a coarse outwash sediment. Tills belonging to this category have been deprived of most of their silt and clay content by water-washing either at the time of their deposition or later. Samples Nos. 24 and 26 were collected at a particularly shallow depth (1 to 2 feet). Sample No. 4 was taken from a gravel pit at the bottom of a steep slope, in a crudely statified till where the action of meltwater was evident.

The percentage of sand, silt and clay in each sample has been computed in Table No. 5 . The relative content of sand and silt varies considerably from one sample to the next, but this is not particularly significant because the predominant grain size in most tills is either very fine sand or very coarse silt. A small variation in mechanical composition produces a large change in the sand-silt ratio.

A study of statistical constants given in Table No. 6, and obtained from the frequency curves, is more significant. The values tabulated may be defined as follows:

The first quartile, Q1 is the grain-size corresponding to the 25% weight mark on the cumulative curve;

The median is the grain-size for the 50% weight mark on the cumulative curve;

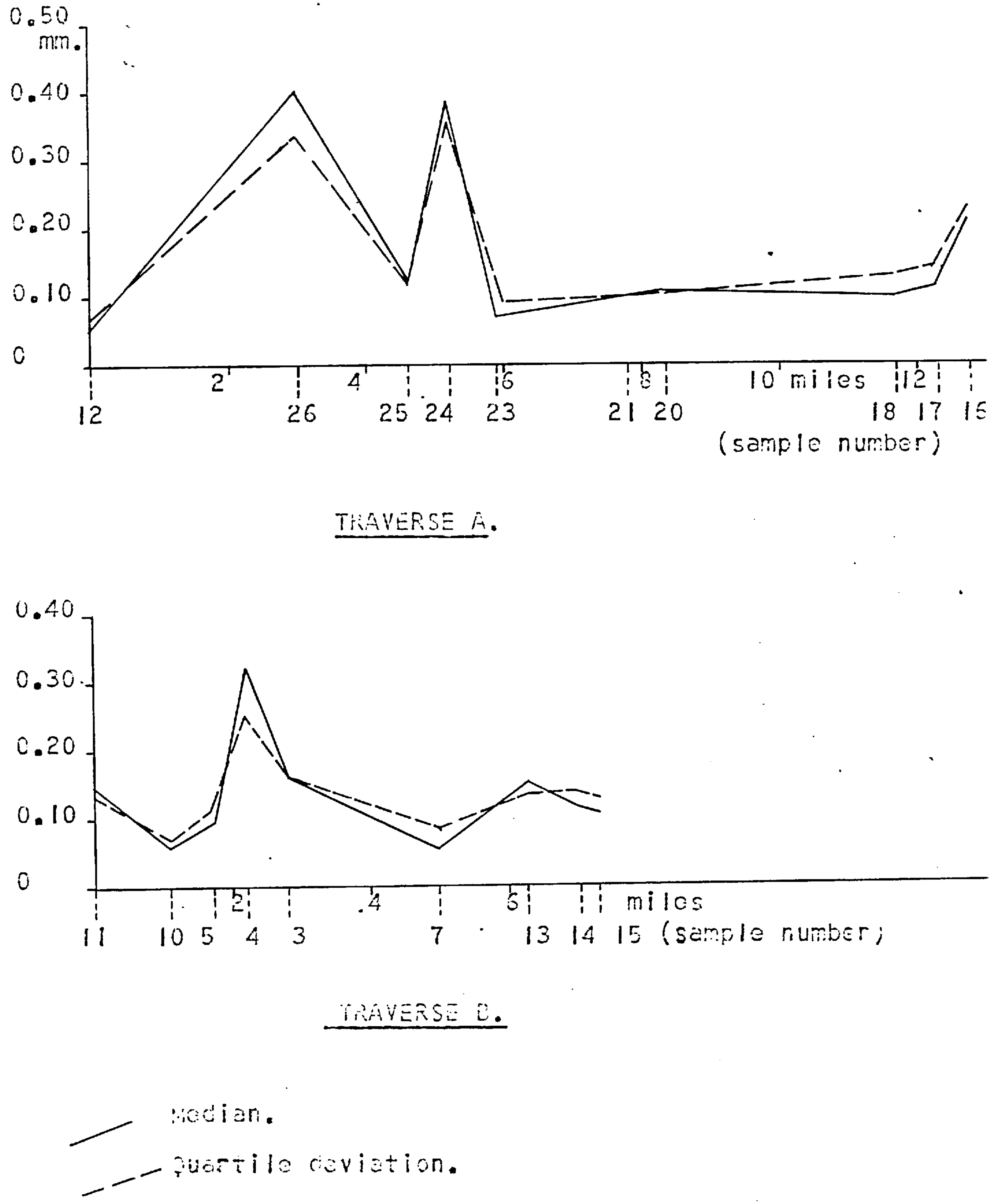
The third quartile, Q3, is the grain-size corresponding to the 75% weight mark on the cumulative curve.

The quartile deviation is $\frac{Q3 - Q1}{2}$

TABLE NO. 6

STATISTICAL CONSTANTS OF THE TILL SAMPLES

Sample	3rd quartile	1st quartile	median	Quartile Difference
3	0.370	0.051	0.160	0.160
4	0.660	0.170	0.310	0.245
5	0.250	0.325	0.096	0.109
6	1.220	0.470	0.76	0.375
7	0.182	0.0185	0.047	0.082
10	0.165	0.0245	0.058	0.070
11	0.330	0.057	0.144	0.136
12	0.150	0.0185	0.054	0.066
13	0.330	0.060	0.151	0.135
14	0.315	0.036	0.115	0.139
15	0.295	0.032	0.105	0.131
16	0.510	0.070	0.205	0.220
17	0.325	0.042	0.115	0.141
18	0.310	0.052	0.098	0.129
20	0.250	0.046	0.106	0.102
21	0.250	0.047	0.100	0.101
23	0.225	0.035	0.068	0.095
24	0.860	0.187	0.385	0.336
25	0.290	0.052	0.126	0.117
26	0.860	0.190	0.400	0.335



STATISTICAL CONSTANTS OF TILLS. Figure 13.

Figure No. 13 shows the variation of the median and the quartile deviation along the two till sampling traverses. The same grouping into two distinct categories, as obtained from the direct study of the cumulative curves, is possible. For the first group of tills which have not been affected by meltwater, the median varies usually between 0.047 and 0.160 mm. The values fluctuate rather irregularly and there is no systematic variation along the direction of ice movement. The median for sample No. 16 is as high as 0.235 mm. The quartile deviation follows closely the median deciation, but is always equal to it or slightly higher; this means that material finer than the median value is the more abundant. For the tills which have been affected by running water, these values are much higher in the median varies from 0.350 to 0.470mm. Here the quartile deviation is always markedly lower than the median deviation which indicates that material coarser than the median predominate.

Conclusions and Comparison with other regions:

As a rule, the tills of the Chibougamau district have a matrix composed predominantly of fine sand. Purely sandy varieties are often found near the surface, where most of the finer particles have been removed by running water. The deepest samples collected, however, show a slight predominance of the silt fraction over the sand. Locally, where meltwater from the ice was involved, sedimentation, a coarse sandy till displaying a crude stratification was deposited. Excluding these variations due to local circumstances, the tills studied have a very constant mechanical composition.

Mechanical composition has been used for correlating till sheets by Krumbein (1933), Dreimanis and Reantley (1953) and others. Krumbein, investigating the stratigraphy of glacial deposits in the northern United States, has shown that mechanical variations comparable to those shown on Figure No. 14 are normally found within a single till sheet. The present study indicates that all the till samples collected in the Chibougamau district were taken from a single geological unit.

Table No. 7 gives the average content of the Chibougamau tills in sand, silt and clay. Samples Nos. 4, 24 and 26 have not been included in the computation of this average as they represent modified types. The results obtained by several workers in the Scandinavian Precambrian shield are also tabulated for comparison. All the data have been recalculated for the size fraction below 2 mm, using the Wentworth class limits.

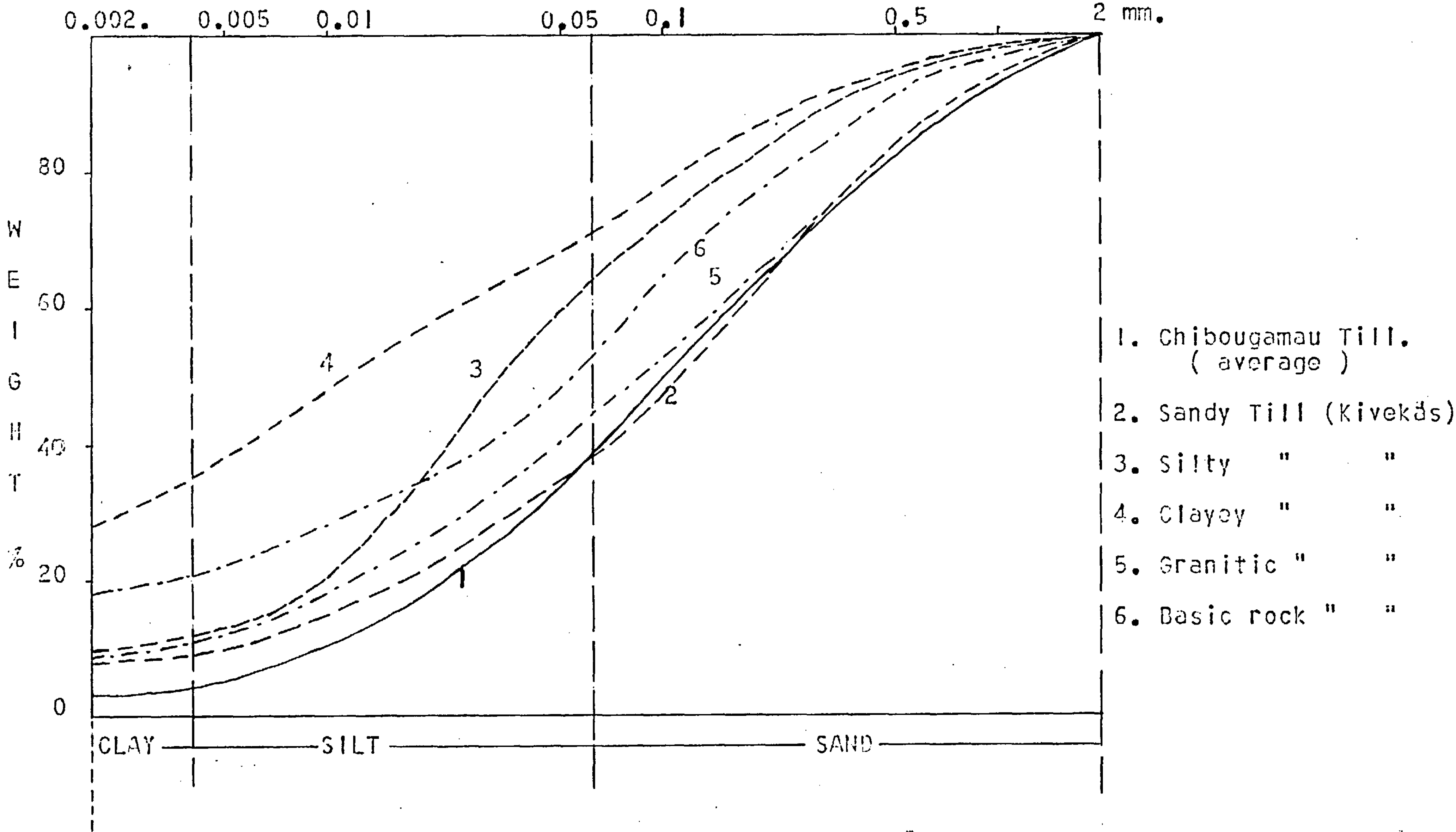
The similarity between the results obtained by Jaeznefors and the present author is striking; Okko's results are also very similar, with a slight increase in the sand content against the silt percentage.

Table No.7

SAND, SILT AND CLAY CONTENT OF TILLS

Author.	Location.	No. of samples.	Sand av.	Sand range.	Silt av.	Silt range	Clay av.	Clay range.
S. V. E.	Chibougamau[1]	16	61.9	41.8-79.3	34.6	19.6-52.6	3.5	0.3-10.5
S. V. E.	Chibougamau[2]	3	92.0	90.3-94.4	7.1	5.2-8.1	0.9	0.4-1.7
Jaernefors P (1952)	Pajala, N. Swede.	4	61.6		35.6		2.8	
Okko (1944)	Northwest Finland.	29	70.6		26.0		4.0	
Kivekas (1946)	Finland[3]	numerous	56.5		33.5		10.0	
Same	Same[4]	Same	47.5		32.5		20.0	
Same	Same[5]	143	62.5		29.5		8.0	
Same	Same[6]	48	37.5		51.5		11.0	

1. Samples no. 3,5,7,10,11,13 to 18,20,21, 23,25.
2. Samples no. 4,24,26.
3. Granite-gneiss till.
4. Basic rocks till.
5. Sandy till.
6. Silty till.



COMPARATIVE MECHANICAL COMPOSITION OF TILLS.

Figure 14

Part of the data contained in Table No. 7 is represented graphically in Figure No. 14. The average mechanical composition of Chibougamau tills is very close to that of the average sandy till of Finland. The clay content in Chibougamau is notably lower, but it should be remembered that the average Finnish figure is partly made up of sandy tills produced from extensive basic bedrocks, which yield a relatively high clay fraction. The curve representing the Chibougamau tills is also close to Kivekäs' average curve for granite-gneiss tills, with the same restrictions concerning the clay content.

Mineralogical study of the fine fraction of tills.

Introduction and previous work:

Most of what has been said on the mechanism of formation of the fine fraction of tills (see section previous) has a direct bearing on its mineralogical composition.

To the knowledge of the writer, only two workers have published results of complete mineralogical studies of the fine fraction of tills.

Kruger (1937) has established the mineralogical characteristics of the four main till sheets in Minnesota, working on sets of widely spaced samples. He has found that the distribution of light minerals (mostly quartz and feldspars) is very irregular and consequently, these minerals cannot be used in correlating sheets. Concerning the heavy minerals, he considers that although the mineralogy is rather complex the different sheets of glacial drift can be identified by their typical heavy minerals assemblages.

Jaeznefors (1952) has studied the mineralogical composition of the fine fraction of tills stratigraphically, and from the variations in mineralogy within a single till sheet in the direction of ice movement. He found that in the two till sheets investigated the composition of the light fraction was rather constant along the traverses. A good distinction between the two tills was obtained on the basis of the magnetite content. Regarding the composition of the fine fraction of tills in relation to the underlying bedrocks, Jaeznefors showed that the relatively easily weathered greenstones appear very rapidly in the fine fraction of tills in the form of abundant hornblende grains.

Kivekäs's (1946) study of Finnish moraines does not include any mineralogical examination of the fine fraction of these sediments; rather, he analysed chemically the minus 0.2mm fraction and calculated a theretical mineralogical composition from the analytical results.

Mineralogical composition of the fine fraction of tills:

The results of the mineralogical study of the minus 100 - plus 150 mesh fraction of tills are given in Table No. 8. The mineralogical composition of a reworked outwash deposit represented by sample No. 6 is also given for comparison.

TABLE No. 8

MINERALOGICAL COMPOSITION OF 100 - 150 MESH FRACTION OF TILLS

Sample	Light Fraction					Heavy Fraction					
	Total W %	Quartz v %	Plagio V %	Kfeld V %	Sericite V %	Total W %	Magn W %	Amph* V %	Epidot* V %	Biot* V %	Undet.* V %
3	92.9	46.5	38	11	4.5	7.1	4.9	67.8	9.5	5.2	17.5
4	84.4	47.5	35.5	13	4	15.6	2.9	69.5	10.5	8.5	11.5
5	94.4	49.5	34.5	12.5	3.5	5.6	6.7	62.5	4	6.5	27
6	81.9	42.5	38	11	8.5	18.1	13.6	64.5	4.5	7	24
7	93.6	46.5	37.5	11	5	6.4	6.3	69.5	3	8.5	19
10	95.4	47	40	10	3	4.6	5.9	67.5	7	5.5	20
11	92.9	49.5	33.5	12.5	4.5	7.1	5.1	73.5	4	7.5	15
12	92.4	48.5	37	9.5	5	7.6	4.1	57	8.5	4	30.5
13	92.7	53.5	32	9.5	5	7.3	3.8	65.5	5	6.5	23
14	92.8	47.5	37	11	4.5	7.3	4.8	57.5	8	7.5	27
15	94.6	47.3	33.6	13.9	5.2	5.4	3.3	62	6.5	10.5	21
16	93.6	48.5	31.5	11.5	8.5	6.4	5.6	59.5	10.5	14	16
17	93	49.5	39.5	7	4	7	4.6	69	6.5	6.5	18
18	95.1	47.3	34.1	10.9	7.7	4.9	8.6	68	10.5	8.5	13
20	93.4	47.5	36.5	14.5	1.5	6.6	5.5	69.5	3.5	8	18
21	93.7	46	36.5	12	5.5	6.3	4.2	66.5	9	5.5	19
23	94.3	47.5	34.5	14	4	5.7	4.4	63.5	3	13.5	20
24	92.1	53	31	12	4	7.9	18.2	65	3	7.5	24.5
25	95	52.4	29	10.5	8.1	5	7	58	3	9	30
26	85	45	37	14	4	15	10.8	56	4	17.5	22.5
Av. cat. No. 1	93.7	48.4	35.3	11.3	5	6.3	5.3	64.8	6.3	8.4	20.5
Av. cat. No. 2	87.2	48.5	34.5	13	4	12.8	10.6	63.5	5.8	10.7	20
Total Av.	92.7	48.4	35.2	11.6	4.8	7.3	6.1	64.6	6.2	8.8	20.4

* Volume percent in the heavy fraction minus magnetite.

The same data are graphically expressed in Figure No. 15 and 16, where the samples from two traverses has been grouped.

The weight percentage of heavy minerals in the undisturbed tills is fairly uniform: it varies from 4.6 to 7.6 and averages 6.3 percent. There is no apparent systematic relation between the mechanical composition of the tills and their heavy minerals content, nor is there a systematic variation in the heavy minerals content in the direction of ice movement.

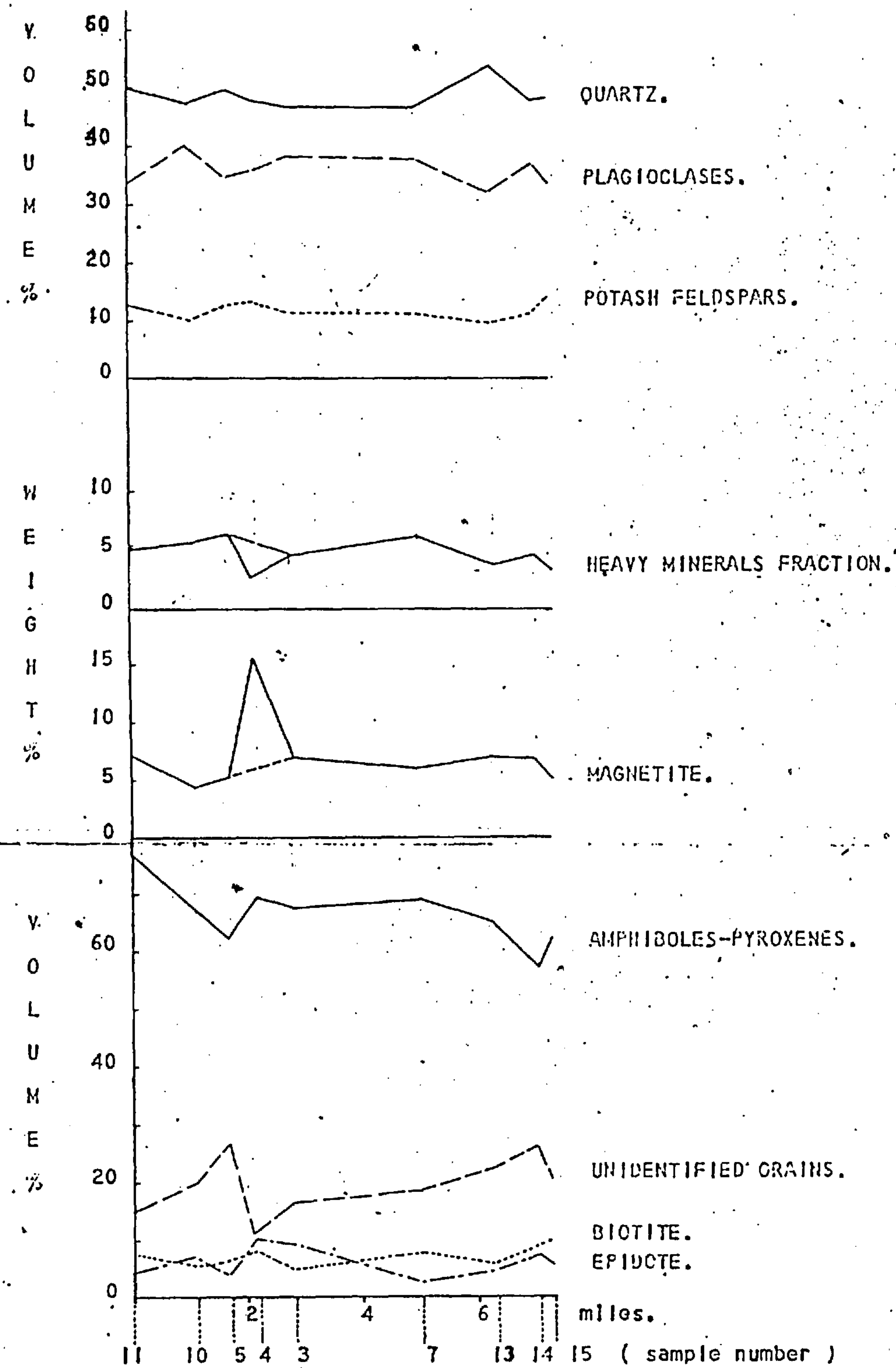
The heavy minerals content of glacial sediments which have been affected by running water (Nos. 4, 24 and 26) is usually much higher. The average for the three samples studied is 12.8 weight percent.

The mineralogical composition of the index size fraction of Chibougamau tills is expressed graphically in volume percent in Figures Nos. 15 and 16.

In the light fraction, quartz is by far the most abundant mineral, with an average volume percent of 48.4 in the 19 till samples examined. The amount varies usually within very narrow limits except in samples Nos. 13, 24 and 25 where it reaches 53 percent. Grains are typically angular.

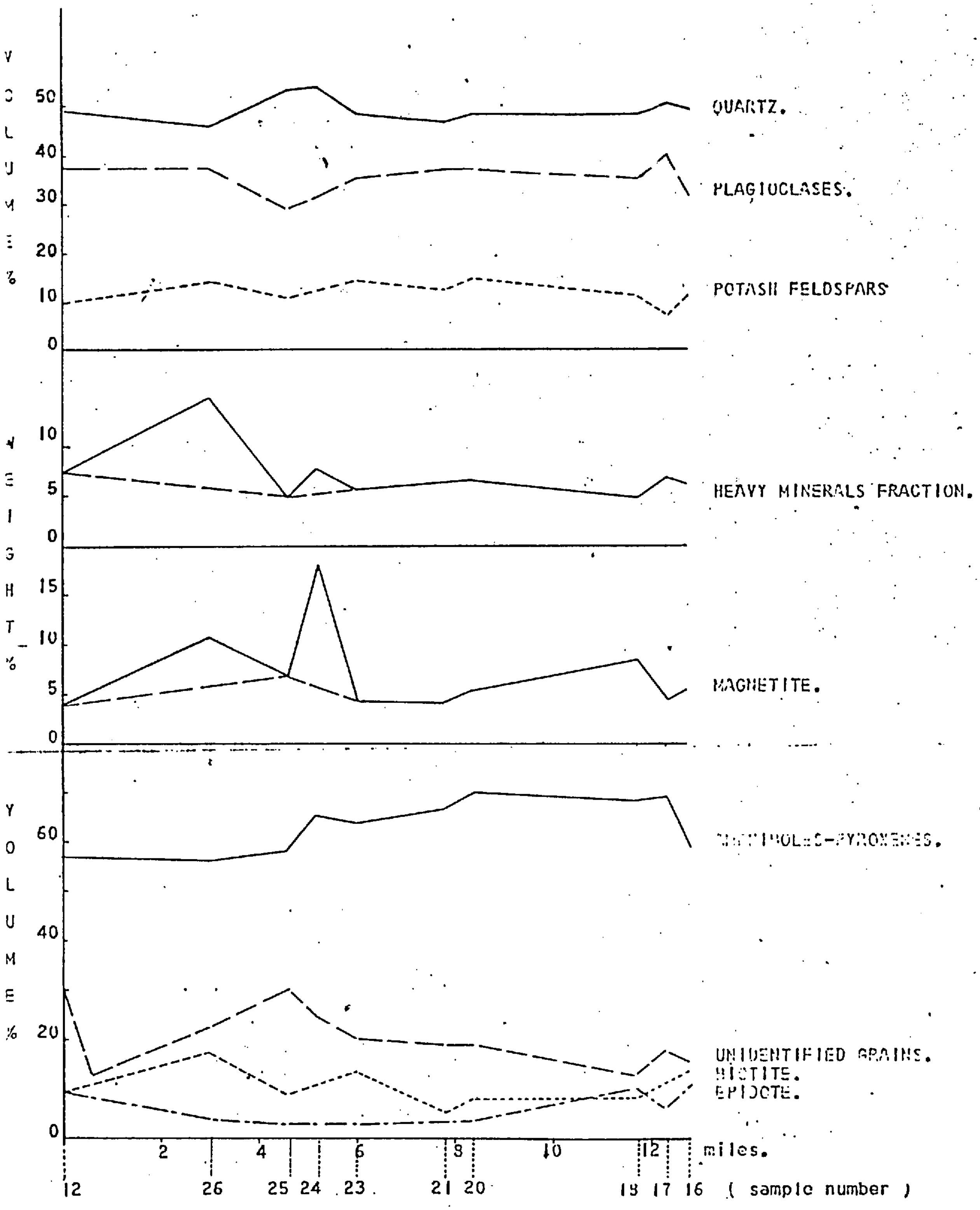
The group of potash feldspers contains also a few flakes of muscovite. The average volume percentage is 11.6.

The plagioclase group includes scarce grains of albite - rich saussuzitization products. The average volume percent



TRAVERSE B. MINERALOGICAL COMPOSITION (100-150 mesh fraction)

Fig. 15.



TRAVERSE A. MINERALOGICAL COMPOSITION (100-150 mesh fraction)

Fig. 16.

for the group is 35.2.

The main part of the undetermined group forms an intermediate fraction of mineral grains having a density approaching 2.85 (which is the density of the liquid used in the gravity separation). This group is made up of abundant cloudy grains representing various alteration products. Sericite is often a major constituent as shown by the spotty yellow stain resulting from the sodium cobaltinitrite treatment. It contains also chloritic grains, and a few flakes of biotite which did not sink during the heavy liquid separation.

There is no systematic variation in the percentage of minerals composing the light fraction along the two traverse lines (in the direction of the ice flow); also, there is no difference in the proportion of these minerals between undisturbed tills and glacial sediments sorted to some extent by water.

The heavy minerals fraction has a much more varied composition.

The group termed amphibole in Table No. 8 is actually a composite group containing the following in order of decreasing abundance: dark green to bluish green, strongly pleiochroic hornblende; more or less uralitized augite with a variable amount of ilmenite inclusions scattered or concentrated along cleavage planes; very pale green to yellowish actinolite; and a few grains of fresh pyroxene.

This group is by far the most abundant in the heavy fraction of tills. Its volume percentage in the heavy minerals fraction varies from 57 to 73.5 percent. In the first traverse (A) there is a marked increase in amphibole-pyroxene content towards the south; the southernmost sample No. 16, makes exception to this general trend. In the second traverse, samples Nos. 11 and 15 have a more erratic distribution of these minerals, but percentages are as a rule higher than average.

In the saussurite column of Table No. 9 is indicated the volume percentage of grains positively identified as a mixture of zoisite and other alteration products. The undetermined group probably contains similar material which could not be identified with certainty. The average for the 19 till samples is 62 volume percent of the heavy fraction, with a variation from 3.0 to 10.5.

The biorite percentage is highly variable, probably because of the ease with which this mineral is concentrated by flotation. The average content is 8.8 percent by volume, and variations from 4 to 17.5 percent were recorded. A small part of the biotite was floated off with the light minerals so that the figures given are slightly below the true content.

The undetermined group of minerals is made up of a variety of mineral species forming the usual suite of accessories of intrusive rocks, a few grains of dolormite, various unrecognizable products of alteration, and mineral grains coated with iron oxides. The amount of undetermined minerals averages 20 percent by volume and varies from 11.3 to 30.5 percent. This variation depends partly on the degree of weathering of the material studied; it has a direct bearing on the recorded amount of identified minerals of the heavy fraction.

The variations in the percentage of the three last groups of heavy minerals are unrelated to the types of material sampled. There is no systematic change in the direction of the ice flow.

The amount of magnetite is expressed in weight percent of the heavy fraction. Undisturbed tills contain from 3.3 to 7.0 percent of this mineral, averaging 5.3 percent. The magnetite content in samples Nos. 24 and 26, which have been partly waterwashed, is much higher, being 13.2 and 10.8 percent respectively. Sample No. 4, which represents a crudely stratified till, has only 2.9 percent magnetite. This compares with 13.6 percent in the reworked outwash deposit represented by sample No. 2. Along the traverses, the variations in magnetite are inconsistent.

The estimated densities of the different mineral groups described above are as follows:

Light minerals -	(quartz 2.65
	(Plagioclases (average-oligoclase)..2.66
	(K feldspars -(microcline & orthoclase).2.55
	(Unidentified...........2.85

Heavy minerals -	(Augite & uralite............3.25
	(Saussurite (rich in zoizite.3.25
	(Biotite.....................3.01
	(Unidentified................3.30

Using these values, and taking into account the average ratio of heavy minerals to light minerals, the average mineralogical composition of the two main types of tills represented in Chibougamau has been calculated. The results are given in Table N . 9 .

Conclusions and comparison with previous work:

The present study has shown that there is little or no relation between the composition of the fine fraction of tills and the nature of the underlying bedrocks.

Traverse A is almost entirely underlain by "greenstones" and gabbroic rocks. Its south end reaches the Chibougamau granite, and anorthosite may be present in a drift covered area between the granite and the Cache Lake gabbro. Traverse B starts, at its north end, near the "greenstone" anorthosite contact, and is entirely underlain by anorthosite. Yet the mineralogical composition of the index size fraction of tills collected along the two lines is very similar.

A large part of the identified light minerals, which make up as much as 90 percent of the index size fraction, has been derived from the vast areas of granites and gneisses located west and east of Mistassini Lake, twenty miles or

TABLE NO. 9

RECALCULATED MINERALOGICAL COMPOSITION - 100-150 MESH FRACTION

OF TILLS

Till Group.	Quartz	Plagio =	K- Feld.	Hornblende	Magnetite	Biotite	Sauss.	Unid.
Normal Till	45.3	33.2	10.2	3.9	0.3	0.5	0.4	6.2
Washed Till	42.3	30.2	10.9	7.4	1.2	1.1	0.7	6.3
Outwash (no.6)	34.7	31.1	8.6	10.3	2.2	1.0	0.7	11.3

more in the direction from which the ice moved. Part of the quartz and plagioclase grains probably belong to the Opemiska sediments, immediately south of the granites and gneisses.

Most of the amphibole and pyroxene grains, which form more than half of the heavy minerals fraction, have a more local origin. Although scarce in the granites and gneisses, these minerals constitute as much as 50 percent of the Opemiska greywackes and the "greenstones" and associated rocks. Traverse B is located entirely south of the hilly belt underlain by these rocks, while traverse A starts within these hills to end in the lower ground south of them. The hornblende-pyroxene content of tills in the northern part of traverse A is markedly lower than that of all the other samples. This may indicate that the hornblende-pyroxene content reaches a maximum, in the index size fraction, immediately south of the hills which were strongly affected by glacial erosion until the latest stage of the glaciation, and provided an abundance of these minerals. The hornblende content drops at the southern end of both traverses, probably because this easily cleaved mineral has undergone further division and is concentrated in fractions finer than the one studied.

The low content of the index size fraction in products of saussuritization is noteworthy, considering the abundance of this material in all the rocks of the Chibougamau district. As an experiment, a piece of typical anorthosite from the

Dore Lake area was crushed and the minus 100- plus 150 mesh fraction was separated by sieving. A gravity separation with the liquid used for the till samples produced a heavy fraction containing 90 percent of the original material. An examination under the microscope showed an abundance of grains rich in fine crystals of zoizite and a few grains of chloritic material in the heavy fraction, and albite rich grains in the light fraction. All the material was readily identifiable. The conclusion is that the anorthosite does not contribute to any noticeable extent to the index size fraction of tills underlain by that rock.

The heavy minerals proportion in Chibougamau tills is quite comparable to the amounts given by Kruger for different till sheets in Minnesota. Finnish tills are markedly richer in heavy minerals. Kivekäs gives an average of 7.5 percent for basic moraines and 10.2 percent for granitic moraines, and Jaesnefors found that in northern Sweden the heavy mineral content of the fine sand fraction of tills fluctuates between 15 and 20 percent.

The composition of the light minerals fraction is also very similar to that given by Kruger. It is difficult to make a comparison with figures given by Jaesnefors because this author grouped the light minerals according to their refractive indices, so that part of the plagioclases were included in the quartz group while the remainder was counted together with potash feldspars. Kivekäs has calculated the average quartz content of granitic moraines to be 47.6 percent by weight, which is very close to the figure obtained in the present study.

The basic rocks of the "greenstone" belt have contributed to the heavy minerals content of tills deposited nearby in the direction of ice-movement. This contribution is in the form of a marked increase of hornblende. A similar situation has been reported by Jacznefors.

In conclusion, the fine fraction of Chibougamau tills was largely derived from the region of granites and gneisses starting east and west of Mistassini Lake and extending far to the north. The distance of travel of this material exceeds twenty miles.

DESCRIPTION OF TILL MATRIX SAMPLES

No. 3 Quebec Chibougamau Gold fields property - 1,000 feet southeast of shaft. Low, oval-shaped till ridge. Opened up for "gravel" extraction. Unsorted boulder till, with boulders up to several feet in diameter. Matrix light grey, very sandy. Sampled about 6 feet below surface, in unweathered material.

No. 4 Copper Rand property - Cedar Bay block. Junction of Copper Cliff coreshack trail and old tractor road to Quebec Chibougamau Goldfield's property. In gravel pit. Very coarsely stratified ground moraines, on the southeast flank of steep hill. Very stony with a coarse sandy matrix. Boulders up to 3 feet in diameter. Sampled about 4 feet below surface, in unweathered material.

No. 5 100 feet southeast of Copper Rand Powder House, on Copper Rand Property (Cedar Bay block). Stripped surface for road construction. Groundmoraine. No particular morphology. Unsorted, sandy with a few very large angular boulders. Sampled about 4 feet below surface, in unweathered material.

No. 6 Copper Rand property - Gouin Peninsula. 1,000 feet southeast of shaft No. 2. In gravel pit. "Crag and tail" ridge. Reworked outwash deposit. Crudely bedded sandy to gravelly material. Abundant scattered boulders. Sampled 20 feet below surface.

No. 7 Obalski Mines (1945) property - In "gravel pit" just north of highway to Campbell Mines, 1,000 feet northwest of Obaski camps. Drumlinoid ridge. Unsorted boulder till with silty matrix. Light grey. Sampled about 10 feet below surface.

No. 10 On peninsula east of Cedar Bay - Copper Rand property. Ground moraine, no particular morphology. Unsorted sandy boulder till. Sampled at an average of 8 feet below surface.

No. 11 Chibougamau Jaculet property, at the shaft site. Ground moraine forming an irregular mantle on sough sloping face. Compact sandy boulder till. Depth of sampling 4 feet.

No. 12 On north side of highway to Copper Rand Mines. At the northeast end of Gilman Lake, Heavy cover of ground moraine on south facing slope (15 feet exposed). Depth of sampling: 10 feet.

No. 13 On west shore of Dore Lake about one mile southwest of Merrill Island. In an exploration trench across a shallow drumlinoid ridge. Unsorted sandy boulder till. Depth of sampling: 3 feet, immediately below the "B" soil horizon.

No. 14 Same, 4,000 feet southwest of sample No. 13. On the same till ridge, in another exploration trench. Depth of sampling 3 feet, beneath a thin surface layer of stratified sand.

No. 15 Same, 1,500 feet southwest of sample No. 14. On the same till ridge (south end) in an exploration trench. Depth of sampling: 3 feet, underneath "B" soil horizon.

