

GEOLOGICAL  
SURVEY  
OF  
CANADA

DEPARTMENT OF ENERGY,  
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PAPER 67-23  
Part II

PROGRESS REPORT ON BIOGEOCHEMICAL RESEARCH  
AT THE  
GEOLOGICAL SURVEY OF CANADA  
1963-1966

J.A.C. Fortescue and E.H.W. Hornbrook



**GEOLOGICAL SURVEY  
OF CANADA**

**PAPER 67-23**  
Part II

**PROGRESS REPORT ON BIOGEOCHEMICAL RESEARCH  
AT THE GEOLOGICAL SURVEY OF CANADA 1963-1966**

- E    Geobotanical and soil geochemical investigations during visits  
to eight landscapes with undisturbed mineral deposits.  
J.A.C. Fortescue and Lily Usik**
- F    Two quick projects, one at a massive sulphide orebody near  
Timmins, Ontario and the other at a copper deposit in  
Gaspé Park, Quebec.  
J.A.C. Fortescue and E.H.W. Hornbrook**
- G    A pilot project at the Silvermine lead deposit,  
Cape Breton Island, Nova Scotia.  
E.H.W. Hornbrook**
- H    A biogeochemical investigation at Mer Bleue bog.  
J.A.C. Fortescue and Lily Usik**

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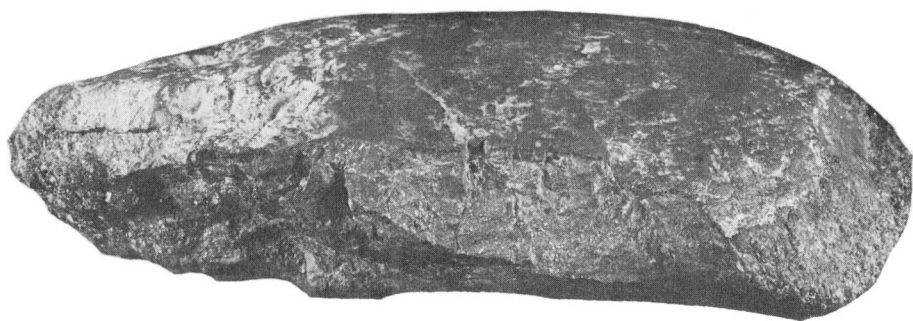
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Frontispiece: Specimen of ore material taken from a test pit located on Line 26S at the Kidd Creek orebody of the Texas Gulf Sulphur deposit near Timmins, Ontario. Note the polished top surface of the specimen without any trace of chemical weathering even though the specimen was collected within 20 feet of the surface of the ground.





## FOREWORD

The initial stage of a biogeochemical research program, commenced at the Geological Survey of Canada in January 1963, was planned to last for five years. This report is the second part of a progress report describing the research during the first four years of the program. A brief review of the theoretical background and general objectives of the program was made in Part I. Descriptions of laboratory facilities, and field, laboratory and data plotting methods specifically adapted for the program, and the results of four greenhouse feasibility experiments were also described in Part I.

Part II describes field experience gained from the investigation of eleven mineral deposits which had been outlined and tested by diamond drilling but were otherwise undisturbed and thus could be regarded as normal and uncontaminated for the purposes of biogeochemical and related surveys above and near them. Also included is a description of an investigation carried out in a peat bog near Ottawa. The investigations were carried out during the summers of 1964, 1965 and 1966. Part II presents examples of the method of investigation proposed as the systematic approach to biogeochemical research (see Part I, Section C). Briefly, a Visit is the investigation by field observations of the geology, botany, etc. of a chosen area near a drilled, undisturbed mineral deposit, made within one or two days during a summer. Its purpose is to evaluate the suitability of the area for further investigation. At the end of the summer three or four areas are selected for Pilot Project study the following summer. A Pilot Project for a selected area is made during an 'instant of time' (see Part I, Section A) of less than thirty days. Thus first hand information is obtained from as many deposits as practical but only those fulfilling certain designated criteria are investigated in greater detail. A third type of investigation, a Quick Project, is undertaken at a mineral deposit that will be disturbed by stripping or mining shortly after it has been brought to the attention of the researchers and before a Pilot Project can be planned and undertaken.

Part II begins with a summary of the background of the research program as an introduction and continues with a brief summary of the findings of the research described later in detail in Sections E, F and G. (Sections A, B, C and D were in Part I). This summary provides the reader with a concise statement of the gist of the report so that he may choose which parts of the detailed sections to read first. The report concludes with a brief section describing the study made of the Mer Bleue bog near Ottawa.



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PROGRESS REPORT ON BIOGEOCHEMICAL RESEARCH  
AT THE GEOLOGICAL SURVEY OF CANADA  
1963-1966

PART II

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GENERAL INTRODUCTION

Research into the scope of biogeochemical or geobotanical prospecting methods must take into account a consideration of the features of the landscape in which an investigation is undertaken and the chemical relationships between individual components of the landscape, i.e. the bedrock, surficial material<sup>1</sup>, soil and vegetation (see Part I, Section A for more details of this approach). Fully effective investigations of this kind are best carried out in landscapes where there is no serious contamination of the surficial material, soil, or plant components by chemicals dissolved in mine waters or by material derived from mining operations. For this reason landscapes in which diamond drilled, but undisturbed, mineral deposits occur have been selected for investigation. At any one time suitable mineral deposits at this stage of development are relatively rare in Canada and consequently the research program must be flexible enough so that areas can be examined at short notice prior to their disturbance. An advantage of this approach is that it allows for application of the same field methods in different landscapes within the same, or different, geographic, geologic, or phytogeographic areas. The presentation of comparable sets of geochemical and biogeochemical data in case study form as presented in this part of the report, should facilitate the interpretation of data obtained by exploration geologists and geochemists in other areas of similar landscape.

This objective may be realized by the method of investigation and selection of field study areas described in Part I, Section C, of this report and summarized in flow sheet form on Figure 1. Examples of Visits, Quick Projects and a Pilot Project are also given in Figure 1. These examples (whose locations are shown in Fig. 2) were chosen during the development of the approach and may not be as comprehensive as similar future investigations carried out when more is known of the physico-chemical processes of

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<sup>1</sup>By 'surficial material' is meant material lying between the bedrock surface and the ground surface.

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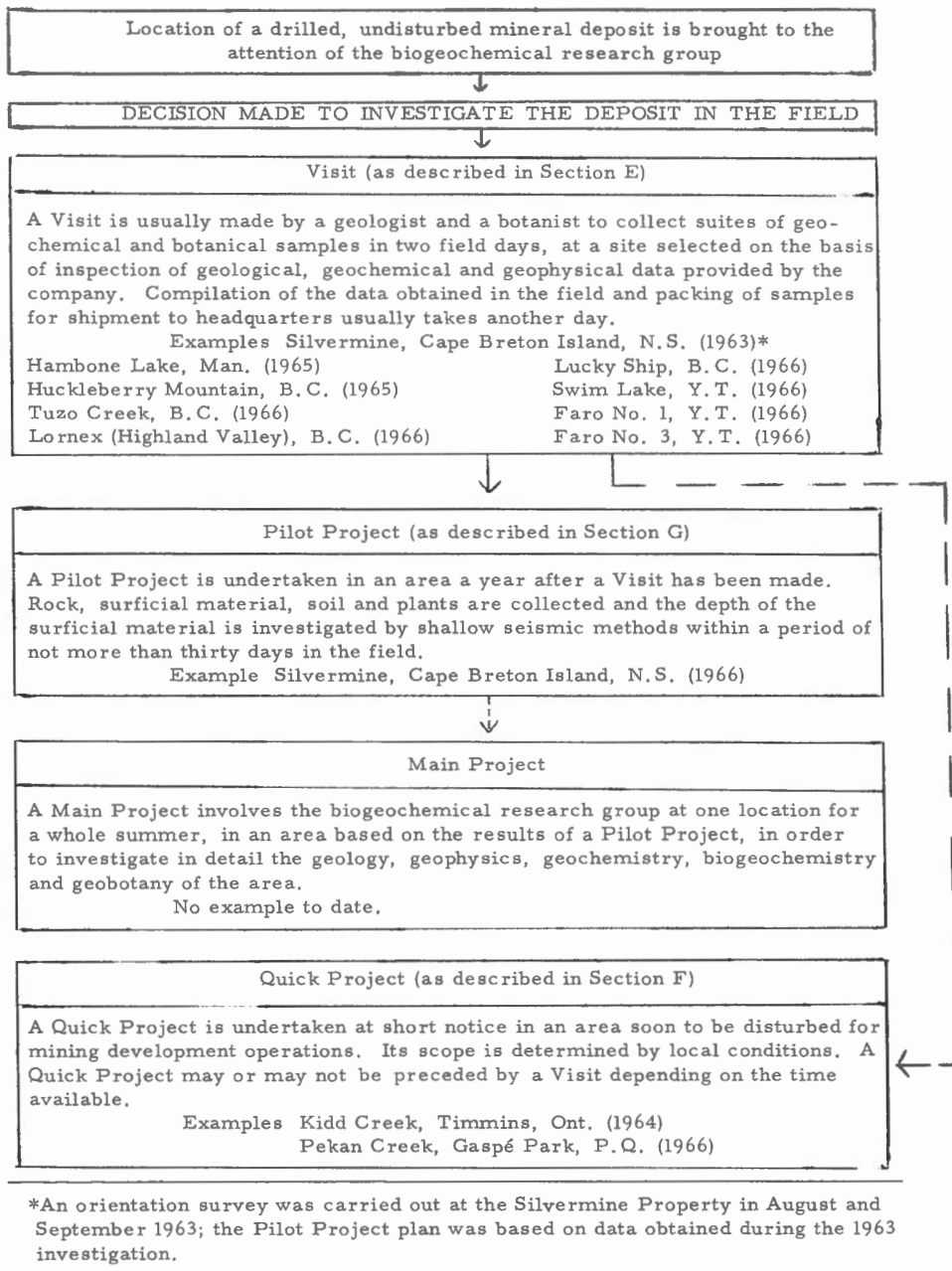


Figure 1. Flow Sheet showing the scope and relationships of field investigations made at drilled, undisturbed mineral deposits between 1964 and 1966.

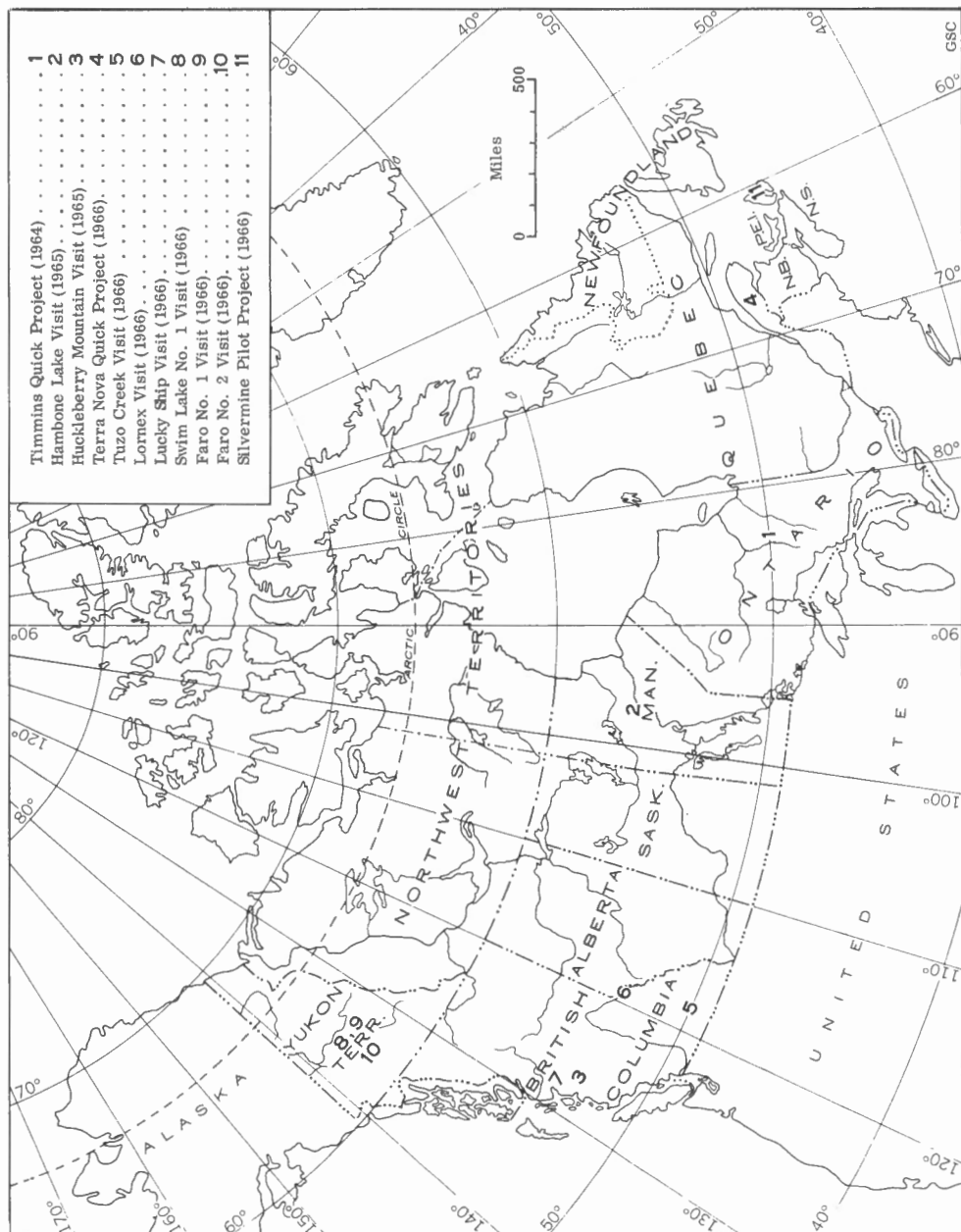


Figure 2. Location of drilled, undisturbed mineral deposits where biogeochemical research was undertaken, 1963-1966

biogeochemistry. Figure 1 shows provision for a fourth type of project, a Main Project, of which no example is given at present. A Main Project would involve the members of the research group for a whole summer in a single field area.

It is proposed that the procedure of successive approximations described above will provide information more rapidly on the scope and limitations of plant prospecting methods under Canadian landscape conditions than will one or two comprehensive Main Projects. It is believed that experience based on investigations made in many parts of Canada will eventually show what types of landscape are the most favourable for the effective application of plant prospecting methods.

Eleven field investigations applying the proposed methods are included in this report. These would not have been possible without the active and sympathetic cooperation of the mining companies engaged in the exploration of the deposits. To facilitate cooperation with a mining company the minimum of detailed geological, geochemical and geophysical information is required during a Visit. Later on, if an area is selected for a Pilot Project (or a Quick Project), more detailed information is necessary; however, this does not include any data on tonnage or grade of the deposit.

The data presented here could not have been collected without the help of the hard-working students who were attached to the biogeochemical research program each summer and who carried out the exacting tasks involved in the collection and spectrochemical analysis of plant material. These included: in 1963 P. C. Kelly, F. A. Sommerville and D. B. Strachan; in 1964 L. R. Chalk, B. D. Simmonds and, for a time, M. Carter; in 1965 Miss L. Usik, M. E. King and E. A. De Bock in the field and K. I. Asplia and D. B. Forman in Ottawa; and in 1966 E. A. De Bock and K. D. Wallin.

The assistance of exploration geologists and geochemists who have taken time and trouble to describe in detail field areas for biogeochemical and geobotanical research is gratefully acknowledged. Specific acknowledgments to companies and to individuals are given within each section.



## SUMMARY OF THE FINDINGS OF THE RESEARCH AT UNDISTURBED MINERAL DEPOSITS

In Part I, Section A background information was given on five subjects which together provided the foundation of the biogeochemical research described. The object of this summary is to mention briefly the findings of the research carried out near eleven undisturbed mineral deposits in relation to these headings in order to summarize the major findings of the report.

### (1) Biogeochemical and geobotanical prospecting

a) The Pilot Project (see Section G) at the Silvermine lead deposit on Cape Breton Island was a good example of a successful biogeochemical research investigation, and showed clearly that biogeochemical prospecting would be applicable in this area. This project provides an introduction to the scope and scale on which future Pilot Projects will be carried out.

This investigation showed that:

- i) Successful biogeochemical prospecting could have been carried out in an area with very few outcrops where the layer of surficial material<sup>1</sup> does not exceed 35 feet in thickness.
- ii) Repeat sampling of the same organ showed that bark, twig, or current growth material could have been used as a reliable basis for biogeochemical prospecting.
- iii) Surveys could equally well have been based on black spruce (Picea mariana) or on balsam fir (Abies balsamea).
- iv) Barium would have been as good a basis for the survey as lead for locating the mineral deposit.
- v) It was clearly demonstrated that a biogeochemical survey based on bark collected 4 1/2 feet above the ground would have been successful in this area. Such a survey could, for example, have been carried out during staking in the winter months.
- vi) The detailed interpretation of the biogeochemical results required a thorough knowledge of the glacial geology of the area.

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<sup>1</sup> Surficial material refers to a layer of material extending from the bedrock surface to the lowest visible horizon of an organic or inorganic soil. This term is used because the layer may be of glacial or more recent origin.

b) The Quick Project (see Section F) at the Kidd Creek massive sulphide deposit near Timmins, Ontario, and the following drilling program, provided first hand information on a limitation of biogeochemical prospecting methods.

This investigation showed that:

- i) Even a few feet of varved clay on clay till in the layer of surficial material is sufficient to insulate growing plants from chemicals derived from an underlying mineral deposit.
- ii) Under favourable conditions strong geochemical anomalies occur in the lower till material beneath the clay layers but these anomalies do not persist into the overlying plants.
- iii) Although no geochemical anomalies in soil or plant material of the type usually associated with base metal deposits in other areas were found near the mineral deposit, some consistent variations were found in the total zinc content of the organic soil layer which might have been associated with the deposit. However, these variations could easily be explained logically on the basis of variations in landscape conditions without reference to the mineral deposit.
- iv) The biogeochemical investigations involved the determination of total copper, zinc, lead, cobalt, nickel, barium, strontium, titanium, manganese, chromium and silver in samples of moss (sphagnum sp.), alder (Alnus rugosa), labrador tea (Ledum groenlandicum) stems and leaves, black spruce (Picea mariana) or trembling aspen (Populus tremuloides) (bark, 2nd year twigs) collected in the vicinity of the mineral deposit and in control area.

c) A second Quick Project (see Section F) which yielded negative results for plants was carried out at the Pekan Creek Deposit in Gaspé Park, Quebec.

This investigation showed that:

- i) In a landscape which was very favourable from the biogeochemical point of view and which includes a copper deposit at shallow depth under coarse textured surficial material, positive results may be obtained from B horizon material and negative results from plants obtained from the same place.

- ii) In this area background lead values in both soils and plants increased up the hillside.

d) A series of tests involving the preparation of plant cover maps and the collection of soil samples showed that it should be practical to obtain systematic sets of geological, geochemical and geobotanical data from undisturbed mineral deposits in a very short time during Visits. Examples of the kind of plant cover maps which can be prepared, and a way in which soil data of this can be brought together and compared, are given in Section E.

## (2) Mineral exploration

a) The choice of landscapes in which undisturbed mineral deposits occur made it possible to obtain the maximum geological, geophysical and geochemical background information prior to any plant prospecting methods research. In this way plant research has been carried out without time consuming systematic orientation surveys in favourable areas which would otherwise have been needed. Experience has shown that a three-day Visit by a geochemist and a botanist is sufficient for the assessment of a property for a Pilot Project or a Quick Project.

b) The Silvermine Pilot Project is an example of positive results which can be expected from biogeochemical prospecting in a favourable area during 'follow up level' exploration. The results from the Kidd Creek area and from Pekan Creek reveal limitations of the biogeochemical method and, in the first case of the soil method of geochemical prospecting as well. It is desirable to obtain a number of other sets of data of the type described here before any definite conclusions regarding the practicality of biogeochemical prospecting methods in Canada can be established.

c) From the point of view of practical prospecting the following should be noted:

- i) In biogeochemical prospecting for lead deposits in landscapes similar to that at Silvermine on Cape Breton Island, bark taken at 4 1/2 feet from the ground from balsam fir or black spruce could have been used and, in addition to lead, barium might have been used as an indicator element.
- ii) In the Kidd Creek area in the Great Clay Belt of Northern Ontario, lower till material could be used for geochemical prospecting with reliable results.

- iii) In the Pekan Creek area in Gaspé Park, and perhaps in other areas as well, geochemical prospecting for copper should be based on B horizon material in preference to plant material.

d) The systematic presentation of chemical data obtained from the different mineral deposits investigated may allow direct visual comparison between sets and may assist in the interpretation of data obtained from other, similar, sources.

### (3) Plant nutrition

a) All the chemical data described in this report have been obtained by semiquantitative methods; however, the data indicate the relative proportions of a number of essential or non-essential minor elements in different organs of plants and associated soils obtained from Canadian landscapes.

b) The positive results obtained near mineral deposits indicate the extreme variation in minor elements that can be found in specific organs of healthy Canadian forest trees.

### (4) Landscape description

a) A series of successively more detailed types of investigation of landscapes (i.e. Visits, Pilot Projects, Quick Projects, etc.) was evolved in order to obtain comparable sets of descriptive and chemical data at different levels of detail. Experience has shown that the most effective Pilot Projects can only be made in areas which have been selected on the basis of preliminary Visits.

b) It is evident, particularly from the Kidd Creek Quick Project results, that in plant prospecting methods research all the components of the landscape must commonly be studied systematically in order to obtain a satisfactory interpretation of the chemical data obtained from plants, and that it is desirable to present these data in a form that can be directly compared with similar sets of data obtained elsewhere. The single, most important factor in the interpretation of the results appears to be the layer of surficial material between the bedrock and the bottom of the soil profile.

(5) General geochemistry

a) The geochemistry of landscapes in which mineral deposits occur will become more and more interesting to geochemists as the details of the migration of elements during the minor geochemical cycle are discovered. For this reason investigations of the type described in Sections F and G will become of increasing interest.

b) The production of like sets of descriptive and chemical data from different landscapes by the methods described in this report could be considered as a first step towards setting up routine methods of landscape geochemistry for pure research or for a geochemical census or for investigation of natural pollution of ecosystems.

(6) Objective 2 of the biogeochemical research program

Part II of this report was carried out in response to the following objective of the research program:

"To concentrate the major part of the field program on landscapes where known, undisturbed mineral deposits occur which are suitable for the demonstration of the scope and limitations of biogeochemical, and, possibly, geobotanical methods of prospecting."

The difficulty of finding landscapes suitable for meaningful biogeochemical prospecting methods research has been stressed. It is clear from the investigations that the importance of the correct selection of landscapes for study so that specific aspects of plant prospecting methods can be studied, merits the time and expense of Visits to deposits prior to more intensive work.