No. 16 Along highway to St. Felicien, just north of bridge on Chibougamau river. Small till ridge parallel to the river. Unsorted sandy boulder till. Depth of sampling: 5 feet.

No. 17 1/2 mile north of No. 16, on west side of highway. Near the top of a drumlin. In unsorted sandy boulder till. Depth of sampling: 5 feet.

No. 18 1-1/4 mile north of No. 16, on east side of highway. Same as No. 17. Depth of sampling: 5 feet.

No. 20 At Fecteau air base, on the west shore of Cache Lake. In excavation for hangar building. Thick cover of ground moraine. Thickness exposed is 15 feet. Unsorted silty boulder till. Depth of sampling is 10 feet.

No. 21 About 1,500 feet north of Boreal Airways base. In old excavation. In ground moraine. Unsorted sandy boulder till. Depth of sampling: 5 feet.

No. 23 One mile south of Campbell Chibougamau sub-station. Cleared patch of ground. At north end of a small drumlinoid ridge. Unsorted boulder till. Depth of sampling: 3 feet, immediately underneath the "B" soil horizon.

No. 24 On east side of highway, three quarters of a mile north of No. 23. In shallow excavation. Boulder till with coarse sandy matrix (probably just a thin layer on normal boulder till). Depth of sampling: 1 to 2 feet.

No. 25 Just south of junction of main highway with road to Campbell Chibougamau Mines. In abandoned "gravel" pit. At the north end of a drumlinoid ridge. Unsorted boulder till. Depth of sampling: 4 feet.

GM-23800

No. 26 One mile and one half northeast of No. 25. In shallow excavation. At the north end of a "crag and tail" ridge. In coarse sandy boulder till. Depth of sampling: 1 to 2 feet.

CHAPTER V

DISPERSION OF BASE METALS IN SOILS

The Normal Base-Metal Content of Surficial Deposits

It has been established by previous workers studying geochemical prospecting that when dealing with podsolic soils the best results are obtained by sampling the B horizon (Bischoff etc.). Therefore, for the regional soil survey of the Chibougamau district it was decided to sample the B horizon. However, where bog soils were encountered the blei horizon underneath the surface organic layer wherever possible was sampled. Bischoff (1954) considers that material from the glei horizon can be used for geochemical prospecting. A reconnaissance soil survey of the Chibougamau district showed that soil conditions in this area are similar to those which exist in the areas described by the authors mentioned above.

The soil sampling tool described earlier can not be used for a direct examination of the soil profile. However, the sample obtained could be fairly accurately related to one of the soil horizons once local pedological conditions were known.

Unless specified otherwise the soil samples which will be described in the following sections were all collected from the B horizon. 'B' samples were usually obtained from the upper part of the B22 horizon of typical podsols, or from the top part of the B21 horizon of brown podsols. The B21 horizon of true podsols was avoided because of its variable content of organic matter. Humus samples were collected from the Ao horizon; the most decomposed material being selected because commonly it is the most homogeneous.

The normal base-metal content of material from the B horizon of podsolic soils and gleified material from bog soils was first established and then compared with that of the A and C horizons of podsolic soils. To insure that true background values were obtained the samples were collected from soils which were removed from any known mineralized bedrock.

The Normal Content of Readily Soluble Metals in Soils

The normal base-metal content of 'B' soils of the Chibougamau district is as follows:

Zinc	:	10 to 45 p.p.m.
Copper	:	5 to 25 p.p.m.
Lead	:	less than 5 p.p.m.

The average zinc content was found to be 25 p.p.m. and the average copper content 15 p.p.m. 'B' samples collected from such different types of surficicial deposits as outwash sands, boulder till, etc., were found to have a similar background metal content.

The background base-metal content of the glei horizon of peat soils is very similar to that of the 'B' horizon of podsolic soils; the frequency curves given in Figure 17 illustrate the similarity and represent the zinc and copper content of 'B' and glei soils from the southwestern part of Merrill Island.

As a rule, there is no systematic difference between the normal base-metal content of the 'B' and 'C' horizons. The variations of background values found in vertical profiles are small and cannot be distinguished from differences caused by inaccurate chemical analyses. In well developed podsols over medium to coarse outwash deposits zinc tends to be slightly concentrated in the 'B' horizon.

The A2 horizon is a zone of intense leaching in which the background is as low as 10 p.p.m. for zinc, 5 p.p.m. for copper; lead is absent.

The Ao horizon or humus layer is a zone of zinc and in some instances lead concentration. The copper content of humus is similar to that of 'B' and 'C' soils, but was mentioned earlier that organic compounds inhibits the extraction of copper by dithozone and as a consequence the humus background values of 0 to 5 p.p.m. may be too low.

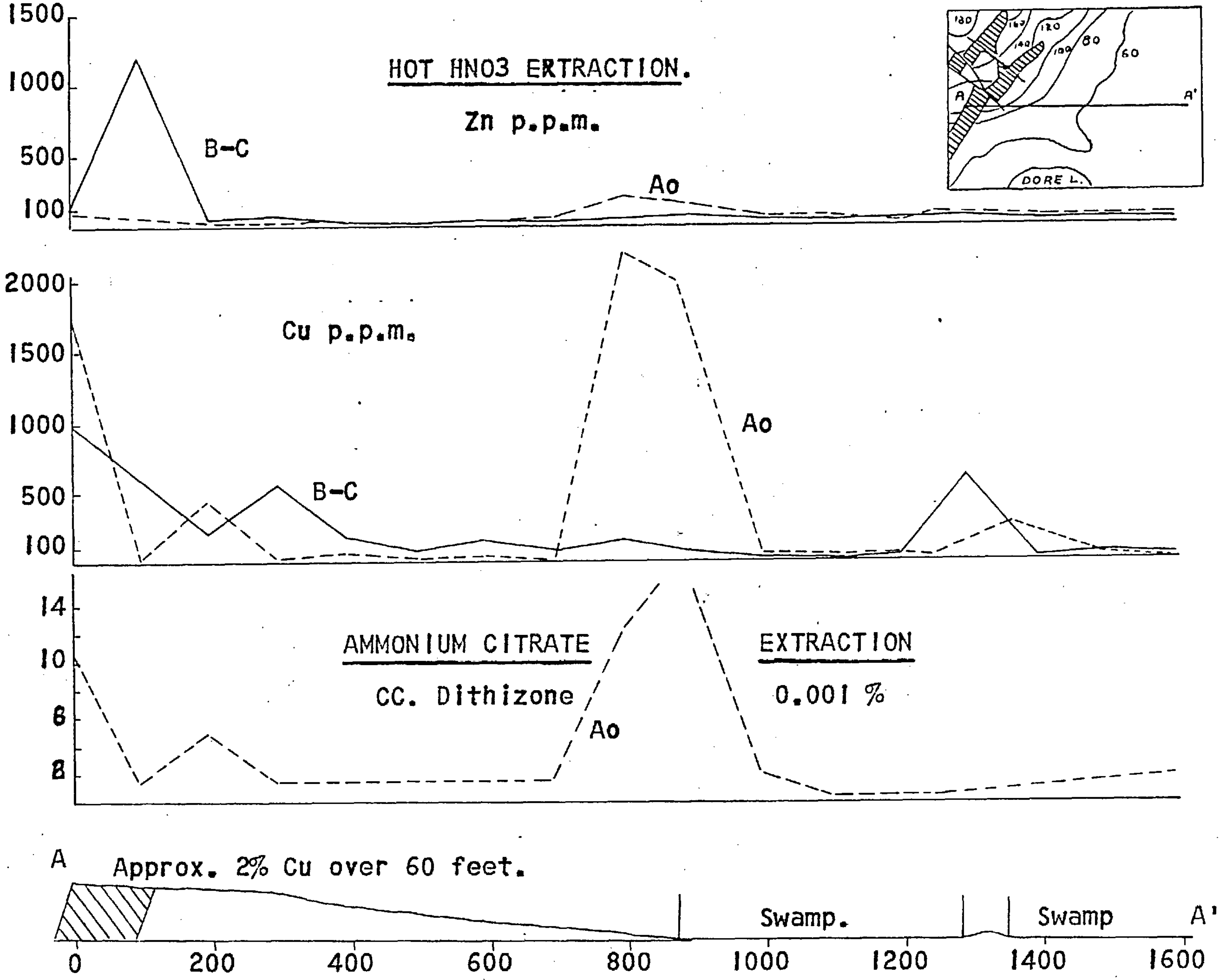
The zinc content of normal humus ranges from

15 to 90 p.p.m. with an average of 35 p.p.m. Thirty-six pairs of samples were collected in different parts of the surveyed area and for each pair the zinc content of the Ao and 'B' horizon was compared. It was found that the Ao horizon contains more zinc than the 'B' horizon; the average concentration factor is 1.4. However, in an area where the bedrock contains abundant pyrite the 'B' soils were found to have an average zinc content of 25 p.p.m. and the humus an average zinc content of 50 p.p.m. (mean of 50 analysed samples). This is a concentration factor of 2.0 and it compares with the concentration factors of 2.0 to 4.0 found by Schmidt (1955) in his study of the humus layer of the more mature podsols of New Brunswick.

Scarce, erratic lead values which attains a maximum of 40 p.p.m. are found above barren 'B' and 'C' horizons.

It is possible that lead which is retained in the rootlets of certain plants would prove toxic if it occurred elsewhere in the plants.

The above conclusions concerning the distribution of base-metals in the soil profile are generally verified by data given in the soil literature Wright (1955). However, it should be kept in mind that soil scientists usually refer to the total metal content of the material analysed whereas geochemists usually refer to the soluble metal content of the material analysed.



PROFILE ACROSS CAMPBELL-MERRILL ORE-ZONE.

Figure 17

Cold Extractable Metals Background

A very dilute solution of dithozone (0.001%) was used to establish the background values of metals using the cold extraction method. The following results were obtained:

Mineral Soils (B and C Horizon) 0 to 1

Organic Soils (Ao Horizon) 0.5 to 5

(Usually 1.5 to 2.5)

For mineral soils, the grain size of the material analysed did not have any apparent influence on the results obtained. Sands, silts and clays have a similar range of background values. However, Byers (1956) from his study of the soils of the Flin-Flon district, Manitoba reached a different conclusion. He found a definite increase in background with an increase in the clay content of soils; the background for sand ranged from 0.5 to 1.0; the background for silts ranged from 1 to 2; and the background for clays ranted from 2 to 5. Riddel's studies (personal communication) of soils of the Canadian Shield do not confirm Byers' conclusions.

Secondary Haloes of Dispersion around Known Mineral Deposits

Campbell-Merrill Ore Zone

The Campbell-Merrill ore bodies are within a zone of sheared and brecciated anothosite which is approximately 500 feet wide and extends across the northeast part of Merrill Island into Dore lake. Figure No.17 shows the surface outline of almost massive sulphide lenses as mapped by Graham (1956) together with the writer's soil sampling results. The heavy sulphides which are overlain by a thin gossan occur southwest of the highest part of the island. The wall rock is fractured for several tens of feet away from the ore with the fracture surfaces heavily stained by iron oxides; in general, there is no copper stain. Assays of surface samples taken across the main ore zone ranged from 2.0 to 2.5 percent. The mineral assemblage has been previously defined.

The northeast part of Merrill Island is a rock hill whose top is 200 feet above the level of Dore lake. The hill slopes are gentle to the west and southwest, and steep or vertical in other directions. Overburden is thin and entirely composed of sandy boulder till. The soils developed are true podsols.

Because the surface plant of Campbell Chibougamau Mines is located over the northwest part of the ore zone it was not possible to survey this part of the zone. In the summer of 1955 it was still possible to survey the central part of the ore zone since Merrill Island Corporation had not begun its large program of underground development. In this area the only possible source of contamination was a small ore dump which contained material extracted during an earlier period of shallow shaft sinking and underground exploration. The soils around the dump may have been enriched by base-metals leached from the dump and for this reason these soils were not sampled. For the same reason, diamond drilling sites and surface drainage channels were also avoided when sampling. It is believed that the distribution of base-metals in the soils such as is illustrated in Figure No. has been produced by natural factors.

All, but two, of the 'B' soil samples collected directly over the zone of mineralization are strongly anomalous in copper; values range from 70 to 4,000 p.p.m. or from 5 to 266 times the background. In the same samples the distribution of zinc is erratic, and only 50 percent of the samples yeild anomalous values. The zinc assays attain a maximum of 1,200 p.p.m. The two barren samples were collected over the centre of the ore zone from a thin soil which probably had been strongly leached. The writer suggests that the low base-metal content of the two samples can be related to the soil. In addition to copper and zinc the two samples located south of point A of Figure No. 17 assayed 60 and 160 p.p.m. of lead.

For several hundred feet southwest of the ore zone downslope of 'B' horizon of the soil has anomalous base-metal values, with copper assays of samples ranging from 2 to 8 times background; here, as elsewhere, the zinc occurs in insignificant amounts erratically distributed.

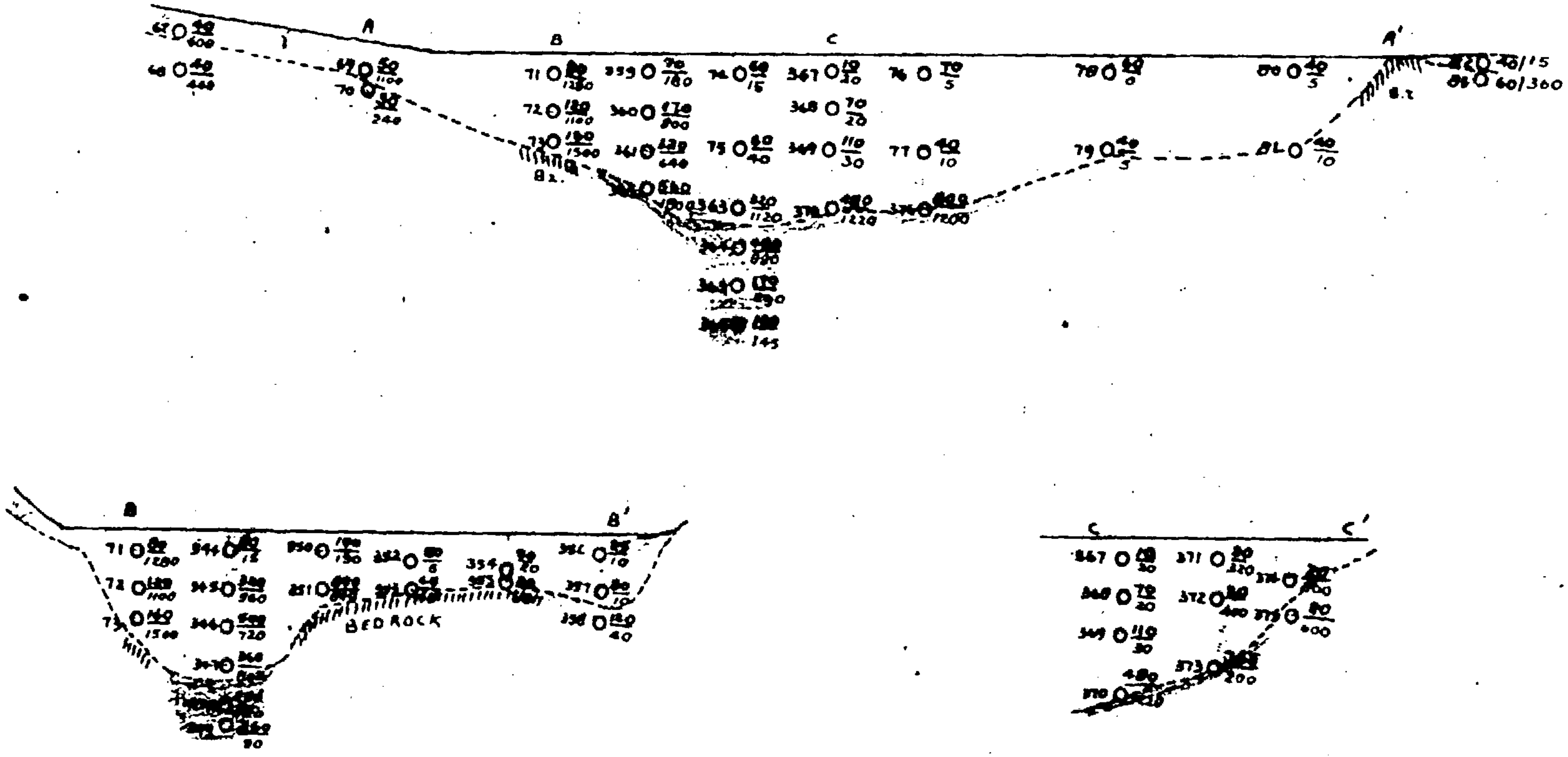
The isolated anomaly in the little swamp south of the ore zone is definitely related to a small outcrop of sheared anorthosite which was observed to contain disseminated pyrite and chalcopyrite. The soils south and west of the swamp are slightly anomalous in copper and it is not known whether or not the anomaly has been caused by weak mineralization of the bed rock or by dispersion of copper from the main zone by glacial transportation.

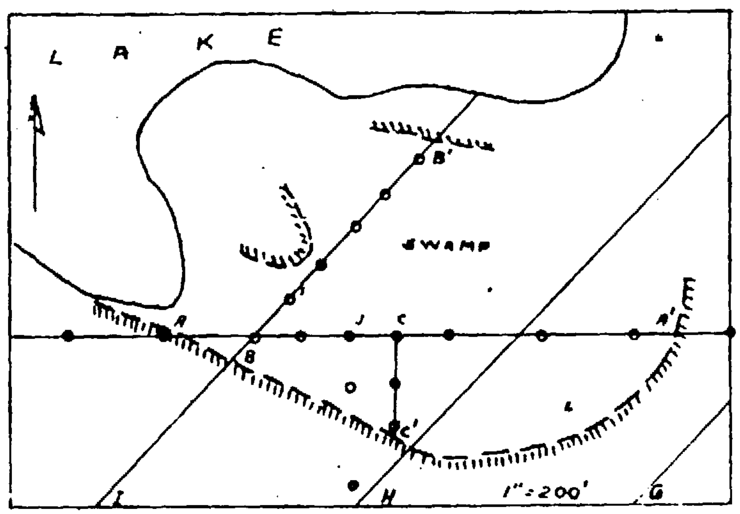
Northeast of the main ore zone the occasional anomalous soil sample probably reflects local concentrations of base-metals in the bedrock. During the most easterly traverse an anomalous sample collected from a locality southwest of the shaft was later found to contain 30 p.p.m. lead as well as copper and zinc.

Figure No.18 shows a profile AA' which extends south from the main ore zone. At each location, samples from the Ao and the 'B' horizons were collected, and it should be noticed that the concentration of copper and zinc in the Ao horizon at the base of the slope exceeds that of the Ao horizon directly above the ore. However, the 'B' horizon at the base of the slope shows no corresponding increase in base-metal content. There is a thin layer of organic material in the swamp which attains a maximum thickness of three feet. It has only a background base-metal content and it is apparent that base metals transported down the slope from the mineralized outcrops did not reach the swamp, but were concentrated in the humus at the base of the slope.

Berrigan Lake Deposits

Only a limited amount of geochemical work was done in the vicinity of the Berrigan Lake zinc deposits. The results are given in Figure No.19 . The Berrigan lake deposits present such unusual features for the Chibougamau district as the predominance of zinc over copper, the existence of local concentrations of galena within the ore, and the intense weathering of the





GEOCHEMICAL SURVEY

(MERRILL ISLAND CORPORATION PROPERTY)

VERTICAL SCALE 1" = 10'

HORIZONTAL SCALE 1" = 100'

O SOIL SAMPLE LOCATION.
360 Sample no. (for 79-360)
600 Zn ppm.
800 Cu ppm

Organic m. Till sand & silt Blue clay.

Fig 18

ore near surface. The deposits occur within the highest hills of the district where the preglacial drainage system has largely escaped the effects of glaciation. It is interesting to compare the distribution of base-metals in this district with that found by Riddel (1954) in his study of the Federal Mines zinc-lead area, Gaspe Peninsula where conditions are somewhat similar.

Glacial striae and grooves, which are oriented south 25 to 35 west regardless of the direction or grade of the surface, indicate that topography did not influence to any large extent the direction of ice movement. The overburden is thin and largely composed of sandy boulder till. Rock slumping has occurred locally forming a talus which is composed of various bedrock fragments and glacial sediments.

A limited amount of trenching and a large amount of diamond drilling may have, to some extent, disturbed the normal distribution of base-metals in soils of the area.

Soil samples were collected along three parallel traverses located 50 feet apart and extending from the west end of the Berrigan zone on the north shore of the lake, across the north zone and down to the bottom of a deep valley. The Berrigan zone is indicated by soils which carry more than eight times the average background amount of zinc. The copper content is near the upper limit of the regional background while lead is generally absent. The soils collected between the Berrigan and the North zones contain as much as 10 times the average zinc background and indicate that zinc is disseminated throughout the area. Several samples contained lead in larger amounts than background.

Soil samples collected in the vicinity of the North zone contained large amounts of zinc (maximum: 2,000 p.p.m. or 100 times the average background), while, with few exceptions copper values are background. The lead assays of samples collected from the west branch of this ore zone ranges from 10 to 1,000 p.p.m Two soil samples were collected at points 800 and 1,100 feet east of the showings on the extension of the fault which follows the east branch of the ore zone. The two samples contain large amounts of zinc and copper, and it is probable that the fault served as a channel-way for mineralizing solutions. Samples from the soils downslope from the north zone yielded high, but erratic zinc values, while two samples collected at the bottom of the slope near its junction with the valley flat yielded slightly anomalous zinc values. The writer velieves that such a distribution of metals in the soils of the slope indicates that dispersion of base-metals is facilitated by slumping rather than by solution and transportation of the metals in the ionic state. The writer's belief is further supported by the high lead anomaly (3,000 p.p.m.) which is to be found 350 feet from the north end of the mineralized outcrops. Here the anomaly is caused by the weathering of galena and the precipitation of insoluble secondary lead minerals in the immediate vicinity of the mineralized outcrops.

Another set of soil samples was collected along the sides of the valley to the north of Berrigan lake. Samples were taken at stations 200 feet apart along the banks of the valley at points slightly above the valley flat. The sampling procedure is identical to that adopted by Riddel for his Gaspe survey. The writer's survey extended 1,000 feet west and 1,200 feet east of the downslope projection of the north zone into the valley. Samples collected along the north side of the valley yielded consistently background values in base-metals, whereas on the south side two samples slightly anomalous in zinc were collected downslope from the north zone; these two samples were described previously. Samples collected west of the north zone along the line of traverse contained quantities of copper, zinc and lead which did not exceed the regional background values. Samples collected at points 600 feet or more east of the North zone along the line of traverse were moderately anomalous in base-metals.

Soil samples were also collected along the north shores of Berrigan lake at points slightly above high water level. The assay results were as follows: 25 to 300 p.p.m. zinc; 30 p.p.m. copper or less; 100 p.p.m. lead or less. Similar results were obtained from samples collected on the south shore at points on the steep north facing hill slope.

It is clear from the above description that the soils which cover a large area around Berrigan lake have a zinc content well above the regional background; at several locations copper and lead were found in slightly anomalous amounts. Notably high assays were obtained from soil samples collected in the vicinity of mineral deposits. The geochemical anomaly extends over an area of complexly faulted and brecciated rocks, but it can not be related to any particular rock type.

The base-metal content of soils from the Berrigan lake area was found by the writer to be similar to that reported by Riddel for a large area around the Federal Mine Gaspe, but it differs from the Gaspe area in so much as no concentration of zinc was found at the junction of the valley slope and valley flat.

Copper Cliff Zinc Zone

The Copper Cliff zinc zone is west of Cedar Bay. It lies within a wide siderite-sericite-chlorite schist zone which trends northwest and dips vertically; outside of the schist zone anorthosite is the most common rock. The mineralized zone is only a few feet thick and contains abundant sphalerite accompanied by small amounts of pyrite anc chalcopyrite embedded in a pale brown carbonate-rich matrix. In the vicinity of the area surveyed samples taken across 6 feet of the zone have been reported by Copper Cliff Consolidated Mines Ltd., to assay as much as 12 percent zinc.

The mineralized zone follows a steep slope which is covered by a thin layer of boulder till; a typical podsol overlies the boulder till. The gangue rock is massive and coated by a thin layer of iron oxides formed from weathered carbonate, whereas the wall rock schist is more deeply weathered.

Surface workings consist of several narrow trenches across the mineralized zone and a number of diamond drill holes whose locations are 150 feet or more south of the trenches.

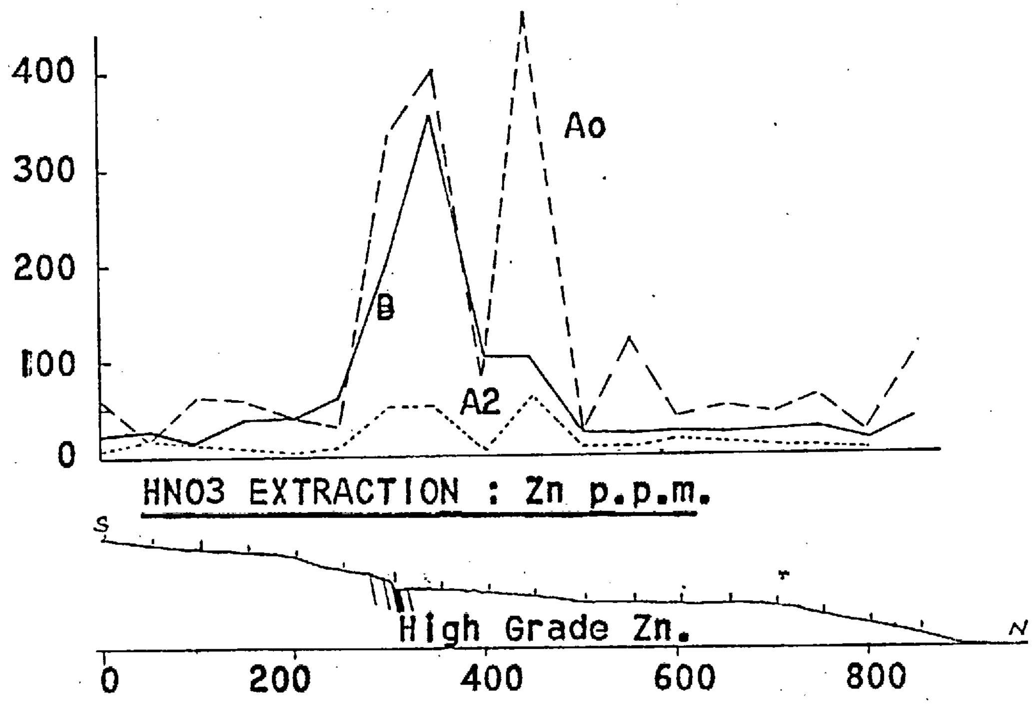
Samples from the Ao, A2 and B horizons were collected at intervals of 50 feet along one traverse which started 300 feet south of the mineralized bedrock and ended at the edge of Towle lake. To avoid collecting samples from soil which had been contaminated by surface work the traverse was located to pass mid-way between two of the surface trenches. The results of the traverse are given in Figure No. 20.

The zinc anomaly in the 'B' soils is narrow with the maximum concentration at a point 50 feet downslope from the mineralized bedrock. In the Ao horizon the zinc anomaly is similarly located. Within the anomaly, there is no relation between the zinc content of the Ao and B horizons. For both horizons there is very slight increase in zinc at the bottom of the slope. The A2 horizon has a low zinc content and as a consequence only weakly reflects the zinc content of the underlying bedrock.

Considering the size of the Copper Cliff zinc zone and the fact that the local topography would permit deep weathering of the zone, the geochemical anomaly is weak. Two factors probably account for the weak anomaly. Firstly, the ore contains only a small amount of iron sulphide and hence very little sulphuric acid was produced from the weathered ore. Secondly, the alteration of siderite formed a thin but compact coat of iron oxides which prevented deep weathering of the sphalerite.

Quebec Chibougamau 'H' Zone

The Quebec Chibougamau 'H' zone is a northwest trending shear on the west shore of Dore lake, about 1½ miles north of the Campbell Chibougamau Mines. Although the zone has



PROFILE ACROSS HIGH GRADE ZINC ZONE.

Fig. 20.

GEOCHEMICAL SURVEY

QUEBEC CHIBOUGAMAU GOLDFIELDS PROPERTY.

H COPPER ZONE

SCALE: 1" = 200'

O SOIL SAMPLE LOCATION.

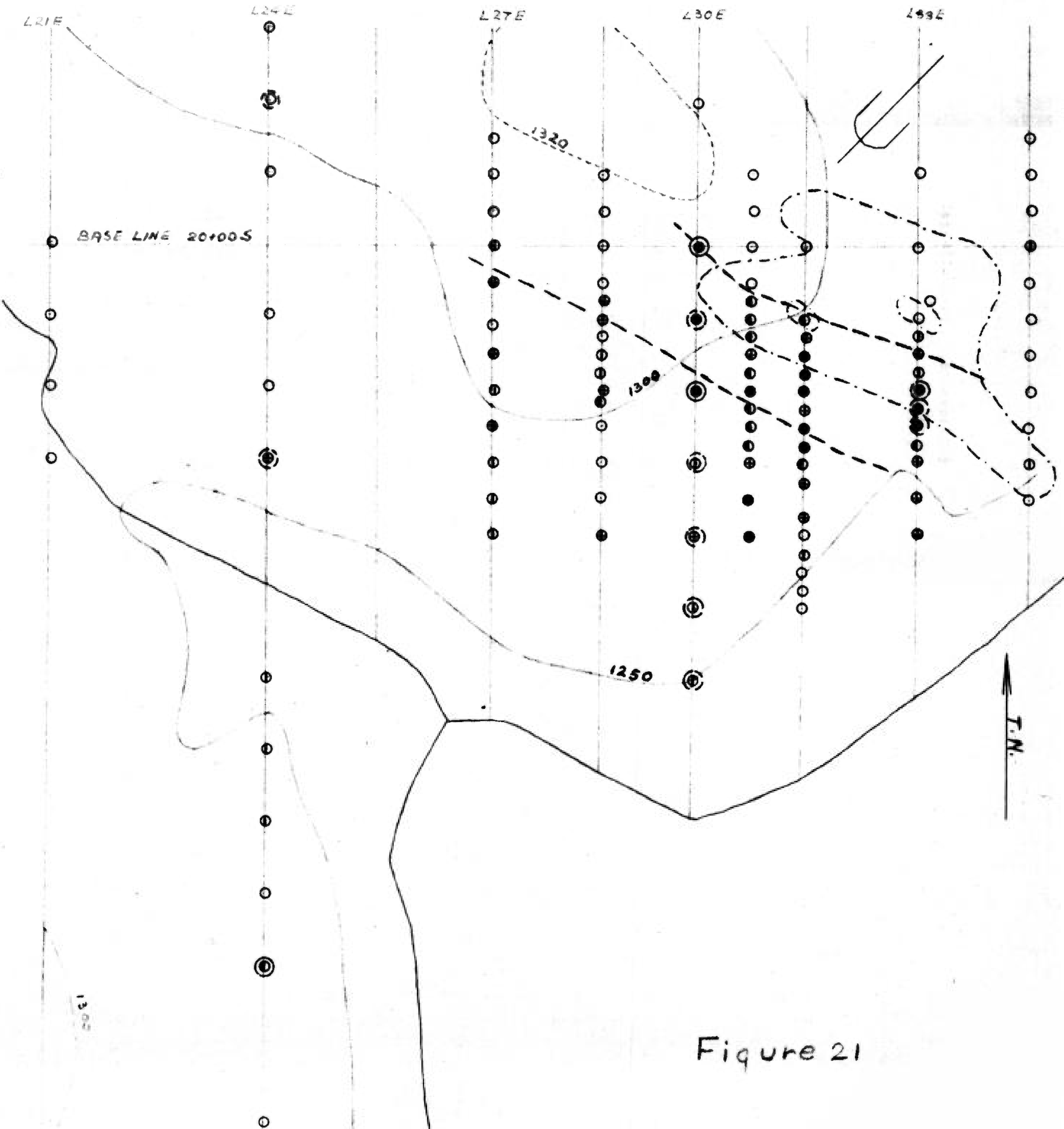


Figure 21

a maximum width of approximately 150 feet the sulphides are confined to two contact zones where intrusion of several basic dykes has taken place. Finely disseminated pyrrhotite, chalcopyrite and minor pyrite are concentrated into irregular shaped lenses which attain a maximum width of 20 feet and are 50 feet or more in length. The widest channel sample reported by the company assayed 2 percent copper over a true width of 22 feet. Narrower channel samples assayed as much as 4 percent copper. The zinc content of the ore is negligible.

The ore outcrops along a moderate slope which is covered by sandy boulder till whose thickness ranges from 1 to 6 feet. A well developed podsol overlies the till. Surface weathering of the ore is moderate and fresh chalcopyrite has been found within one or two inches from the bedrock surface.

The first traverses were made along lines 24E and 30E and later traverses were made along lines cut by Quebec Chibougamau Goldfields Company for a geophysical survey. Samples collected on the first two traverses were analysed at the Geochemical Laboratory, McGill University and by the time the assays were available the company had completed a magnetometer and self-potential survey; because the two geophysical surveys revealed geophysical anomalies additional soil samples were collected and analysed in the field laboratory. The H zone was subsequently uncovered by stripping and surface diamond drilling proved that it dipped steeply southwest.

It is interesting to compare the location of the geophysical and geochemical anomalies with the mineral outcrop.

The south part of the self-potential anomaly covers the north half of the shear zone while to the east the anomaly extends far beyond the ore over fractured and rusted bedrock. The north part of the self-potential anomaly covers barren rock and can not be explained. No anomaly was obtained over the south half of the shear zone.

The north limit of the geochemical anomaly very closely follows the north boundary of the shear zone. The best ore occurs between lines 30 and 31 50 and here most of the samples collected above the ore zone assayed are more than eight times the average copper background. Along line 33E the underlying bedrock is almost barren and the high copper values obtained from samples collected along this line are best explained by the transportation of copper in surface waters downslope. The existence of two mineralized bands within the shear zone is suggested by the distribution of copper in the overlying soil. The maximum concentration of copper in the soils occurs downslope from the ore zone. The copper content of soils north and west of the ore zone does not exceed the regional background but most samples collected from soils south and southwest of the ore zone have weak anomalous copper values. East of line 30E the weak copper anomaly can be attributed to the transportation of copper in solution downslope from the ore zone. However, west of line 30E the topography is such that the weak copper anomaly could not be attributed to the transportation of copper in solution and it is suggested that copper was transportated from the 'H' zone by glaciers.

Only a few samples collected from the 'H' zone area were anomalous in zinc and those that were usually had a high copper content. Samples collected along lines 21, 24 and 30E were analysed for lead and only background values found.

North Copper Cliff Zone

The north Copper Cliff zone is northwest of Cedar Bay and lies within the gabbroic border phase of the anorthosite in a chlorite-siderite schist zone. The schist zone is 200 feet wide and dips steeply southwest, to the north it joins the south branch of the Savage Lake fault. Pyrite and chalcopyrite are concentrated, within several narrow bands, on the footwall side of the schist zone. Individual sulphide-rich bands assay as much as 3 percent copper, but the overall grade calculated from widths of 50 to 100 feet ranges from 0.5 to 1.0 percent copper.

Figure No. 22 shows the outline of the North Copper Cliff zone and the results of the writer's geochemical survey. The surface outline of the zone as illustrated on the figure is only approximate and has been drawn from sections provided by the Copper Rand Company. East of the southwest flowing creek the mineralized band trends down a moderate slope while west of it the band follows a gulley through a fairly steep scarp. A sandy boulder till covers the area and increases in thickness from west to east; the till is a few feet thick in the west and approximately 15 feet thick over the mineralized zone. Near the junction of the two creeks in the southwest corner of the area the overburden is interbedded sand and silt. The soils

GEOCHEMICAL SURVEY

COPPER RAND CORPORATION PROPERTY

NORTH COPPER CLIFF ZONE

SCALE: 1" = 200'

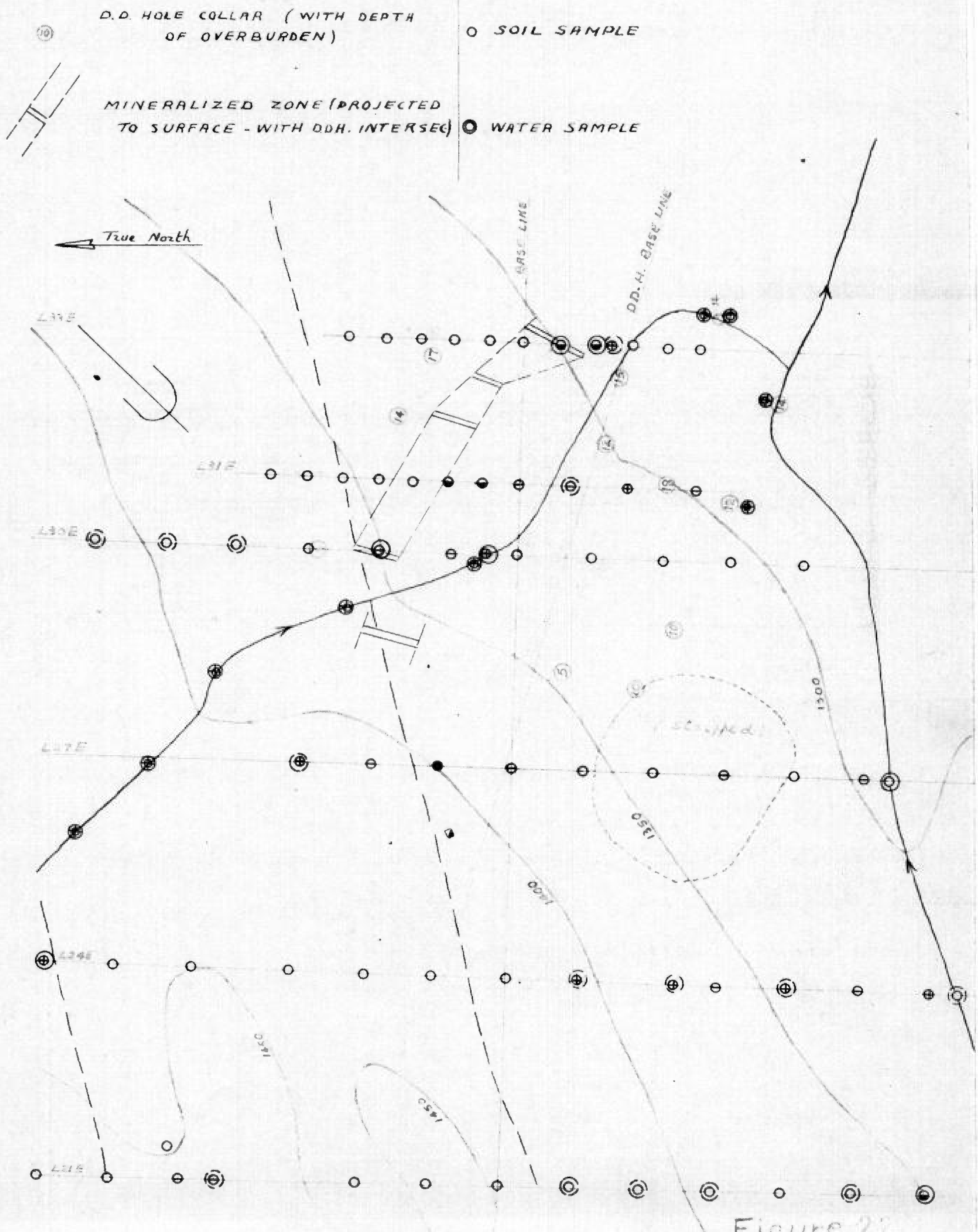


Figure 22

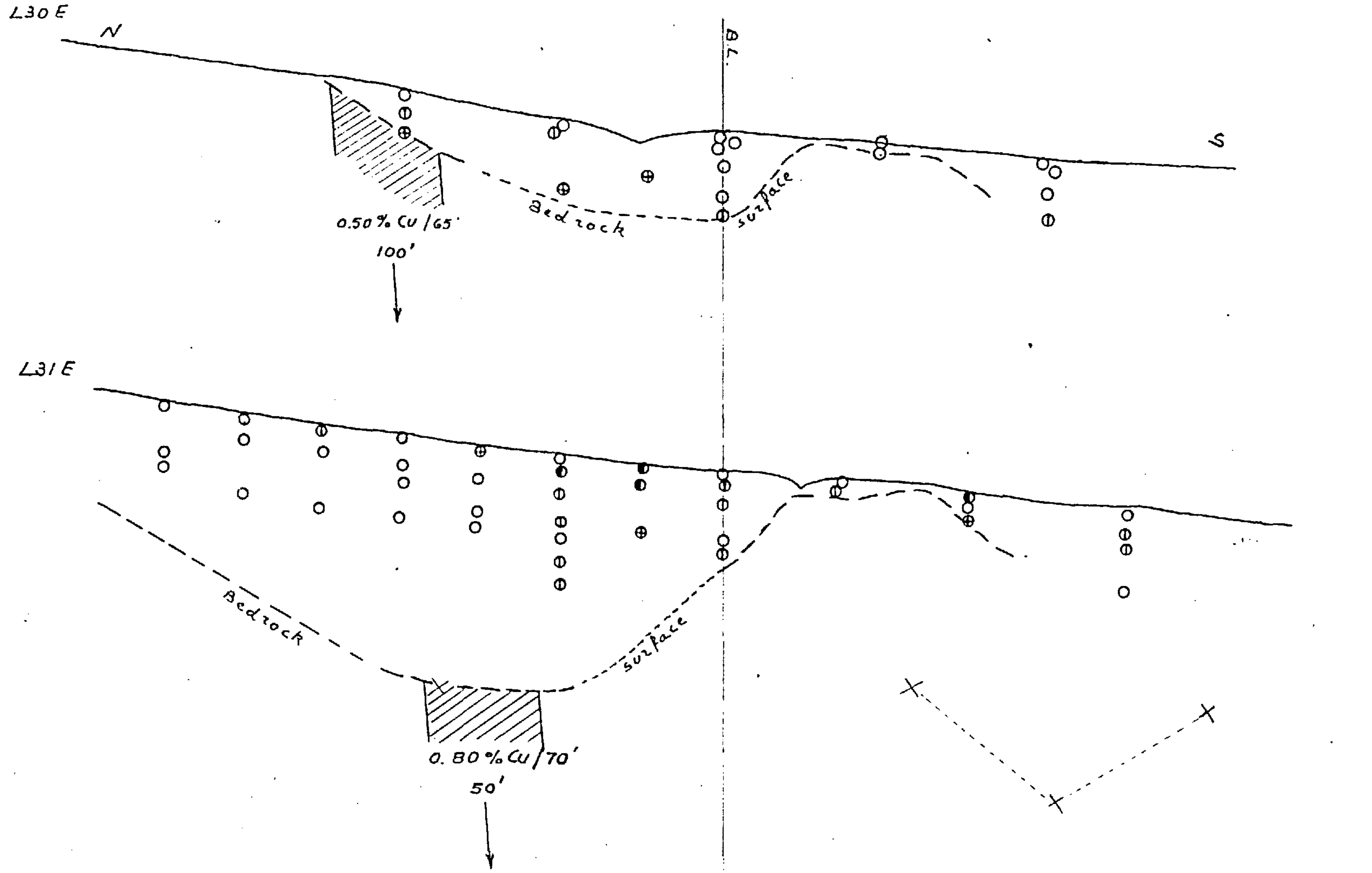
developed, grade from true podsols to brown podsols over most of the area except in the south where the water table surface is shallow and a half-bog has formed.

No trenches were dug over the North Copper Cliff zone, but a few trenches and a shallow pit were dug to explore weakly mineralized subsidary fractures near line 27E. In addition a trench had been dug to explore a massive pyrite lens near line 21E in the vicinity of the north boundary of the Savage Lake Fault zone. Most of the diamond drill holes were started from locations 200 to 400 feet southwest of the North Copper Cliff Zone and drilled to the east, but some holes were drilled towards the west from locations northeast of the mineralized schist.

A narrow but well defined copper anomaly marks the presence of the North Copper Cliff zone. It is slightly displaced downslope such that the northeast boundary of the anomaly lies vertically above the southwest boundary of the mineralized schist. To the south the anomaly is limited by a small valley. The highest assay is 12 times background. Along line 27E several samples were collected near the surface workings mentioned above. The samples were anomalous for copper and it is probable that the soil from which they had been collected was contaminated during the trenching operations. A few anomalous soil samples were also obtained near the north boundary of the Savage Lake fault zone. Samples collected north of the copper zone had only background values, while those collected south and southwest of the zone many had a slightly anomalous copper content. Similar to those of the Quebec Chibougamau 'H' zone the weak anomalies may have been caused by glacial dispersion of the copper.

Several soil samples collected near the copper bearing schist have a moderately anomalous zinc, as well as, copper content. Weak zinc anomalies were also found within the fault zone and southwest of the copper zone. Samples were not analysed for lead.

The vertical distribution of copper and zinc in the overburden near the North Copper Cliff Zone was also investigated. Wherever possible, soil samples were taken to a depth of 5 feet along three traverses (lines 30, 31 and 33E) across the mineralized band. At several locations attempts were made to reach bedrock, but they were unsuccessful because of the rocky nature of the overburden. At each sampling site a sample was first collected from the Ao horizon and then another collected from the B horizon; deeper samples were also taken at different levels within the C horizon. The results are shown in Figure No.23/23A and even though the profiles are incomplete they permit a few conclusions to be drawn. At several locations near the mineralized zone, where the overburden is thick, there is a marked concentration of copper near surface, in the B horizon, and sometimes in the top part of the C horizon (line 31E etc.). Zinc tends to be concentrated in a manner similar to copper. Samples taken immediately underneath the anomalous layer have a lower metal content which is either, slightly anomalous, or background. Although the overburden covering the mineralized zone could not be sampled close to bedrock there are indications that a second anomalous zone exists



X BEDROCK SURFACE (FROM D.D.H)

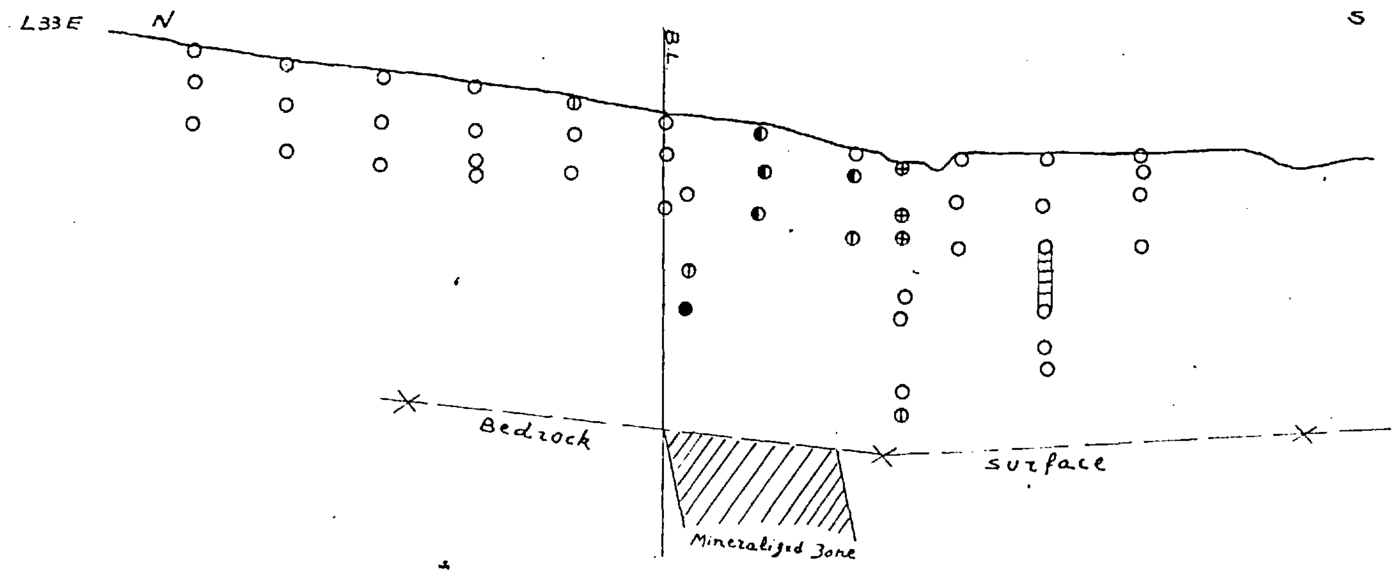
O SOIL SAMPLE

NORTH COPPER CLIFF ZONE.

HORIZONTAL SCALE 1" = 100'

VERTICAL SCALE:
TOPO. PROFILE: 1" = 100'
SOIL SAMPLING PROFILES: 1" = 10'

Figure 23



NORTH COPPER CLIFF ZONE

HORIZONTAL SCALE 1" = 100'

VERTICAL SCALE :
TOPO. PROFILE : 1" = 100'
SOIL SAMPLING PROFILES : 1" = 10'

X BEDROCK SURFACE (FROM D.D.H.)

O SOIL SAMPLE

Figure 23A

close to bedrock (line 31E etc.). A distribution of base-metals in thick transported overburden similar to that which has been just described has been noted by other workers. Hawkes (personal communication) calls the upper anomalous layer a superimposed halo.

Kokko Creek Copper Zone

The Kokko Creek ore zone is about one mile north of the Campbell Chibougamau Mines. Graham (1953) states that the mineralized shear has a maximum width of 50 feet and dips vertically. It is in anorthosite and extends for a distance of 2,000 feet northwest from the northwest shore of Dore lake. The deposit, which has a similar mineralogy to that of the Campbell-Merrill ore zone, contains in order of decreasing abundance pyrrhotite, chalcopyrite, pyrite and sparse sphalerite.

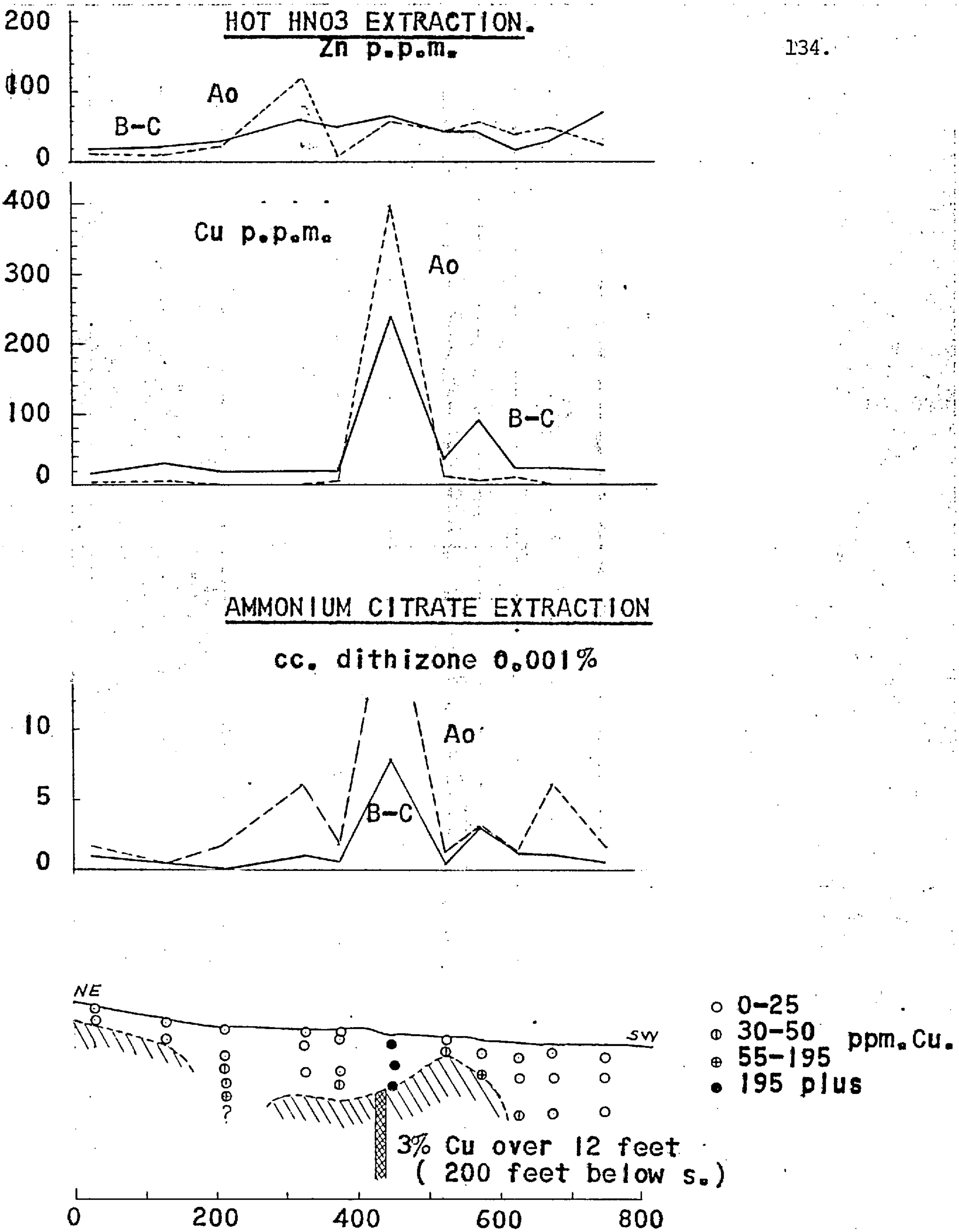
The mineralized schist, which is a few tens of feet above the level of Dore lake, is in rather low ground. At the north and south end of the shear zone where the shear has been exposed in several trenches the overburden is very shallow. Channel samples assayed 1 to 2 percent copper over 7 to 42 feet. The central part is reported by geologists of Campbell Chibougamau Mines Company to be covered by overburden which ranges in thickness from 10 to 20 feet. It has only been investigated by diamond drill holes which were collared 200 feet or more northeast of the projected surface outline of the ore.

The soils near the Kokko Creek ore zone grade from true podsols to bog soils. The type of soil formed depends on local drainage.

Only one traverse was made across the Kokko Creek ore zone and its purpose was to investigate the width of the secondary halo of dispersion which is developed in transported overburden forming level ground near an ore deposit. The results of the survey are shown in Figure No. 24. Ogden (1954) made a similar survey along the same traverse line during 1954.

On the traverse line the ore is near the top of a small rock knob which protrudes from almost level ground. Near to and southwest of the ore zone the writer found the overburden to be 2 to 4 feet thick and not 10 to 20 feet as had been previously reported. It is also probable that southeast and northwest of the sampling line, along the strike of the ore the overburden is not as thick as reported. The sampling procedure is similar to that used over the North Copper Cliff ore zone where an Ao, 'B' or 'G' sample was collected at each sampling site; if the C horizon was present it was also sampled to a maximum depth of 5 feet.

The copper anomaly in the B horizon of the soil over the Kokko Creek ore zone is intense but narrow with maximum values obtained directly over the ore. 'B' soils show a slightly higher increase in zinc, as well as copper content. From the Ao horizon only one sample taken directly over the ore was anomalous for copper and humus samples collected from either side of it which were analysed using hot nitric acid and potassium bisulphate methods only contained background amounts of copper.



(Scale in vertical profiles exaggerated 20 times.)

KOKKO CREEK COPPER ZONE.

Fig.24

No superimposed anomaly such as the one described over the North Copper zone was found near the Kokko Creek copper zone. Samples collected along the bedrock surface on either side of the ore zone were slightly anomalous in copper, and at the sampling site 200 feet northeast of the ore the copper content of the soil increased steadily from the top to the bottom of the sample hole.

The results obtained using the field test and those obtained using the hot extraction method correspond while the field test results are also very similar to those obtained by Ogden who used the same field test.

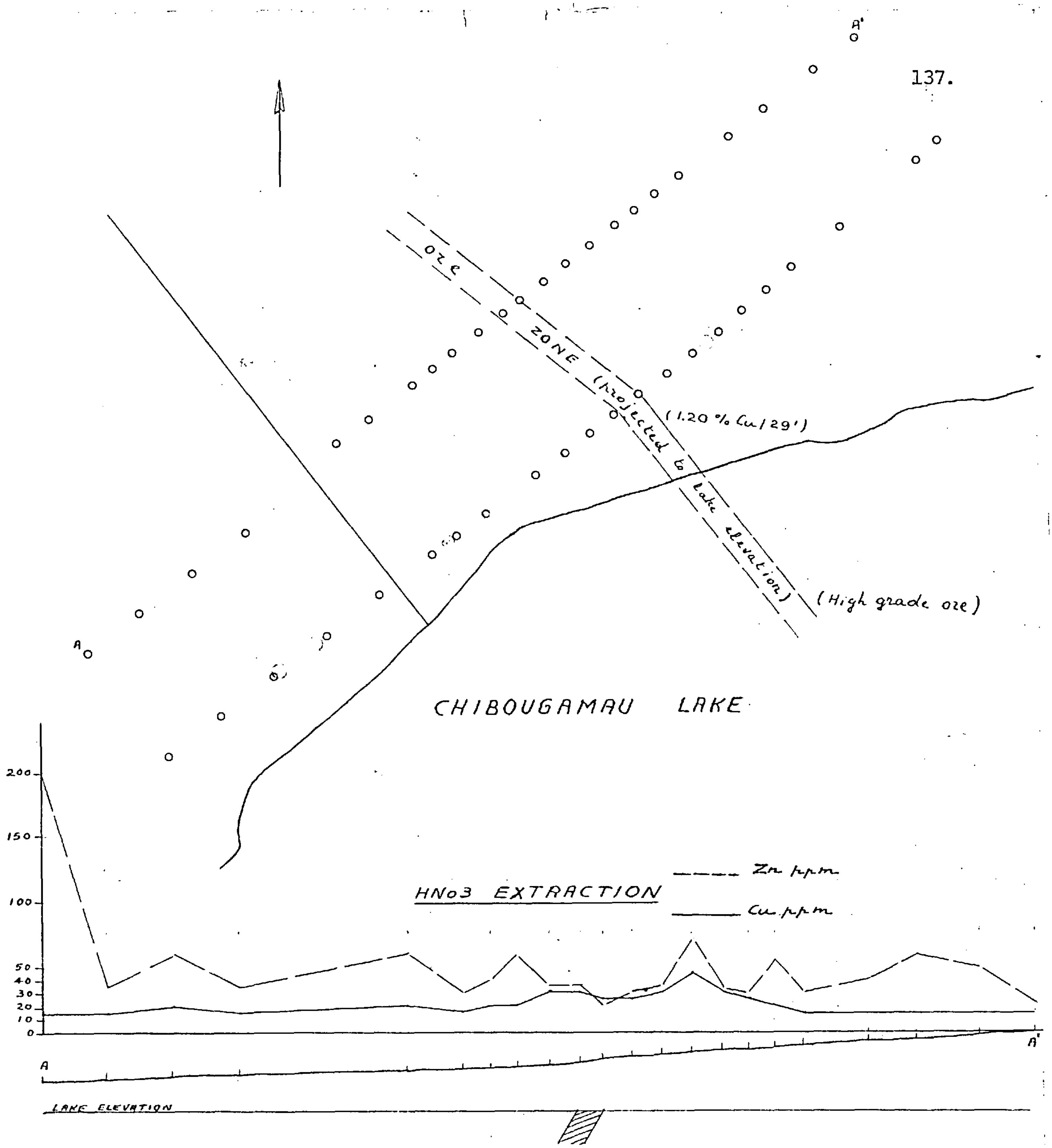
Eaton Bay Copper Zone

The Eaton Bay Copper zone is on Gouin Peninsula 3¼ miles northeast of the Campbell Chibougamau Mines. It is situated between Dore and Chibougamau lakes and extends beneath Eaton Bay of Chibougamau lake. Large amounts of pyrite, chalcopyrite and pyrrhotite occur within the footwall of a zone of shearing and alteration, 500 to 700 feet wide, which dips 50 to the southwest. Gangue minerals are siderite, quartz, sericite and chlorite. Pyrite and chalcopyrite are also widely scattered between the ore zone and the fault that makes the southwest boundary of the schist zone. Dikes are present along the mineralized zone.

Near the ore deposit the bedrock surface is covered by a "crag and tail" which is composed of boulder till; in several places diamond drilling has proved the overburden to be as much as 150 feet thick. Part of the ground surface is covered by a boulder pavement and this makes soil sampling very difficult. Less than 1,000 feet to the north rock outcrops are plentiful. The soils of the area are true podsols.

No information is available on the grade or degree of weathering of ore near the bedrock surface. Along the fault forming the southwest limit of the zone of shearing and alteration, the oxides have been oxidized to a reported depth of several hundred feet; the oxidation probably occurred before glaciation. Shallow diamond drilling has indicated that the best ore lies underneath Chibougamau lake. In the area covered by the soil survey a diamond drill intersected at a point 80 feet below the level of Dore lake, of which 29 feet of ore assayed 1.20 percent copper.

Figure No.25 shows the results of the geochemical survey. Soil samples were collected at 50 and 100 feet intervals along two parallel traverses across the Eaton Bay ore zone. The overburden over the mineral deposit is estimated to be seventy feet thick. Above the ore, in both traverses, a very weak copper anomaly which extended for a distance of 300 feet was found in the 'B' soils. The highest assay is 45 p.p.m. copper or three times the average background. Several samples, collected on the southernmost traverse at points away from the ore zone had a slightly anomalous copper content. The significance of these samples is not known. The zinc content of samples collected along the two sampling lines varies erratically with several samples having zinc in excess of the background amount. In addition to samples from the 'B' horizon, Ao samples were collected at points within 250 feet of either side of the ore



GEOCHEMICAL SURVEY

(COPPER RAND CORPORATION PROPERTY)

SCALE: 1" = 200'

○ Soil Sample Location

D.D. Hole Collar with Depth of Overburden.

Figure 25

zone. The copper content of the Ao samples was the same as the regional background and the zinc content varies as erractically as that of samples taken from the 'B' horizon.

It would have been very interesting to investigate the vertical distribution of base-metals in the soils above the Eaton Bay deposit, but unfortunately the boulder pavement on surface and the abundant boulders in the till prevented vertical sampling.

Merrill Island Corporation Mainland Property

The geochemical anomalies described in previous sections are secondary haloes of dispersion developed near well defined sulphide deposits with an economic or sub-economic base-metal content, whereas the geochemical anomaly about to be described cannot be related to any well defined sulphide deposit.

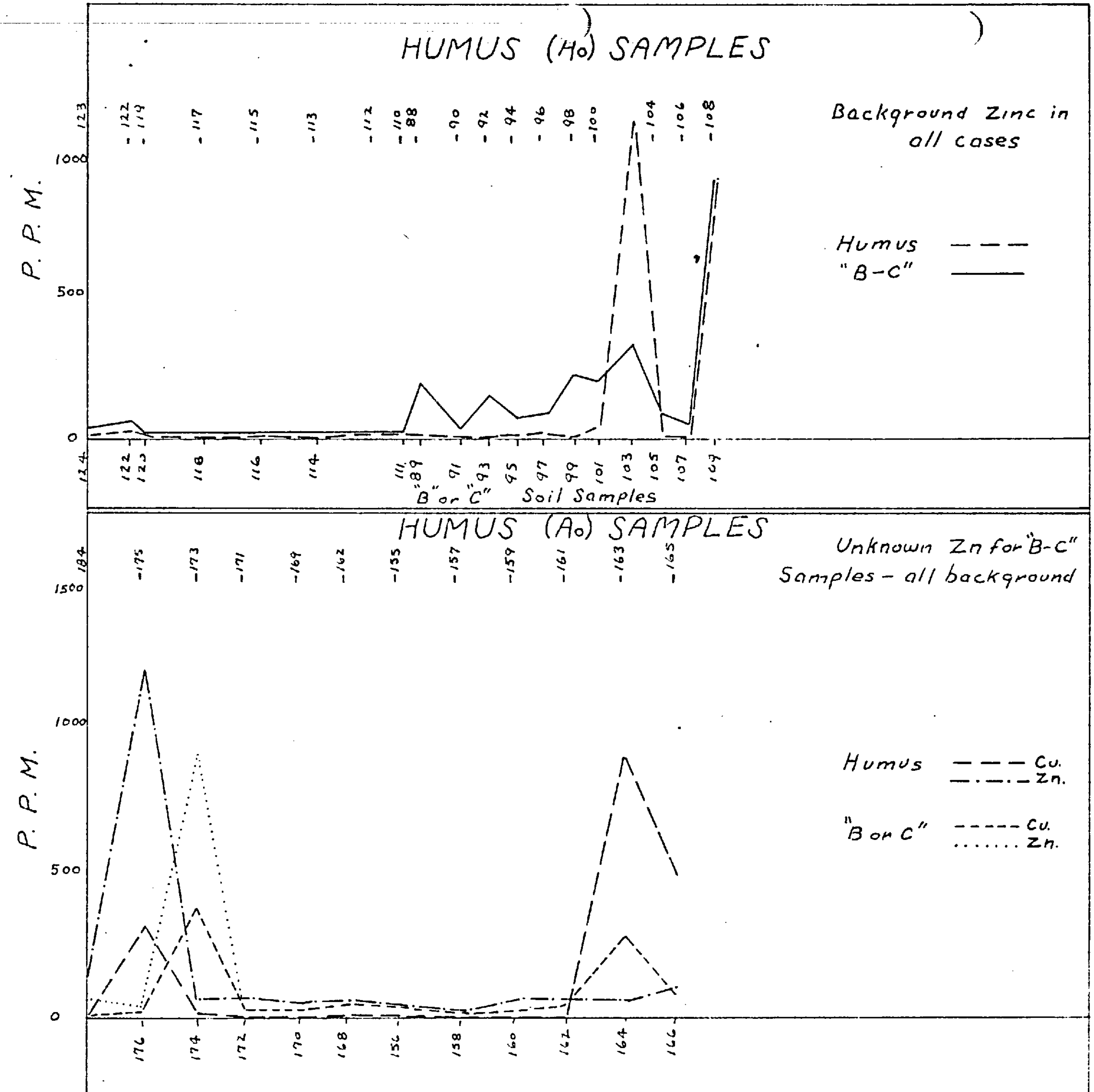
A series of soil samples collected at the end of the first field season on the mainland northwest of Campbell Chibougamau Mines yielded anomalous copper values over the surprising distance of 4,000 feet. No mineral deposits were known in the immediate vicinity, and the topography almost excluded the possibility that the anomaly was caused by a single zone of mineralization such as has been described previously. The ground was examined, and a wide area of fractured and rusted rocks in which as much as 10 percent pyrite occurred, either scattered through the rock or concentrated on fracture surfaces, was roughly outlined. Minor amounts of chalcopyrite was found in several places associated with pyrite. The sulphides are to be found chiefly in anorthosite and its gabbroic border phase with lesser amounts of pyrite occurring in 'greenstones'. After the anomaly had been discovered additional soil samples were taken along several east-west lines. Figure No. | and Maps No. 1 & 2 (see back folder) show the geology of the area and the results of the geochemical survey.

The topography is rugged and the boulder till cover seldom exceeds a few feet. True podsols cover most of the area while peat bogs are found over limited areas around lakes and in the bottom of valleys.

At the time the soil survey was performed, the Merrill Island mainland property and the adjacent claims to the west were almost free of surface exploration workings, but at the end of the summer of 1956, a diamond drill had explored the area of anomalous soils, and wide rock sections containing abundant pyrite and assaying 0.1 to 0.2% copper were intersected.

The main copper anomaly in the 'B' soils covers an area of approximately 275 acres; it is underlain by anorthosite. Several tongues of soils anomalous in copper extend into the "greenstones". Within the anomaly, the distribution of copper is somewhat erratic although there is a marked concentration of high values west and south of the small lake shown in the center of Figure No. 26. The highest copper assay is 1850 p.p.m. while with a few exceptions, the zinc content of the soils (within the copper anomaly) does not exceed the regional background.

A broad and weak semicircular zinc anomaly in the


HUMUS (Ao) SAMPLES
Background Zinc in all cases
P. P. M.
1000
500
0
Humus
"B-C"
123
122
119
117
115
113
112
110
88
90
92
94
96
98
100
104
106
108
124
122
120
118
116
114
111
89
91
93
95
97
99
101
103
105
107
109
"B" or "C" Soil Samples
HUMUS (Ao) SAMPLES
Unknown Zn for "B-C" Samples - all background
P. P. M.
1500
1000
500
0
Humus
Cu.
Zn.
"B or C"
Cu.
Zn.
184
175
173
171
169
162
155
157
159
161
163
165
176
174
172
170
168
156
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160
162
164
166

Fig. 27.

'B' horizon of soils borders the copper anomaly to the west and north, cutting across geological contacts. Zinc assays range from 50 to 2000 p.p.m. The copper values, with a few exceptions are of background range.

The writer believes that the space relationship between the copper and zinc anomalies reflects a zoning of these metals in the underlying bedrock. It is interesting to note that the zone of shattering and weak mineralization described above lies on the northwest extension of the Campbell-Merrill ore zone.

A third anomaly, of much smaller size, follows the bottom of a valley in the southwest corner of the area. The soils are enriched in both copper and zinc. It is probable that here, base-metals have been concentrated from waters draining the two large anomalies located west and east.

The copper content of humus is compared to that of the underlying 'B' horizon Figure No.27 , along several traverses covering part of the main copper anomaly. Both the humus samples and 'B' samples were leached with hot nitric acid. Even though it has been shown earlier that this procedure is not entirely satisfactory, there is nevertheless a general agreement between the results obtained for two different soil horizons. The copper anomaly in the humus is often stronger but more restricted in space than the corresponding anomaly in the 'B' horizon. Several humus samples collected along traverse A (Figure No.27) were also analysed after having been fused with potassium bisulphate to extract more copper. Higher copper results were obtained for a few of these samples, but the humus anomaly is still smaller in size than the one found in the 'B' horizon. At several locations, on sloping ground, anomalous values in the humus are found 100 or even 200 feet upslope from the corresponding anomaly in the 'B' horizon, and this probably means that when the overburden is relatively thin. In thin overburden base-metals are picked up from the weathered bedrock surface and later integrated into the surface layer of decaying organic matter. Water containing base-metals leached from the bedrock moves predominantly downslope and reaches the upper part of the mineral soil at some distance from the bedrock source. Base-metals washed from the enriched humus layer by run off water may also be deposited in 'B' soils at some distance downslope.

General Character of Secondary Halos of Dispersion

The following conclusions may be drawn from a study of the above descriptions of secondary halos of dispersion in the Chibougamau district:

a) Base-metals are present in anomalous amounts in the overburden covering known mineral deposits. The existence of such deposits is still clearly indicated in surface and subsurface material through 15 feet of sandy boulder till. With 70 feet of similar overburden, only a very weak and broad anomaly was found in the 'B' soil horizon. No mineral deposit covered by a thickness of overburden intermediate between the above figures was known in the district. It is assumed therefore, that for local conditions of mineralization and weathering, the limit of sensitivity of the soil prospecting method is reached with a cover of 30 to 40 feet of sandy to silty boulder till. This compares with the following figures given by Bischoff (1954) for northeastern Canada; 30 to 50 feet of clay and 20 to 30 feet of fine sand.

b) The vertical distribution of zinc and copper in the overburden depends on the depth of it. When the overburden covering a mineral deposit is shallow, the distribution of base-metals throughout the 'B' and 'C' horizons is fairly uniform. When the overburden is thick (more than 10 feet), the anomalous values may be concentrated at two levels; at the bottom of the 'C' horizon near the bedrock surface, and in the upper few feet of soil. The intervening zone may be slightly anomalous or have only a background base metal content.

The A2 horizon is always strongly leached of its metal content and reflects very weakly the presence of base-metal deposits in the underlying bedrock.

The use of humus in geochemical prospecting has been so far very limited in Canada. Several authors (Bischoff, 1954; Byers, 1956) have expressed the opinion that the base metal content of surface material is erratic under northern conditions. In Norway, several workers are reported to have obtained satisfactory results with humus, but their findings have not been published as yet. The base-metal content of the Ao horizon of podsolic soils has been compared earlier to that of the underlying mineral horizons in background areas. The composition of the same material over several mineral deposits is given in the above parts earlier. From this information, it appears that in the Chibougamau district, the Ao horizon reflects fairly accurately the presence of base-metal concentrations in the underlying bedrock. These conclusions are probably only valid for areas of uniform vegetation where podsolic soils are widely distributed. If important changes in vegetation occur within a district, the distribution of base-metals in the Ao horizon may be complicated by the difference in the capacity of the predominant tree species to concentrate these metals (for example birch is a strong accumulator of zinc).

c) The shape and size of a secondary halo of dispersion depends primarily on the geometrical characteristics of the mineral deposit from which it is formed. Topography also is a most important factor, as it has been shown repeatedly in previous parts of this chapter that both copper and zinc travel for considerable distances from their source along the hill slope. One should not expect, however, to find important concentrations of base-metals in the soils at the bottom of slopes several hundred feet away from their bedrock source as reported for areas covered by residual soils. Dispersion of ore minerals from their bedrock source in the fine fraction of glacial deposits in the direction of the ice movement may apparently also have some influence on the size and shape of secondary halos of dispersion. This point will be discussed further.

d) Provided that base-metals are present in the bedrock in appreciable amounts (i.e. well above traces) the intensity of the secondary halo of dispersion depends more on the degree of weathering of the mineral deposit than on its actual metal content. In Chibougamau, the pre-glacial surface weathering zone has been removed by glacial erosion from most, if not all, the mineral deposits investigated. Wherever allowed by topographic conditions, the surface layer of mineralized bedrock undergoes presently active oxydation. This process is particularly intense in the presence of pyrite and pyrrhotite which both desintegrate with production of abundant sulfuric acid; the mineralogy of the mineral deposit plays therefore also an important role. This explains how on the Merrill Island Corporation mainland property, conditions being ideal, concentrations in the bedrock of the order of 0.1 to 0.2% copper are reflected in the 'B' horizon of the soil by a highly anomalous copper content.

e) The influence of the nature of the overburden on the development of secondary halos of dispersion from base-metals deposits could not be investigated properly in the Chibougamau district because of the uniformity of the overburden covering these deposits. It should be mentioned, however, that on the Merrill Island Corporation mainland property, a large majority of the samples carrying highly anomalous amounts of zinc and copper contain an unusually high proportion of clay.