When suitable landscapes have been found the next most important finding of the research is that intensive study of the glacial history and the layer of surficial material is required before the results of the plant prospecting research can be fully interpreted.

Although experience in plant cover mapping had been gained in two areas before the end of 1966 no geobotanical prospecting research had been completed.

Although the approach to the study of landscape biogeochemistry described in this report is specifically in relation to plant prospecting methods research, it is likely that the same approach may be used in relation to plant, animal, or human nutrition problems related to geology, or in similar problems involving pollution, or geochemical census.

SECTION E GEOBOTANICAL AND SOIL GEOCHEMICAL  
INVESTIGATIONS DURING 'VISITS' TO EIGHT  
LANDSCAPES WITH UNDISTURBED  
MINERAL DEPOSITS

J. A. C. Fortescue and Lily Usik

E 1 Geobotanical investigation near mineral deposits

The concept of a 'Visit' originated as a result of systematic observations made during geobotanical investigations near two undisturbed mineral deposits in the summer of 1965, and as a result of the collection of similar sets of soil samples near six undisturbed mineral deposits in the summer of 1966. The first systematic application of both biogeochemical and geobotanical aspects of Visits at the same site was planned for the summer of 1967.

In botanical prospecting the objective is to attempt to establish a relationship between some component of the plant cover and the mineral deposit within that landscape. In the vicinity of a mineral deposit a botanical relationship may be indicated by the presence or absence of plant species (indicator plants), by physiological and morphological abnormalities in the plants (appearance), and by the chemical composition of the plants (plant analysis) (see Part I, Section A2). The investigation and determination of the botanical relationships may be made by the preparation of geobotanical maps for areas of interest. Such maps, which are prepared directly from ground observations, may be detailed and large-scale showing species composition, distribution, and, possibly, plant abnormalities. Detailed mapping is made not only of the vegetation directly above the mineralized zone but also of the vegetation in the area beyond the zone in order to compare botanical similarities or differences and, hence to determine any botanical relationships with the deposit. The limits for the botanical investigation around a deposit may be determined by preliminary observations and mapping of the general plant associations or plant cover types that are present over and around the area of the deposit. General plant cover type maps are prepared from an examination of low altitude air photographs and from aerial and ground surveys. Comparison of the plant association types over the mineral deposit with those for the area beyond the mineralized zone can be made in order to detect possible plant indicators of the deposit. Detailed geobotanical observation and mapping will also provide information for the species and possibly the plant organ for chemical analysis (i.e. during biogeochemical prospecting) as well as finally aid in the interpretation of the effects of elements on plant growth in an area of a deposit.

The objectives and procedures for geobotanical mapping were investigated in the summer of 1965 in four study areas. Two sites were situated away from known mineral deposits. In the other two the geobotanical investigations were made at and around known mineral deposits; one a

nickel deposit at Hambone Lake, near Thompson, Manitoba; the other, a copper deposit at Huckleberry Mountain in central British Columbia (see Fig. 2). The botanical investigations for these two sites illustrate the feasibility and speed of the method developed for fulfilling the objectives of botanical prospecting research. Also, comparison of the observations made in the two areas reveals the advantages and problems of plant-cover and species-distribution mapping procedures for geobotanical and biogeochemical prospecting research.

## E 2 The Hambone Lake nickel deposit site, near Thompson, Manitoba

The Hambone Lake site is the property of the International Nickel Company<sup>1</sup> and is about 39 miles south of Thompson, Manitoba and about 1 mile east of the highway between Thompson and The Pas. Examination of data obtained from the company at Thompson revealed unfavourable surficial material conditions near the mineralized zone making it unsuitable for a Pilot Project study at this time. However, field observations of the site suggested that the area offered opportunity for experience in geobotanical mapping procedures.

The site is typical of the Canadian Shield in this region and consists of a complex of organic and mineral terrain. The region has been described by Godard (1963) as follows:

"The glacial deposits are largely covered with moss, soils, muskeg or stratified clay and are exposed in only a few places. The drift includes boulder-clay, gravel and sand and in character and distribution is typical of ground moraine debris. Throughout the area, lacustrine varved and stratified clays overlie the drift. The clays fill the hollows in the drift surface, and over large areas cover all the rocks. The low lying portions of the area commonly contain rounded elongate ridges which parallel the bedrock trends in higher areas. On many of these low ridges no rock exposures can be found, but it is reasonably certain that they are bedrock features mantled with lacustrine clay. These clays were apparently deposited in postglacial Lake Agassiz that extended southward in front of the retreating ice-sheet and for a time covered the entire area (McInnes, 1913)."

The occurrence of nickel, and, possibly, cobalt sulphide mineralization at Hambone Lake was also described by Godard (op. cit.):

"The deposit at Hambone Lake is similar to the Thompson type of higher grade deposits found in the folded gneisses in the area. It occurs in gneiss, largely granitic gneiss, intruded by small serpentinite bodies. As at

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<sup>1</sup> The writers thank the International Nickel Company for selecting this property for investigation, and in particular Mr. K. Deibel and his staff for assistance in the office at Thompson and in the field at Hambone Lake.

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the Thompson Mine, the sulphides occur mainly in the gneisses rather than in the serpentinite. Also as at the Thompson mine, the ore at Hambone Lake occurs in a large drag-fold within the gneiss."

Thus although the bedrock setting was favourable for geochemical prospecting methods research the use of the area at this stage of the research program was severely restricted by the presence of boulder clay and lacustrine clays within the layer of surficial material.

The Hambone Lake area lies in the Nelson River section of the Boreal Forest region and is described by Rowe (1959) as follows:

"Stands of black spruce Picea mariana make up a large part of the forest cover, but proximity of the numerous and extensive swamps that lie back from the rivers is reflected in a restriction of growth. Where drainage is better as along the sides of rivers, on islands or on low ridges, good stands of white spruce Picea glauca with some balsam poplar Populus balsamifera, white birch Betula papyrifera, aspen Populus tremuloides, and balsam fir Abies balsamea are customary, with possibly more aspen and balsam poplar under such conditions on the east side of Lake Winnipeg. Extensive and repeated fires have, however, fragmented all the forest cover, and large areas support small growth aspen, white birch, and scattered white and black spruce, or jack pine Pinus banksiana and aspen, or grassy shrub on rock barrens. Tamarack Larix laricina is present with black spruce in the swamps; isolated occurrences of green ash Fraxinus pennsylvanica var., subintegerrima and Manitoba maple Acer negundo var. interius are reported on some of the river banks, and there is little bur oak Quercus macrocarpa in the southern arm of the section . . . . ."

" . . . . On the well drained (surficial) materials, podzolic (soil) profiles normally develop. Podzolic gleysols are typical of poorly drained slopes, while moss and woody peat characterize the spruce-tamarack muskegs ."

In the geobotanical investigation at Hambone Lake a plant collection was made and general plant cover type maps were prepared as were lists of the species in each cover type (Table E 1). The plant cover types identified in the Hambone Lake area are shown in Figure E 1.

After designation on the ground, the cover types were identified on an aerial photograph. For comparison of cover-type boundaries delineated from ground survey (Fig. E 1) with those which appear in a low altitude aerial photograph (Fig. E 2) the two figures should be compared. The 19th base line, which traverses the area mapped and which may be seen in Figure E 2 facilitated the preparation of the general plant cover type map. It may be seen (Fig. E 1) that five of the six plant cover types in the area occur along this line. The drafting of the plant cover-type map from the aerial photograph was done in one day and the field work on which it was based in two days.



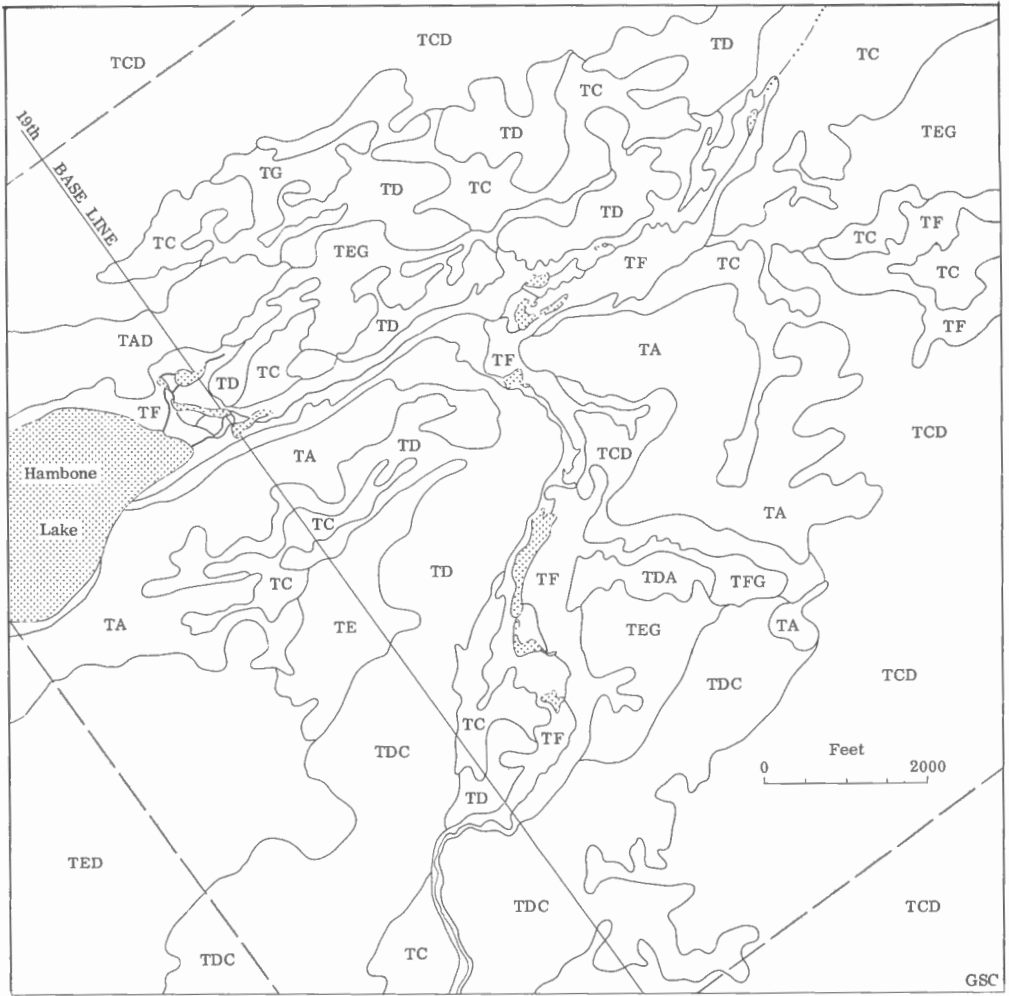
Table E 1 Hambone Lake Visit: Plant species found in ground, understory and overstory cover in the five main plant-cover types identified along the 19th base line.

| Plant Species                   | Plant Cover Type |    |    |    |    |
|---------------------------------|------------------|----|----|----|----|
|                                 | TA*              | TC | TD | TE | TF |
| <i>Betula papyrifera</i>        | Op               |    | Op | Op | Op |
| <i>Larix laricina</i>           |                  |    |    | Op |    |
| <i>Picea glauca</i>             | Op               |    | Od |    |    |
| <i>P. mariana</i>               |                  | Od |    | Od |    |
| <i>Pinus banksiana</i>          |                  |    |    |    | Op |
| <i>Populus balsamifera</i>      | Oa               |    |    |    |    |
| <i>P. tremuloides</i>           | Od               |    |    |    |    |
| <i>Amelanchier</i> sp.          |                  |    | Up |    |    |
| <i>Alnus crispa</i>             | Ud               |    | Up |    | Up |
| <i>Arctostaphylos</i> sp.       | Gf               |    |    |    |    |
| <i>Betula glandulosa</i>        |                  |    |    | Up |    |
| <i>Chamaedaphne calyculata</i>  |                  |    |    | Ua |    |
| <i>Kalmia polifolia</i>         |                  |    |    | Up |    |
| <i>Ledum Groenlandicum</i>      | Gf               | Ud | Gf | Ua |    |
| <i>Linnaea borealis</i>         | Gf               |    | Gf |    |    |
| <i>Rosa acicularis</i>          | Ga               | Gf | Gp |    |    |
| <i>Rubus strigosus</i>          |                  |    |    |    | Gp |
| <i>Salix</i> sp.                |                  |    |    | Up | Od |
| <i>Vaccinium myrtilloides</i>   |                  |    | Gp |    |    |
| <i>V. oxycoccus</i>             |                  | Ga |    | Gf |    |
| <i>V. vitis-idaea</i>           | Ga               | Ga | Ga |    |    |
| <i>Viburnum edule</i>           | Ua               |    | Up |    |    |
| <i>Anemone</i> sp.              |                  |    |    |    | Gp |
| <i>Actaea rubra</i>             | Gf               |    |    |    |    |
| <i>Aster</i> sp.                | Gf               |    |    |    |    |
| <i>Caltha palustris</i>         |                  |    |    |    | Gd |
| <i>Carex aquatilis</i>          |                  | Gf |    | Gf |    |
| <i>Carex</i> sp.                |                  | Gp |    |    | Gp |
| <i>Commandra lividum</i>        |                  |    | Gf |    |    |
| <i>Cornus canadensis</i>        | Ga               |    | Gf |    |    |
| <i>Epilobium angustifolium</i>  | Ga               |    | Gp |    | Gp |
| <i>Equisetum pratense</i>       |                  |    | Gf |    |    |
| <i>E. scirpoides</i>            |                  |    | Gp |    |    |
| <i>E. sylvaticum</i>            | Gp               | Ga | Gp | Gf |    |
| <i>Galium triflorum</i>         | Gf               |    |    |    | Gp |
| <i>Galium</i> sp.               |                  |    |    |    | Gf |
| <i>Gentiana amarella</i>        | Gp               |    |    |    |    |
| <i>Lathyrus</i> sp.             | Gp               |    |    |    |    |
| <i>Lycopodium clavatum</i>      | Gf               |    |    |    |    |
| <i>Mitella nuda</i>             | Gf               |    | Gp |    |    |
| <i>Parnassia palustre</i>       |                  | Gp |    |    | Gp |
| <i>Petasites palmatus</i>       | Ga               |    | Gp |    |    |
| <i>Potentilla palustris</i>     |                  |    |    |    | Gp |
| <i>Pyrola</i> sp.               | Gf               |    |    |    |    |
| <i>Rubus chamaemorus</i>        |                  |    |    | Gf |    |
| <i>R. pubescens</i>             | Gf               |    | Gp |    | Gp |
| <i>Sedge</i> sp.                |                  |    |    | Ga |    |
| <i>Vicia</i> sp.                |                  |    | Gp |    | Gp |
| <i>Viola</i> sp.                |                  |    |    |    | Gf |
| <i>Cladonia alpestris</i>       |                  | Gf | Gf | Gf |    |
| <i>C. rangiferina</i>           |                  | Gf | Gf | Gf |    |
| <i>Dicranum</i> sp.             |                  | Gf | Gf | Gf |    |
| <i>Hypnum crista-castrensis</i> |                  |    | Gf |    |    |
| <i>H. schreberi</i>             |                  |    | Gd |    |    |
| <i>Peltigera</i> sp.            |                  |    | Gf |    |    |
| <i>Sphagnum</i> sp.             |                  | Gd | Gp | Gd |    |
| Other moss                      | Gf               | Gf | Gp | Gp | Gf |

Stratification  
O = overstory  
U = understory  
G = ground

Relative abundance  
d = dominant  
a = abundant  
f = frequent  
p = present

\* Designations of cover types same as on Figure E 1



TA Deciduous forest  
 TC Muskeg spruce-sphagnum forest  
 TD Mineral soil spruce-hypnum forest  
 TE Mixed muskeg spruce-shrub and spruce-sedge forest

TF Shrub-sedge sites associated with water courses, or lake or pond margins  
 TG Muskeg shrub/sedge moss sites

Limit of aerial photograph (Figure E2) . . . . .

Figure E1. Hambone Lake Visit. General plant cover map

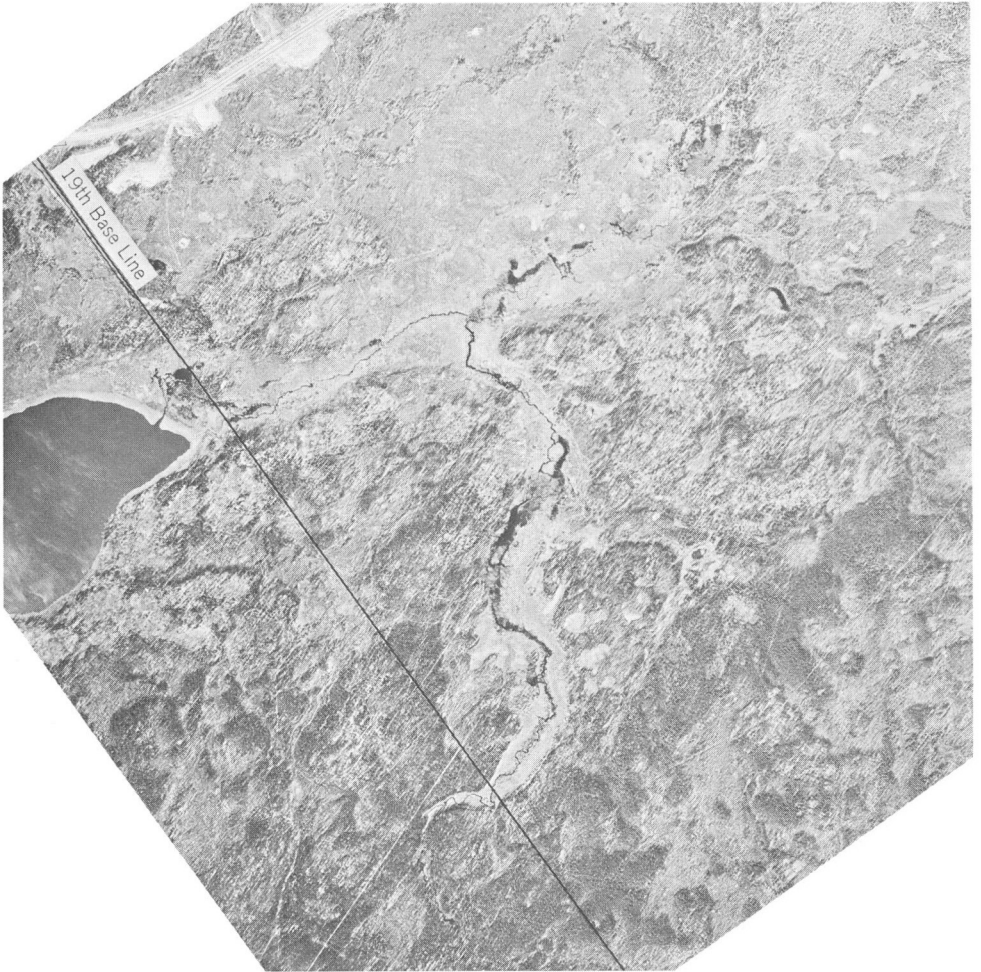


Figure E 2 Hambone Lake Visit: Aerial photograph of Hambone Lake area shown in general plant cover type map.

During the preliminary ground investigations specimens of the individual plant species in each cover type were collected for a herbarium established at the Geological Survey of Canada in Ottawa. Also an attempt was made to obtain photographs representative of each cover type (Figs. E 3, E 4, E 5, E 6, and E 7).

Table E 2 Hambone Lake Visit: Distribution of plant species within the six plant-cover types.

|                                                                        |           |
|------------------------------------------------------------------------|-----------|
| Number of plant species which occur in <u>all six</u> cover types..... | none      |
| Number of plant species which occur in <u>five</u> cover types.....    | none      |
| Number of plant species which occur in <u>four</u> cover types.....    | 3         |
| Number of plant species which occur in <u>three</u> cover types.....   | 9         |
| Number of plant species which occur in <u>two</u> cover types .....    | 14        |
| Number of plant species which occur in <u>one</u> cover type only..... | <u>30</u> |
| Total                                                                  | <u>56</u> |

Table E 3 Hambone Lake Visit: The number of dominant and abundant species within each plant-cover type.

| Plant Cover Type<br>( <u>see</u> Fig. E 1) | Number of species | Number of dominant<br>and abundant species |
|--------------------------------------------|-------------------|--------------------------------------------|
| TA                                         | 24                | 9                                          |
| TC                                         | 14                | 6                                          |
| TD                                         | 28                | 3                                          |
| TE                                         | 18                | 5                                          |
| TF                                         | 17                | 2                                          |

The data in Table E 1 can also be summarized according to number of species and number of dominant species within each cover type as shown in Table E 3. Also when the botanical data in Table E 1 is summarized, as shown in Table E 2, it is seen that, on a presence or absence basis, very few species occur in more than three different cover types. When the relative abundance of individuals is taken into account the choice of suitable plants for biogeochemical prospecting research is even more limited. However, if a landscape in which a mineral deposit and surrounding control areas are included in the same cover type, the problem of biogeochemical research is considerably simplified.

Plant-cover maps should eventually be of value in practical prospecting. For example, if previous experience had focussed attention on a single organ of a particular plant species as being a reliable indicator of nickel in the Nelson River section of the Boreal Forest, then a plant-cover map of the Hambone Lake area would indicate where, and to what extent, biogeochemical prospecting based on a particular plant could be undertaken in the area. Similarly, if lists of species of plants in each cover type were available, the parts of the area where indicator plants occur could be outlined, providing of course that such indicator plants were known in the Boreal Forest. In either case the plant-cover maps of the kind described above would facilitate practical prospecting based on plants.

In conclusion, the geobotanical investigation at Hambone Lake provided a simple introduction to the methods of preparation of geobotanical maps for biogeochemical research. The scale and intensity of the approach and the speed of map preparation should be noted as well as the role played by plant specimen collecting, ground photography and aerial photography in the preparation of the maps. It should be noted that once plant-cover types in an area have been designated by a botanist, representative photographs of each cover type can be prepared and carried along cut lines by personnel not trained in botany or ecology who can then prepare cover type maps.

### E 3 Huckleberry Mountain copper deposit, British Columbia

In September 1965 a Visit was made to a copper deposit near Huckleberry Mountain in central British Columbia (see Fig. 2). The deposit is about 2 miles southwest of Huckleberry Mountain which lies just north of Tahtsa Reach in north-central British Columbia. A general plant cover type map was made (Fig. E 8) and, as a result of this Visit a Pilot Project was planned for the area during 1967. To avoid anticipating the data to be included in the report of the data obtained during the Pilot Project no detailed information on the geology, geophysics or geochemistry of the area is presented here.