Dispersion of Base-Metals in the Drainage System

Heavy Metals Content of Water

A very limited amount of water testing was carried out during the field season of 1956. The summer was extremely rainy, and in August, when the survey was performed, the water level in lakes and streams was still very high.

The characteristics of the drainage system in the Chibougamau district have been given earlier. In low ground, the well organized preglacial drainage pattern has been replaced by a disrupted and immature system comprising an abundance of lakes and swamps. In hilly areas, the main preglacial valleys are now occupied by ponds and swamps, and small tributary streams along till covered hill slopes are scarce.

Water samples were tested in three areas which the writer considered as being most suitable, namely in the vicinity of the Berrigan Lake zinc deposits, near the North Copper Cliff zone and on the mainland property of Merrill Island Corporation.

Results of the water survey in the Berrigan Lake area are shown in Figure No.19 . They vary between 0 and 1 indicating a maximum heavy metals content of 0.005 p.p.m. zinc equivalent. The highest readings were obtained in the water from Berrigan lake, near the outcrops of the Berrigan zone and at the discharge of the lake, and in a small creek flowing northward across the swamp occupying the northeast corner of the area. Five hundred feet downstream from Berrigan lake, the heavy metal content of the water had already dropped considerably. Along the 3/4 of a mile sampled, the main southwest creek did not contain any detectable amount of heavy metals. This stream is meandering through a swampy valley flat, and it is suggested that base-metals brought into the valley by waters draining the south valley flank are tied up in the bog material before reaching the creek.

Water samples from the creek flowing across the

Savage lake fault zone and the North Copper Cliff zone showed the same range in heavy metals content (Figure No.   Page) as waters from the Berrigan lake area. The maximum reading was obtained immediately downstream from the copper zone, but detectable amounts of heavy metals were also found further upstream, where the creek flows over the fault zone. In the same area, it has been shown that the zinc content of soils is somewhat above the regional background. Water from diamond drill holes which intersected the mineralized schist contain but low concentrations of heavy metals.

On the mainland property of Merrill Island Corporation, water samples were analysed within the soil anomalies described earlier. Assays fluctuated between 0 and ½, indicating a maximum heavy metal content of 0.0025 p.p.m. zinc equivalent. Two samples taken downstream from the anomalous area for soils did not contain any detectable amount of heavy metals.

Base Metals Content of Stream Sediments

The base-metals content of stream sediments was investigated in the Berrigan lake area; results are shown in Figure No. 19 . Samples were taken in the active channel of the stream approximately two feet below the bottom of the water. The stream sediments show a gradation from medium sand to silt. Variations in the zinc content (of stream sediments) can be correlated with the distribution of this metal in the bedrock. The highest assay 640 p.p.m., was obtained in fine sand collected in the creek draining Berrigan lake, near the junction with the main southwest valley. A silt sample from the small stream flowing northward through the swamp in the northeast corner of the area yielded similar results. Along the southwest valley, the zinc content of stream sediments varies from 70 to 240 p.p.m. Values up to 100 p.p.m. are probably within the normal background for this type of material; higher assays are related to zinc concentrations in the bedrock south of the creek. The copper content of all the samples fluctuates between 30 to 50 p.p.m. which is apparently within the background range for stream sediments in the area. Lead is also present in detectable amounts (5 p.p.m. or more) in all but one sample. Values up to 10 p.p.m. are regarded as the normal background. For higher values, there seems to be a direct relation between the zinc and the lead content of stream sediments. The highest lead assay, 45 p.p.m. occurs together with the highest zinc value.

The anomaly found along the valley draining part of the mainland property of Merrill Island Corporation and some adjacent ground to the west has already been mentioned earlier. Background limit values used in outlining the boundaries of the anomaly are the same as those established for ordinary soils, which as has just been shown for the Berrigan lake area, may not be correct. Some results, however, are well above the expectable background even for creek sediments.

Silt samples were collected on the bottom of Dore lake, between the northeast tip of Merrill Island and the northwest shore of the lake, by the staff of Campbell Chibougamau Mines. They were analysed at the mines using the cold extraction method of Bloom (see results in Figure No. , page). The writer obtained part of these samples through the courtesy of the Company, and in turn handed them to Schmidt who was at the time investigating the base-metal content of lake sediments from other localities (see Schmidt, 1956). A set of thirteen samples which had given with the cold extraction method results ranging from 1 to 14, were analysed by the hot nitric acid extraction method. Results varied between very narrow limits, giving an average of 30 p.p.m. for zinc, 10 p.p.m. for copper and less than 5 p.p.m. for lead. The discrepency between the two methods will be discussed. Schmidt studied two of the samples by differential thermal analysis and came to the conclusion that sediments from the bottom of Dore lake are essentially made up of quartz and probably one of the clay minerals.

SUMMARY AND CONCLUSIONS

From the present study the following conclusions can be drawn concerning the distribution of heavy metals in the soils of the Chibougamau district:

1. A very rapid examination of the physiography and vegetation of a district may be of great help in outlining the areas favourable for geochemical prospecting.
2. There is a close relationship between the zinc and copper content of the humus layer in podsolic soils and their distribution in the B and C horizons. The Ao horizon may be of greater use in geochemical prospecting than has been previously considered.
3. The secondary haloes outlined in the Chibougamau district are similar to those which occur in transported glacial soils in other parts of the Canadian shield. The limit of sensitivity of the soil prospecting method is reached with a depth of 30 to 40 feet of sandy to silty boulder till. For the Chibougamau district soil sampling along traverses 200 feet apart is adequate. Along the traverse lines sample locations should be spaced 100 feet apart on sloping ground of 3 percent or more and 50 feet apart on level ground.

4. When the overburden covering a mineral deposit is only a few feet thick, the distribution of the base metals in the B and C horizons is fairly uniform (apart from a maximum concentration immediately above the bedrock surface). When the overburden is thick, the anomalous values may be concentrated at two levels; at the bottom of the C horizon just above the bedrock surface; and in the upper few feet of soil. The intervening zone may be slightly anomalous, or have only a background content in heavy metals.

   The B horizon is consequently the best level in which to collect soil samples. The depth of sampling may vary from a few inches to about two feet depending on local drainage.

5. The A2 horizon should always be avoided because it is intensely leached. The zinc content may be as low as one tenth of what is in the immediately overlying and underlying Ao and B horizons.

6. There is no general increase in background values of soils in the drumlinoid ridges southwest of the main area of mineralization in the Chibougamau district. Only a few very widely spaced samples are slightly anomalous.

7. The "cold extraction" field method of analysis described by Bloom (1955) has a limited application in Chibougamau although in many instances satisfactory results may be

obtained. Even by increasing the sensitivity of the method to the maximum, weak but significant copper anomalies may be overlooked. Peat assays are sometimes negative even though a high concentration of copper is present. Consequently it is unsafe to rely on the results obtained by this method.

A sample of the soil should always be kept for further studies when the "cold extraction" technique is used in the field.

8. The water testing method used could not detect less than 0.01 p.p.m. zinc equivalent. This was the maximum concentration found in anomalous waters in the Chibougamau district. Therefore, more sensitive methods of analysis must be employed for geochemical prospecting by water testing in the area.

9. The heavy metal content of the B and C horizons is quite consistent regardless of the type of material. There is no systematic difference between the content of the B and C horizons; in very well drained soils, zinc tends to be slightly concentrated in the B horizon. The zinc content varies from 10 to 40 p.p.m.; the copper content from 5 to 25 p.p.m.; and the lead content is less than 5 p.p.m. The most frequent background values are 25 p.p.m. zinc and 15 p.p.m. copper.

10. The A2 horizon is typically a zone of leaching. The background is 10 p.p.m. for zinc; 5 p.p.m. for copper; and lead is absent.

11. The Ao (humus) horizon in podsolic soils is a zone of concentration of zinc and in certain instances lead.

The average background for zinc is 35 p.p.m. and represents a concentration factor of 1.4 when compared with the average zinc content of the underlying B and C horizons. This concentration factor may reach the value of 2.0 when light overburden covers rocks rich in disseminated pyrite. A concentration factor of 2 to 4 has been found by Schmidt (1955) in the more mature podsolic soils of New Brunswick.

Erratic lead values reaching 40 p.p.m. are found above barren "B" and "C" soils.

The copper content found in the Ao horizon in background areas for "B" and "C" soils is usually as low as 5 p.p.m. It is possible that when only small amounts of copper are present in organic soils this metal can not be detected by the analytical technique used because stable organic complexes of copper are formed in the solution.

These conclusions are generally verified by data given in the soil science literature (see Wright, 1955). However, it should be kept in mind that soil scientists refer to the total heavy metal content of soils; they use an analytical technique in which the lattice of the silicate minerals is completly broken down.

12. Too little work has been done on humus materials from swamps in background areas to reach any conclusions. However, it has been noticed that in certain circumstances, peat material concentrates zinc but not copper.

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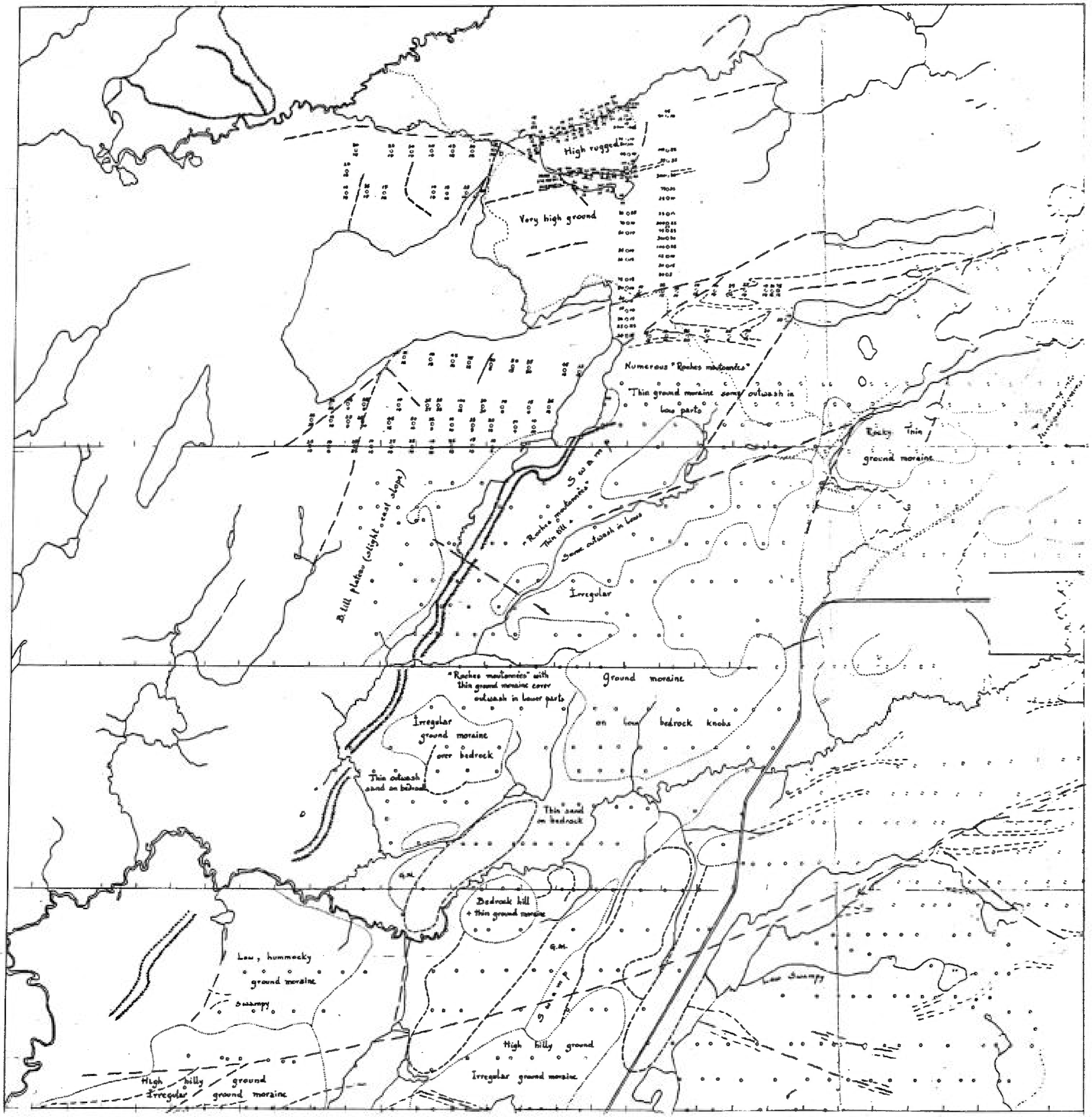
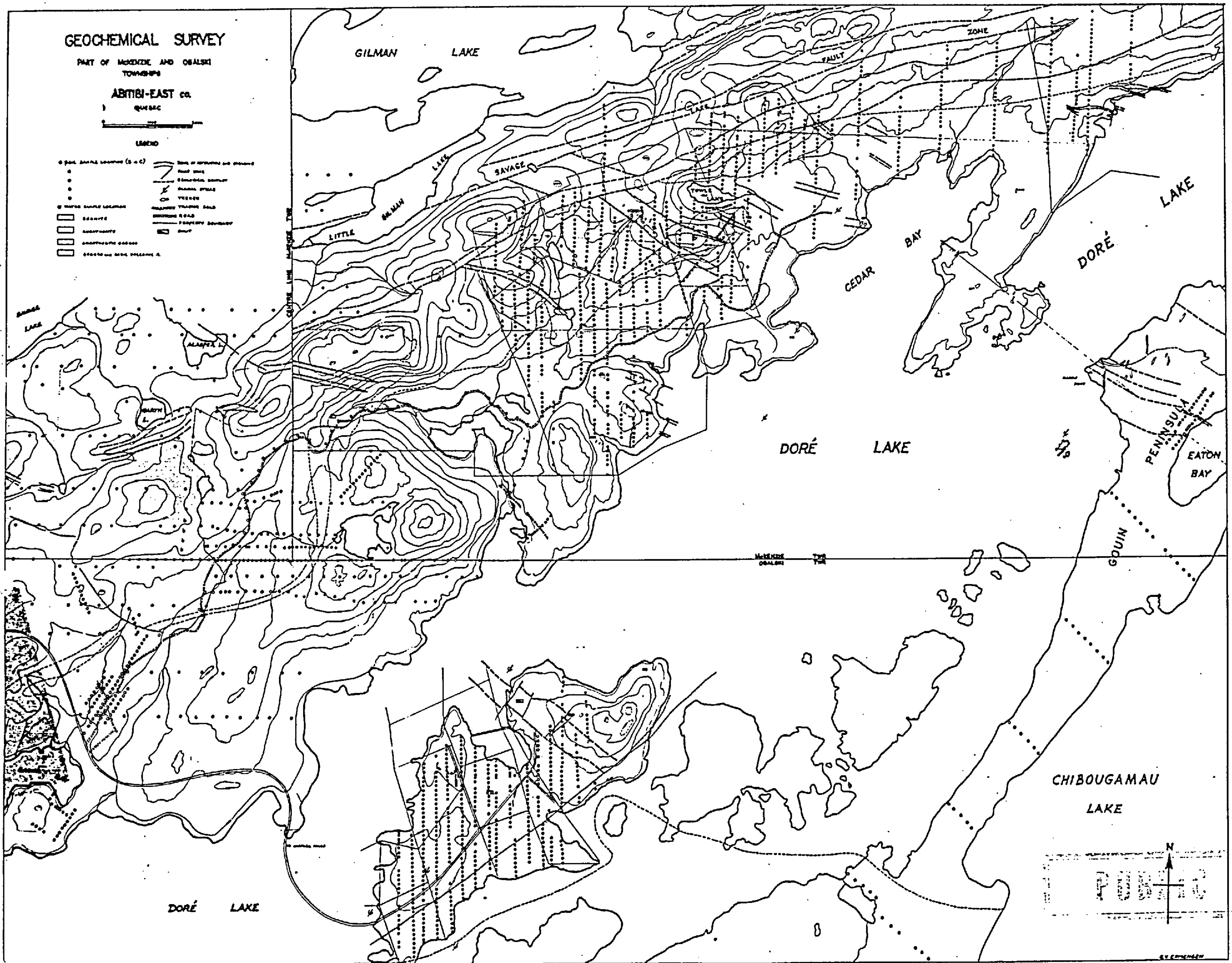
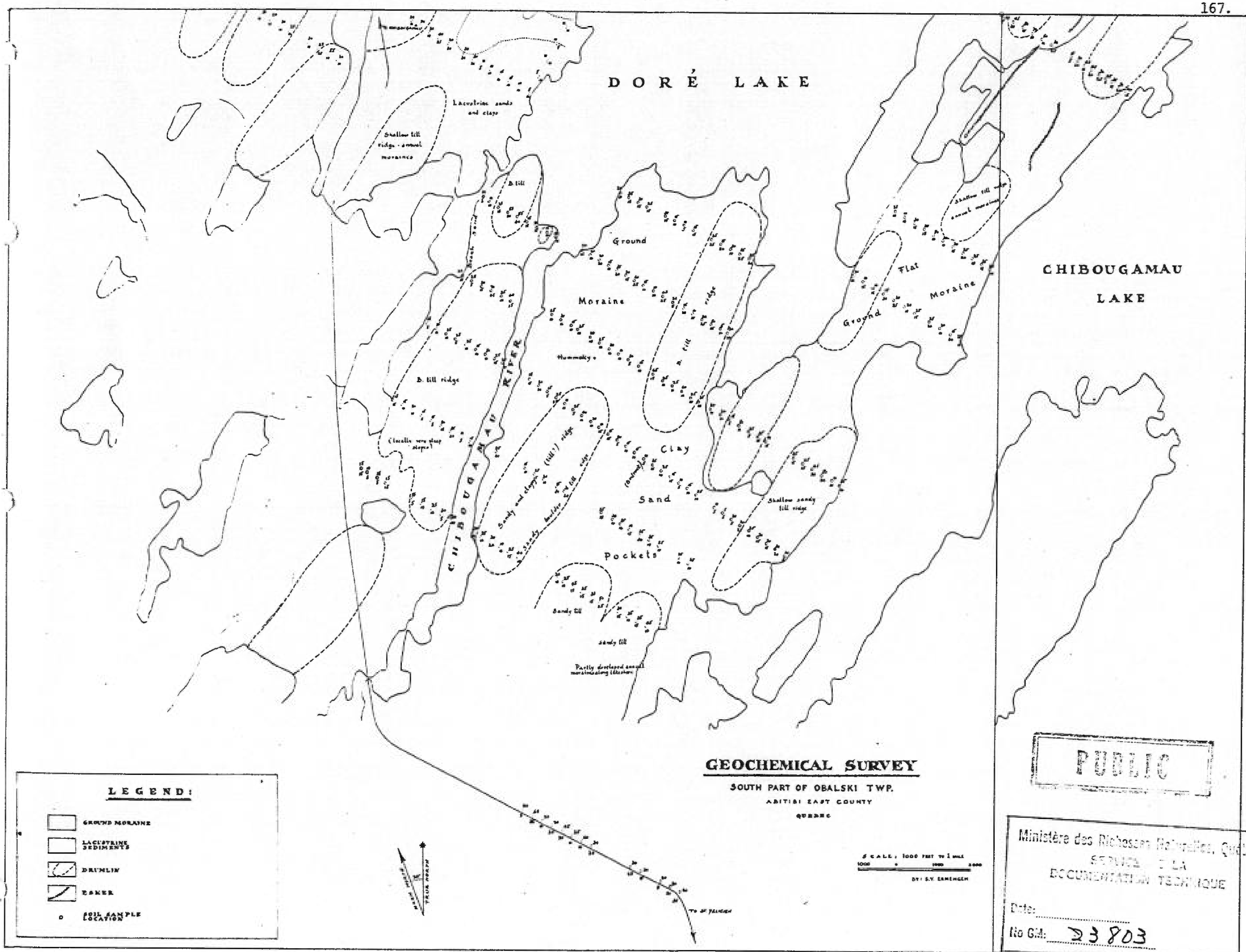
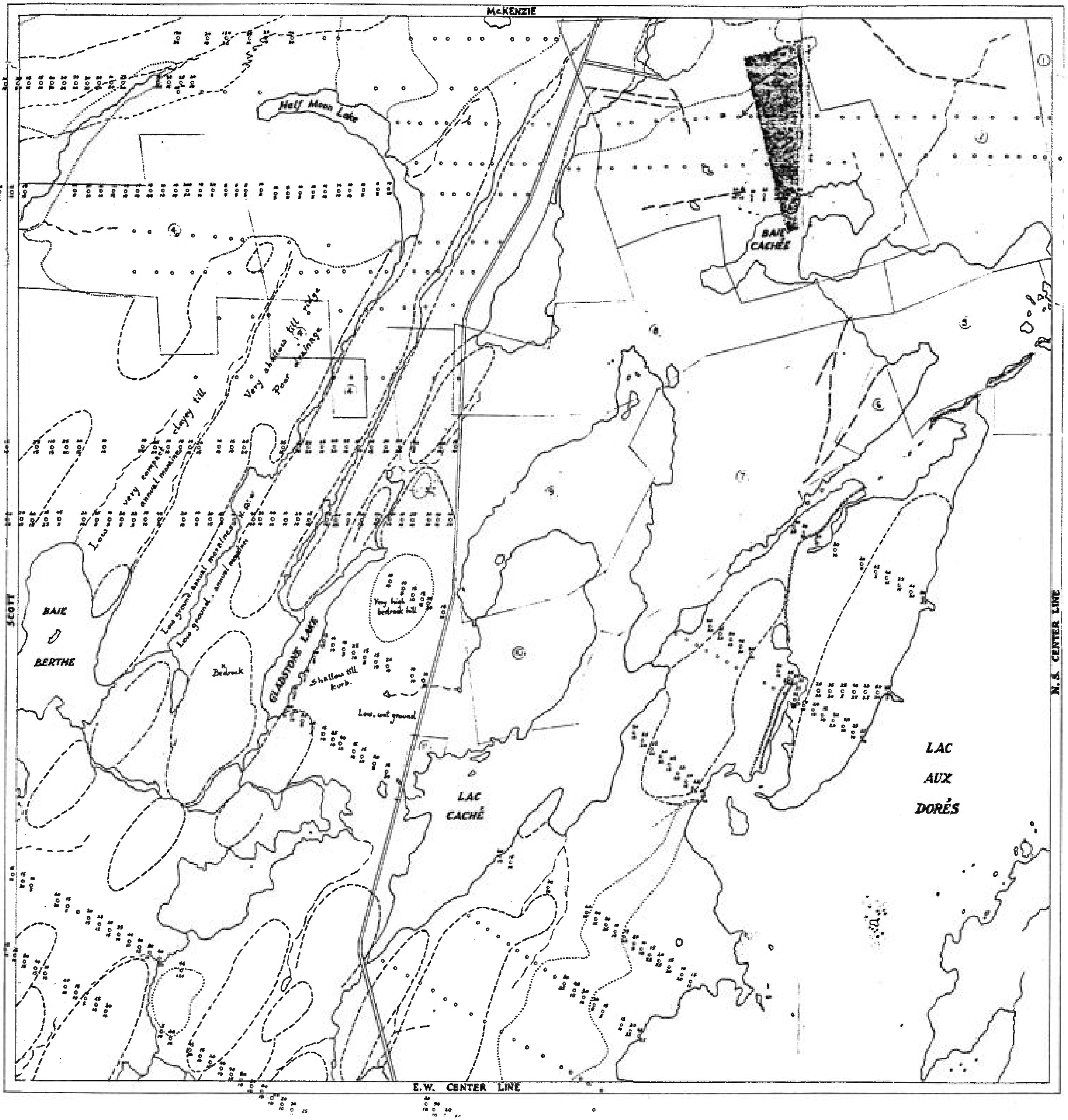

High rugged
Very high ground
Numerous "Roches moutonnées"
Thin ground moraine some outwash in low parts
Rocky Thin ground moraine
Swamp
"Roches moutonnées" Thin till + Some outwash in lows
Till plateau (slight east slope)
Irregular
"Roches moutonnées" with thin ground moraine cover outwash in lower parts
Ground moraine on low bedrock knobs
Irregular ground moraine over bedrock
Thin outwash sand on bedrock
Thin sand on bedrock
G.M.
Bedrock hill + thin ground moraine
G.M.
Low, hummocky ground moraine
Swampy
Low Swampy
Swamp
High hilly ground
Irregular ground moraine
High hilly ground
Irregular ground moraine


GEOCHEMICAL SURVEY
PART OF McKENZIE AND OBALSKI TOWNSHIPS
ABITIBI-EAST Co.
QUEBEC
LEGEND
GILMAN LAKE
GILMAN LAKE
LITTLE GILMAN
SAVAGE
ZONE
FAULT
CENTRE LINE McKENZIE TWP.
CEDAR BAY
DORÉ LAKE
DORÉ LAKE
DORÉ LAKE
PENINSULA
EATON BAY
GOUIN
CHIBOUGAMAU LAKE
N
PUBLIC

Gm 23803



DORÉ LAKE
CHIBOUGAMAU LAKE
Lacustrine sands and clays
Shallow till ridge - annual moraines
B. till
Ground
Moraine
Hummocky
B. till ridge
B. till ridge
(Locally very steep slopes)
CHIBOUGAMAU RIVER
Clay
Sand
Pockets
Shallow sandy till ridge
Sandy till
Sandy till
Ground
Flat
Moraine
GEOCHEMICAL SURVEY
SOUTH PART OF OBALSKI TWP.
ABITIBI EAST COUNTY
QUEBEC
LEGEND:
GROUND MORAINE
LACUSTRINE SEDIMENTS
DRUMLIN
ESKER
SOIL SAMPLE LOCATION
TRUE NORTH



LEGEND:

GROUND MORAINE	GLACIAL STRIAE
DRUMLIN	FAULT
OUTWASH AND LACUSTRINE SEDIMENTS	LOCATION OF SOIL SAMPLE
ESKER	SHAFT
BEDROCK HILL	
ZONE OF ALTERATION (CARBONATIZATION AND SERICITIZATION)	

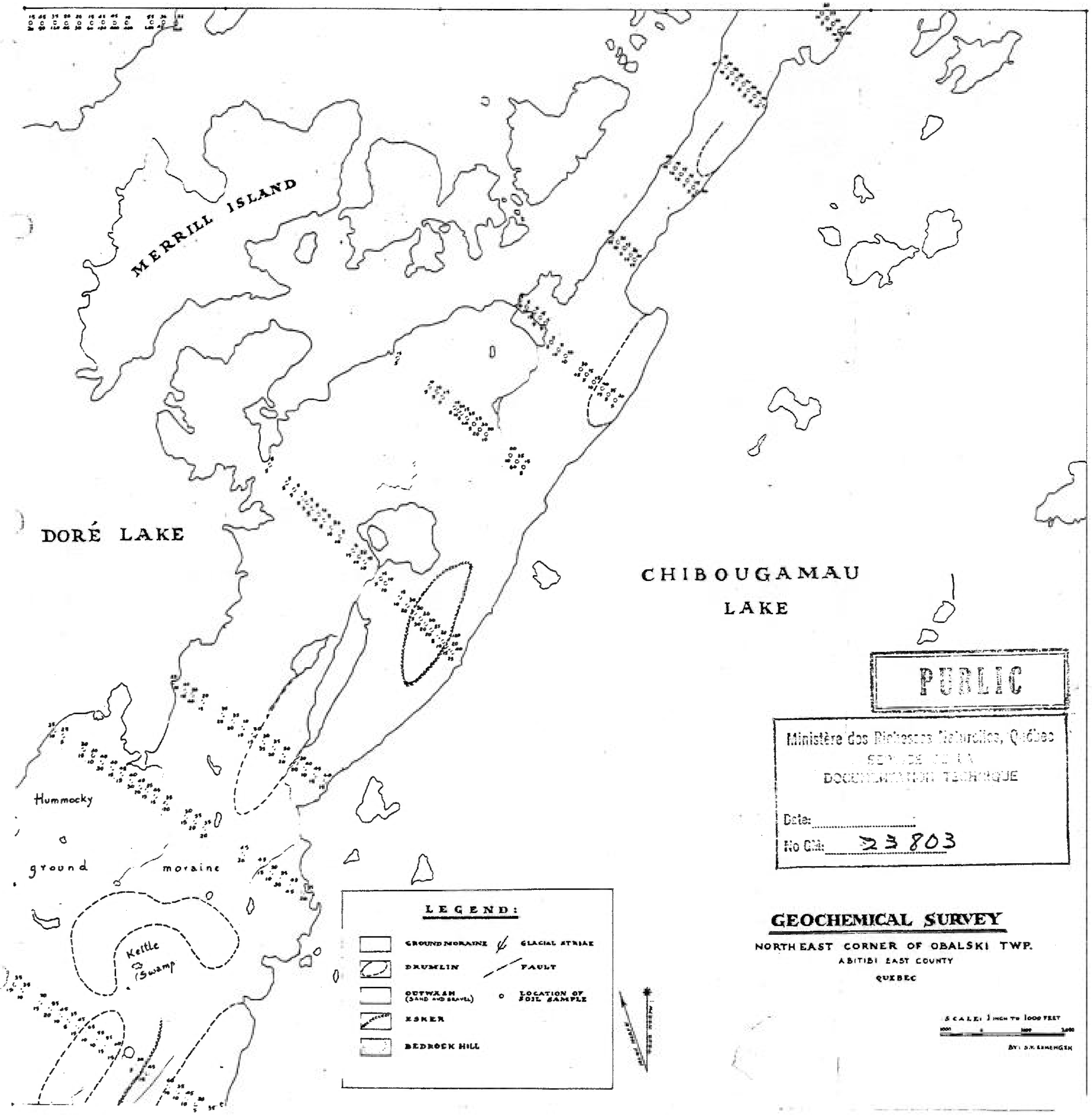
GEOCHEMICAL SURVEY

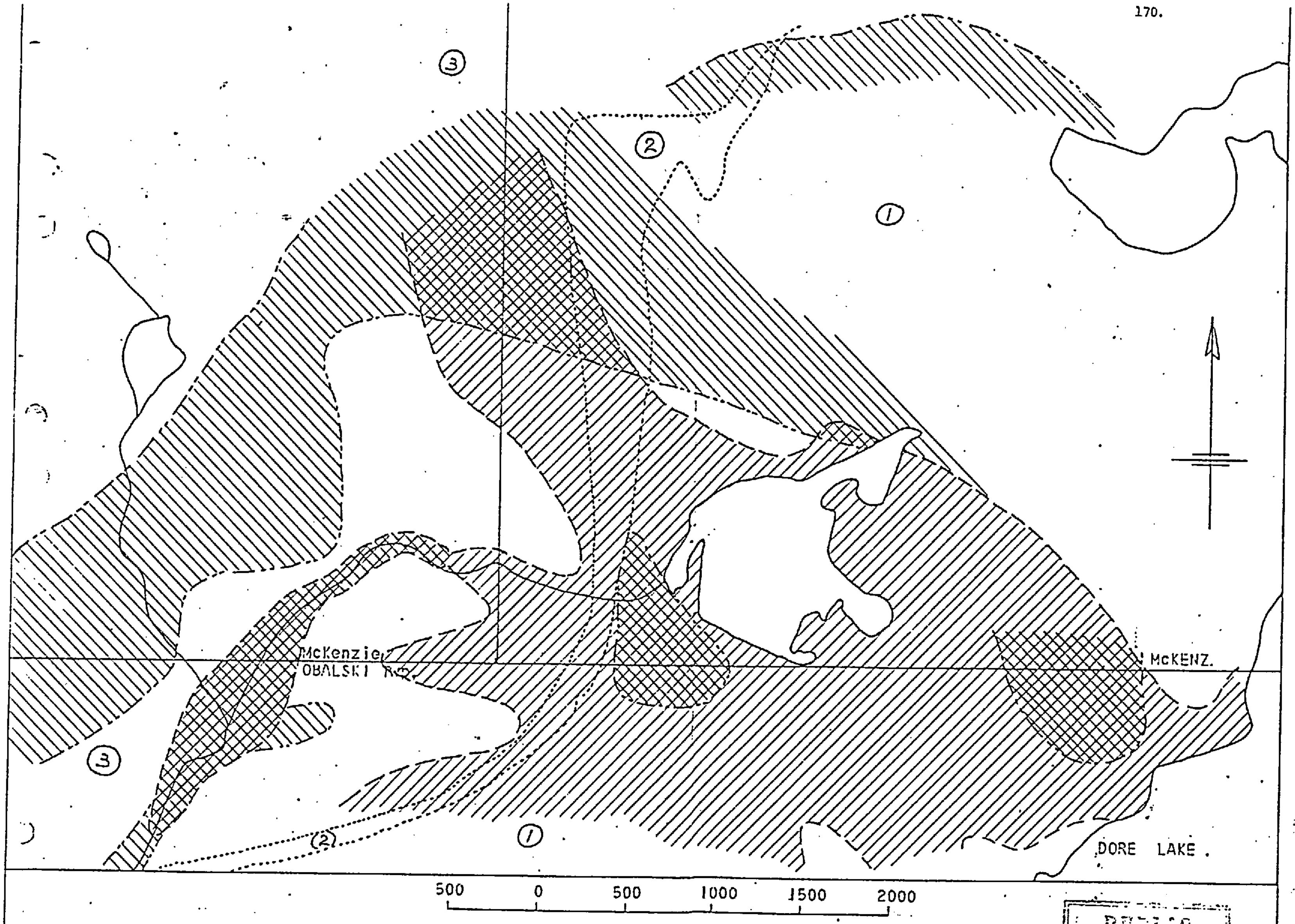
NORTHWEST QUARTER OF OBALSKI TWP.

ABITIBI EAST COUNTY

QUEBEC

SCALE: 1 INCH TO 1000 FEET


MERRILL ISLAND
DORÉ LAKE
CHIBOUGAMAU
LAKE
Hummocky
ground
moraine
Kettle
Swamp
LEGEND:
GROUND MORAINE
GLACIAL STRIAE
DRUMLIN
FAULT
OUTWASH
(SAND AND GRAVEL)
LOCATION OF SOIL SAMPLE
ESKER
BEDROCK HILL
GEOCHEMICAL SURVEY
NORTH EAST CORNER OF OBALSKI TWP.
ABITIBI EAST COUNTY
QUEBEC
SCALE: 1 INCH TO 1000 FEET



COPPER SOIL ANOMALY ZINC SOIL ANOMALY GEOLOGICAL CONTACT.