Figure E 3

Hambone Lake Visit:  
Plant-cover type TA,  
deciduous forest.  
(GSC 200237-D)



Figure E 4

Hambone Lake Visit:  
Plant-cover type TC,  
muskeg spruce-sphagnum  
forest. (GSC 200237-F)

Figure E 5

Hambone Lake Visit:  
Plant-cover type TD,  
mineral soil spruce-  
hypnum forest.  
(GSC 200237-E)





Figure E 6 Hambone Lake Visit: Plant-cover type TE, mixed muskeg spruce-shrub and spruce-sedge sites.



Figure E 7 Hambone Lake Visit: Plant-cover type TF, shrub-sedge sites associated with water courses, lake and pond margins.

Briefly, the copper deposit is associated with a small quartz diorite stock intruding Hazleton rocks of Middle Jurassic age (see Duffell 1959) and the general suboutcrop of the deposit occurs in the central part of Figure E 8. Exploration of the deposit has been carried out by Kennco Explorations (Canada) Ltd.<sup>1</sup>

The Huckleberry Mountain area is included in the Montane Transition Section of the Montane Forest Region as described by Rowe (1959) as follows:

"The forests of the relatively low-lying land on the northern half of the Nechako plateau are transitional in composition between the Montane and the Subalpine. Relationship to the latter region is most apparent, as the characteristic forest type consists of spruce (Picea glauca P. engelmanni and their intergrades) and alpine fir (Abies lasiocarpa). However, blue Douglas fir (Pseudo tsuga taxifolia var. glauca) is also scattered throughout, and its presence has led to the inclusion of this section in the Montane Forest Region.

"The widely distributed spruce-fir forest has been decimated by fires, resulting in an expansion of associations of aspen (Populus tremuloides), western white birch (Betula papyrifera var. commutata) and lodgepole pine (Pinus contorta var. latifolia). Under the present conditions of environment, Douglas fir appears to be losing the position of prominence that it formally had in the vegetation pattern, except perhaps in the drier, open forest types. On the eastern side of the section, there is a gradation into the northern Columbia forest with the appearance of mixed stands of Engelmann spruce, western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) and of Engelmann spruce with Douglas fir. Westward, the hemlock appears again in the foothills of the Coast Range. Along the rivers and lakes, black cotton-wood (Populus trichocarpa) is commonly found. Numerous grassy openings and parklands with groves of aspen occur, particularly in the western half of the section.

"The major part of the northern interior plateau is a rolling upland at about 2,500 feet altitude, and only a few hills and low mountains exceed 5,000 feet. The underlying bedrock is of rather flat-lying Paleozoic and Mesozoic sediments, with some local Tertiary sediments and lavas. Large sections were flooded by post glacial lakes, remnants of which still remain in the comparatively broad, flat valleys, and there has been a thick deposition of lacustrine deposits. Upper slopes and highlands are covered with glacial drift. The soils are grey wooded or podzolic under coniferous stands, and grey-black or immature under the more open mixed and hardwood forests of the lowlands."

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<sup>1</sup> Special thanks are due to Mr. C. J. Sullivan the president of Kennco Explorations (Canada) Ltd. for permission to investigate the Huckleberry Mountain property and also to Dr. J. Gower, Mr. R. Stevenson and members of the company staff for assistance in the office in Vancouver and in the field.



The plant-cover types of Huckleberry Mountain area are shown in Figure E 8. Figure E 9 is an aerial photograph of the area which was taken before any prospecting operations had been initiated. Plant-cover types identified are illustrated in Figures E 10 to E 15. Table E 4 lists the plant species identified and collected in each of the cover types. The ground survey for the delineation of cover types was facilitated by the presence of the 9th base line shown in Figures E 8, E 9, E 10 and E 12.

Several botanical features of the Huckleberry Mountain area suggest that this area is suitable for further geobotanical and biogeochemical investigation. Of greatest importance is the presence of similar cover types (i.e. cover type H - I, Fig. E 8) as well as different cover types over and away from the mineral deposit. As previously pointed out this allows comparison of the botanical features of the mineralized and unmineralized areas for the determination of botanical relationships with the deposit. Another advantage of this area is the relative uniformity of the size of individuals, distribution and composition of species in the different cover types. For example, the forest tree Lodgepole pine (Pinus contorta Dougl.) is ubiquitous throughout British Columbia and thus offers an opportunity for comparison of the morphological, physiological and chemical characteristics of the species growing over and away from a deposit. Finally, the area has vegetation associations of contrasting terrain types (i.e. of poorly drained organic soil types (peat) and of well-drained mineral soil types). The plant associations of the bog area at Huckleberry Mountain (e.g. the Moss-Lichen-Shrub association) not only occurs in other parts of British Columbia but also in areas of organic terrain (bog, muskeg) throughout Canada. Based on these observations, and others like them involving soil cover and geology the Huckleberry Mountain deposit was selected for Pilot Project study.

#### E 4 Summary of the findings of geobotanical research

Geobotanical investigations that were made at two drilled undisturbed mineral deposits during Visits resulted in the establishment of plant-cover type mapping methods, methods of plant species collection and identification, and the production of the Herbarium at the Geological Survey of Canada. The scale and scope of geobotanical investigation that can be made during a brief inspection of the landscape including a mineral deposit are indicated.

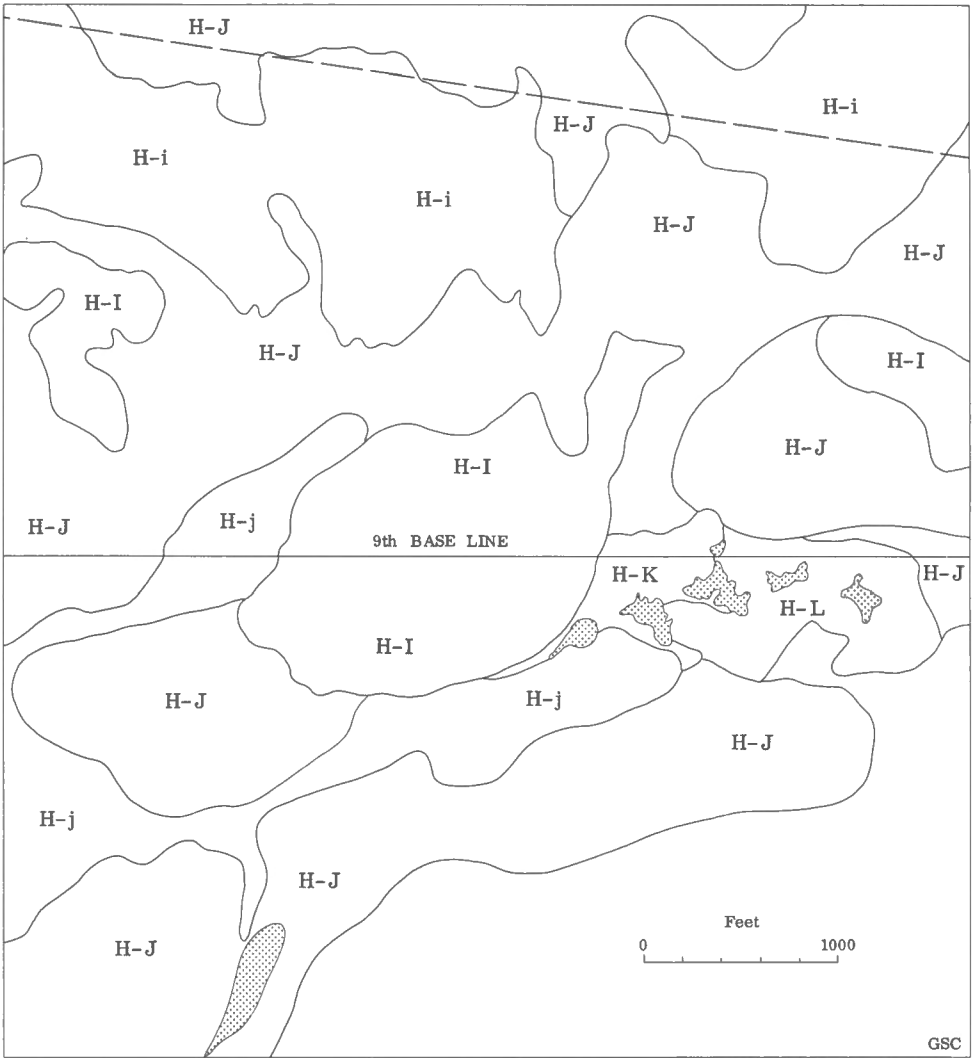
As pointed out earlier (Part I, Section A) geobotanical prospecting research may be considered primarily as the investigation of plant-cover types near a mineral deposit for the recognition of variations which indicate the presence of the mineral deposit in the bedrock. Therefore the preparation of plant species lists and the preparation of plant-cover maps for areas of known mineral deposits provides a means for determining botanical indicators by comparison of the lists and maps for different, or similar, deposit

Table E 4 Huckleberry Mountain Visit: Plant species found in ground, understory, and overstory vegetation in the five principal plant cover-types designated along the 9th base line.

| Plant Cover-Type (see Fig. E 8)    |       |       |       |       |       |
|------------------------------------|-------|-------|-------|-------|-------|
| Plant Species                      | H - I | H - J | H - j | H - K | H - L |
| <i>Abies lasiocarpa</i>            | Oa    | Od    | Od    |       | Op    |
| <i>Pinus albicaulis</i>            | Op    |       |       |       |       |
| <i>Pinus contorta</i>              | Od    | Op    | Op    |       | Op    |
| <i>Populus trichocarpa</i>         | Op    | Of    | Of    |       |       |
| <i>Tsuga mertensiana</i>           |       |       |       |       | Op    |
| <i>Alnus crispa</i>                | Uf    | Ud    | Ud    |       | Up    |
| <i>Cassiope lycopodiodes</i>       |       |       |       |       | Gf    |
| <i>Cladothamnus pyrolaeiflorus</i> | Ud    |       |       |       |       |
| <i>Empetrum nigrum</i>             |       |       |       |       | Gd    |
| <i>Kalmia polifolia</i>            |       |       |       |       | Uf    |
| <i>Ledum palustre</i>              |       |       |       |       | Uf    |
| <i>Lonicera involucrata</i>        | Up    |       | Up    |       |       |
| <i>Menziesia ferruginea</i>        | Ua    |       |       |       | Up    |
| <i>Pachystima myrsinites</i>       |       | Up    |       |       |       |
| <i>Phyllodoce empetriformis</i>    |       |       |       |       | Ga    |
| <i>Ribes lacustre</i>              |       |       |       |       | Ga    |
| <i>Rubus parviflorus</i>           |       | Ua    |       |       |       |
| <i>Salix sp.</i>                   | Up    | Ua    | Ua    |       |       |
| <i>Sorbus scopulina</i>            |       |       | Up    |       |       |
| <i>Sorbus sitchensis</i>           | Uf    | Uf    |       |       | Up    |
| <i>Spirea douglassi</i>            |       |       |       |       | Up    |
| <i>Vaccinium caespitosum</i>       |       |       |       |       | Up    |
| <i>Vaccinium membranaceum</i>      | Uf    | Up    |       |       |       |
| <i>Vaccinium ovalifolium</i>       | Ua    |       |       |       |       |
| <i>Vaccinium oxycoccos</i>         |       |       |       |       | Gf    |
| <i>Viburnum edule</i>              |       |       |       | Up    |       |
| <i>Actaea rubra</i>                |       |       | Gp    |       |       |
| <i>Agrostis sp.</i>                | Gf    |       |       | Ga    | Gf    |
| <i>Anaphalis margaritacea</i>      | Gp    | Gf    | Gp    |       |       |
| <i>Arnica amplexicaulis</i>        | Gf    |       |       |       |       |
| <i>Arnica cordifolia</i>           |       |       | Gf    |       |       |
| <i>Aster foliaceus</i>             |       |       |       | Gp    | Gf    |
| <i>Aster modestus</i>              |       |       | Ga    |       |       |
| <i>Athyrium filix-femina</i>       |       |       | Ga    |       |       |
| <i>Calamagrostis canadensis</i>    | Gp    |       | Gd    |       |       |
| <i>Calamagrostis sp.</i>           |       |       |       |       | Gf    |

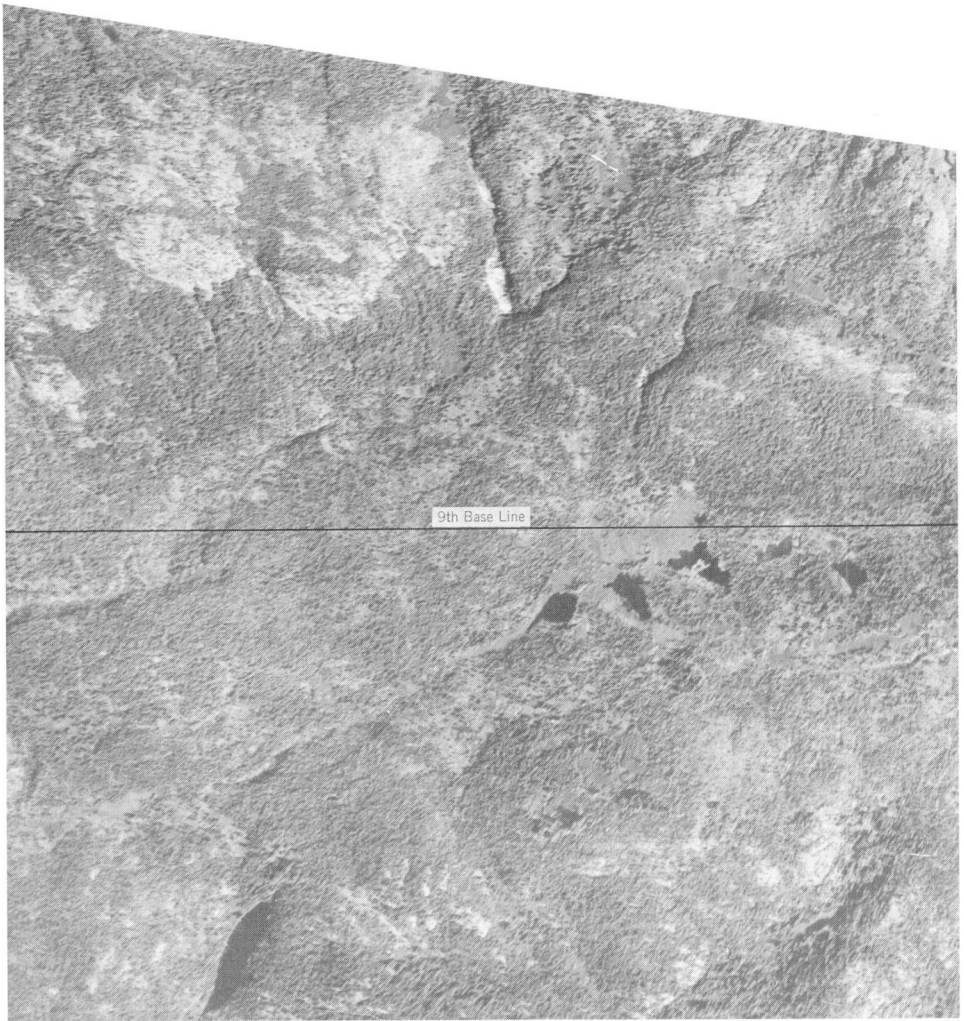
Table E 4 Huckleberry Mountain Visit: Plant species found in ground, understory, and (cont'd) overstory vegetation in the five principal plant cover-types designated along the 9th base line.

| Plant Cover-Type (see Fig. E 8) |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|
| Plant Species                   | H - I | H - J | H - j | H - K | H - L |
| <i>Carex buxbaumii</i>          |       |       |       | Ga    |       |
| <i>Carex sitchensis</i>         |       |       |       | Ga    | Gp    |
| <i>Castilleja miniata</i>       | Gp    | Gf    |       |       | Gp    |
| <i>Clintonia uniflora</i>       |       | Gp    |       |       |       |
| <i>Cornus intermedia</i>        | Gd    | Gp    |       |       | Gf    |
| <i>Drosera rotundifolia</i>     |       |       |       |       | Gf    |
| <i>Epilobium angustifolium</i>  |       | Gf    |       | Gp    | Gp    |
| <i>Eriophorum angustifolium</i> |       |       |       | Gp    | Gp    |
| <i>Equisetum arvense</i>        | Gp    | Gf    | Gf    | Gf    | Gf    |
| <i>Gymnocarpium dryopteris</i>  | Gp    | Gf    |       |       |       |
| <i>Habenaria dilatata</i>       | Gp    |       |       | Gp    |       |
| <i>Heracleum lanatum</i>        | Gp    |       |       |       |       |
| <i>Juncus oreganus</i>          |       |       |       |       | Ga    |
| <i>Juniperus communis</i>       |       |       |       |       | Gp    |
| <i>Leptarrhena</i> sp.          |       |       |       |       | Gf    |
| <i>Lupinus arcticus</i>         | Gf    |       |       |       |       |
| <i>Lazula</i> sp.               | Gf    |       |       |       |       |
| <i>Lycopodium annotinum</i>     |       |       | Gf    |       |       |
| <i>Lycopodium complanatum</i>   | Ga    |       |       |       |       |
| <i>Lycopodium sitchense</i>     | Gf    |       |       |       |       |
| <i>Parnassia fimbriata</i>      | Gp    |       |       | Gp    |       |
| <i>Potentilla palustris</i>     |       |       |       | Gf    |       |
| <i>Pyrola asarifolia</i>        |       |       | Gp    |       |       |
| <i>Pyrola minor</i>             | Ga    |       |       |       |       |
| <i>Pyrola secunda</i>           | Gp    | Gp    |       |       |       |
| <i>Sanguisorba canadensis</i>   | Gp    |       | Gf    | Gp    | Gp    |
| <i>Saxifraga ferruginea</i>     | Gp    |       |       |       |       |
| <i>Scirpus caespitosus</i>      |       |       |       | Gd    |       |
| <i>Senecio triangularis</i>     | Gp    |       | Gf    |       |       |
| <i>Streptopus amplexifolius</i> |       |       |       |       | Gf    |
| <i>Streptopus roseus</i>        | Gf    | Gp    |       |       |       |
| <i>Thalictrum occidentale</i>   |       | Gf    | Gf    |       |       |
| <i>Tiarella unifoliata</i>      | Gp    |       | Gp    |       |       |
| <i>Valeriana sitchensis</i>     | Gp    | Gp    | Gf    | Gp    |       |
| <i>Valhodea atropurpurea</i>    | Gp    |       |       |       |       |
| <i>Veratrum viridi</i>          | Gp    |       |       |       | Gp    |
| <i>Viola palustris</i>          |       |       |       | Gp    |       |
| <i>Lichen</i> sp.               | Gp    |       |       |       | Ga    |
| <i>Sphagnum</i> sp.             |       |       |       | Ga    | Gd    |
| Other moss sp.                  | Ga    |       |       | Gd    | Ga    |



- |                                                  |                                                 |
|--------------------------------------------------|-------------------------------------------------|
| H-I Conifer-shrub                                | H-j Mixed conifer-deciduous-shrub-grasses-herbs |
| H-i Conifer-shrub, bare rock                     | H-K Meadow grass-sedge bog                      |
| H-J Mixed conifer-deciduous-shrub                | H-L Moss-lichen-shrub bog                       |
| Limit of aerial photograph (Figure E9) . . . . . |                                                 |

Figure E8. Huckleberry Mountain Visit. General plant cover map



Limit of the map coverage shown in Figure E 8.

Figure E 9 Huckleberry Mountain Visit: Aerial photograph of the area shown in the general plant-cover map. (EMR 11012-31)

from different, or similar, regions of Canada. Comparisons are made for the absence or presence of a particular plant species or of particular associations of plant species.

Biogeochemical prospecting methods may be considered to be primarily the collection and subsequent chemical analysis of plant material. Chemical analysis is usually carried out on particular organs (i.e. current

growth, or other age of twigs, needles or bark) of particular plant species. This is done for plants growing near, as well as away from, the mineral deposit in order to compare, and hence evaluate, the results in terms of the chemistry of the mineral deposit. Therefore it is necessary to establish the complexity of the plant-cover types and access the species present and their frequency over and beyond the suboutcrop area of the mineral deposit to provide control data in plant sampling for chemical analysis. Such botanical observations are thus a primary aim of a Visit. At the present initial stage of the biogeochemical research program, the areas selected for Pilot Projects must therefore have plant-cover types that are relatively well-defined in extent and are uniform with respect to the distribution of the species within them.

Some of the problems of botanical investigation and mapping may be noted in the Hambone Lake example. Table E 1 shows that numerous plant species occur in the ground, understory and overstory vegetation in



Figure E 10 Huckleberry Mountain Visit: Mixed conifer/deciduous cover type in the foreground with the grass sedge bog with associated ponds and the conifer shrub cover type in the background. Note clearing which is associated with a bulldozer trench paralleling the 9th base line in the background.

Figure E 11

Huckleberry Mountain Visit:  
Conifer shrub cover type associ-  
ated with areas of bare rock.  
(GSC 200237-C)

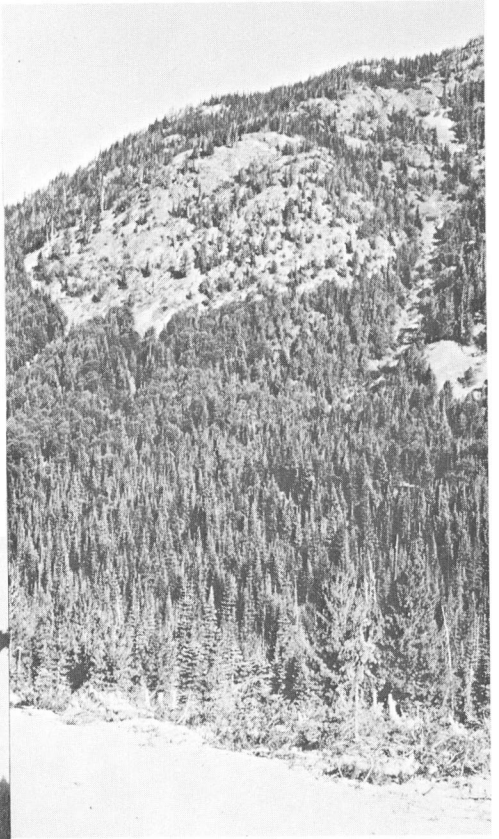


Figure E 12

Huckleberry Mountain Visit:  
The cut along the 9th base line  
looking east with mixed conifer/  
deciduous shrub in the foreground  
and conifer shrub in the back-  
ground. (GSC 200237-B)

each of the six plant-cover types. Hence the plant-cover of the area is complicated and difficult to describe because of the numerous species not only within each of the three strata but also within each cover type.

Thus the Hambone Lake example shows the value of a general plant-cover type map as an essential preliminary to systematic plant prospecting methods research. After more experience has been gained it should be possible to carry out effective biogeochemical research in areas where several cover types occur because detailed information on the chemical composition of common species of plants affected and unaffected by mineral deposits will be available as a guide to the interpretation of results.