1. Anorthosite. 2. Anorthositic Gabbro 3. Volcanics etc.

Figure 26

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
1-14	Outwash	B	25	0	25
1-15	Fine gravel	B	25	20	25

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
2- 1	Boulder clay	B	15	0	0
2- 2	B.C. (edge of moraine)	B	15	10	0
2- 3	B.C. (thin cover)	B	10	10	25-
2- 4	B.C. outwash	B	50	15	0
2- 5	Boulder clay	B	20	5	25-
2- 6	Outwash & till	B	20	5	0
2-7	B.C. (thin on bedrock)	B	5	0	50 plus
2- 8	Gritty outwash	B	10	10	25-
2- 9	Residual	B	20	0	0
2-10	Pebbly outwash	B	20	5	0
2-11	Boulder clay	B	15	0	25 plus
2-12	-	-	-	-	-
2-13	Boulder clay	B	15	15	25-
2-14	Thin (clayey) till	B	25	75	25-

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
3- 1	Boulder clay	B	25		25-
3- 3	Clay	B	5	5	25-
3- 5	Residual ?	B	10	0	0
3- 7	S.G.	B	10	0	25
3- 9	Stratified sand & gravel	B	5	5	25
3-11	Sand and clay	B	15	0	0
3-13	Sandy outwash	B	5	10	20plus
3-15	Fine sand	B	150	125	25
3-17	Stratified sand & clay	B	20	0	0
3-19	Clay and sand	B	15	0	0
3021	Sand (gravel) m	B	20	0	0
3-23	Sandy clay	B	25	0	0
3-25	Boulder clay	B	30	0	0
3-27	Silty clay	B	15	0	50
3-29	Boulder clay	B	5	0	0
3-31	Residual ?	B	10	10	25
3-33	Boulder clay	B	20	0	0
3-35	Shaley sand	B	5	0	25
3-37	Residual ?	B	20	5	0
3-37	Residual	B	10	0	0
3-39	Sand	B	100	50	25-
3-41	Residual ?	B	10	0	0
3-43	Clay-sand	B	25	10	0

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
3- 2	Fine outwash	B	100	75	0
3- 4	Fine sand	B	c	0	100
3- 6	Till	B	10	0	25
3- 8	Till	B	5	0	0
3-10	Boulder clay	B	10	5	0
3012	Boulder clay	B	10	0	0
3-14	Boulder clay	B	5	0	0
3-16	Boulder clay	B	50	0m	0
3-18	Boulder clay (till)	B	15	10	0
3-20	Outwash	B	20	5	25
3-22	Till like (but)?	B	15	0	0
3-24	Till	B	25	0	25
3-26	Sandy till	B	15	0	25
3-28	Outwash	B	10	5	0
3-30	Till mantle	B	15	0	0
3-32	Sandy till	B	20	0	25
3-32A	Till mantle	B	20	5	0
3-34	Till	B	20	0	25
3-36	Outwash (swamp)	B	200	150	75
3-38	Boulder clay	B	10	0	25

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
4- 1	Coarse sand	B	20	0	25-
4- 3	Gravely sand	B	25	0	0
4- 5	Silt	B	25	0	25
4- 7	Sand	B	25	0	0
4- 9	Residual	B	20	0	25
4-11	Sand	B	20	5	25
4-13	Sand	B	15	0	25
4-15	Leached sand	B	20	0	0
4-17	Coarse sand	B	20	0	0
4-19	Clay-sand	B	25	10	25
4-21	Sand	B	15	0	0

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
4- 2	Outwash (fine)	B	25	0	0
4- 4	Outwash	B	15	0	0
4- 6	Boulder clay (till)	B	25	0	20plus
4- 8	Fine outwash	B	25	5	0
4-10	Silt (gritty)	B ?	25	0	0
4-12	Residual	B	25	0	25
4-14	Till	B	25	5	0
4-16	Pebbly outwash (leached)	B	75	60	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
5- 1	Residual	B	25	10	0
5- 3	Clay residual	B	5	10	0
5- 5	B-Clay	B	20	25	0
5- 7	B-Clay	B (just top)	45	10	0
5- 9	B-Clay	B	35	25	0
5-11	B-Clay (pebbly)	B	20	10	0
5-13	Residual clay	B	15	10	0
5-15	Sandy	B	10	25	0
5-17	Clay	B	25	10	0
5-19	Till	B	15	10	0
5-21	Sandy	B	25	10	0
5-23	B-Clay	H-B	40	10	10
5-25	B-Sandy clay	B	10	10	0
5-27	Sand	B	15	10	0
5-29	Sand	B	5	10	0
5-31	Sand	B	35	10	0
5-33	Sand	B	5	10	0
5-35	Sand	B	10	10	0
5-37	Ferrug sand	B	0	10	0
5-39	Ferrug sand	B	0	10	0
5-39b	Sand	B	15	10	0
5-41	Sandy	B	10	10	0
5-43	Sand	B	5	10	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
5- 2	Sand	B	25	25	0
5- 4	Outwash	B	10	10	0
5- 6	Outwash	B	50	10	0
5- 8	Till	B	10	10	0
5-10	B-Clay	B	50	10	0
5-12	B-Clay	B	5	10	0
5-14	Outwash	B	5	10	0
5-16	Outwash	B	20	10	0
5-18	Till	B	10	10	0
5-20	Till	B	25	10	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
6- 1	Boulder clay	B	15	4	10
6- 2	Fine outwash	B & fresh rock	20	0	0
6- 3	Boulder clay	B	25	0	0
6- 4	Clay sand	B	10	0	0
6- 5	Boulder clay	B	25	5	0
6- 6	Blue clay	Fresh C ?	5	0	4
6- 7	Coarse outwash	A	5	0	0
6- 8	Sand	B	20	0	0

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
7- 1	Sand	B	5	0	25
7- 3	Clayey sand	B	25	20	25
7- 3A	Sand and boulders	B	20	10	25
7- 5	Boulder sand	B	25	0	0
7- 5A	Sand	B	10	10	0
7- 7	Sand	B	5	0	0
7- 7A	Sand	A	10	0	25
7- 9	Sand	B	15	0	25
7- 9A	Fine sand	B	15	0	0
7-11	Sand (fine)	B	10	0	0
7-11A	Residual	B	25	0	0
7-13	Sand	B	25	10	25
7-13A	Boulder clay	B	10	0	0
7-15	Sand	B	25	0	25
7-17	Sandy boulder clay	B	20	0	0
7-19	Sandy boulder clay	B	25	0	25
7-21	Sandy boulder clay	B	15	0	50
7-23	Residual ?	B	20	0	50
7-25		B	30	5	0
7-27	Sandy boulder clay	B	20	0	25
7-29	Sandy outwash	B	15	0	25
7-31	Till	B	25	5	25
7-35	Gravely boulder till	B	5	0	25
7-37	Coarse sand	B-C	10	0	25
7-39	Fine outwash	B	25	10	25
7-41	Sand outwash	B	5	0	50
7-43	Sandy outwash	B	5	0	25
7-45	Boulder sandy clay	B	15	0	25
7-47	Outwash	B	15	5	25
7-51	Till	B	25	0	0
7-53	Till	B	25	5	5
7-55	Boulder till	B	20	0	25
7-57	Moraine	B	25	0	25
7-59	Moraine	B	75	25	50

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
7- 2	Till (fine mat)	B	20	15	25
7- 4	Till	B	15	0	0
7- 6	Boulder clay	B	0	0	0
7- 6A	Leache zone		5	0	0
7- 8	outwash	B	25	5	0
7-10	Boulder clay	B	15	10	0
7-12	Boulder clay	B	5	5	0
7-14	Outwash	B	25	0	0
7-16	Outwash	B	15	0	0
7-18	Boulder clay till	B	20	5	25
7-20	Boulder clay	B	25	0	0
7-22	Sandy mat.	B	20	0	0
7-24	Till (sandy)	B	25	0	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
8- 1	Sandy B-Till	B	20	0	
8- 3	B-Till sand	B	10	0	
8- 5	Sandy outwash	B	10	0	
8- 7	Fe sand	B	25	0	
8- 9	Gravely outwash	B	20	0	
8-11	Outwash sand	B	10	0	
-13	Fine gravel	B	35	0	
8-15	Gravely outwash	B	10	0	
8-17	Sandy outwash	B	15	0	
8-19	Sandy outwash	B	25	0	
8-21	Sand (gravelly)	B	5	0	
8-23	Sand & gravel outwash	B	40	0	
8-25	Boulder sandy Till	B	10	2	
8-27	Fine outwash	B	10	1	
8-29	Clayey outwash	B	0	0	
8-31	B Till & sand	B	10	0	
8-33	Fe outwash sand	B	10	0	
8-35	Fine sand	B	50	0	
8-37	Sand outwash	B	15	0	
8-39	Outwash	B	5	0	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
8- 2	Sandy B-Till	B	20	0	
8- 4	Boulder (sandy)	B	15	0	
8- 6	B-sand	B	10	0	
8- 8	Till	B	15	0	
8-10	Residual	B	15	0	
8-12	Outwash	B	20	0	
8-14	Outwash (resid.)	B	5	0	
8-16	B-Clay	B	5	0	
8-18	Outwash	B	15	0	
8-20	Till	B	10	0	
8-22	Boulder sand	B	0	0	
8-24	Residual	B	5	0	
8-26	Outwash	B	20	0	
8-28	Outwash	B	20	5	
8-30	Outwash	B	0	0	
8-32	Outwash	B	25	0	
8-34	Sandy Till	B	10	1	

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
9- 1	Sand and small boulders	B	50	25	0
9- 3	Sand (outwash)	B	15	0	0
9- 5	Sandy moraine	B	15	0	0
9- 7	Sandy outwash	B	20	0	25
9- 9	Sand and boulders	B	25	5	25
9-11	Sand and boulders	B	25	0	25
9-13	Sand and boulders	B	15	5	0
9-15	Sand (outwash)	B	10	0	0
9-17	Part residual	B	20	5	0
9-19	Sand (outwash)	B	20	5	25
9-21	Outwash (sand)	B	5	0	0
9-23	Thin sand cover	B	10	5	50
9-25	Residual	B	15	0	25
9-27	Fine gravel	B	15	0	25
9-29	Sand and gravel	B	25	0	0
9-31	Clayey residual ?	B	15	0	50
9-33	Sand and boulders	B	20	0	50
9-35	Sandy till	B	25	0	25
9-37	Boulder till	B	10	0	25
9-39	Till (clayey)	B	20	0	25
9-41	Boulder sand till leached	A	25	0	50
9-43	Sand	B	15	0	25
9-45	Sand	B	5	0	50
9-47	Boulders,gravel & sand	B	25	0	25
9-49	Sand	B	15	10	0
9-51	Sand	B	25	0	0
9-53	Sand	B	5	5	30
9-55	Sand	B	5	0	25
9-57	Till (sandy)	B	20	5	0
9-59	Fine sand	B	10	10	25
9-61	Sand	B	10	5	0
9-63	Sand	A-B	25	0	25
9-65	Sand (clayey)	B	5	0	0
9-67	Sand (clayey)	B	5	0	0
9-69	Sand	B	10	0	25
9-71	Clayey sand & pebbles	B	5	5	0
9-73	Sandy till	B	25	0	25

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
9- 2	Outwash	B	20	10	50
9- 4	Outwash	B	15	0	0
9- 6	Outwash	B	20	5	30
9- 8	Outwash	B	25	0	25
9-10	Outwash	B	25	0	0
9-12	Boulder clay or sand	B	15	5	25
9-14	Boulder sand	B	35	5	50
9-16	Outwash	B	20	0	50
9-18	Till (sandy)	B	5	5	25
9-20	Till	B	25	0	0
9-22	Till	B	25	5	50
9-24	Outwash (sandy)	B	15	5	0
9-26	Outwash	B	10	0	25
9-28	Drift	B	25	0	25
9-30	Boulder clay	B	10	0	25
9-32	Till (leached)	B	20	15	0
9-34	Till (sandy)	B	25	0	0
9-36	Boulder clay	B	10	0	25
9-38	Boulder clay	B	15	0	25
9-40	Top esker (Gl,Fe)	B	25	0	25
9-42	Outwash	B	20	0	25
9-44	Boulder clay	B	45	0	0
9-46	Boulder clay	B	10	0	25
9-48	Boulder clay	B	10	10	0
9-50	Boulder clay	B	15	5	0
9-52	Boulder clay	B	15	0	25
9-54	Sandy outwash	B	100	5	50
9-56	Sandy till	B	25	0	25
9-58	Sandy outwash	B	15	5	0

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
10- 1	Outwash	B	25	0	12
10- 3	Till	B	5	20	12
10- 5	Till	B	10	0	25
10- 7	Till	B	15	0	25
10- 9	Outwash	B	10	0	35
10-11	Boulder clay	B	25	0	25
10-13	Till	B	5	0	0
10-15	Outwash	B	5	0	25
10-15A	Outwash	B	5	0	25
10-17	Till	B	5	0	0
10-19	Till	B	0	0	0
10-21	Till	B	5	0	25
10-23	Outwash	B	25	0	25

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
10- 2	Till	B	15	0	0
10- 4	Till	B	5	0	0
10- 6	Till	B	25	0	12
10- 8	Outwash	B	5	0	25
10-10	Boulder clay	B	0	0.	25
10-12	Till	B	5	0	0
10-14	Outwash	B	5	0	12
10-16	Outwash	B	10	0	25
10-18	Till (sandy)	B	50	0	12
10-20	Till	B	20	0	12
10-22	Till	B	10	0	25

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
11- 1	Boulder sand till	B	15	0	25
11- 3	Sand	B	15	0	25
11- 5	Boulder sand till	B	35	0	0
11- 7	Fe sand	B	5	0	25
11- 9	Sand	B	15	0	25
11-11	Sand (little gravel)	B	25	0	0
11-13	Gravel (fine)	B	20	0	0
11-15	Sandy gravel	B	25	0	0
11-17					
11-17A					
11-19					
11-21					
11-23					

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
11- 2	Boulder clay sandy	B	15	0	25
11- 4	Boulder clay	B	0	0	25
11- 6	Till	B	10	0	25
11- 8	Till	B	20	0	25
11-10	Till boulder	B	15	5	35
11-12	Till on bedrock	B	50	0	0
11-14	Till	B	20	0	0
11-16	Till	B	5	0	0
11-18					
11-20					

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
12- 1	Sand (Fe)	B	10	0	0
12- 3	Boulder till ± resid.	B	15	0	0
12- 5	Boulder till	B	15	5	0
12- 7	Boulder till	B	20	5	25
12- 9	B.till very sandy	B	15	0	50
12-11	Boulder till	B	20	0	25
12-13	Boulder till	B	10	5	25
12-15	Boulder till (sandy)	B	25	0	25
12-17	Sand & gravel outwash	B	25	0	0
12-19	Sandy outwash	B	25	0	0
12-21	Sand	B	15	0	25
12-23	Sand outwash	B	10	0	0
12-25	Sand outwash	B	10	0	0
12-27	Sand outwash	B	10	5	0
12-29	Boulder till	B	25	0	0
12-31	Sandy outwash	B	15	0	0
12-33	Sand	B	25	0	0
12-35	Sand	B	20	0	0
12-37	Sand	B	10	0	0
12-39	Sand	B	10	0	25
12-41	Sand	B	5	0	0
12-43	Sand	B	5	25	25
12-45	Boulder till	B	10	5	0
12-47	Sand	B	15	0	25
12-49	Gravelly till	B	5	5	0
12-51	Sand	B	10	0	25
12-53	Boulder clay	B	10	0	0
12-55	Sandy till	B	10	0	25
12-57	Sandy boulder till	B	20	0	0

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
12- 2	Outwash	B	15	0	25
12- 4	Clay	B	15	20	0
12- 6	Outwash (coarse)	B	25	5	25
12- 8	Till	B	15	0	0
12-10	Till	B	25	10	0
12-12	Till	B	25	25	25
12-14	Till	B	10	0	0
12-16	Till	B	25	15	25
12-18	Till	B	20	15	25
12-20	Till	B	20	0	25
12-22	Till	B	10	0	25
12-24	Till	B	5	0	0
12-26	Till	B	10	0	0
12-28	Till	B	25	10	0
12-30	Esker mat.	B	25	0	0
12-32	Till	B	20	0	0
12-34	Outwash	B	25	5	0
12-36	Outwash	B	20	5	5
12-38	Outwash	B	15	0	25
12-40	Outwash	B	10	0	25
12-42	Till	B	20	0	0
12-44	Till	B	10	0	0
12-46	Till	B	15	0	0
12-48	Till	B	15	0	25
12-50	Till	B	20	0	25
12-52	Till	B	10	0	25
12-54	Till	B	10	0	25
12-56	Till	B	15	0	25

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
13- 1	Sand and boulders	B	15	0	0
13- 3	Sand	B	5	0	25
13- 5	Clayey and boulders	B	5	5	50
13- 7	Sandy	B	0	0	25
13- 9	Sandy	B	20	0	25
13-11	Course sand	B	10	5	0
13-13	Silt	B	25	15	25
13-15	Sandy residual	B	25	0	25
13-17	Sand	B	10	5	25
13-19	Sand	B	5	0	0
13-21	Sand	B	10	5	25
13-23	Sand	B	0	0	25
13-25	Sand	B	30	0	25
13-27	Sand	B	10	0	25
13-29	C.sand and boulders	B	20	10	0
13-31	Boulders, sand	A	20	10	0
13-33	Silty and pebbles	B	20	0	0
13-35	Residual	B	15	0	25
13-37	Residual	B	15	0	25
13-39	Boulder till	B	20	5	0
13-43	Residual	B	20	0	25
13-45	Clay	B	25	0	0
13-47	Residual?	B	15	10	0
13-49	Sand	B	20	0	25
13-51	Sandy	B	0	0	25
13-53	Sand	B	15	0	0
13-55	Sand	B	15	5	25
13-57	Sand and boulders	B	5	0	0
13-59	Boulders	B	10	0	25
13-61	Residual	B	10	10	25

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
13- 2	Boulders sand	B	5	0	0
13- 4	Boulders sand	B	5	0	25
13- 6	Till	B	0	0	0
13- 8	Till	B	25	0	25
13-10	Till	B	10	0	0
13-12	Till	B	5	0	25
13-14	Outwash	B	15	0	0
13-16	Outwash	B	25	10	25
13-18	Boulder clay	B	15	5	25
13-20	Till	B	20	15	25
13-22	Till	B	15	0	0
13-24	Outwash	B	25	0	25
13-26	Outwash	B	25	15	25
13-28	Till	B	15	0	25
13-30	Boulder clay	B	25	0	0
13-32	Outwash	B	10	5	25
13-34	Outwash	B	15	0	0
13-36			10	5	25
13-38	Enriched	4¼'	20	0	25
13-42	Outwash	B	20	0	0
13-44	Outwash	B	25	0	25
13-46	Till	B	10	5	0
13-48	Till	B	15	5	25
13-50	Outwash	B	25	0	25
13-52	Till	B	0	0	25
13-54	Outwash	B	15	0	25
13-56	Outwash	B	10	0	0
13-58	Outwash	B	0	0	25
13-60	Boulder sand	B	15	0	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
15- 1	Till	B	25	10	
15- 3	Till	B	50	0	
15- 5	Residual	B	15	0	
15- 7	Residual	B	25	0	
15- 9	Till	B	20	5	
15-11	Till	B	5	0	
15-13	Till	B	25	0	
15-15	Till	B	15	0	
15-17	Till	B	15	0	
15-19	Till	B	20	0	
15-21	Till (gravely)	B	20	5	
15-23	Till	B	20	0	
15-25	Till	B	25	0	
15-27	Residual	B	20	0	
15-29	Till	B	25	5	
15-31	Till	B	10	0	
15-33	Till	B	15	0	
15-35	B Clay	B	60	10	
15-37	Till	A & B	10	5	
15-39	Till	B	25	0	
15-41	Till	B	25	10	
15-43	Till	B	10	0	
15-45	Till	B	20	0	
15-47	Till	B	20	0	
15-49	Till	B	25	0	
15-51	Till	A & B	25	25	
15-53	Till	B	20	0	
15-55A	Residual	B	10	0	
15-55	Till	B	20	0	
15-57	Till & Residual	A & B	20	10	
15-59	B-Clay	A & B	15	0	
15-61	B-Till	B	10	5	
15-63	Till	B	10	10	
15-65	B-Till	B	10	40	
15-67	Residual ?	B	5	25	
15-69	Till	B	20	10	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
15- 2	Till	B	0	0	
15- 4	Leached till	B	25	10	
15- 6	Outwash	B	10	0	
15- 8	Till	B	50	0	
15-10	Till	B	15	0	
15-12	Till	B	15	0	
15-14	Outwash	B	10	0	
15-16	Outwash (coarse)	B	25	5	
15-18	Till	B	25	5	
15-20	Till	B	10	0	
15-22	Outwash	B	25	0	
15-24	Till	B	10	0	
15-26	Till	B	15	5	
15-28	Till	B	15	0	
15-30	Outwash	B	25	5	
15-32	Till	B	15	0	
15-34	Till	B	25	0	
15-36	Outwash	B	25	0	
15-38	Till	B	20	0	
15-40	Till	B	40	0	
15-42	Outwash	B	15	0	
15-44	Outwash	B	25	0	
15-46	Till	B	15	0	
15-48	Till	B	15	0	
15-50	Till	B	100	10	
15-52	Till	B	30	0	
15-56	Till	B	35	20	
15-58	Till	B	10	20	

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
16- 1	Residual and till	B	25	20	
16- 3	Thin till	B	25	50	
16- 5	Till	B	15	0	
16- 7	Sandy	B	0	0	
16- 9	Till (sandy)	B	0	0	
16-11	Blue clay		5	20	
16-13	Till	B	20	20	
16-15	Till	B	10	0	
16-17	Till	B	15	0	
16-19	Till	B	10	0	
16-21	Boulder till	humus & clay	50	25	
16-23	Till	B	25	0	
16-25	Residual	B	25	0	
16-27	Till	B	25	0	
16-29	Till	B	5	0	
16-31	Clay	B	15	0	
16-33	Till	B	25	0	
16-37	Till	B	20	50	
1639	Till	B	20	0	
16-41	Fe, sandy	B	15	0	
16-43	Till	B	20	0	
16-45	Till	B	20	0	
16-49	Till residual	B	25	0	
16-51	Till	B	25	0	
16-53	Till ?	B	5	0	
16-55	Till	B	10	0	
16-57	Residual	B	10	0	
16-59	Till	B	25	0	
16-61	Till	A-B	60	5	25

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
16- 2	Till	B	15	15	
16- 4	Till	B	5	0	
16- 6	Residual	B	15	10	
16- 8	Residual or till	B	10	0	
16-10	Till	B	5	0	
16-12	Till	B	25	0	
16-14	Till	B	25	0	
16-16	Till	B	15	0	
16-18	Till	B	20	0	
16-20	Till	B	25	0	
16-22	Till	B	15	0	
16-24	Till	B	10	0	
16-26	Till	B	100	40	
16-28	Till	B	20	0	
16-30	Till	B	10	0	
16-32	Till	B	15		
16-36	Till	B	20	0	
16-38	Till	B	0	0	
16-40	Till	B	10	0	
16-42	Till	B	15	0	
16-44	Till	B	20	0	
16-46	Till	B	15	0	
16-48	Till	B	10	0	
16-50	Till	B	0	0	
16-52	Till	B	20	0	
16-54	Till	B	15	0	
16-56	Till	B	25	10	
16-58	Till	B	35	0	
16-60	Till	B	25	0	25
16-62	Till	B	15	0	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
17- 1	Sand	B	15	0	0
17- 2	Sand and till	B	10	0	25
17- 3	Till	B	50	0	25
17- 4	Till	B	25	0	25
17- 5	Sandy till	B	20	0	25
17- 6	Sand	B	25	0	0
17- 7	Sand	B	20	0	25
17- 8	Sand	B	30	0	25
17- 9	Sand	B	30	0	0
17-10	Sand	B	30	0	50
17-11	Till ?	B	50	0	25
17-12	Residual	B	150	0	25

Samples No.	S.T.	S.A.	Zn.	Cu.	Pb.
18- 1	Boulder till	B	20	0	0
18- 3	Boulder clay	B	25	0	25
18- 5	Thi. residual	B	25	0	25
18- 7	Residual	A	15	0	25
18- 9	Sandy residual	B	15	0	50
18-11	Till	B	25	0	25
18-13	Till	B	25	10	25
18-15	Till	B	15	0	25
18-17	Till	B	5	0	25
18-19	Till	B	25	0	25
18-21	Till	B	15	0	0
18-23	Clayey	B	10	0	0
18-25	Clayey till	B	10	0	25
18-27	Till and residual	B	15	0	50
18-29	Till ?	B	15	0	25
18-31	Resid	B	25	0	25
18-33	Till	B	10	10	
18-35	till	B	10	10	
18-37	Till	B	50	10	
18-39	Sandy till	B	50	10	
18-41	Till	B	45	10	
18-43	Till	B	20	10	
18-45	Till	B	30	10	
18-47	Residual	B	50	20	
18-49	Residual	B	45	5	
18-51	Residual	B	15	5	
18-53	Residual	B	45	5	
18-55	Residual	B	25	5	
18-57	Till	B	25	5	
18-59	Residual	B	15	5	
18-61	Boulder till	B	20	5	
18-63	Boûlder till	B	15	5	
18-65	Boulder till	B	20	5	
18-67	Boulder till	B	25	5	
18-69	Boulder till	B	50	5	
18-71	Till	B	45	5	

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
18- 2	Till	B	50	0	25
18- 4	Sandy till	B	25	0	0
18- 6	Till	B	15	0	50
18- 8	Till	B	10	0	0
18-10	Till	B	15	0	25
18-12	Till	B	25	0	0
18-14	Till	B	35	0	25
18-16	Till	B	30	0	25
18-18	Sandy till	B	25	0	50
18-20	Till	B	20	0	25
18-22	Till	B	10	0	50
18-24	Till	B	50	0	0
18-26	Till	B	10	0	0
18-28	Till	B	20	0	25
18-30	Till	B	100	10	25
18-32	Till	B	15	10	
18-34	Till	B	135	20	
18-36	Till	B	45	10	
18-38	Till (sandy)	B	15	10	
18-40	Till	B	25	10	
18-42	Till	B	35	10	
18-44	Till	B	25	10	
18-46	Till	B	10	5	
18-48	Till	B	20	5	
18-50	Till	B	10	5	
18-52	Till	B	15	5	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
19- 1	B Till	B	15	5	
19- 3	B Till	B	5	5	
19- 5	B Till	B	50	5	
19- 7	Till	A & B	15	5	
19- 9	B Till	B	15	10	
19-11	B Till	B	25	5	
19-13	B Till	B	90	5	
19-15	B Till	B	80	5	
19-17	B Till	B	25	5	
19-19	B Till	B	20	5	
19-21	B Till	B	10	5	
19-23	B Till	B	15	5	
19-25	B Till	B	25	5	
19-27	B Till	B	20	5	
19-29	Till-Residual	B	25	5	
19-33	Till	B	20	5	
19-35	B Till	B	25	15	
19-37	B Till	B	10	5	
19-39A	Residual	B	25	10	
19-39	B Till	B	20	10	
19-41	Residual	B	10	5	
19-43	Residual	B	20	10	
19-45	Residual	B	15	10	
19-47	Till	B	15	10	
19-49	Sandy till	B	30	10	
19-51	Sand (outwash)	B	15	10	
19-53	Residual	A & B	25	10	
19-55			20	10	
19-57	B Till	B	20	10	
19-59	B Till	B	25	10	
19-61	B Till	A & B	10	10	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
19- 2	Till	B	25	5	
19- 4	Till	B	25	5	
19- 6	Sandy Till	B	80	5	
19- 8	Till (sandy)	B	25	5	
19-10	Sandy Till	B	20	5	
19-12	Till	B	15	5	
19-14	Till	B	25	5	
19-16	Till	B	20	5	
19-18	Till	B	10	5	
19-20	Till	B	15	5	
19-24	Till	B	10	5	
19-26	Till	B	15	5	
19-30	Till	B	70	5	
19-32	Till	B	10	5	
19-34	Till	B	25	15	
19-36	Sandy Till	B	20	15	
19-38	Till	B	20	10	
19-40	Till	B	25	10	

Samples no.	Soil Type	S.H.	Zn	Cu	Pb
20- 1	B Till	B	12	6	0
20- 3	B Till	B	6	6	0
20- 5	B Till	B	12	12	0
20- 7	B Till	B	6	18	0
20- 9	B Till	B	12	25	0
20-11	B Till	B	12	50	0
20-13	B Till	B	25	25	0
20-15	B Till	B	6	12	0
20-17	B Till	B	6	12	0
20-19	B Till	A & B	25	12	0
20-21	B Till	B	6	6	0
20-23	B Till	B	12	12	0
20-25	B Till	B	37	12	0
20-27	B Till	B	6	12	0
20-29	B Till	B	6	12	0
20-31	B Till	B	25	25	0
20-33	Clayey till	B	6	12	0
20-35	Clayey till ?	B	18	12	0
20-37	Clayey till ?	B	25	18	0
20-39	B Till	B	37	25	0
20-41	B Till (sandy)	B	12	6	0
20-43	Sand	B	12	12	0
20-45	Sand	B	25	12	0
20-47	Sand & fine gravel	B	37	6	0
20-49	Sandy till (?)	B	25	12	0
20-51	Sandy till	B	12	12	0
20-53	Sandy till	B	25	12	0
20-55	B Till	B	50	12	0
20-57	B Till	B	37	12	0
20-59	Coarse sand	B	62	25	0
20-61	B Till	B	37	12	0
20-63	B Till	B	0	6	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
20- 2	Till	B	31	12	0
20- 4	Till	B	31	25	0
20- 6	Till	B	12	12	0
20- 8	Till	B	6	6	0
20-10	Till	B	6	6	0
20-12	Till	B	12	12	0
20-14	Till	B	6	6	0
20-16	Till	B	6	12	0
20-18	Till	B	25	12	0
20-20	Till	B	12	25	0
20-22	Till	B	37	18	0
20-24	Till	B	25	12	0
20-26	Till	B	12	12	0
20-28	Till	B	25	12	0
20-30	Till	B	6	12	0
20-32	Till	B	12	12	0
20-34	Till	B	12	6	0
20-36	Till	B	25	6	0
20-38	Till	B	18	12	0
20-40	Till	B	25	12	0
20-42	Till	B	25	12	0
20-44	Till	B	25	12	0
20-46	Till	B	25	12	0
20-48	Till	B	25	12	0
20-50	Till	B	25	25	0
20-52	Till	B	6	6	0
20-54	Till	B	12	6	0
20-56	Till	B	50	12	0

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
21- 1	Residual	B	20	0	0
21- 3	Boulder till	A-B	20	0	25
21- 5	Till	B	20	0	0
21- 7	Boulder till	B	15	0	25
21- 9	Residual and till	B	25	15	0
21-11	Till & residual ?	B	10	0	100
21-13	Till	B	20	15	0
21-15	Till	B	15	5	0
21-17	Boulder till	B	35	15	25
21-19	Till	B	5	0	0
21-19A	Residual	B	25	0	25
21-21	Resid. & little till	B	25	0	0
21-23	Residual	B	50	10	0
21-25	Residual	B	100	10	25
21-27	Residual	B	25	5	0
21-29	Sand (Fe)	B	25	0	25
21-31	Sand	B	50	20	0
21-33	A humus & residual		20	0	0
21-35	Residual	B	50	25	20
21-37	Residual	A-B	20	20	20
21-39		B	70	20	0
21-41	Residual	B	60	20	0
21-43	Sandy	B	50	0	25
21-45	Residual	B	15	10	0
21-47	Sandy till	B	15	15	0
21-49	Sandy till		20	20	25
21-51	Sand	B	5	0	0
21-53	Sandy till	B	20	10	25
21-55	Residual	B	10	5	0
21-57	Boulder till (sandy)	B	25	0	0
21-59	Boulder till	B	50	0	0
21-61	Boulder till	B	5	0	25
21-63	Sandy till	B	5	0	25

Sample No.	S.T.	S.A.	Zn.	Cu.	Pb.
21- 2	Till	B	15	10	25
21- 4	Till	B	15	0	0
21- 6	Till	B	30	0	0
21- 8	Till	B	25	0	0
21-10	Till	B	20	0	0
21-12	Till	B	25	10	0
21-14	Till	B	5	0	50
21-16	Till	B	25	0	25
21-18	Till	B	25	0	0
21-20	Till	B	15	5	25
21-22	Till	B	15	0	25
21-24	Till	B	10	0	0
21-26	Till	B	25	0	25
21-28	Till	B	20	5	25
21-30	Till (sandy)	B	20	0	25
21-32	Till	B	25	5	25
21-34	Till	B	15	0	0
21-36	Till	B	0	5	0
21-38	Till	B	20	0	20
21-40	Till	B	20	5	25
21-42	Residual	B	10	0	0
21-44	Till	B	50	0	0
21-46	Residual	B	25	50	0
21-48	Till	B	20	20	0
21-50	Till	B	10	0	0
21-52	Till	B	25	20	25
21-54	Till	B	25	0	50
21-56	Till	B	20	5	5
21-58	Till	B	15	0	100
21-60	Till	B	5	0	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
22- 1	B Till	B	15	10	
22- 3	Till & Residual	B	45	25	
22- 5	Residual	B	25	10	
22- 7	Residual	B	35	10	
22- 9	Residual ?	B	30	5	
22-11	Residual	B	20	5	
22-13	Residual	B	35	5	
22-15	Residual	B	25	5	
22-17	Residual	B	20	5	
22-19	Residual	B	30	5	
22-21	Residual	B	10	5	
22-23	Sandy Till	B	15	10	
22-25	B-Till	B	30	10	
22-27	B-Till	B	10	5	
22-29	B-Till	B	15	0	
22-31	B-Till	B	25	10	
22-33	Sandy	A	15	10	
22-35	B-Till ?	B	20	10	
22-37	Sandy B Till	B	25	10	
22-39	B-Till	B	20	5	
22-41	B-Till sandy	B	25	5	
22-43	B-Till	B	25	5	
22-45	B-Till	B	25	5	
22-47	B-Till sandy	B	20	5	
22-49	B-Till	B	15	5	
22-51	Residual	B	15	5	
22-53	B-Till	B	25	5	
22-55	B-Till	B	40	15	
22-57	B-Till	B	10	5	
22-59	Till and Residual	B	15	15	
22-61	B-Till sandy	B	20	5	
22-63	B-Till	B	10	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
22- 2	Till	B	40	15	
22- 4	Till	B	20	15	
22- 6	Till	B	25	10	
22- 8	Till	B	20	25	
22-10	Till	B	60	10	
22-12	Till	B	20	10	
22-14	Till	B	15	5	
22-16	Till	B	25	5	
22-18	Till	B	40	5	
22-20	Till	B	30	10	
22-22	Till	B	30	10	
22-24	Till	B	150	30	
22-26	Till	B	35	5	
22-28	Till	B	35	0	
22-30	Till	B	30	10	
22-32	Till	B	30	10	
22-34	Till	B	70	10	
22-36	Till	B	10	10	
22-38	Till	B	20	5	
22-40	Till	B	15	5	
22-42	Till	B	20	5	
22-44	Till	B	15	5	

Samples No	S.T.	S.A.	Zn.	Cu.	Pb.
23- 1	Fe (sand) ?	B	25	5	
23- 3	Till	B	15	5	
23- 5	Till (sandy) res.	B	25	5	
23- 7	Sandy material	B	10	5	
23- 9	Boulder till fine	B	10	5	
23-11	Till	B	20	5	
23-13	Till	B	10	5	
23-13A	Till - Residual	B	15	5	
23-15	Residual (till)	B	20	5	
23-17	Sand	B	10	5	
23-19	Till	B	20	5	
23-21	Till	B	25	5	
23-23	Sand	B	5	5	

Samples No	S.T.	S.A.	Zn.	CU.	Pb.
23- 2	Sand outwash	B	15	5	
23- 6	Residual	B	20	5	
23- 8	Outwash sand	B	5	5	
23-10	Boulder till	B	25	5	
23-12	Till	B	20	5	
23-14	Boulder till	B	25	5	
23-16	Till and resid	B	15	5	
23-18	Boulder till (Fe sandy)	B	10	5	
23-20	Till (residual)	B	5	5	
23-22	Sand	B	20	5	
23-24	Sand	B	15	5	

Samples No	S.T.	S.A.	Zn.	Cu.	Pb.
24-1	Boulder till	B	20	5	
24-3	Till	B	15	5	
24-5	Till	B	20	5	
24-7	Boulder till	B	20	5	
24-9	?	B	25	5	
24-11	?	B	25	5	
24-13	?	B	20	5	
24-15	?	B	15	0	
24-17	?	B	25	0	
24-19		B	25	0	
24-21		B	10	0	
24-23	?	B	15	0	
24-25	Fine sand	B	5	0	
24-27	Sand	B	15	20	
24-29	Sand	B	20	0	
24-31	Sand	B	15	0	
24-33	Sand	B	20	0	
24-35	?	B	30	15	
24-37	Sand	B	10	0	
24039			20	0	
24-41			15	0	
24-43			20	0	
24-45			20	5	