In conclusion the geobotanical observations made during a Visit are used to select areas for Pilot Project study. Plant-cover type mapping investigations are considered to be essential not only for geobotanical and biogeochemical studies of an area but also in the initial selection of an area



Figure E 13

Huckleberry Mountain Visit:  
Close-up of the conifer-shrub  
cover type showing a fire  
scar on trunk of dead tree  
at left. (GSC 200237-G)





Figure E 14 Huckleberry Mountain Visit: Meadow grass-sedge bog cover type looking southwest from 9th base line. (GSC 200237-H)



Figure E 15 Huckleberry Mountain Visit: Moss-lichen-shrub bog cover type showing bog pond in background. (GSC 200237-A)

for detailed studies (Pilot Project). Plant-cover mapping is feasible and practical from low altitude aerial photographs only after a ground survey has been made. During the botanical mapping procedure detailed descriptive material, species composition, distribution and stratification, of each cover type and herbarium specimens are collected. The data obtained for those areas not selected for further study contribute to a library of systematic botanical information for comparative purposes.

#### E 5 Soil geochemical investigations near mineral deposits

The object of soil geochemical investigations made during Visits is to discover if chemicals derived from the mineral deposit can be detected in the soil collected over the deposit. In order to assess the suitability of an area for a Pilot Project on the basis of soil geochemistry a simple system was devised to collect one site set (see Part I, Section C) consisting of fifteen samples of B horizon material during each Visit. In the ideal case five samples would be collected in a part of the area unaffected by chemicals derived from the deposit, five above the suboutcrop of the deposit, and five in a part of the area where chemicals derived from the deposit might have been transported during the minor geochemical cycle (e.g. downhill from the deposit). In practice the samples were in nearly all cases collected from stations at regular intervals along a cut line traversing the deposit. The choice of the particular line is made on the basis of geological and/or geochemical information supplied by the company. This procedure obviates the need for an orientation survey to locate geochemical anomalies due to the presence of the deposit. During the sampling of the soil an effort is made to collect like material (i.e. from the same part of the B horizon) from a small pit dug with a trenching tool to not more than 24 inches at each sample station to expose the soil profile. A vertical face exposing the soil profile is then prepared and note taken of the thickness and nature of each recognizable soil horizon. Small samples of B horizon material are collected and shipped to Ottawa for analysis. Total copper, lead, zinc, nickel and, in some cases, molybdenum is determined in each sample after an  $\text{HF}/\text{HClO}_4$  extraction by methods described in Part I, Section C of this report. The results of the chemical analyses are considered to be accurate to within  $\pm 25$  per cent of the amount of an element present in the sample. Semiquantitative methods of this kind are considered satisfactory because it has always been found that the significant variation in the content of an element in soil (due to the addition of chemicals from the deposit) is greater than two-fold and usually between two-fold and ten-fold, or greater.

#### E 6 Data from soil geochemical investigations made during Visits

A scan sheet (see Part I, Section C) has been set up to display results of chemical analysis of B horizon samples collected during six Visits made during 1966 as well as for similar sets of data obtained from two Quick

Projects and a Pilot Project (to be described later). Briefly, a scan sheet is made of rows and columns of 'panels'. Each panel is a small graph showing the amount of an element in each sample in parts per million on the vertical scale and the location of the sample sites along a traverse (i.e. cut line) on the horizontal scale (Fig. E 16). In Figure E 16 each row of panels contains data for the same element in nine different sets of samples and each column shows data for different elements in the same set of samples. Data for all elements are plotted on the same vertical arithmetic scale in order to facilitate direct comparisons between different sets of data. Owing to the need for comparison of data from different panels the horizontal scale has been altered in some cases in order to produce an apparently uniform interval between sample points. The distance between sample points was generally 100 feet although for the Pekan Creek data it was 200 feet and for the Silvermine data 300 feet. The important point is not the horizontal scale used but the fact that an attempt was made to collect the first five samples in a control area, the middle five above the deposit and the right-hand five down-slope from the deposit. The variations of total metal content in mineral soil in the vicinity of each deposit are of greatest interest as a guide to the choice of Pilot Project areas and therefore only the minimum of background information regarding the deposits is given in tabular form (Table E 5).

On the scan sheet (Fig. E 16) the nine batches of chemical data have been grouped according to type of mineral deposit above which they were collected. In some cases variations from typical forest soil profiles were observed during sampling. For example samples taken at Kidd Creek were collected in some cases from a mineral layer lying below some 18 inches of peaty material. At the three sites in the Yukon a layer of volcanic ash was present between the humus layer and the underlying B horizon (for details of the minor element content of both layers see Fortescue, 1957), also, some of the B horizon samples collected from Swim Lake were taken from ground which was still frozen in early August and may involve B horizon plus volcanic ash. However, in spite of these local variations in soil profile samples of this kind provide valuable information regarding the distribution of metals in soils, which itself facilitates the selection of field areas for detailed investigations.

In selecting landscapes for biogeochemical prospecting investigations interest is focussed on the contrast between the concentration of a given element in normal soil and in soil collected near a mineral deposit. Experience with greenhouse experiments has shown (e.g. Part I, Section D) that a ten-fold increase in the content of an element in soil is usually accompanied by a much smaller increase in the content of the element in the plant. Considerations of this type resulted in the selection of a factor of five for the increase of metal in the soil to be used as a minimum requirement in landscapes selected for either biogeochemical or geobotanical research of the type described in this report. Using this factor as a guide the data on Figure E 16 and Table E 6 have been interpreted in terms of the suitability of the different areas for Pilot Project research in Table E 7.

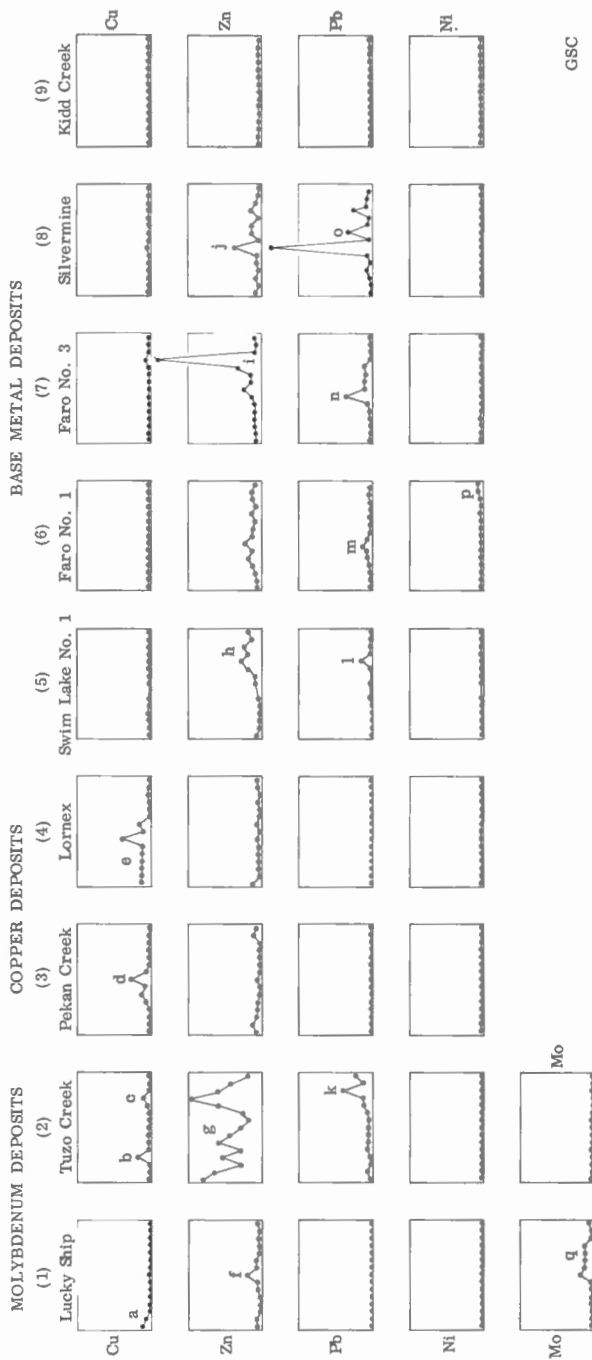


Figure E16. Scan sheet showing plots of the minor element content of B horizon (or equivalent) samples in a single Site Set taken in the vicinity of nine drilled, undisturbed mineral deposits located in different parts of Canada (Numerical data on Table E6).

Table E 5 Summary of general information on eight drilled, but undisturbed mineral deposits to which Visits were made during 1965-1966.

| DATE | NAME OF DEPOSIT         | PROVINCE         | MINERALIZATION TYPE                            | SURFICIAL MATERIAL LAYER                                                       | SOIL COVER                                    | VEGETATION COVER                                  | REMARKS                  |
|------|-------------------------|------------------|------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------|--------------------------|
| 1965 | Hambone Lake            | Manitoba         | nickel bearing sulphides                       | outcrops to several tens of feet of lake clays over drift                      | forest soil                                   | variable; bog, marsh, forest                      | No Pilot Project planned |
| 1965 | Huckleberry Mountain    | British Columbia | disseminated copper sulphides                  | few outcrops, coarse material shallow to deep, some open bog                   | forest soil or peat                           | forest, or open sedge bog or sphagnum bog         | Pilot Project planned    |
| 1966 | Tuzo Creek              | British Columbia | molybdenum deposit                             | some outcrop with a few feet of surficial material in other areas              | well-drained forest soil                      | open areas, and forest with open or closed canopy | Pilot Project planned    |
| 1966 | Lornex, Highland Valley | British Columbia | disseminated copper sulphides minor molybdenum | no outcrops, surficial ten to several tens of feet thick                       | well-drained forest soil                      | uniform second growth pine forest                 | Pilot Project planned    |
| 1966 | Lucky Ship              | British Columbia | molybdenite deposit                            | some outcrop with a few feet of surficial material in other areas: steep slope | well-drained forest soil                      | relatively uniform medium aged forest             | Pilot Project planned    |
| 1966 | Faro No. 1              | Yukon            | lead zinc copper sulphide deposit              | surficial material variable in thickness possible local permafrost             | ash layer forest soil some peat locally       | forest with some bog                              |                          |
| 1966 | Faro No. 3              | Yukon            | lead zinc copper sulphide deposit              | variable conditions surficial material probably several feet thick             | ash layer well- to poorly drained forest soil | forest with some open areas covered with bushes   |                          |
| 1966 | Swim Lake No. 1         | Yukon            | base metal sulphide deposit                    | surficial material probably several feet thick, permafrost                     | forest soil frozen locally ash layer          | forest with some open bog                         |                          |

Notes

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Table E 6 The total metal content of samples of B horizon (or equivalent) mineral soil collected in landscapes containing nine drilled, undisturbed mineral deposits.