Samples No	S.T.	S.A.	Zn.	Cu.	Pb.
24- 2	Till	B	25	5	
24- 4	Till	B	25	5	
24- 6	Till	B	15	5	
24- 8	See notes	B	15	5	
24-10	?	B	10	5	
24-12	?	B	10	5	
24-14	?	B	10	0	
24-16	?	B	10	0	
24-18	?	B	20	0	
24-20		B	25	0	
24-22		B	10	0	
24-24	Sand	B	10	0	
24-26	Sand	B	20	15	
24-28	Sand	B	15	0	
24-30	Sand	B	25	0	
24-32	Sand	B	10	0	
24-34	Sand	B	15	0	
24-36	Till	B	5	0	
24-38			5	0	
24-40			20	0	
24-42			10	0	
24-44			25	0	
24-46			25	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
25- 1	B Till	B	12	6	0
25- 3	B Till	B	12	6	0
25- 5	B Till	B	12	6	0
25- 7	B Till	B	12	12	0
25- 9	B Till	B	18	25	0
25-11	B Till	B	6	18	0
25-13	B Till	B	31	12	0
25-15	B Till	B	6	18	0
25-17	B Till	B	12	6	0
25-21	Fe sand	B	12	12	0
25-23	Sand	B	12	6	0
25-25	Fe sand	B	6	25	0
25-27	B Till	B	12	25	0
25-29	B Till	B	12	25	0
25-31	B Till	B	12	6	0
25-33	B Till	B	18	75	0
25-35	B Till	B	12	6	0
25-37	B Till	B	12	18	0
25-39	B Till	B	18	6	0
25-41	B Till	B	12	6	0
25-43	B Till	B	12	6	0
25-45	B Till	B	12	6	0
25-47	Sand	B	12	18	0
25-49	Sand	B	37	25	0
25-51	Sand	B	12	6	0
25-53	B Till	B	25	6	0
25-55	B Till	B	6	6	0
25-57	Sand	B	6	6	0
25-59	Sand	B	6	12	0
25-61	B Till	B	6	12	0
25-63	B Till	B	6	6	0
25-65	B Till	B	12	12	0
25-67	B Till	B	37	25	0
25-69	B Till	B	6	12	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
25- 2	Residual	B	25	25	0
25- 4	B. Till	A & B	25	25	0
25- 6	B. Till	B	25	25	0
25- 8	Till		18	12	0
25-10	Till	B	18	6	0
25-12	Till	B	12	25	0
-14	Till	B	12	6	0
25-16	Till	B	12	6	0
25-18	Till	B	12	6	0
25-20	Till	B	25	12	0
25-22	Till	B	18	12	0
25-24	Till	B	12	12	0
25-26	Till	B	12	6	0
25-28	Till	B	12	6	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
26- 1	Till & Residual	B	100	15	0
26- 1a	Till & Residual	A	25	15	0
26- 1b	Till & Residual	B	90	15	0
26- 3	B. Till	B	200	10	0
26- 3a	B. Till	B	1000	30	0
26- 3b	B. Till	B	525	25	0
26- 5	B. Till	B	600	60	0
26- 5a	B. Till	B	600	25	0
26- 5b	B. Till	B	350	10	0
26- 7	B. Till	B	3500	200	3000
26- 7a	B. Till	B	225	25	0
26- 7b	B. Till	B	500	10	0
26- 9	B. Till	B	100	10	5
26- 9a	B. Till	B	200	10	0
26- 9b	B. Till	B	450	100	5
26-11	B. Till (trench)	B	2500	300	600
26-13	B. Till	B	700	25	35
26-13a	B. Till (trench)	B	700	25	10
26-13b	B. Till	B	2000	1000	0
26-13b	Residual	B	100	15	10
26-15	B. Till	B	125	25	0
26-15a	B. Till (trench)	B	200	25	50
26-15b	B. Till (trench)	B	2000	90	10
26-17	B. Till	B	1750	25	15
26-17a	B. Till	B	250	25	300
26-17b	B. Till	B	100	10	0
26-19	B. Till	B	300	25	75
26-19a	B. Till (trench)	B	100	25	10
26-19b	B. Till	B	50	10	5
26-21	B. Till	B	300	10	10
26-21a	B. Till	B	350	50	100
26-21b	B. Till	B	250	10	0
26-23	B. Till	B	250	35	0
26-23a	B. Till	B	200	25	10
26-23b	B. Till	B	200	15	5
26-25	B. Till	B	100	15	25
26-25a	B. Till	B	250	25	0
26-25b	B. Till	B	200	25	0
26-27	B. Till	B	75	25	15
26-27a	B. Till	B	300	25	25
26-27b	B. Till	B	100	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
26-29	B. Till	B	60	30	0
26-29a	B. Till	B	25	10	0
26-31	B. Till	B	60	10	0
26-31a	B. Till	B	45	15	65
26-31b	B. Till	B	60	15	0
26-33a	B. Till (trench)	B	900	30	0
26-33b	B. Till	B	35	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
26- 2	B. Till	B	45	15	0
26- 4	B. Till	B	250	25	100
26- 6	B. Till	B	250	6	60
26- 8	B. Till	B	200	10	0
26-10	B. Till	B	450	25	100
26-12	B. Till	B	350	75	0
26-14	B. Till (trench)	B	900	30	10
26-16	B. Till (trench)	B	600	25	5
26-18	B. Till	B	200	10	0
26-20	B. Till	B	500	10	0
26-22	B. Till	B	25	22	0
26-24	B. Till	B	10	10	0
26-26	B. Till	B	100	15	0
26-28	B. Till	B	300	30	0
26-30	B. Till	B	50	10	0
26-32	B. Till	B	50	25	0
26-34	B. Till	B	250	25	15
26-36	B. Till	B	275	25	50
26-38	B. Till	B	35	25	0
26-40	B. Till	B	900	70	0
26-40a	B. Till	B	160	10	10
26-42	B. Till	B	900	450	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
27- 1	Clay	B	600	25	0
27- 3	Clay	B	600	10	0
27- 5	Residual	B	55	35	0
27- 7	B. Till	B	60	10	5
27- 9	B. Till	B	45	10	0
27-11	Residual	B	50	10	0
27-13	Residual	B	75	10	0
27-15	B. Till (in trench)	B	2500	400	15
27-17	Clayey Till	B	35	10	10
27-19	Compact clay	B	150	50	0
27-21	Compact clay	B	1250	150	5
27-23	Compact clay	B	30	25	5
27-25	Clayey Till	B	60	75	0
27-27	Clayey Till	B	25	10	0
27-29	Residual	B	60	50	0
27-31	B. Till	B	200	15	0
27-33	Outwash sand (?)	B	25	5	0
27-35	Outwash sand (?)	B	15	10	0
27-37	Sand	B	35	10	0
27-39	Sand	B	50	15	0
27-41	Sand	B	15	10	0
27-43	Clayey	B	25	10	5
27-45	Compact clay	B	25	25	0
27-47	Clayey	B	30	10	0
27-49	Clayey	B	25	15	0
27-51	Bluish clay	-	10	25	0
27-53	Boulder clay	B	10	25	0
27-55	B. Till	B	25	30	0
27-57	B. Till	B	25	15	0
27-59					
27-61	B. Till	B	15	45	0
27-63	Sandy Till (trench)	B	15	25	0
27-65	Clay under coarse sand	A & B	35	10	0
27-67	Sandy Till & Residual	B	35	25	0
27-69	Residual clay	B	15	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
27- 2	Slump	B	35	25	0
27- 4	Till & Residual	B	75	10	0
27- 6	Till	B	50	10	0
27- 8	Till	B	35	10	0
27-10	Till	B	30	15	0
27-12	Sandy Till	B	75	15	0
27-14	Till	B	50	10	0
27-16	Sandy Till	B	30	15	0
27-18	Sandy Till	B	15	10	0
27-20	Sandy Till	B	30	15	0
27-22	Sandy Till	B	25	25	0
27-24	Sandy Till	B	25	15	0
27-26	Sandy Till	B	25	15	0
27-28	Sandy Till	B	25	10	0
27-30	Sandy Till	B	35	25	0
27-32	Sandy Till	B	30	15	0
27-34	Sandy Till	B	25	5	0
27-36	Sandy Till	B	25	10	0
27-38	Sandy Till	B	35	10	0
27-40	Sandy Till	B	75	15	0
27-42	Till (in trench)	B	35	15	0
27-44	Till	B	10	15	0
27-46	Till	B	25	10	0
27-48	Till	B	25	10	0
27-50	Till (Fe rich)	B	10	10	0
27-52	Till	B	10	15	0
27-54	Till	B	10	10	0
27-56	Till	B	25	15	0
27-58	Till	B	10	25	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
28- 1	Till	B	35	10	0
28- 3	Coarse sand (outwash)	B	10	0	0
28- 5	Sand (outwash)	B	25	25	0
28- 7	Sand	B	10	10	0
28- 9	Sandy Till	B	35	10	0
28-11	Sandy Till	B	25	10	0
-13	Sandy Till	B	10	10	0
28-15	Sandy Till	B	25	10	0
28-17	Residual clay	B	15	10	0
28-19	B. Till (clayey)	B	10	0	0
28-21	Sandy Till	B	25	5	0
28-23	Sandy Till	B	10	10	0
28-25	B. Till	B	10	0	0
28-27	B. Till	B	25	10	0
28-29	B. Till	B	35	5	0
28-31	B. Till (sandy)	B	10	10	0
28-33	B. Till (sandy)	B	35	5	0
28-35	B. Till (sandy)	B	50	10	0
28-37	B. Till	B	45	15	0
28-39	B. Till (clayey)	B	25	10	0
28-41	B. Till	B	25	5	0
28-43	B. Till	B	10	25	0
28-45	B. Till	B	25	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
28- 2	Residual	B	45	25	0
28- 4	Till	B	35	0	0
28- 6	Till	B	25	0	0
28- 8	Residual & Till	B	10	10	0
28-10	Residual & Till	B	35	25	0
28-12	Boulder clay	B	35	25	0
28-14	Till	B	100	15	0
28-16	Till	B	30	30	0
28-18	Till	B	10	0	0
28-20	Till	B	15	0	0
28-22	Till	B	35	0	0
28-24	Till	B	25	10	0
28-26	Till	B	45	10	0
28-28	Till	B	35	50	0
28-30	Till	B	50	15	0
28-32	Till & Slump	B	50	5	0
28-34	Till	B	75	10	0
28-36	Till	B	45	10	0
28-38	Till	B	10	15	0
28-40	Till	B	10	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
29- 1	Mostly residual	B	10	10	0
29- 3	Till & Residual	B	30	15	0
29- 5	Till & Residual	B	45	10	0
29- 7	B. Till	B	60	10	0
29- 9	B. Till	B	30	10	0
29-11	B. Till	B	25	10	0
29-13	Residual	B	30	10	0
29-15	Clayey Till	B	25	15	0
29-17	B. Till	B	10	10	0
29-19	Creamy clay	B	35	10	0
29-21	Clayey residual	B	15	10	0
29-23	Boulder clay	B	10	10	0
29-25	Till & Residual	B	15	10	0
29-27	B. Till	B	25	10	0
29-29	B. Till	B	25	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
29- 2	Residual	B	30	5	0
29- 4	Till	B	30	15	0
29- 6	Till	B	25	10	0
29- 8	Slump (?)	B	100	25	5
29-10	B. Till	B	300	30	0
29-12	B. Till	B	75	25	25
29-14	B. Till	B	200	25	0
29-16	B. Till	B	25	15	0
29-18	Residual	B	25	10	5
29-20	Till	B	75	25	0
29-22	B. Till	B	300	30	0
29-24	B. Till (trench)	B	75	35	0
29-26	B. Till (trench)	B	110	25	0
29-28	Slump	B	50	10	45

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
30- 1A	Humus	Ao	30	25	
30- 1B	Residual (leached)	Al	10	5	
30- 1C	Residual	B	25	5	
30- 2A	Humus	Ao	20	25	
30- 2B	Residual (leached)	Al	20	5	
30- 2C	Residual	B	25	5	
30- 3A	Humus	Ao	50	20	
30- 3B	Residual (leached)	Al	15	5	
30- 3C	Residual	B	15	5	
30- 4A	Humus	Ao	50	40	
30- 4B	B. Till (leached)	Al	10	5	
30- 4C	B. Till	B	40	10	
30- 5A	Humus	Ao	35	20	
30- 5B	B. Till (leached)	Al	5	5	
30- 5C	B. Till	B	40	10	
30- 6A	Humus	Ao	30	20	
30- 6B	B. Till (leached)	Al	10	5	
30- 6C	B. Till	B	60	50	
30- 7A	Humus	Ao	300	40	
30- 7B	B. Till (leached)	Al	50	5	
30- 7C	B. Till	B	220	5	
	(taken between two well mineralized trenches)				
30- 8A	Humus	Ao	160	20	
30- 8B	B. Till (leached)	Al	50	5	
30- 8C	B. Till	B	350	5	
30- 9A	Humus	Ao	100	25	
30- 9B	B. Till (leached)	Al	5	5	
30- 9C	B. Till	B	100	5	
30-10A	Humus	Ao	240	40	
30-10B	B. Till (leached)	Al	60	5	
30-10C	B. Till	B	100	5	
30-11A	Humus	Ao	20	25	
30-11B	B. Till (leached)	Al	10	5	
30-11C	B. Till	B	25	5	
30-12A	Humus	Ao	30	15	
30-12B	B. Till (leached)	Al	10	5	
30-12C	B. Till	B	20	5	
30-13A	Humus	Ao	30	25	
30-13B	B. Till (leached)	Al	20	5	
30-13C	B. Till	B	25	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
30-14A	Humus	Ao	30	25	
30-14C	B. Till	B	20	5	
30-15A	Humus	Ao	30	25	
30-15B	B. Till (leached)	Al	10	5	
30-15C	B. Till	B	25	5	
30-16A	Humus	Ao	30	25	
30-16B	B. Till (leached)	Al	10	5	
30-16C	B. Till	B	25	5	
30-17A	Humus	Ao	25	25	
30-17B	B. Till (leached)	Al	5	5	
30-17C	B. Till	B	10	5	
30-18A	Humus	Ao	60	80	
30-18B	Coarse sand	B	35	5	
30-18C	Fine sand	B	25	5	

Note: Humus samples assayed at McGill.
Results expressed in p.p.m. in ash.

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
31- 1	B Till (Clayey)	B	50	5	
31- 3	B Till	A & B	5	10	
31- 5	B Till	B	10	10	
31- 7	B Till	B	15	10	
31- 9	B Till	B	25	10	
31-11	Residual	B	50	40	
31-13	Residual	B	100	40	
31-15	Residual	B	65	5	
31-17	Fe Sand	B	25	15	
31-19	Till (Sandy)	B	25	10	
31-21	Sand	B	70	10	
31-23	Sand	B	150	100	
31-25	Till	B	25	5	
31-27	Till	B	35	10	
31-29	Till	B	75	10	
31-31	Till	B	50	5	
31-33	Till	B	20	5	
31-35	Till	B	30	5	
31-37	Till	B	35	10	
31-39	Till	B	50	15	
31-41	Till	B	75	5	
31-43	Till	B	135	25	
31-45	Sand	B	20	10	
31-47	Clayey Sand	A	25	10	
31-49	B Till	B	20	10	
31-51	Till	B	25	5	
31-53	Till	B	15	10	
31-55	Till	B	50	5	
31-57	Till	B	50	10	
31-59	Till	B	15	10	
31-61	Till	B	25	15	
31-63	Sandy Till	B	25	10	
31-65	Sandy Till	B	20	5	
31-67	Sandy Till	B	20	5	
31-69	Sandy Till	B	10	10	
31-71	B Till	A & B	5	5	
31-73	B Till (Sandy)	B	40	35	
31-75	Gravelly Till	B	70	35	
31-77	-	-	-	-	
31-79	B Till	B	15	10	
31-81	B Till	B	30	10	
31-83	B Till	B	40	10	
31-85	Clayey Till	B	80	15	
31-87	-	-	-	-	
31-89X	Residual	A & B	25	5	
31-89Y	Residual	A & B	60	5	
31-91	B Till	B	20	0	
31-93	Coarse Sand	B	50	10	
31-95	Sand	B	20	15	
31-97	Fine Sand	B	45	10	

Sample No.	Soil Type.	S.H.	Zn	Cu	Pb
31- 2	Till	B	40	25	
31- 4	Till	B	30	5	
31- 6	Till	B	20	5	
31- 8	Till	B	25	5	
31-10	Till	B	25	5	
31-12	Till	B	50	15	
31-14	Till	B	10	5	
31-16	Till	B	15	5	
31-18	Till	B	10	5	
31-20	Till	B	15	5	
31622	Till	B	15	5	
31-24	Till	B	15	15	
31-26	Till	B	20	5	
31-28	Till	B	10	25	
31-30	Till	B	20	40	
31-32	Slump	B	10	5	
31-34	Till	B	80	15	
31-36	Till	B	125	80	
31-38	Till (Clayey)	B	25	15	
31-40	Till	B	60	10	
31-42	Till	B	20	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
32- 1	B Till	B	10	10	
32- 3	B Till (Clayey)	B	15	10	
32- 5	Sand	B	15	5	
32- 7	Sand	B	20	35	
32- 9	B Till	B	20	10	
32-11	B Till	B	10	5	
32-13	Till	B	10	5	
32-15	Residual	B	20	20	
32-17	Residual	B	700	160	
32-19	Residual	B	10	70	
32-21	Residual	B	10	10	
32-23	B Till	B	50	20	
32-25	B Till	B	30	10	
32-27	Coarse sand	B	20	10	
32-29	Fine sand	B	20	10	
32-31	B Till	B	25	5	
32-33	B Till	B	80	5	
32-35	B Till	B	30	10	
32-37	B Till	B	20	5	
32-39	B Till	B	45	10	
32-41	B Till (Sandy)	B	25	10	
32-43	Sandy Till	B	10	10	
32-45	B Till	B	20	10	
32-47	B Till (Sandy)	B	65	5	
32-49	Sand	B	15	25	
32-51	B Till	B	15	20	
32-53	B Till	B	5	10	
32-55	B Till (Sandy)	B	15	20	
32-57	B Till	B	15	5	
32-59	Sand	B	40	20	
32-61	Med. sand	B	20	15	
32-63	Med. sand	B	15	20	
32-65	B Till	B	50	10	
32-67	B Till (Sandy)	B	20	10	
32-69	B Till	B	10	10	
32-71	Gravelly sand	B	25	10	
32-73	Sand	B	45	5	
32-75	Sand	B	10	5	
32-77	Sand	B	10	5	
32-79	Sand	B	25	5	
32-81	Sand	B	20	5	
32-83	Sand	B	75	100	
32-85	Sand	B	10	5	
32-87	Sand	B	25	5	
32-89	Sand	B	20	5	
32-91	Sand and boulders	A & B	125	75	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
32- 2	Humus	Ao	40	15	
- 2	Till	A	15	5	
- 2	Till	B	25	15	
32- 4	Humus	Ao	15	15	
- 4	Till (sandy)	A	10	5	
- 4	Till (sandy)	B	65	15	
32- 6	Humus	Ao	15	25	
- 6	Till	A	15	5	
- 6	Till	B	25	15	
32- 8	Humus	Ao	500	500	
- 8	Till and slump	A	50	75	
- 8	Till and slump	B	70	100	
32-10	Humus	Ao	300	300	
32-12	Humus	Ao	40	40	
-12	Till	A	25	10	
-12	Till	B	70	15	
32-14	Humus	Ao	25	25	
-14	Till	A	10	5	
-14	Till	B	40	10	
32-16	Humus	Ao	10	10	
-16	Till	A	15	5	
-16	Till	B	25	5	
32-18	Humus	Ao	25	25	
-18	Till	A	10	5	
-18	Till	B	15	10	
32-20	Humus	Ao	15	15	
-20	Till	A	15	5	
-20	Till	B	25	10	
32-22	Humus	Ao	20	20	
-22	Till	A	5	5	
-22	Till	B	15	10	
32-24	Humus	Ao	80	80	
-24	Till	A	25	45	
-24	Till	B	50	160	
32-26	Humus	Ao	30	30	
-26	Till	A	0	5	
-26	Till	B	10	5	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
32-28	Humus	Ao	40	40	
-28	Sandy till	A	20	30	
-28	Sandy till	B	20	10	
32-30	Humus	Ao	15	15	
-30	Till	A	15	5	
-30	Till	B	100	15	
32-32	Humus	Ao	15	15	
-32	Residual	A	15	5	
-32	Residual	B	5	5	
32-34	Residual	B	5	10	
32-36	Till and residual	B	10	5	
32-38	Till	B	20	15	
32-40	Till	B	15	5	
32-42	Till	B	15	10	
32-44	Sandy till	B	20	5	
32-46	Till	B	10	5	
32-48	Till	B	15	5	
32-50	Till	B	15	5	
32-52	Till	B	15	10	
32-54	Till	B	25	5	
2-56	Till	B	20	5	
32-58	Till	B	15	5	
32-60	Till	B	20	10	
32-62	Till	B	20	5	
32-64	Till	B	15	15	
32-66	Till	B	10	10	
32-68	Till	B	25	10	
32-70	Sandy till	B	20	5	
32-72	Till (sandy)	B	10	10	
32-74	Residual L	A	30	5	
32-76	Till	B	70	5	
32-78	Till	B	40	5	
32-80	Till	B	25	10	
32-82	Till (washed)	B	20	10	
32-84	Till	B	30	5	
32-86	Slump and till	B	25	10	
32-88	Till	B	10	30	
32-90	Till	B	15	10	
32-92	Till	B	20	5	
32-94	Till	B	15	10	
32-96	Till	B	10	10	
32-98	Till	B	25	15	
32-100	Till	B	20	10	
32- X	Till	B	15	50	
32- Y	Till	B	20	10	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
33- 1	B Till	B	25	10	
33- 3	B Till	B	15	5	
33- 5	B Till	B	30	10	
33- 7	B Till	B	25	10	
33- 9	B Till	B	35	10	
33-11	B Till	B	15	10	
33-13	B Till	B	20	10	
33-15	B Till	B	15	10	
33-17	B Till	B	35	10	
33-19	B Till	B	20	10	
33-21	B Till	B	25	10	
33-23	B Till	B	20	5	
33-25	B Till	B	95	5	
33-27	B Till	B	20	5	
33-29	B Till	B	15	10	
33-31	B Till	B	30	15	
33-33	B Till	B	25	10	
33-35	B Till	B	25	25	
33-37	B Till	B	15	5	
33-39	B Till	B	50	10	
33-41	B Till	B	20	15	
33-43	B Till	B	25	5	
33-45	B Till	B	45	15	
33-47	B Till	B	35	10	
33-49	B Till	B	35	5	
33-51	B Till	B	30	10	
33-53	B Till	B	20	5	
33-55	B Till	B	25	10	
33-57	B Till	B	75	10	
33-59	B Till	B	25	5	
33-61	B Till	B	20	5	
33-63	B Till	B	15	5	
33-65	B Till	B	25	10	
33-67	B Till	B	20	5	
33-69	B Till	B	20	5	
33-71	B Till	B	25	5	
33-73	B Till	B	25	5	
33-75	B Till	B	15	5	
33-77	B Till	B	15	55	
33-79	B Till	B	20	5	
33-81	B Till	B	25	5	
33-83	B Till	B	5	5	
33-85	B Till	B	25	5	
33-89	Sand	B	15	5	
33-91	Sandy B Till	B	10	5	
33-93	B Till	B	25	5	
33-95	B Till	B	75	5	
33-97	B Till	B	15	5	
33-99	B Till	B	20	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
33- 2	Till	B	30	5	
33- 4	Till sandy	B	45	10	
33- 6	Sandy Till	B	15	5	
33- 8	Till	B	25	10	
33-10	Till	B	40	10	
33-12	Till	B	15	10	
33-14	Till	B	10	10	
33-16	Till	B	25	10	
33-18	Till	B	90	10	
33-20	Till	B	35	10	
33-22	Till	B	30	10	
33-24	Till	B	175	60	
33-26	Till	B	20	10	
33-28	Till (Clayey)	B	40	10	
33-30	Till	B	25	10	
33-32	Till	B	60	10	
33-34	Till	B	20	5	
33-36	Till	B	15	10	
33-38	Till	B	85	30	
33-40	Till	B	25	10	
33-42	Till	B	25	10	
33-44	Till	B	25	5	
33-46	Till	B	40	20	
33-48	Till	B	50	10	
33-50	Till	B	45	10	
33-52	-	-	-	-	
33-54	Till	B	20	5	
33-56	Boulder Till	B	30	20	
33-58	Till	B	20	5	
33-60	Till (Residual)	B	20	5	
33-62	Till	B	25	10	
33-64	Till	B	15	5	
33-66	Till (Sandy)	B	25	15	
33-68	Till	B	15	5	
33-70	Till	B	20	5	
33-72	Till	B	20	5	
33-74	Till	B	20	5	
33-76	Till (Sandy)	B	25	5	
33-78	Till (Sandy)	B	15	5	
33-80	Till	B	70	5	
33-82	Till	B	25	5	
33-84	Till	B	10	30	
33-86	Till (leached)	B	10	15	
33-88	Till	B	20	35	
33-90	Till	B	20	35	
33-92	Till (Sandy)	B	35	35	
33-94	Till	B	15	15	
33-96	Till	B	10	10	
33-98	Till	B	25	30	
33-100	Till	B	20	35	
33-102	Till	B	10	25	
33-104	Till	B	10	25	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
34- 1	B Till	B	40	15	
34- 3	B Till	B	20	15	
34- 5	B Till	B	10	10	
34- 7	B Till	B	25	10	
34- 9	B Till	B	30	10	
34-11	B Till	B	15	45	
34-13	Thin B Till & Residual	B	30	90	
34-15	Mostly Residual	A & B	40	100	
34-17	B Till	B	15	10	
34-19	B Till	B	15	20	
34-21	B Till	A & B	30	5	0
34-23	Mostly Residual	B	75	50	0
34-25x	B Till	B	30	5	0
34-25y	Residual	B	40	25	0
34-27	Residual	B	35	50	0
34@29	Residual	B	25	5	0
34-31	Residual	B	25	10	10
34-33	Residual	B	10	5	0
34-35	Residual	B	45	5	0
34-37	B Till	B	10	5	0
34-39	Residual	B	30	5	0
34-41	Sandy Till	B	45	5	0
34-43	Sandy Till	B	35	5	0
34-45	Sandy Till	B	25	5	0
34-47a	B Till	B	50	5	0
34-47b	B Till	B	25	10	0
34-49	B Till	B	30	5	0
34-51	B Till (Sandy)	B	50	5	0
34-53	B Till (Sandy)	B	25	5	0
34-55	B Till	B	25	5	0
34-57	B Till (Sandy)	B	15	5	0
34-59	B Till	B	30	5	0
34-61	B Till	B	10	5	0
34-63	B Till	B	1370	50	0
34-65	B Till	B	45	5	0
34-67	Sandy	B	60	5	0
34-69	Sand	B	50	10	0
34-71	B Till (Clayey)	B	25	5	0
34-73	B Till	A & B	10	5	0
34-77	Fe sand	B	10	30	0
34-79	Sandy Till	B	45	5	0
34-81	B Till	B	30	5	0
34-83	B Till	B	10	20	0
34-85	Gravelly Till	B	35	30	0
34-87	B Till	B	30	20	0
34-89	B Till	B	30	5	0
34-91	B Till	B	35	10	0
34-93	B Till	B	25	10	0
34-95	B Till	B	45	10	0
34-97	Sandy Till	B	30	5	0
34-99	B Till	B	25	5	0
34-101	B Till	B	75	10	0
34-103	B Till	B	25	5	0
34-105	B Till	B	25	5	0
34-107	B Till	B	25	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
34- 2	Till	B	25	5	
34- 4	Till	B	20	5	
34- 6	Till	B	10	10	
34- 8	Till	B	15	5	
34-10	Till	B	15	10	
34-12	Till (Slump)	B	15	10	
34-14	Till (Leached)	A	15	10	
34-16	Till	B	15	25	
34-18	Till	B	150	300	
34-20	Till	B	15	20	
34-22	Till	B	15	5	
34-24	Till	B	15	5	
34-26	Till	B	15	5	
34-28	Till	B	15	15	
34-30	Till	B	20	10	
34-32	Till	B	25	10	
34-34	Till	B	20	15	
34-36	Till (Slump)	B	15	10	
34-38	Leached	A	15	15	
34-40	Till	B	20	15	
34-42	Till	B	25	10	
34-44	Till	B	25	10	
34-46	Till	B	15	10	
34-48	Till (Sandy)	B	5	15	
34-50	Till	B	15	10	
34-52	Till	B	10	10	
34-54	Till	B	15	5	
34-56	Till	B	15	5	
34-58	Till	B	10	10	
34-60	Till	B	20	5	
34-62	Till	B	20	20	
34-64	Till	B	20	10	
34-66	Till	B	10	10	
34-68	Till	B	20	10	
34-70	Till	B	25	10	
34-72	Till	B	15	5	
34-74	Till	B	15	5	
34-76	Till	B	20	10	
34-78	Till (Clayey)	B	25	10	
34-80	Till	B	25	15	
34-82	Till	B	20	10	
34-84	Till	B	25	5	
34-86	Till	B	25	20	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
35- 1	Slump	B	30	10	
35- 2	Till	B	10	5	
35- 3	Till	B	15	10	
35- 4	Till	B	25	10	
35- 5	Till	B	25	20	
35- 6	Till	B	35	15	
35- 7	Till	B	40	15	
35- 8	Till and Slump	A & B	10	5	
35- 9	Till	B	30	10	
35-10	Till	B	15	15	
35-11	Till and Slump	B	40	70	
35-12	Residual, Slump	B	25	10	
35-13	Till	B	25	10	
35-14	Residual	B	20	5	
35-15	Till	B	35	15	
35-16	Till	B	10	5	
35-17	Till	B	20	5	
35-18	Till	B	15	5	
35-19	Till	B	25	5	
35-20	Till	B	50	5	
35-21	Slump	B	75	5	
35-22	White sand	B	45	5	
35-23	Till	A	10	5	
35-24	Till	B	30	10	
35-25	Till	B	15	5	
35-26	Slump	B	20	10	
35-27	Till	B	20	10	
35-28	Till	B	25	5	
35-29	Till	B	20	5	
35-30	Residual	B	25	10	
35-31	Till	B	50	5	
35-32	Till	B	15	5	
35-33	Slump	B	10	5	

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
36- 1	Till sandy (leached)	A	15	10	0
36- 2	Till sandy	B	25	10	0
36- 3	Till	B	10	5	0
36- 4	Till	B	15	5	0
36- 5	Till	B	10	5	0
36- 6	Till	B	10	5	0
36- 7	Till	B	25	10	0
36- 8	Till	B	25	10	0
36- 9	Till	B	25	10	0
36-10	Till	B	10	5	0
36-11	Till (sandy)	B	25	10	0
36-12	Till (sandy)	B	50	15	0
36-13	Till	B	40	50	0
36-14	Till	B	10	5	0
36-15	Till	B	40	10	0
36-16	Till	B	30	10	0
36-17	Till	B	40	10	0
36-18	Till	B	25	10	0
36-19	Till	B	40	10	0
36-20	Till	B	40	10	0
36-21	Till	B	50	25	0
36-22	Till	B	30	5	0
36-23	Till	B	30	10	0
36-24	Residual	B	75	35	0
36-25	Till	B	45	15	0
36-26	Till	B	30	15	0
36-27	Till	B	10	5	0
36-28	Till	B	40	10	0
36-29	Till	B	10	5	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
37- 1	Sand ?	B	30	5	0
37- 2	Sand ?	B	30	5	0
37- 3	Till	B	100	5	0
37- 4	Till	B	30	10	0
37- 5	Till	B	30	10	0
37- 6	Till	B	40	5	0
37- 7	Till	B	25	10	0
37- 8	Till	A & B	30	10	0
37- 9	Till	A & B	80	5	0
37-10	Till	B	30	10	0
37-11	Till	B	30	5	0
37-12	Till	B	65	5	0
37-13	Sandy till	B	110	5	0
37-14	Sandy till	B	45	5	0
37-15	Sandy till	B	250	80	0
37-16	Till	B	125	10	0
37-17	Till	B	30	5	0
37-18	Till	B	10	5	0
37-19	Sandy till	B	25	5	0
37-20	Sandy till	B	45	5	0
37-21	Sandy till	B	10	5	0
37-22	B Till	B	200	120	0
37-23	Sandy till	B	10	5	0
37-24	B Till	B	10	5	0
37-25	B Till	B	10	5	0
37-26	B Till	B	10	10	0
37-27	B Till	B	75	20	0
37-28	B Till	B	60	5	0
37-29	B Till	B	30	10	0
37-30	B Till	B	40	20	0
37-31	B Till	B	45	10	0
37-32	Sandy till	B	45	5	0
37-33	Sandy till	B	5	5	0
37-34	Sandy till	B	10	5	0
37-35	Sandy till	B	15	10	0
37-36	Sandy till	B	30	5	0
37-37	B Till	B	45	40	25
37-38	B Till	B	75	20	0
37-39	B Till	B	50	5	0
37-40	Sand ?	B	75	5	0
37-41	Sand ?	B	45	5	5
37-42	B Till	B	75	10	0
37-43	B Till	B	75	5	0
37-44	B Till	B	25	15	0
37-45	B Till	B	45	10	0
37-46	B Till	B	25	5	0
37-47	B Till	B	40	5	0
37-48	B Till	B	10	5	0
37-49	B Till	B	40	5	0
37-50	B Till	B	40	5	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
37-51	B Till	B	25	10	0
37-52	B Till	B	25	15	0
37-53	B Till	B	45	15	0
37-54	B Till	B	25	25	0
37-55	B Till	B	25	10	0
37-56	B Till	B	25	10	0
37-57	B Till	B	10	5	0
37-58	B Till	B	25	10	0
37-59	B Till	B	25	10	0
37-60	B Till	B	40	15	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
38- 2	Till	B	15	10	0
38- 4	Till	B	25	5	0
38- 6	Till	B	30	5	0
38- 8	Till	B	10	5	0
38-10	Till	B	10	5	0
38-12	B Till	B	25	5	0
38-14	Till	B	15	5	0
38-16	Till	B	25	5	0
38-18	Till	B	15	5	0
38-20	Till	B	15	5	0
38-22	Till	B	25	5	0
38-24	Till	B	45	5	0
38-26	Till	B	10	5	10
38-28	Till	B	15	10	0
38-30	Till	B	25	10	0
38-32	Till	B	30	5	0
38-34	Till	B	10	5	0
38-36	Till	B	10	5	0
38-38	Till	B	5	15	0
38-40	Till	B	25	5	0
38-42	Till	B	30	10	0
38-44	Residual	B	15	20	5
38-46	Slump	B	25	15	0
38-48	Slump	B	40	20	0
38-50	Residual	B	25	15	0
38-52	Slump	B	15	10	0
38-54	Slump	B	25	5	0
38-56	Slump	B	10	30	0
38-58	Till & Slump	B	25	5	0
38-60	Till	B	45	10	0
38-62	Slump	B	10	50	0
38-64	Slump	B	25	35	0
38-66	Till	B	40	5	0
38-68	Slump	B	45	5	0
38-70	Slump	B	25	35	0
38-72	Slump	B	15	5	0
38-74	Till	B	25	5	0
38-76	Till	B	15	10	0
38-78	Till	B	15	25	0
38-80	Till	B	25	25	0
38-82	Till	B	15	20	0
38-84	Till	B	10	5	0
38-86	Till & Slump	B	25	5	0
38-88	Till	B	25	5	0
38-90	Till	B	10	5	0
38-92	Till	B	25	10	0
38-94	Till	B	10	5	0
38-96	Till	B	30	5	0
38-98	Till	B	30	200	0
38-100	Till	B	45	5	0
38-102	Till (sandy)	B	150	10	0
38-104	Till	B	15	5	0
38-106	Till	B	15	10	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
38-108	Till	B	10	5	0
38-110	Till	B	25	10	0
38-112	Till	B	50	5	0
38-114	Till	B	10	10	0
38-116	Till	B	10	15	0
38-118	Till	B	10	5	0
38-120	Till (sandy)	B	10	5	0
38-122	Till (clayey)	B	45	5	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
38- 1	Medium sand	B	10	5	0
38- 3	B Till	B	50	10	0
38- 5	B Till	B	250	150	0
38- 7	B Till	B	65	20	0
38- 9	B Till	B	25	20	0
38-11	B Till	B	25	5	0
38-13	B Till	B	25	5	0
38-15	B Till	B	45	25	0
38-17	B Till	B	40	20	0
38-19	B Till	B	25	10	0
38-21	B Till	B	25	10	0
38-23	B Till	B	25	15	0
38-25	B Till	B	30	30	0
38-27	Residual	B	30	25	0
38-29	Residual & Till	B	30	30	0
38-31	Till (sandy)	B	25	5	0
38-33	B Till	B	25	5	0
38-35	B Till (sandy)	B	30	5	0
38-37	B Till (sandy)	B	30	20	0
38-39	B Till	B	30	80	0
38-41	B Till	B	40	10	0
38-43	B Till	B	25	15	0
38-45	B Till (sandy)	B	25	5	0
38-47	Till (sandy)	B	30	5	0
38-49	Till (sandy)	B	30	5	0
38-51	B Till	B	25	10	0
38-53	B Till	B	55	5	
38-55	Coarse sand	B	80	10	
38-57	Coarse sand	B	50	10	
38-59	Residual	B	25	5	
38-61	Residual clayey	B	40	40	
38-63	Coarse sand	B	30	5	
38-65	Coarse sand	B	60	60	
38-67	B Till	B	75	5	
38-69	Coarse sand	B	25	5	
38-71	B Till	B	25	10	
38-73	B Till	B	10	5	
38-75	B Till	B	10	15	
38-77	B Till	B	35	5	
38-79	Fine sand	B	5	5	
38-81	B Till (sandy)	B	25	10	
38-83	B Till	B	10	5	
38-85	Coarse sand	B	5	5	
38-85A	B Till	B	5	5	
38-87	Pebbly sand	B	5	5	
38-89	B Till	B	5	5	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
39- 1	Sandy till	B	5	5	
39- 3	Sand & clay	A & B	5	10	
39- 5	Coarse sand	B	20	5	
39- 7	Clay	B	45	40	
39- 9	Fine sand	B	15	5	
39-11	Blue clay	B	20	15	
39-13	Clay-sand	B	5	5	
39-15	Fine sand	B	15	15	
39-17	B Till	B	10	20	
39-19	Fe sand	B	15	10	
39-21	Sandy till?	B	10	5	
39-23	B Till	A & B	20	15	
39-25	B Till	B	10	10	
39-27	Sandy till	B	15	5	
39-29	Sandy till	B	60	10	
39-31	B Till (sandy)	B	40	5	
39-33	Gravelly sand	B	50	5	
39-35	B Till (clayey)	B	10	10	
39-37	B Till	B	50	15	
39-39	Residual	B	80	5	
39-41	Till & Residual	B	100	5	
39-43	Residual	B	80	5	
39-45	Residual	B	200	250	
39-47	B Till	B	70	10	
39-49	B Till	B	20	5	
39-51	Gossan	B	80	40	
39-53	B Till (sandy)	B	15	5	
39-55	B Till	B	25	5	
39-57	B Till (sandy)	B	20	10	
39-59	Fine sand	B	30	10	0
39-61	Clay	A & B	25	50	0
39-63	Clay	B	30	10	0
39-65	Residual (clayey)	B	25	10	0
39-67	B Till	B	40	5	0
39-69	B Till	B	30	10	0
39-71	B Till	B	25	10	0
39-73	B Till	B	25	10	0
39-75	B Till	B	5	10	0
39-77	B Till	B	30	10	0
39-79	Fine sand	B	40	10	0
39-81	Fine sand	B	40	25	0
39-83	Medium sand	B	40	25	0
39-85	Fine bluish sand	-	30	10	0
39-87	B Till (Sandy)	B	30	10	0
39-89	Sandy clay	B	30	10	0
39-91	Sand	B	40	25	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
39- 2	Residual	B	40	10	0
39- 4	Residual	B	45	10	0
39- 6	Residual	B	25	10	0
39- 8	Till	B	25	5	5
39-10	Till	B	30	5	0
39-12	Till	B	50	5	5
39-14	Till (leached)	A	40	25	0
39-16	Till	B	10	5	0
39-18	Till	B	30	5	0
39-20	Till	B	25	10	0
39-22	Slump	B	25	5	0
39-24	Till	B	40	25	0
39-26	Residual	B	25	10	0
39-28	Slump	B	10	10	0
39-30	Slump	B	25	10	0
39-32	Till	B	25	5	0
39-34	Till	B	25	10	0
39-36	Till	B	30	15	0
39-38	Till	B	30	15	0
39-40	Till	B	15	10	0
39-42	Till (clayey)	B	25	25	0
39-44	Outwash sand	B	25	10	0
39-46	Till	B	25	250	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
40- 1	Sand	A & B	25	10	0
40- 3	Fine sand	A & B	25	10	0
40- 5	Blue clay	-	30	15	0
40- 7	B. Till	B	10	10	0
40- 9	B. Till (sandy)	B	25	15	0
40-11	B. Till	B	25	10	0
40-13	B. Till (sandy)	B	10	10	0
40-15	Sand	B	25	10	0
40-17	Fine sand	B	10	5	0
40-19	B. Till (sandy)	B	25	0	0
40-21	B. Till (sandy)	B	25	0	0
40-23	Fine sand	B	25	0	0
40-25	Sand	B	10	5	0
40-27	Sand	B	15	5	0
40-29	Sand	B	40	0	0
40-31	Sand	B	10	0	0
40-33	Sand	B	25	0	0
40-35	B. Till	B	25	25	0
40-37	B. Till	B	25	0	0
40-39	B. Till	B	10	5	0
40-41	B. Till	A & B	30	0	0
40-43	B. Till (sandy)	B	50	25	0
40-45	B. Till (sandy)	B	50	10	0
40-47	B. Till (sandy)	B	25	5	0
40-49	B. Till (sandy)	B	40	5	0
40-51	B. Till	A	30	15	0
40-53	B. Till	B	30	15	0
40-55	B. Till	A & B	30	25	0
40-57	B. Till & Residual	B	25	10	0
40-59	B. Till	B	40	15	0
40-61	Clayey sand	B	15	10	0
40-63	Sandy Till (?)	B	10	0	0
40-65	Residual	B	30	0	0
40-67	B. Till	B	30	10	0
40-69	B. Till	B	30	5	0
40-71	B. Till	B	25	10	0
40-73	B. Till	B	40	10	0
40-75	B. Till (sandy)	B	30	25	0
40-77	B. Till	B	25	10	0
40-79	B. Till	B	25	5	0
40-81	B. Till	B	25	15	0
40-83	B. Till	B	30	5	0
40-85	Sandy Till	B	25	10	0
40-87	Sandy Till	B	25	0	0
40-89	Sandy Till	B	25	10	0
40-91	Sandy Till	B	40	10	0
40-93	Sandy Till	B	10	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
40- 2	Blue clay (gritty)	-	5	0	0
40- 4	Sand	B	10	25	0
40- 6	Till	B	5	25	0
40- 8	Till	B	0	10	0
40-10	Till	B	0	10	0
40-12	Till	B	0	10	0
40-14	Till	B	5	5	0
40-16	Till	B	5	10	0
40-18	Sandy Till	B	5	5	0
40-20	Sandy Till	B	10	5	0
40-22	Till	B	10	10	0
40-24	Till	B	5	5	0
40-26	Till	B	5	0	0
40-28	Till	B	10	0	0
40-30	Till	B	5	0	0
40-32	Sandy Till	B	5	5	0
40-34	Sandy Till	B	15	25	0
40-36	Till	B	60	60	0
40-38	Sandy Till	B	25	10	0
40-40	Till	B	0	10	0
40-42	Sandy Till	B	10	25	0
40-44	Till	B	0	5	0
40-46	Till	B	10	10	0
40-48	Till & Slump	B	15	200	0
40-50	Till (leached)	A	10	10	0
40-52	Sandy Till	B	5	10	0
40-54	Till	B	5	25	0
40-56	Till	B	0	10	0
40-58	Till	B	5	10	0
40-60	Till	B	0	5	0
40-62	Till	B	5	5	0
40-64	Till	B	5	10	0
40-66	Till	B	5	0	0
40-68	Till (sandy)	B	0	5	0
40-70	Till	B	5	10	0
40-72	Till	B	5	10	0
40-74	Till	B	30	5	0
40-76	Till	B	10	10	0
40-78	Till (coarse sandy)	B	5	10	0
40-80	Till (sandy)	B	5	10	0
40-82	Till (coarse sandy)	B	50	15	0
40-84	Till (coarse sandy)	B	25	5	0
40-86	Till (coarse sandy)	B	40	10	0
40-88	Till (leached)	A	5	10	0
40-90	Till (coarse sandy)	B	25	10	0
40-92	Till (sandy)	B	5	5	0
40-94	Till (leached)	A	5	50	0
40-96	Till	B	0	10	0
40-98	Till	B	25	5	0
40-100	Till	B	25	10	0
40-102	Till	B	10	10	0
40-104	Till	B	10	25	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
40-106	Till	B	5	10	0
40-108	Till	B	15	10	0
40-110	Till	B	25	10	0
40-112	Till	B	25	10	0
40-114	Till	B	10	10	0
40-116	Till	B	40	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
41- 1	Till	B	25	5	0
41- 3	Till (sandy)	B	25	6	0
41- 5	Residual	B	37	18	0
41- 7	Residual	B	12	6	0
41- 9	Residual	B	25	6	0
41-11	Residual (?)	B	12	12	0
41-13	B. Till (?)	B	12	6	0
41-15	Residual	B	12	6	0
41-17	Residual	B	12	12	0
41-19	Residual	B	12	12	0
41-21	B. Till	B	12	12	0
41-23	B. Till	B	12	12	0
41-25	B. Till	B	12	12	0
41-27	B. Till	B	12	12	0
41-29	Residual (?)	B	25	37	0
41-31	B. Till	B	12	12	0
41-33	B. Till	B	12	12	0
41-35	B. Till	B	18	25	0
41-37	B. Till	B	12	12	0
41-39	B. Till	B	25	31	0
41-41	B. Till	B	25	6	0
41-43	B. Till	B	6	6	0
41-45	B. Till	B	12	6	0
41-47	B. Till	B	12	6	0
41-49	B. Till	B	6	6	0
41-51	B. Till	B	12	6	0
41-53	B. Till	B	25	6	0
41-55	B. Till	B	12	6	0
41-57	B. Till	B	12	12	0
41-59	B. Till	B	12	6	0
41-61	B. Till	B	6	6	0
41-63	B. Till	B	12	6	0
41-65	B. Till	B	12	6	0
41-67	Sandy Till	B	12	6	0
41-69	B. Till	B	12	6	0
41-71	Clayey Till	B	25	6	0
41-73	B. Till	B	6	6	0
41-75	B. Till	B	37	50	0
41-77	B. Till	B	12	6	0
41-79	B. Till	B	12	6	0
41-81	B. Till	B	12	6	0
41-83	B. Till	B	25	6	0
41-85	B. Till	B	12	6	0
41-87	B. Till	B	12	6	0
41-89					
41-91	B. Till	B	12	6	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
41- 2	Till	B	10	20	0
41- 4	Till	B	10	5	0
41- 6	Till (clayey)	B	10	30	0
41- 8	Till	B	10	15	0
41-10	Till	B	10	5	0
41-12	Till	B	10	5	0
41-14	Till	B	10	15	0
41-16	Till	B	10	10	0
41-18	Till	B	80	4000	0
41-20	Till	B	25	250	0
41-22	Till	B	5	300	0
41-24	Till	B	10	40	0
41-26	Till (sandy)	B	25	80	0
41-28	Till	B	10	40	0
41-30	Till	B	30	30	0
41-32	Till (sandy)	B	0	20	0
41-34	Till	B	25	200	0
41-36	Till	B	10	25	0
41-38	Till	B	10	40	0
41-40	Till	B	12	30	0
41-42	Till	B	12	30	0
41-44	Till (clayey)	B	25	80	0
41-46	Till	B	12	10	0
41-48	Till	B	12	15	0
41-50	Till	B	12	10	0
41-52	Till	B	12	15	0
41-54	Till (leached)	A	12	10	0
41-56	Till	B	12	5	0
41-58	Till	B	12	5	0
41-60	Till (Fe stained)	B	12	10	0
41-62	Till	B	30	10	0
41-64	Slump & Till	B	12	10	0
41-66	Till	B	6	10	0
41-68	Sandy Till	B	12	10	0
41-70	Clayey Till	B	18	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
42- 1	B. Till & residual	B	25	10	0
42- 3	Residual	B	12	20	0
42- 5	Residual	B	37	10	0
42- 7	Residual	B	12	10	0
42- 9	Residual	B	12	5	0
42-11	Residual	B	12	10	0
42-13	Residual	B	12	20	0
42-15	B. Till & Residual	B	12	5	0
42-17	B. Till	B	12	15	0
42-19	Residual	B	50	15	0
42-21	Residual	B	12	15	0
42-23	Residual	B	300	20	0
42-25	B. Till	B	12	10	0
42-27	Residual (?)	B	12	60	0
42-29	Residual (?)	B	12	5	0
42-31	B. Till	B	12	5	0
42-33	B. Till	B	12	5	0
42-35	B. Till	B	37	10	0
42-37	B. Till	B	25	30	0
42-39	B. Till	B	12	5	0
42-41	B. Till (sandy)	B	12	5	0
42-43	B. Till	B	12	10	0
42-45	B. Till	B	12	5	0
42-47	B. Till	B	25	5	0
42-49	B. Till (sandy)	B	25	30	0
42-51	B. Till	B	25	5	0
42-53	Sandy Till	B	25	30	0
42-55	Sand	B	25	10	0
42-57	Medium sand	B	25	30	0
42-59	Fine sand	B	25	5	0
42-61	B. Till	B	12	5	0
42-63	Sandy Till	B	12	30	0
42-65	Sandy Till	B	12	5	0
42-67	B. Till	B	12	5	0
42-69	B. Till	B	25	10	0
42-71	B. Till	B	12	10	0
42-73	B. Till	B	25	5	0
42-75	B. Till	B	25	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
42- 2	Sandy Till	B	12	10	0
42- 4	Till	B	6	10	0
42- 6	Till	B	12	5	0
42- 8	Slump	B	12	5	0
42-10	Slump	B	12	10	0
42-12	Residual	B	12	5	0
42-14	Till	B	25	5	0
42-16	Till	B	12	5	0
42-18	Till	B	12	5	0
42-20	Till	B	12	5	0
42-22	Till	B	12	5	0
42-24	Till	B	12	5	0
42-26	Till	B	12	5	0
42-28	Till	B	6	5	0
42-30	Till	B	12	5	0
42-32	Till	B	12	5	0
42-34	Till	B	12	30	0
42-36	Till	B	12	10	0
42-38	Till	B	12	10	0
42-40	Till	B	12	5	0
42-42	Slump	B	12	5	0
42-44	Slump	B	12	10	0
42-46	Slump	B	12	30	0
42-48	Till	B	75	3000	0
42-50	Slump	B	12	60	0
42-52	Slump	B	25	20	0
42-54	Till	B	12	20	0
42-56	Till	B	12	5	0
42-58	Slump	B	25	10	0
42-60	Residual	B	25	10	0
42-62	Till	B	25	10	0
42-64	Till	B	12	5	0
42-66	Till (clayey)	B	12	30	0
42-68	Till	B	12	15	0
42-70	Residual	B	12	10	0
42-72	Till	B	12	10	0
42-74	Till	B	25	5	0
42-76	Till	B	150	20	0
42-78					
42-80	Till	B	150	10	0
42-82	Till	B	12	15	0
42-84	Till	B	25	5	0
42-86	Till	B	25	35	0
42-88					
42-90	Till	B	12	5	0
42-92	Till	B	12	15	0
42-94	Till	B	12	20	0
42-96	Till	B	12	15	0
42-98	Till	B	12	10	0
42-100	Till	B	25	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
42-102	Till	B	12	5	0
42-104	Till	B	25	15	0
42-106	Till	B	15	10	0
42-108	Till	B	12	5	0
42-110	Till (sandy)	B	25	10	0
42-112	Till (sandy)	B	25	15	0
42-114	Residual	B	25	10	0
42-116	Till	B	25	5	0
42-118	Till	B	25	10	0
42-120	Till	B	12	10	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
43- 2	Till	B	15	10	0
43- 4	Till (sandy)	B	30	20	0
43- 6	Till (sandy)	B	70	25	0
43- 8	Clay	B	5	5	0
43-10	Till (sandy)	B	10	10	0
43-12	Till (sandy)	B	5	5	0
43-14	Till (sandy)	B	5	5	0
-16	Till (Fe rich)	B	10	25	0
43-18	Till	B	40	30	0
43-20	Till	B	10	15	0
43-22	Blue clay	-	15	5	0
43-24	Till	B	40	10	0
43-26	Till	B	15	10	0
43-28	Blue clay	-	10	10	0
43-30	Sandy clay	B	15	10	0
43-32	Clay	B	15	10	0
43-34	Sandy clay	B	10	5	0
43-36	Sandy Till	B	40	5	0
43-38	Sandy Till	B	25	5	0
43-40	Sandy clay	B	10	5	0
43-42	Blue clay	-	25	10	0
43-44	Blue clay	-	15	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
44- 2	Blue clay	-	25	20	0
44- 4	Blue clay	-	20	5	0
44- 6	Blue clay (leached)	A	20	5	0
44- 8	Till (sandy)	B	5	5	0
44-10	Till	B	10	5	0
44-12	Till	B	10	5	0
44-14	Blue clay	-	20	5	0
44-16	Till	B	15	15	0
44-18	Till	B	70	120	0
44-20	Blue clay	-	15	10	0
44-22	B. Till	B	5	5	0
44-24	B. Till	B	5	10	0
44-26	B. Till	B	5	5	0
44-28	B. Till (sandy)	B	20	30	0
44-30	Blue clay	-	15	10	0
44-32	Sandy clay	B	15	10	0
44-34	Sandy clay	B	10	5	0
44-36	Fine sand	B	15	5	0
44-38	Fine sand	B	10	5	0
44-40	Fine sand	B	20	5	0
44-42	Fine sand	B	35	10	0
44-44	Med. sand	B	15	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
45- 1	B. Till (sandy)	B	5	15	0
45- 3	Blue Sandy Clay	-	10	10	0
45- 5	Fine clayey sand	B	20	15	0
45- 7	Brown clayey sand	B	15	15	0
45- 9	Blue clay	-	20	20	0
45-11	Blue clay	-	40	20	0
45-13	Blue clay	-	20	20	0
45-15	Blue clay (sandy)	-	15	15	0
45-17	Sandy till (?)	B	10	10	0
45-19	Sandy till (?)	B	15	15	0
45-21	B. Till	A & B	5	5	0
45-23	Fine brown sand	B	10	10	0
45-25	Fine sand	B	10	15	0
45-27	Fine sand	B	15	10	0
45-29	B. Till (?)	B	10	15	0
45-31	Brown sand	B	20	30	0
45-33	Brown sand	B	15	20	0
45-35	Blue clayey sand	-	20	20	0
45-37	Blue clay	-	30	15	0
45-39	Blue clay	-	35	20	0
45-41	Blue clay	-	15	15	0
45-43	B. Till	B	40	40	0
45-45	B. Till (clayey)	B	20	20	0
45-47	B. Till (clayey)	B	30	25	0
45-49	B. Till	B	10	35	0
45-51	B. Till (sandy)	B	5	40	0
45-53	B. Till (sandy)	B	30	45	0
45-55	Sandy clay	B	30	15	0
45-57	Rusted silt	B	15	5	0
45-59	B. Till	B	140	120	0
45-61	Blue sandy clay	-	40	30	0
45-63	Blue clay	-	25	20	0
45-65	Residual, rusty	B	15	15	20
45-67	B. Till(?)	B	20	30	0
45-69	Clay	B	120	50	0
45-71	Blue clay	-	30	25	0
45-73	Blue clay	-	25	15	0
45-75	Fine sand	B & C	200	60	0
45-77	B. Till	B	60	15	60
45-79	B. Till	B	10	10	0
45-81	B. Till	B	80	50	0
45-83	B. Till	B	80	15	0
45-85	B. Till	B	10	10	0
45-87	Fine sand	B	10	20	0
45-89	Fine sand	B	15	10	0
45-91	Fine sand	B	15	10	0
45-93	Fine sand	B	20	20	0

Samples No.	Soil Type.	S.M.	Zn	Cu	Pb
45- 2	Sandy clay	B	20	15	0
45- 4	Sandy clay	B	15	15	0
45- 6	Sand	B	10	10	0
45- 8	Clayey sand	B	15	15	0
45-10	Till (clayey)	B	30	10	0
45-12	Sandy clay	B	15	20	0
45-14	Blue clay	-	10	15	0
45-16	Clay	B	25	20	0
45-18	Till (clayey)	B	20	10	0
45-20	Blue clay	-	10	5	0
45-22	Sandy clay	B	15	5	0
45-24	Sandy Till	B	35	5	0
45-26	Sandy Till	B	15	20	0
45-28	Till (Fe stained)	B	10	5	0
45-30	Till (sandy)	B	5	5	0
45-32	Till (sandy)	B	10	5	0
45-34	Till (sandy)	B	20	20	0
45-36	Till (sandy)	B	15	25	0
45-38	Till (sandy)	B	15	20	0
45-40	Blue clay	-	15	15	0
45-42	Till (sandy)	B	20	20	0
45-44	Till	B	25	50	0
45-46	Blue clay	-	20	35	0
45-48	Till (Fe stained)	B	15	10	0
45-50	Till	B	15	50	0
45-52	Till (Fe stained)	B	10	10	0
45-54	Residual	B	10	10	0
45-56	Till (Fe rich)	B	10	10	0
45-58	Sandy clay	B	35	30	0
45-60	Blue clay	-	35	10	0
45-62	Coarse sand	B	20	5	0
45-64	Clay	B	15	5	0
45-66	Sandy clay	B	20	10	0
45-68	Sandy clay	B	20	10	0
45-70	Blue clay	-	25	15	0
45-72	Blue clay	-	15	5	0
45-74	Blue clay	-	30	25	0
45-76	Clay	-	35	20	0
45-78	Clayey till	B	15	10	0
45-80	Clayey till	B	10	20	0
45-82	Clay	B	20	35	0
45-84	Clay	B	25	15	0
45-86	Clay	B	5	30	0
45-88	Sandy till	B	10	10	0
45-90	Sandy till	B	5	5	0
45-92	Sandy till	B	10	5	0
45-94	Sandy till	B	15	15	0
45-96	Clayey till	B	10	40	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
46- 1	Blue sandy Clay	-	10	10	0
46- 3	B. Till	B	10	5	0
46- 5	Sand	B	20	25	0
46- 7	Blue clay	-	40	10	0
46- 9	Blue clay	-	10	10	0
46-11	Blue clay	-	20	10	0
46-13	Clayey sand	B	10	10	0
46-15	B. Till (sandy)	B	20	200	0
46-17	Clayey sand- Blue	-	10	10	0
46-19	Blue clay	-	20	10	0
46-21	Blue clay	-	20	10	0
46-23	B. Till	B	20	40	0
46-25	Sandy Till	B	10	10	0
46-27	Clay	B	20	10	0
46-29	Clay	B	20	10	0
46-31	Blue clay	-	20	10	0
46-33	Fine sand	B	30	20	0
46-35	Clayey sand	B	10	10	0
46-37	Sandy Till	B	30	10	0
46-39	Sandy Clay	B	10	10	0
46-41	Clayey sand	B	10	10	0
46-43	Sandy Clay	B	20	10	0
46-45	Chayey sand	B	10	10	0
46-47	Fine sand	B	20	10	0
46-49	Fine sand	B	10	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
46- 2	Blue clay	-	5	25	0
46- 4	Blue clay	-	30	15	0
46- 6	Clay	-	15	15	0
46- 8	Clay	-	20	20	0
46-10	Till	B	20	15	0
46-12	Till (sandy)	B	5	20	0
46-14	Residual	B	5	10	0
46-16	Residual (sandy)	B	5	40	0
46-18	Sandy till	B	5	5	0
46-20	Clayey till	B	15	5	0
46-22	Clayey till	B	15	5	0
46-24	Sandy till	B	10	30	0
46-26	Sandy till	B	15	25	0
46-28	Sandy till	B	20	5	0
46-30	Sandy clay	B	15	10	0
46-32	Sandy clay	B	15	5	0
46-34	Sandy till	B	15	5	0
46-36	Sandy till	B	35	5	0
46-38	Clayey till	A	10	5	0
46-40	Sandy till	B	20	5	0
46-42	Sandy	B	35	5	0
46-44	Sandy	B	10	10	0
46-46	Till	B	25	5	0
46-48	Till	B	5	5	0
46-50	Till	B	5	5	0
46-52	Fine sand	B	30	10	0
46-54			30	5	0
46-56	Blue clay	-	40	10	0
46-58			30	10	0
46-60			20	10	0
46-62	Till	B	20	10	0
46-64	Sandy clay	B	20	15	0
46-66			20	10	0
46-68			40	50	0
46-70			50	15	0
46-72	B. Till	B	10	5	0
46-74	B. Till	B	10	5	0
46-76	B. Till	B	20	10	0
46-78	B. Till	B	10	10	0
46-80			50	250	0
46-82			20	40	0
46-84			20	10	0
46-86			20	20	0
46-88	B. Till	B	10	10	0
46-90			10	20	0
46-92			10	15	0
46-94			20	20	0
46-96	Blue sandy clay	-	20	15	0
46-98			20	20	0
46-100	Sandy clay		30	20	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
47- 1	Blue clay	-	20	15	0
47- 2	Blue clay	-	30	20	0
47- 3	Blue clay	-	20	30	0
47- 4	Blue clayey sand	-	10	10	0
47- 5	Fine blue sand	-	30	20	0
47- 6	Fine sand	B	20	10	0
47- 7	Sand	B	10	5	0
47- 8	Med. sand	B	10	10	0
47- 9	B. Till (sandy)	B	10	15	0
47-10	B. Till (sandy)	B	20	10	0
47-11	Clayey blue sand	-	20	10	0
47-12	Med. sand	B	20	10	0
47-13	B. Till (sandy)	B	10	10	0
47-14	B. Till	B	10	10	0
47-15	B. Till (sandy)	B	20	10	0
47-16	Fine clayey sand	B	20	10	0
47-17	B. Till (sandy)	B	20	10	0
47-18	Blue clayey sand	-	20	15	0
47-19	Blue clayey sand	-	20	10	0
47-20	Blue clayey sand	-	20	15	0
47-21	Fine sand	B	40	30	0
47-22	B. Till (sandy)	B	20	10	0
47-23	Blue clay	-	20	20	0
47-24	Med. blue sand	-	20	50	0
47-25	B. Till (sandy)	B	10	20	0
47-26	B. Till	B	40	40	0
47-27	B. Till	B	10	10	0
47-28	B. Till	B	10	10	0
47-29	Med. sand	B	40	50	0
47-30	Sandy till	B	10	10	0
47-31	Sandy till	B	10	5	0
47-32	Sandy till (Fe)	B	10	5	0
47-33	Sandy till	B	20	40	0
47-34	B. Till (sandy)	B	30	40	0
47-35	B. Till (sandy)	B	40	25	0
47-36	B. Till	B	60	35	0
47-37	B. Till	B	25	10	0
47-38	B. Till	B	40	5	0
47-39	B. Till (sandy)	B	20	5	0
47-40	B. Till	B	45	50	0
47-41	B. Till	B	10	15	0
47-42	B. Till	B	20	5	0
47-43	B. Till	B	25	20	0
47-44	B. Till	B	10	5	0
47-45	B. Till (sandy)	-	40	10	0
47-46	Blue clayey sand	-	20	15	0
47-47	Med. sand	B	10	5	0
47-48	Fine clayey sand	B	20	5	0
47-49	Fine sand	B	10	5	0
47-50	Fine sand	B	50	10	0
47-51	Blue clayey sand	-	30	20	0
47-52	Blue clayey sand	-	20	15	0
47-53	B. Till (sandy)	B	30	45	0
47-54	Sand	B	10	5	0
47-55	Micauous sand	B	40	20	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
47-56	Clayey blue sand	-	20	10	0
47-57	Fine sand	B	20	5	0
47-58	B. Till (sandy)	B	20	45	0
47-59	B. Till (sandy)	B	20	10	0
47-60	B. Till	B	30	5	0
47-61	B. Till	B	20	5	0
47-62	Fine sand	B	10	5	0
-63	Dark clayey sand	B	30	5	0
47-64	Fine bluish sand	-	20	5	0
47-65	Med. sand	B	120	30	0
47-66	Brown clay	B	10	5	0
47-67	Clay	B	40	15	0
47-68	B. Till	B	10	5	0
47-69	Blue clay	-	20	5	0
47-70	Blue sand	-	20	55	0
47-71	Blue clayey sand	-	30	5	0
47-72	Fine sand	B	20	5	0
47-73	Blue clay	-	20	10	0
47-74	B. Till (clayey)	B	10	20	0
47-75	B. Till	B	15	80	0
47-76	B. Till	B	20	10	0
47-77	B. Till	B	10	5	0
47-78	B. Till	B	20	10	0
47-79	B. Till	B	40	40	0
-80	B. Till	B	40	5	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
48- 1	Clayey, residual	B	120	1000	60
48- 3	B. Till	B	1200	600	160
48- 5	Clayey till	B	50	200	0
48- 7	B. Till (clayey)	B	80	550	0
48- 9	B. Till	B	30	160	0
48-11	B. Till (clayey)	B	10	80	0
8-13	B. Till (sandy)	B	30	160	0
48-15	B. Till	B	20	80	0
48-17	B. Till	B	60	160	0
48-19	B. Till	B	60	80	0
48-21	Clay	B	30	10	0
48-23	B. Till	B	20	5	0
48-25	B. Till (clayey)	B	40	20	0
48-27	Residual (rusty)	B	50	600	0
48-29	Sandy clay (blue)	-	15	10	0
48-31	Fine sand	B	20	35	0
48-33	B. Till	B	20	20	0
48-35	Blue clay	-	20	20	0
48-37	Fine sand	B	30	5	0
48-39	Clay	B	30	15	0
48-41	Blue sandy clay	-	30	15	0
48-43	Blue clay	-	20	10	0
48-45	Clayey sand	B	10	5	0
8-47	Sandy clay	B	10	10	0
48-49	Blue sandy clay	-	10	10	0
48-51	Blue clay	B	10	5	0
48-53	Med. sand	B	10	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
48- 2	Sand	B	10	5	0
48- 4	Sandy clay	B	20	10	0
48- 6	Till (sandy)	B	20	80	0
48- 8	B. Till	B	30	35	0
48-10	Till	B	10	10	0
48-12	Till	B	10	5	0
48-14	Till (Fe stained)	B	5	10	0
48-16	Till	B	5	10	0
48-18	Till	B	20	10	0
48-20	Till	B	20	25	0
48-22	Blue clay	-	20	5	0
48-24	Blue clay	-	10	5	0
48-26	Blue clay	-	30	10	0
48-28	Blue clay	-	10	10	0
48-30	Sandy clay	-	10	10	0
48-32	Sandy clay	-	20	15	0
48-34	Sandy clay	-	10	5	0
48-36	Clay	-	40	10	0
48-38	Sandy clay	-	20	5	0
48-40	Sand (Fe)	B	10	10	0
48-42	Sandy clay	-	30	5	0
48-44	Sandy clay	-	20	15	0
48-46	Blue clay	-	30	20	0
48-48	Sandy clay	-	30	15	0
48-50	Sandy clay	-	10	5	0
48-52	Blue clay	-	20	5	0
48-54	Blue clay	-	20	10	0
48-56	Sandy clay	-	10	15	0
48-58	B. Till (sandy)	B	15	15	0
48-60	B. Till (clayey)	B	20	20	0
48-62	Clay	B	20	10	0
48-64	Sandy clay	B	10	10	0
48-66	Sandy clay	B	20	15	0
48-68	Clay	B	20	20	0
48-70	Clay	B	10	10	0
48-72	Clay	B	30	25	0
48-74	Clay	B	20	30	0
48-76	Sandy clay	B	40	50	0
48-78	Till (sandy)	B	30	30	0
48-80	Till (clayey)	B	20	40	0
48-82	Till	B	10	30	0
48-84	Till	B	30	50	0
48-86A	Till (clayey)	B	40	120	0
48-86	Till	B	20	45	0
46-88	Till	B	20	50	0
46-90	Till	B	30	60	0
46-92	Sandy clay	B	100	450	0
46-94	Till	B	140	800	30

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
49- 1	Fine clayey sand	B	20	15	
49- 3	B. Till	B	10	5	
49- 5	B. Till (sandy)	B	15	5	
49- 7	Sandy Till	B	25	10	
49- 9	Brownish clay	B	20	10	
49-11	Sandy Till (?)	B	15	5	
49-13	Blue clay	-	25	5	
49-15	Clay	B	25	5	
49-17	Sandy Till	B	15	5	
49-19	Fine sand	B	10	15	
49-21	Light brown clay	B	25	20	
49-23	B. Till	B	15	5	
49-25	B. Till	B	5	5	
49-27	Coarse sand	B	10	5	
49-29	Coarse sand	B	10	5	
49-31	B. Till	B	25	5	
49-33	Sandy Till	B	15	10	
49-35	B. Till	B	60	15	
49-37	B. Till	B	15	5	
49-39	B. Till	B	35	40	
49-41	B. Till	B	60	140	
49-43	B. Till & coarse sand	B	300	800	
49-45	Residual	B	5	5	
49-47	B. Till	B	5	5	
49-49	B. Till	B	20	150	
49-51	B. Till & Residual	B	35	550	
49-53	B. Till & Residual	B	10	70	
49-55	B. Till	B	10	5	
49-57	B. Till	B	10	10	
49-59	B. Till & humus		140	270	
49-61	Residual Sandy Clay	B	10	5	
49-63	B. Till	B	40	50	
49-65	B. Till	B	50	40	
49-67	Residual (?)	B	10	5	0
49-69	Fine clayey sand	B	5	5	0
49-71	Fine clayey sand	B	40	25	0
49-73	B. Till (clayey)	B	15	5	0
49-75	B. Till (sandy)	B	250	140	30
49-77	B. Till (sandy)	B	15	15	0
49-79	B. Till (sandy)	B	40	45	0
49-81	B. Till (sandy)	B	40	10	0
49-85	B. Till (sandy)	B	25	80	0
49-85A	B. Till (sandy)	B	40	80	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
49- 2	Residual	B	10	550	0
49- 4	Residual (humus)	A & B	55	800	0
49- 6	Residual	B	350	4000	0
49- 8	Coarse sandy Till	B	15	90	0
49-10	Residual	B	30	15	0
49-12	Till	B	40	160	0
49-14	Till	B	45	90	0
49-16	Till	B	20	10	0
49-18	Till	B	30	10	0
49-20	Till (sandy)	B	30	30	0
49-22	Gray sand	B	30	5	0
49-24	Gray sand	B	55	160	0
49-26	Till	B	15	5	0
49-28	Till	B	40	55	0
49-30	Till	B	20	40	0
49-32	Till	B	35	20	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
50- 1	Coarse sand	B	50	25	0
50- 3	Gravelly sand	B	35	10	0
50- 5	Sandy Till	B	15	5	0
50- 7	Sandy Till	B	30	10	0
50- 9	Sandy Till	B	30	15	0
50-11	Beach sand	B	45	10	0
50-13	Fine sand	B	15	10	0
50-15	Green sand	B	15	10	0
50-17	B. Till	B	10	5	0
50-19	Sandy Till	B	15	5	0
50-21	Sandy Till	B	20	5	0
50-23	Fine beach sand	B	15	5	0
50-25	B. Till	B	30	10	0
50-27	B. Till	B	40	5	0
50-29	B. Till	B	35	5	0
50-31	B. Till	B	40	5	0
50-33	B. Till	B	20	5	0
50-35	B. Till	B	40	5	0
50-37	B. Till	B	40	10	0
50-39	Coarse beach sand	B	40	5	0
50-41	B. Till	B	35	20	0
50-43	B. Till (sandy)	B	35	5	0
50-45	B. Till	B	30	5	0
50-47	B. Till	B	30	5	0
50-49	B. Till (sandy)	B	25	5	0
50-51	Coarse sand	B	20	5	0
50-53	Coarse sand	B	20	5	0
50-55	Med. sand	B	15	5	0
50-57	B. Till	B	20	10	0
50-59	B. Till	B	35	5	0
50-61	B. Till	B	40	30	0
50-63	B. Till	B	30	10	0
50-65	Sandy (till?)	B	40	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
50- 2	Sandy till	B	15	5	0
50- 4	Residual	B	10	5	0
50- 6	Residual (leached)	A	10	5	0
50- 8	Residual	B	15	5	0
50-10	Residual (leached)	A	10	5	0
50-12	Till	B	20	10	0
50-14	Till	B	15	5	0
50-16	Blue clay, sandy	B & C	35	60	0
50-18	Sandy till	B	25	5	0
50-20	Sandy clay	B	30	20	0
50-22	Blue clay	-	20	10	0
50-24	Sandy clay	B	40	10	0
50-26	Sandy clay	B	25	60	0
50-28	Blue clay	-	15	5	0
50-30	B. Till	B	20	5	0
50-32	B. Till	B	35	5	0
50-34	B. Till	B	40	15	0
50-36	B. Till	B	15	10	0
50-38	B. Till (sandy)	B	15	5	0
50-40	Sandy Till	B	30	45	0
50-42	Sandy Till	B	10	10	0
50-44	Till	B	5	10	0
50-46	Blue clay	-	5	5	0
50-48	Sandy clay	B	5	5	0
50-50	Till	B	15	5	0
50-52	Blue clay	-	5	15	0
50-54	Till (Fe stained)	B	5	10	0
50-56	Till	B	5	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
51- 1	B. Till	B	5	5	0
51- 2	B. Till	B	5	5	0
51- 3	B. Till	B	5	5	0
51- 4	B. Till	B	5	5	0
51- 5	B. Till	B	5	5	0
51- 6	B. Till	B	5	5	0
1- 7	B. Till	B	10	10	0
)1- 8	B. Till	B	5	5	0
51- 9	B. Till	B	30	10	0
51-10	B. Till	B	5	10	0
51-11	B. Till	B	5	15	0
51-12	B. Till	B	20	10	0
51-13	B. Till	B	10	10	0
51-14	B. Till	B	15	5	0
15-15	B. Till	B	10	10	0
51-16	Fine sand	B	15	10	0
51-17	Clayey sand	B	30	20	0
51-18	Sandy Till	B	50	15	0
51-19	Sandy Till	B	30	30	0
51-20	B. Till	B	30	20	0
51-21	B. Till	B	35	20	0
51-22	B. Till	B	20	5	0
51-23	B. Till	B	120	10	0
)1-24	B. Till	B	20	15	0
51-25	B. Till	B	40	25	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
52- 1	Clayey blue sand	-	15	10	
52- 2	B. Till	B	10	5	
52- 3	B. Till	B	10	10	
52- 4	Sand	B	5	5	
52- 5	Sandy B. Till	B	10	10	
52- 6	Sandy Till	B	15	10	
52- 7	Gravelly sand	B	-	-	
52- 8	Gravelly outwash	B	20	10	
52- 9	B. Till	B	30	10	
52-10	Fine sand	B	10	10	
52-11	B. Till	B	15	10	
52-12	B. Till	B	10	10	
52-13	B. Till	B	15	10	
52-14	Residual & Till	B	10	10	
52-15	B. Till	B	10	5	
52-16	Fine sand	B	10	10	
52-17	Fine gravel	B	15	10	
52-18	Med. sand	B	10	5	
52-19	Med. sand	B	10	10	
52-20	Fine sand	B	10	10	
52-21	Med. sand	B	10	5	
52-22	Fine sand	B	10	10	
52-23	Fine sand	B	5	10	
52-24	Fine sand	B	10	10	
52-25	Sandy Till (?)	B	15	10	0
52-26	Sandy Till	B	15	10	0
52-27	Sandy Till	B	10	10	0
52-28		B	10	5	0
52-29	Compact white clay	B	20	20	0
52-30	Fine clayey sand	B	20	20	0
52-31	Blue clayey sand	B	20	20	0
52-32	Sandy Till	B	40	25	0
52-33	B. Till	B	20	10	0
52-34	B. Till	B	90	10	0
52-35	B. Till	B	20	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
53- 1	B. Till	B	15	30	
53- 2	B. Till	B	20	5	
53- 3	B. Till	B	15	10	
53- 4	B. Till	B	15	10	
53- 5	Sand	B	40	10	
53- 6	B. Till	B	25	10	
53- 7	B. Till	B	15	10	
3- 8	B. Till	B	20	5	
53- 9	B. Till	B	20	5	
53-10	B. Till	B	20	10	
53-11	B. Till	B	20	10	
53-12	B. Till	B	15	5	
53-13	B. Till	B	15	5	
53-14	B. Till	B	10	5	
53-15	B. Till & sand	B	15	15	
53-16	B. Till	B	10	10	
53-17	B. Till	B	15	5	
53-18	B. Till	B	25	10	
53-19	B. Till	B	15	5	
53-20	B. Till	B	15	10	
53-21	Sandy Till	B	20	10	
53-22	Clay	B	10	10	
53-23	B. Till	B	10	10	
53-24	B. Till (sandy)	B	15	10	
3-25	Sandy B-Till	B	20	20	
53-26	Till & Slump	B	15	15	
53-27	B. Till	B	15	10	
53-28	B. Till	B	10	5	
53-29	Residual	B	10	10	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
54- 1	B Till	B	45	150	0
54- 2	Med. sand	B	40	20	0
54- 3	Blue clay		50	15	0
54- 4	Sand	B	50	15	0
54- 5	Med. outwash sand	B	40	10	0
54- 6	B-Till	B	35	10	0
54- 7	B-Till	B	20	15	0
54- 8	B-Till (clayey)	B	25	15	0
54- 9	B-Till	B	30	10	0
54-10	B-Till	B			0
54-11	Clayey sand	B	15	5	0
54-12	B-Till	B	60	30	0
54-13	Blue sandy clay		10	5	0
54-14	B-Till	B	15	30	0
54-15	B-Till	B	15	10	0
54-16	B-Till	B	25	20	0
54-17	B-Till	B	10	35	0
54-18	Blue clay		20	5	0
54-19	Till	B	10	5	0
54-20	Clayey till	B	30	10	0
54-21	Blue clay		10	20	0
54-22	Sandy Till	B	5	10	0
54-23	Till	B	5	5	0
54-24	Till	B	15	10	0
54-25	Till (clayey)	B	15	10	0
54-26	Till	B	50	15	0
54-27	Till	B	40	15	0
54-28	Sandy Till	B	10	10	0
54-29	Sandy Till	B	20	10	0
54-30	Sandy Till	B	15	10	0
54-31	Till	B	10	5	0
54-32	Till	B	25	10	0
54-33	Till	B			0
54-34	Till	B	30	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
55- 1	B Till	B	15	10	0
55- 2	B Till	B	40	10	0
55- 3	B Till	B	15	30	0
55- 4	B Till	B	15	10	0
55- 5	B Till	B	20	10	0
55- 6	B Till	B	40	10	0
55- 7	B Till	B	90	15	0
- 8	B Till	B	50	10	0
55- 9	B Till	B	30	10	0
55-10	B Till	B	40	10	0
55-11	B Till	B	50	10	0
55-12	B Till	B	20	10	0
55-13	B Till	B	30	20	0
55-14	B Till	B	25	10	0
55-15	B Till	B	20	10	0
55-16	B Till (sandy)	B	25	25	0
55-17	B Till (sandy)	B	55	10	0
55-18	Till	B	20	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
56- 1	B-Till	B	15	10	0
56- 2	B-Till	B	20	10	0
56- 3	B-Till	B	140	5	0
56- 4	B-Till	B	20	20	0
56- 5	B-Till	B	30	20	0
56- 6	B-Till	B	10	15	0
56- 7	Sand	B	15	10	0
56- 8	B-Till	B	25	10	0
56- 9	B-Till	B	45	20	0
56-10	B-Till	B	45	10	0
56-11	B-Till	B	50	20	0
56-12	Blue clay	B	10	15	0
56-13	B-Till	B	35	15	0
56-14	B-Till	B	20	20	0
56-15	B-Till (sandy)	B	15	10	0
56-16	B-Till (sandy)	B	10	10	0
56-17	B-Till (sandy)	B	20	15	0
56-18	B-Till (sandy)	B	10	10	0
56-19	Fine clayey sand	B	15	15	0
56-20	B-Clay	B	10	10	0
56-21	B-Clay	B	35	20	0
56-22	Sandy clay	B	10	20	0
56-23	B-Till	B	10	10	0
56-24	B-Till	B	20	15	0
56-25	B-Till	B	25	20	0
56-26	B-Till	B	110	15	0
56-27	B-Till	B	35	15	0
56-28	B-Till	B	15	10	0
56-29	B-Clay	B	15	10	0
56-30	B-Clay	B	30	15	0
56-31	Sandy clay	B	20	10	0
56-32	B-Till (sandy)	B	40	10	0
56-33	B-Till (sandy)	B	20	15	0
56-34	B-Till	B	60	15	5
56-35	Sand	B	15	25	0
56-36	B-Till (sandy)	B	45	5	0
56-37	Clay	B	20	10	0
56-38	Clay	B	25	5	0
56-39	Till	B	10	5	0
56-40	Clay	B	30	5	0
56-41	Blue clay	B	25	5	0
56-42	Blue clay	B	15	10	0
56-43	Clay	B	40	5	0
56-44	Till	B	20	10	0
56-45	Sandy Till	B	10	5	0
56-46	Sandy Till	B	30	15	0
56-47	Till (leached)	A	15	5	0
56-48	Blue clay	B	10	15	0
56-49	Till	B	40	20	0
56-50	Till (clayey)	B	30	10	0
56-51	Till (sandy)	B	40	10	0
56-52	Till (sandy)	B	10	10	0
56-53	Till (sandy)	B	20	10	0
56-54	Fine sand	B	15	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
56-55	Till	B	15	10	0
56-56	Till	B	50	25	0
56-57	Clay	B	10	5	0
56-58	Till	B	20	10	0
56-59	Till	B	20	10	0
56-60	B-Till	B	50	10	0
56-61	B-Till	B	10	10	0
6-62	B-Till	B	35	10	0
56-63	B-Till	B	30	10	0
56-64	B-Till	B	40	10	0
56-65	B-Till	B	10	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
57- 1	Blue clay		15	10	
57- 2	B. Till	B	5	5	
57- 3	B. Till	B	15	5	
57- 4	B. Till	B	10	10	
57- 5	Sandy Till	B	10	10	
57- 6	Sandy Till	B	10	10	
57- 7	Sandy Till	B	10	5	
57- 8	Sandy Till	B	10	5	
57- 9	Sandy Till	B	5	5	
57-10	Sandy Till	B	10	5	
57-11	Residual, clayey	B	10	5	
57-12	Residual, clayey	B	5	5	
57-13	Till	B	5	5	
57-14	Till	B	5	5	
57-15	Till	B	20	5	
57-16	Fine sand	B	10	10	
57-17	Till	B	300	100	
57-18	Brown clay	B	10	10	
57-19	B. Till	B	10	10	
57-20	B. Till	B	15	40	
57-21	B. Till	B	10	10	
57-22	B. Till (sandy)	B	10	15	
57-23	B. Till	B	10	10	
57-24	B. Till	B	15	10	
57-25	B. Till	B	30	10	
57-26	B. Till	B	40	5	
57-27	B. Till	B	15	15	
57-28	B. Till	B	15	10	
57-29	B. Till	B	10	5	
57-30	B. Till (sandy)	B	10	10	
57-31	B. Till	B	20	10	
57-32	B. Till	B	10	10	
57-33	B. Till	B	10	10	
57-34	B. Till (sandy)	B	10	10	
57-35	B. Till	B	10	25	
57-36	B. Till	B	15	5	
57-37	B. Till	B	20	15	
57-38	B. Till (sandy)	B	25	50	
57-39	B. Till	B	25	15	
57-40	B. Till	B	15	10	
57-41	Till	B	40	80	
57-42	Till	B	30	30	
57-43	Till	B	25	60	
57-44	Till	B	30	30	
57-45	Till	B	20	20	
57-46	Sand	B	10	20	
57-47	Sand	B	25	40	
57-48	Slump	B	15	25	
57-49	Till	B	15	25	
57-50	Slump & Till	B	15	10	
57-51	Slump & Till	B	15	10	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
58- 1	Blue clay and Sand	B	15	10	0
58- 3	Sand	B	10	5	0
58- 5	Blue sand	B	15	10	0
58- 7	Till (sandy)	B	20	15	0
58- 9	Till (sandy)	B	15	10	0
58-11	Till (sandy)	B	10	5	0
58-13	Till (sandy)	B	10	15	0
58-15	Yellow clay	B	5	10	0
58-17	Sand	B	10	5	0
58-19	B-Till (Sandy)	B	5	5	0
58-21	Blue clay		25	15	0
58-23	Yellow clay	B	10	10	0
58-25	B-Till	B	20	10	0
58-27	B-Till	B	15	10	0
58-29	B-Till	B	30	20	0
58-31	B-Till	B	20	10	0
58-33	B-Till	B	25	10	0
58-35	B-Till	B	45	10	0
58-37	Sand	B	15	10	0
58-39	Till (sandy)	B	25	20	0
58-41	Till (sandy)	B	20	15	0
58-43	B-Till	B	25	20	0
58-45	B-Till	B	45	15	0
58-47	B-Till	B	60	35	0
58-49	B-Till	B	35	20	0
58-51	Sand	A	55	20	0
58-53	Blue clay		30	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
58- 2	Till	B	10	10	0
58- 4	Till	B	10	10	0
58- 6	Till (sandy)	B	20	10	0
58- 8	Till (sandy)	B	10	5	0
58-10	Till	B	20	10	0
58-12	Till (sandy)	B	10	15	0
58-14	Till (clayey)	B	10	10	0
58-16	Sandy clay	B	10	10	0
58-18	Till	B	15	10	0
58-20	Till	B	10	5	0
58-22	Till (sandy)	B	50	25	0
58-24	Till	B	45	15	0
58-26	Till	B	30	10	0
58-28	Clay	B	30	15	0
58-30	Sandy clay	B	15	5	0
58-32	Sandy clay	B	15	10	0
58-34	Clay	B	30	25	0
58-36	Till	B	45	25	0
58-38	Clay	B	15	15	0
58-40	Fine sand	B	10	20	0
58-42	Till	B	15	20	0
58-44	Till	B	20	25	0
58-46	Fine sand	B	15	25	0
58-48	Till	B	10	10	0
58-50	Till	B	20	5	0
58-52	Clay	B	15	25	0
58-54	Till	B	10	10	0
58-56	Sandy Till	B	30	35	0
58-58	Till	B	40	15	0
58-60	Coarse sand	B	60	10	0
58-62	Fine sand	B	30	10	0
58-64	Sandy till	B	15	10	0
58-66	Till	B	20	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
59- 1	B-Till	B	30	15	0
59- 2	Clayey sand	B	20	35	0
59- 3	B-Till	B	30	50	0
59- 4	B-Till	B	20	5	0
59- 5	B-Till (sandy)	B	20	15	0
59- 6	Blue clay		30	25	0
59- 7	B-Till	B	40	10	0
59- 8	B-Till	B	35	10	0
59- 9	Coarse sand	B	45	20	0
59-10	Sandy Till	B	20	25	0
59-11	B-Till	B	20	10	0
59-12	Gravelly Till	B	45	35	0
59-13	Gravelly Till	B	20	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
60- 1	Clayey Sand (Blue)		15	15	0
60- 3	Gravelly sand	B	20	30	0
60- 5	Fine sand	B	15	5	0
60- 7	Coarse sand	B	25	25	0
60- 9	Gravelly sand	B	10	10	0
60-11	Clayey sand	B	25	5	0
60-13	Gravelly sand	B	40	10	0
-15	Gravelly sand	B	20	10	0
60-17	B. Till	B	10	15	0
60-19	B. Till (Bluish)	B	15	15	0
60-21	B. Till (Bluish)	B	20	5	0
60-23	Till (Sandy, bluish)	B	15	10	0
60-25	Fine clayey sand (Boulders)	B	15	10	0
60-27	Clayey, residual (?)	B	10	5	0
60-29	Clayey sand	B	35	15	0
60-31	Clayey sand (Blue)		25	10	0
60-33	Clayey sand (Blue)		15	15	0
60-35	B. Till (Clayey)	B	10	5	0
60-37	B. Till	B	15	10	0
60-39	B. Till	B	25	10	0
60-41	B. Till	B	10	5	0
60-43	B. Till	B	5	5	0
60-45	B. Till (very sandy), packed	B	20	5	0
60-47	Sandy till (?) packed	B	20	25	0
60-49	B. Till	B	25	10	0
60-51	B. Till	B	20	15	0
60-53	B. Till	B	20	15	0
60-55	B. Till	B	20	20	0
60-57	B. Till	B	20	5	0
60-59	B. Till	B	35	10	0
60-61	B. Till	B	10	10	0
60-63	B. Till	B	50	30	0
60-65	Clayey sand	B	45	30	0
60-67	Clayey sand	B	25	15	0
60-69	B. Till	B	25	15	0
60-71	Blue clay		30	15	0
60-73	B. Till	B	35	15	0
60-75	B. Till	B	25	5	0
60-77	Till (sandy)	B	50	10	0
60-79	Till	B	15	5	0
60-81	Blue clay		20	10	0
60-83	Yellow clay	B	20	10	0
60-85	Clayey sand (yellow)	B	35	10	0
60-87	B. Till (clayey)	B	25	10	0
60-89	B. Till	B	40	10	0
60-91	B. Till	B	25	10	0
60-93	B. Till	B	65	10	0
60-95	B. Till	B	65	15	0
60-97	B. Till (Bluish)	B	15	10	0
60-99	Till (sandy)	B	30	5	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
60-101	Till	B	10	10	0
60-103	Till (sandy)	B	30	10	0
60-105	Clayey sand (Brown)	B	25	10	0
60-107	B. Till	B	30	10	0
60-109	Clayey sand	B	25	10	0
60-111	Clayey sand	B	15	10	0
60-113	B. Till	B	30	10	0
60-115	Till (sandy)	B	25	10	0

Sample No.	S.T.	S.H.	Zn	Cu	Pb	Lab no.
60- 2	Till (clayey)	B	25	20	0	16294
4	Sand (washed)	"	15	10	0	5
6	sand	"	25	15	0	6
8	clayey sand	"	20	10	0	7
10	till (sandy)	"	15	30	0	8
12	till (coarse sandy)	"	30	20	0	9
14	clayey sand	"	35	15	0	300
16	" "	"	30	10	0	1
18	till (sandy)	"	35	10	0	2
20	till "	"	70	15	0	3
22	" "	"	35	30	0	4
24	sandy clay	"	35	10	0	5
26	" "	"	25	10	0	6
28	till	"	28	10	0	7
30	"	"	35	10	0	8
32	sandy till	"	45	10	0	9
34	" "	"	35	15	0	10
36	" "	"	35	10	0	1
38	till	"	30	15	0	2
40	sandy till	"	50	25	0	3
42	" "	35	35	15	0	4
44	" "	"	35	15	0	5
46	" "	"	45	15	0	6
48	" "	"	25	10	0	7
50	" "	"	20	10	0	8
52	till	"	40	10	0	9
54	fine sand	"	25	15	0	20
56	" "	"	10	10	0	1
58	" "	"	20	20	0	2
60	" "	"	25	10	0	3
62	" "	"	30	10	0	4

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
61- 1	B. Till	B	20	10	0
61- 2	B. Till	B	35	15	0
61- 3	B. Till	B	30	15	0
61- 4	Blue clay		25	15	0
61- 5	B. Till	B	30	15	0
61- 6	B. Till	B	15	10	0
61- 7	Sand (med.)	B	10	5	0
61- 8	Till (sandy)	B	15	15	0
61- 9	B. Till	B	25	25	0
61-10	B. Till	B	15	20	0
61-11	B. Till	B	30	10	0
61-12	B. Till	B	35	25	0
61-13	B. clay	B	35	20	0
61-14	Sandy clay (Blue)		30	20	0
61-15	B. Till	B	5	10	0
61-16	B. Till	B	50	15	0
61-17	B. Till	B	20	25	0
61-18	B. Till	B	10	15	0
61-19	B. Till	B	15	20	0
61-20	Blue clay		20	5	0
61-21	Blue clay		45	25	0
61-22	Blue clay		10	10	0
61-23	Blue (clayey)		15	10	0
61-24	Coarse sand	B	60	35	0
61-25	Fine clayey sand	B	20	15	0
61-26	Brown clay	B	35	20	0
61-27	B. Till	B	15	10	0
61-28	Blue clay & sand		20	20	0
61-29	Blue clay		20	10	0
61-30	Blue clay		20	15	0
61-31	Sandy clay (yellow)	B	15	10	0
61-32	B. Till	B	15	10	0
61-33	Yellow clay (Till?)	B	30	15	0
61-34	Yellow clay (Till?)	B	15	15	0
61-35	B. Till	B	55	40	0
61-36	B. Till	B	55	30	0
61-37	B. Till	B	25	15	0
61-38	Till (sandy)	B	10	10	0
61-39	Fe sand	B	10	5	0
61-40	Fine sand	B	20	10	0
61-41	B. Till	B	25	5	0
61-42	B. Till	B	30	15	0
61-43	B. Till	B	70	45	0
61-44	B. Till	B	35	10	0
61-45	B. Till (sandy)	B	40	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
62- 1	B. Till (clayey)	B	20	10	0
62- 2	B. Till	B	30	5	0
62- 3	B. Till	B	25	10	0
62- 4	Sandy till	B	15	10	0
62- 5	Sand	A	15	5	0
62- 6	Find sand (Blue)	B	15	15	0
62- 7	B. Till	B	15	5	0
62- 8	B. Till (clayey)	B	10	5	0
62- 9	Brown clay	B	15	15	0
62-10	B. Till	B	15	15	0
62-11	Coarse sandy mat.	B	15	10	0
62-12	B. Till	B	20	10	0
62-13	B. Till	B	15	5	0
62-14	B. Till	B	15	5	0
62-15	B. Till	B	30	15	0
62-16	B. Till	B	35	20	0
62-17	B. Till	B	10	5	0
62-18	B. Till	B	15	10	0
62-19	B. Till	B	20	10	0
62-20	B. Till	B	25	15	0
62-21	B. Till	B	50	15	0
62-22	B. Till	B	15	10	0
62-23	B. Till	B	25	10	0
62-24	B. Till	B	25	5	0
62-25	B. Till	B	25	10	0
62-26	B. Till	B	35	10	0
62-27	B. Till (clayey)	B	15	5	0
62-28	Clayey sand	B	30	10	0
62-29	B. Till (sandy)	B	10	15	0
62-30	B. Till	B	10	15	0
62-31	Clayey sand (Blue)		15	30	0
62-32	Till (sandy)	B	20	25	0
62-33	Boulder Till	B	20	10	0
62-34	B. Till (clayey)	B	25	15	0
62-35	B. Till (sandy)	B	25	20	0
62-36	B. Till (clayey)	B	30	10	0
62-37	Bl Till	B	15	80	0
62-38	Clayey sand	B	25	15	0
62-39	B. Till (Clayey)	B	30	10	0
62-40	B. Till (clayey)	B	25	15	0
62-41	B. Till (sandy)	B	25	15	0
62-42	B. Till (sandy)	B	25	20	0
62-43	B. Till (sandy)	B	20	15	0
62-44	B. Till (sandy)	B	30	10	0
62-45	B. Till (very coarse)	B	50	10	0
62-46	Sand (medium)	B	20	15	0
62-47	Till (sandy)	B	30	15	0
62-48	Till (sandy)	B	10	10	0
62-49	Clayey sand (blue)		25	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
63- 1	B. Till	B	60	60	0
63- 2	B. Till (clayey)	B	55	90	0
63- 3	B. Till	B	50	10	0
63- 4	B. Till	B	20	10	0
63- 5	B. Till	B	30	15	0
63- 6	B. Till	B	15	20	0
63- 7	B. Till	B	45	90	0
63- 8	B. Till	B	35	160	0
63- 9	B. Till	B	20	45	0
63-10	B. Till (clayey)	B	20	30	0
63-11	B. Till	B	15	60	0
63-12	B. Till	B	45	180	0
63-13	B. Till	B	45	400	10
63-14	Slump	B	10	400	0
63-15	Clayey Till	B	55	600	0
63-16	Yellow clay	B	30	45	0
63-17	Yellow clay (sandy)	B	55	260	0
63-18	B. Till	B	35	25	0
63-19	B. Till	B	35	30	0
63-20	B. Till	B	45	30	0
63-21	B. Till	B	15	10	0
63-22	B. Till	B	45	15	0
63-23	B. Till	B	45	10	0
63-24	B. Till	B	30	10	0
63-25	B. Till	B	20	10	0
63-26	Clayey Till	B	20	10	0
63-27	B. Till	B	15	10	0
63-28	Yellow clay	B	50	35	0
63-29	Med. sand	B	55	10	0
63-30	B. Till	B	40	10	0
63-31	B. Till	B	55	55	0
63-32	B. Till (clayey)	B	45	30	0
63-33	B. Till	B	50	25	0
63-34	B. Till	B	45	30	0
63-35	B. Till	B	50	45	0
63-36	B. Till	B	40	25	0
63-37	B. Till	B	50	20	0
63-38	B. Till	B	50	15	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
64- 1	Beach sand	B	35	5	0
64- 2	B. Till	B	50	30	0
64- 3	B. Till	B	20	25	0
64- 4	B. Till	B	40	25	0
64- 5	B. Till	B	25	5	0
64- 6	B. Till (sandy)	B	35	30	0
64- 7	Yellow clay	B	20	20	0
64- 8	B. Till	B	25	35	0
64- 9	Sandy Till (?)	B	55	60	0
64-10	B. Till (?)	B	35	5	0
64-11	B. Till	B	50	10	0
64-12	Yellow clay	B	50	40	0
64-13	B. Till	B	40	30	0
64-14	B. Till	B	50	15	0
64-15	Sand	B	25	20	0
64-16	Blue clay		50	20	0
64-17	Med. sand	B	30	25	0
64-18	Sandy Till	B	50	25	0
64-19	Sandy Till	B	50	15	0
64-20	Med. sand	B	30	10	0
64-21	Blue Clayey sand	B	20	5	0
64-22	Till (sandy)	B	45	5	0
64-23	B. Till	B	40	15	0
64-24	B. Till	B	25	15	0
64-25	B. Till	B	40	20	0
64-26	Sandy Till	B	50	25	0
64-27	B. Till	A & B	20	15	
64-28	B. Till	B	10	10	
64-29	B. Till	B	5	5	
64-30	B. Till	B	15	10	
64-31	B. Till	B	15	15	
64-32	B. Till	B	15	20	

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
65- 1	B. Till	B	55	5	0
65- 2	B. Till	B	50	10	0
65- 3	B. Till	B	60	45	0
65- 4	B. Till	B	15	10	0
65- 5	B. Till	B	45	15	0
65- 6	B. Till	B	35	20	0
65- 7	B. Till	B	10	10	0
65- 8	Sandy Till	B	50	15	0
65- 9	B. Till	B	30	35	0
65-10	B. Till (clayey)	B	35	20	0
65-11	B. Till	B	50	20	0
65-12	B. Till	B	30	20	0
65-13	B. Till	B	40	10	0
65-14	B. Till	B	45	15	0
65-15	B. Till (sandy)	B	60	15	0
65-16	Blue clay		35	20	0
65-17	B. Till	B	45	45	0
65-18	B. Till	B	35	30	0
65-19	B. Till (clayey)	B	30	10	0
65-20	B. Till (clayey)	B	45	15	0
65-21	B Till (")	B	45	30	0
65-22	B. Till	B	35	20	0
65-23	B. Till	B	55	20	0
65-24	B. Till	B	30	15	0
65-25	B Till	B	35	20	0
65-26	Brown clay	B	45	15	0
65-27	Blue clay	B & C	35	15	0
65-28	Blue clay		40	21	0
65-29	B. Till	B	40	30	0
65-30	B. Till	B	45	15	0
65-31	Blue clay		40	15	0
65-32	B. Till	B	40	30	0
65-33	B. Till	B	30	10	0
65-34	B. Till	B	30	15	0
65-35	B. Till	B	25	5	0
65-36	B. Till (Fe stained)	B	35	10	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
66- 1	Blue clay		50	10	0
66- 2	B. Till	B	35	45	0
66- 3	B. Till	B	35	15	0
66- 4	B. Till	B	40	35	0
66- 5	B. Till	B	35	20	0
66- 6	Blue clay		35	15	0
66- 7	Clayey sand	B	45	15	0
66- 8	Blue clay		35	15	0
66- 9	B. Till (clayey)	B	35	10	0
66-10	B. Till	B	70	15	0
66-11	B. Till	B	55	20	0
66-12	B. Till	B	45	10	0
66-13	B. Till	B	35	5	0
66-14	B. Till	B	45	15	0
66-15	Beach sand (blue)		65	10	0
66-16	B. Till	B	55	10	0
66-17	B. Till	B	55	15	0
66-18	B. Till	B	40	15	0
66-19	Fine sand	B	30	5	0
66-20	B. Till	B	45	15	0
66-21	Blue clay		60	10	0
66-22	B. Till (sandy)	B	35	10	0
66-23	B. Till (gravelly)	B	45	10	0
66-24	B. Till (gravelly)	B	20	5	0
66-25	B. Till	B	35	15	0
66-26	B. Till	B	120	15	0
66-27	B. Till	B	50	20	0
66-28	B. Till	B	35	15	0
66-29	B. Till (sandy)	B	45	5	0
66-30	B. Till	B	90	25	0
66-31	Clay	B & C	45	20	0
66-32	B. Till	B	45	10	0
66-33	Clay	B	30	20	0
66-34	Clay	B	15	5	0
66-35	B. Till	B	30	25	0
66-36	B. Till	B	50	10	0
66-37	B. Till	B	70	10	0
66-38	B. Till	B	50	15	0
66-39	B. Till	B	45	20	0
66-40	Fine sand	B	20	5	0
66-41	Blue sandy clay	B & C	35	10	0
66-42	Sandy Till	B	30	20	0
66-43	B. Till	B	35	25	0
66-44	Beach sand (Fe stained)	B	140	15	0
66-45	Sand & Blue clay	B & C	45	30	0

Samples No.	Soil Type	S.H.	Zn	Cu	Pb
67- 1	Brown clay	B	30	10	0
67- 2	B clay	B	25	5	0
67- 3	B clay	B	30	10	0
67- 4	B Till	B	25	5	0
67- 5	Clayey Till	A & B	30	5	0
67- 6	Clayey Till	B	60	15	0
67- 7	Residual clay (?)	B	20	25	0

Samples No.	Soil Type.	S.H.	Zn	Cu	Pb
H- 1	Fine sand (esker)	C	43	38	0
H- 2	Med. sand (esker)	C	25	18	0
H- 5	Coarse gravel (esker)	B	25	31	0
H- 6	Fine sand (esker)	C	37	25	0
H- 7	Clay (bluish) (esker)	C	56	25	0

Photo 1 - [illegible] Campbell
[illegible] .

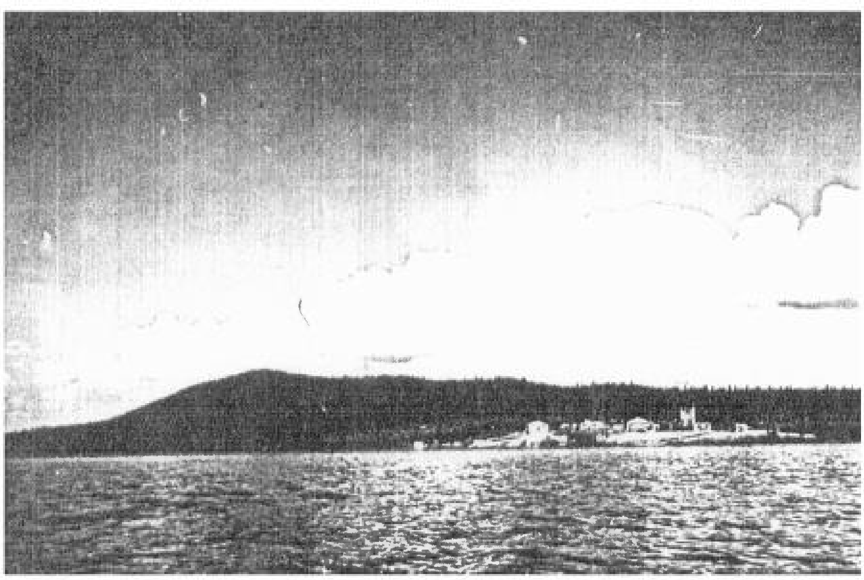


Photo 2 - "Crag and tail" or penninsula separating
Dore and Chibougamau Lakes.

Photo 3

Photo 4

Photo 5

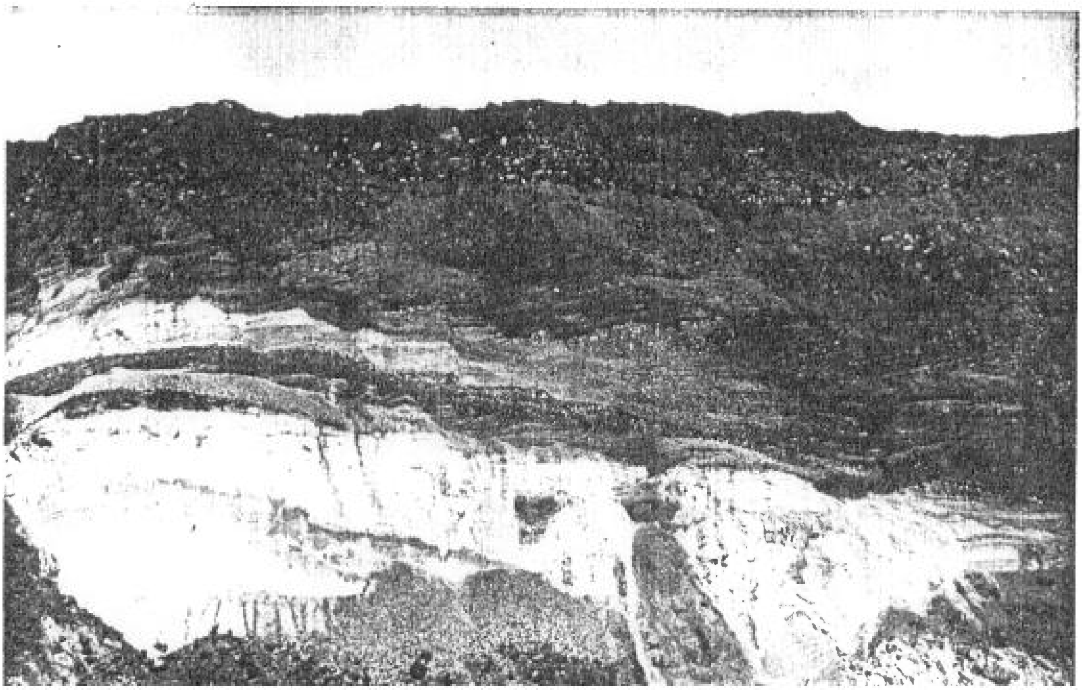


Photo 6

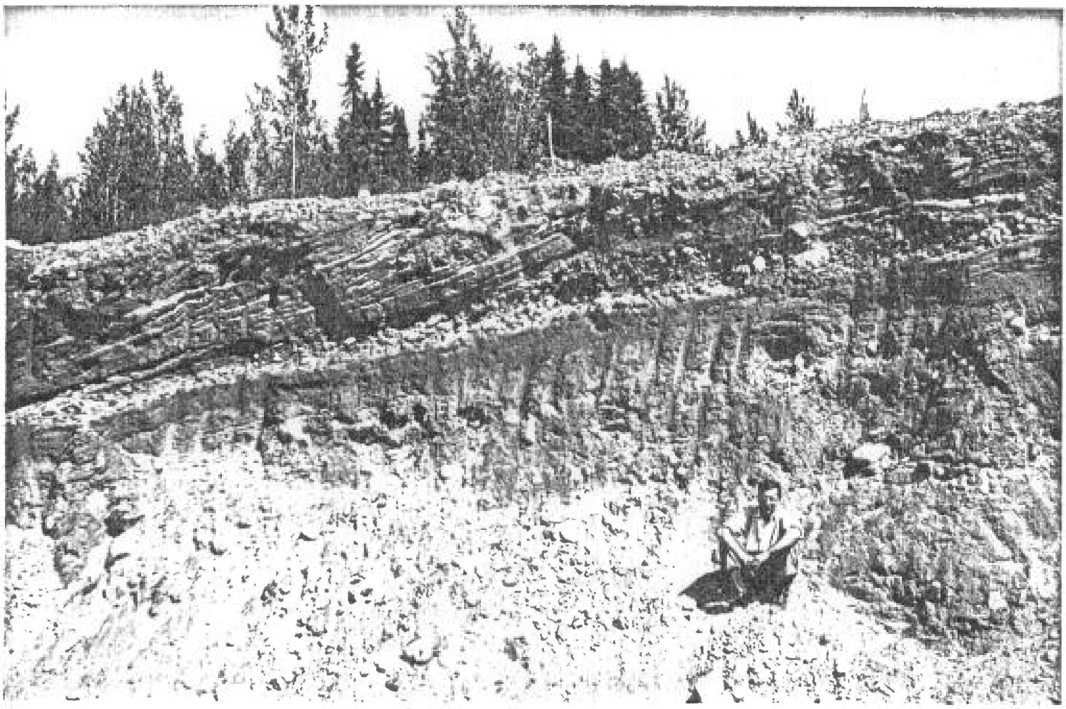


Photo 7

Photos 3 - 7 - Sections across esker between Cache and Dore Lakes.