| Stn.<br>No. | deposit number    |       |       |       |       |     |        |       |    |
|-------------|-------------------|-------|-------|-------|-------|-----|--------|-------|----|
|             | 1                 | 2     | 3     | 4     | 5     | 6   | 7      | 8     | 9  |
|             | <u>COPPER</u>     |       |       |       |       |     |        |       |    |
| A           | 100 a             | 72    | 40    | 260   | 32    | 36  | 32     | 12    | 16 |
| B           | 32                | 36    | 40    | 260   | 20    | 36  | 36     | 28    | 24 |
| C           | 20                | 52    | 36    | 250   | 32    | 16  | 32     | 36    | 12 |
| D           | 20                | 360 b | 32    | 220 e | 32    | 24  | 56     | 20    | 4  |
| E           | 20                | 68    | 160   | 220   | 40    | 20  | 44     | 32    | 12 |
| F           | 36                | 56    | 260   | 220   | 40    | 20  | 44     | 32    | 16 |
| G           | 20                | 48    | 170 d | 800   | 40    | 28  | 72     | 64    | 4  |
| H           | 32                | 68    | 560   | 210   | 40    | 20  | 48     | 20    | 4  |
| I           | 20                | 52    | 110   | 310   | 20    | 28  | 48     | 32    | 4  |
| J           | 24                | 40    | 40    | 30    | 48    | 24  | 40     | 32    | 4  |
| K           | 12                | 110 c | 56    | 60    | 68    | 32  | 68     | 36    | 4  |
| L           | 4                 | 220 c | 76    | 24    | 48    | 8   | 120    | 32    | 4  |
| M           | 12                | 40    | 40    | 56    | 48    | 32  | 20     | 36    | 4  |
| N           | 4                 | 16    | 80    | 36    | 48    | 40  | 20     | 32    | 20 |
| Ø           | 12                | 36    | 36    | 52    | 48    | 36  | 24     | 20    | 16 |
|             | <u>ZINC</u>       |       |       |       |       |     |        |       |    |
| A           | 110               | 1600  | 170   | 270   | 130   | 110 | 130    | 130   | 50 |
| B           | 70                | 1800  | 240   | 70    | 80    | 120 | 130    | 60    | 70 |
| C           | 30                | 560   | 170   | 90    | 90    | 170 | 170    | 130   | 60 |
| D           | 50                | 1100  | 110   | 100   | 120   | 230 | 180    | 70    | 60 |
| E           | 70                | 580   | 100   | 100   | 130   | 340 | 170    | 120   | 60 |
| F           | 150               | 1200  | 60    | 90    | 170   | 260 | 180    | 110   | 80 |
| G           | 30                | 900 g | 40    | 110   | 180   | 460 | 240    | 700 j | 70 |
| H           | 190 f             | 660   | 110   | 80    | 280   | 260 | 460    | 80    | 80 |
| I           | 130               | 380   | 70    | 110   | 280   | 220 | 270    | 240   | 80 |
| J           | 90                | 520   | 40    | 80    | 360   | 170 | 290    | 240   | 70 |
| K           | 120               | 1200  | 80    | 70    | 540   | 270 | 600    | 70    | 90 |
| L           | 70                | 2000  | 80    | 100   | 360   | 140 | 3400 i | 270   | 60 |
| M           | 70                | 1200  | 60    | 70    | 460 h | 240 | 170    | 140   | 30 |
| N           | 70                | 850   | 210   | 100   | 270   | 240 | 150    | 80    | 90 |
| Ø           | 110               | 360   | 170   | 130   | 360   | 180 | 180    | 60    | 50 |
|             | <u>MOLYBDENUM</u> |       |       |       |       |     |        |       |    |
| A           | 7                 | 56    |       |       |       |     |        |       |    |
| B           | 7                 | 12    |       |       |       |     |        |       |    |
| C           | 2                 | 9     |       |       |       |     |        |       |    |
| D           | 27                | 12    |       |       |       |     |        |       |    |
| E           | 52                | 50    |       |       |       |     |        |       |    |
| F           | 160               | 9     |       |       |       |     |        |       |    |
| G           | 21                | 17    |       |       |       |     |        |       |    |
| H           | 160               | 5     |       |       |       |     |        |       |    |
| I           | 140 q             | 14    |       |       |       |     |        |       |    |
| J           | 160               | 7     |       |       |       |     |        |       |    |
| K           | 360               | 5     |       |       |       |     |        |       |    |
| L           | 96                | 5     |       |       |       |     |        |       |    |
| M           | 46                | 27    |       |       |       |     |        |       |    |
| N           | 17                | 9     |       |       |       |     |        |       |    |
| Ø           | 14                | 28    |       |       |       |     |        |       |    |

Table E 6 The total metal content of samples of B horizon (or equivalent) (cont'd) mineral soil collected in landscapes containing nine drilled, undisturbed mineral deposits.

| Stn.<br>No. | deposit number |                  |    |    |                  |                  |                  |                 |    |
|-------------|----------------|------------------|----|----|------------------|------------------|------------------|-----------------|----|
|             | 1              | 2                | 3  | 4  | 5                | 6                | 7                | 8               | 9  |
|             | LEAD           |                  |    |    |                  |                  |                  |                 |    |
| A           | 5              | 80               | 30 | 5  | 20               | 15               | 35               | 5               | 5  |
| B           | 5              | 170              | 35 | 5  | 30               | 5                | 30               | 5               | 20 |
| C           | 5              | 60               | 15 | 5  | 5                | 35               | 25               | 65              | 5  |
| D           | 5              | 80               | 10 | 5  | 50               | 90               | 50               | 150             | 5  |
| E           | 5              | 140              | 25 | 5  | 140              | 140              | 90               | 50              | 5  |
| F           | 5              | 120              | 10 | 5  | 120              | 140              | 140              | 140             | 5  |
| G           | 10             | 120              | 10 | 5  | 55               | 230 <sup>m</sup> | 700              | 3200            | 5  |
| H           | 5              | 120              | 15 | 5  | 55               | 140              | 200 <sup>n</sup> | 90 <sup>o</sup> | 10 |
| I           | 5              | 110              | 15 | 5  | 30               | 50               | 220 <sup>n</sup> | 650             | 10 |
| J           | 5              | 160              | 15 | 10 | 70               | 40               | 130              | 110             | 10 |
| K           | 5              | 210              | 10 | 10 | 300 <sup>l</sup> | 70               | 220              | 35              | 30 |
| L           | 5              | 220              | 15 | 5  | 65               | 20               | 45               | 500             | 10 |
| M           | 5              | 800              | 5  | 5  | 40               | 55               | 30               | 120             | 5  |
| N           | 5              | 240 <sup>k</sup> | 15 | 5  | 40               | 100              | 20               | 35              | 5  |
| Ø           | 5              | 460              | 10 | 5  | 50               | 45               | 80               | 40              | 5  |
|             | NICKEL         |                  |    |    |                  |                  |                  |                 |    |
| A           | 20             | 10               | 20 | 35 | 20               | 10               | 40               | 10              | 35 |
| B           | 5              | 10               | 25 | 20 | 20               | 30               | 35               | 5               | 35 |
| C           | 20             | 5                | 30 | 20 | 20               | 25               | 40               | 5               | 60 |
| D           | 10             | 10               | 15 | 20 | 40               | 50               | 60               | 5               | 20 |
| E           | 10             | 5                | 15 | 35 | 35               | 55               | 35               | 5               | 50 |
| F           | 20             | 5                | 10 | 35 | 25               | 60               | 35               | 5               | 45 |
| G           | 5              | 15               | 5  | 35 | 20               | 40               | 45               | 20              | 40 |
| H           | 15             | 5                | 10 | 25 | 30               | 50               | 40               | 20              | 40 |
| I           | 15             | 15               | 5  | 20 | 15               | 40               | 45               | 5               | 40 |
| J           | 5              | 5                | 5  | 20 | 15               | 15               | 40               | 5               | 35 |
| K           | 10             | 10               | 5  | 30 | 40               | 25               | 40               | 5               | 40 |
| L           | 5              | 10               | 15 | 20 | 35               | 10               | 30               | 5               | 40 |
| M           | 15             | 5                | 10 | 20 | 30               | 10               | 40               | 20              | 5  |
| N           | 5              | 5                | 20 | 20 | 20               | 80               | 40               | 20              | 60 |
| Ø           | 15             | 5                | 20 | 35 | 35               | 75 <sup>p</sup>  | 35               | 5               | 20 |

Name of deposit

Notes

Number

Station interval

|                   |                   |         |
|-------------------|-------------------|---------|
| <u>Molybdenum</u> | 1 = Lucky Ship    | 100 ft. |
| <u>deposits</u>   | 2 = Tuzo Creek    | 100 ft. |
| <u>Copper</u>     | 3 = Pekana Creek* | 200 ft. |
| <u>deposits</u>   | 4 = Lornex        | 100 ft. |
| <u>Base Metal</u> | 5 = Swim Lake     | 100 ft. |
| <u>deposits</u>   | 6 = Faro No. 1    | 100 ft. |
|                   | 7 = Faro No. 3    | 100 ft. |
|                   | 8 = Silvermine*   | 300 ft. |
|                   | 9 = Kidd Creek*   | 200 ft. |

The location of each of these mineral deposits is shown on Figure 2.

The subscripts 'a' to 'q' refer to anomalies in Table E 7.

These results are plotted on the scan sheet, Figure E 16.

The figures which have been boxed indicate stations near which positive results from plant prospecting methods research might be expected.

\*This data was not obtained during Visits and is later described in Section F or G.

Table E 7 Summary of chemical data obtained from nine site sets of mineral soil samples each collected in the vicinity of a drilled, undisturbed mineral deposit.

| Deposit                 | Element          | Anomaly | Extent     | Contrast*                | Remarks                                             |
|-------------------------|------------------|---------|------------|--------------------------|-----------------------------------------------------|
| Tuzo Creek<br>B.C.      | Zinc             | g       | 1,500 feet | 2 - 10 fold <sup>+</sup> | Whole length of line                                |
|                         | Lead             | k       | 1,500 feet | 4 - 40 fold <sup>+</sup> | Whole length of line                                |
|                         | Copper           | b       | 1 station  | 10 fold                  | <u>Deposit suitable for a</u>                       |
|                         | Copper           | c       | 2 stations | 4 <sup>+</sup> fold      | <u>Pilot Project</u>                                |
|                         | Molybdenum       |         | 8 stations | 2 - 10 fold              | At random along line                                |
| Silvermine<br>N.S.      | Lead             | o       | 1,200 feet | 3 - 300 fold             | Pilot Project complete                              |
|                         | Zinc             | j       | 1 station  | 6 fold                   | (see Section G)                                     |
| Lucky Ship<br>B.C.      | Molybdenum       | q       | 700 feet   | 2 - 18 fold              | <u>Deposit suitable for</u>                         |
|                         | Zinc             | f       | 1 station  | 2 fold                   | <u>Pilot Project</u>                                |
|                         | Copper           | a       | 1 station  | 4 fold                   |                                                     |
| Faro No. 3<br>Y.T.      | Zinc             | i       | 2 stations | 17 fold                  |                                                     |
|                         | Lead             | n       | 500 feet   | 3 - 14 fold              |                                                     |
| Swim Lake No. 1<br>Y.T. | Lead             | l       | 1 station  | 5 fold                   |                                                     |
|                         |                  | h       | 500 feet   | 2 - 3 fold               |                                                     |
| Lornex<br>B.C.          | Copper           | e       | 800 feet   | 5 + fold                 | <u>Deposit suitable for</u><br><u>Pilot Project</u> |
| Pekan Creek<br>P.Q.     | Copper           | d       | 800 feet   | 5 + fold                 | <u>Quick Project complete</u><br>(see Section F)    |
| Faro No. 1              | Lead<br>(Nickel) | m       | 300 feet   | 3 - 4 fold               | only higher than normal<br>values found             |
|                         |                  | p       | 100 feet   | none                     |                                                     |
| Kidd Creek<br>Ont.      | Zinc             | none    | none       | none                     | <u>Quick Project complete</u>                       |
|                         | Copper           |         |            |                          | (see Section F)                                     |

\*The figure given for contrast is in all cases only a first approximation determined empirically.

+In these cases relatively high values were obtained at all stations. Background was assumed to be similar to that in other areas.



The data as presented on Table E 7 indicate that, from the point of view of soil geochemistry the Tuzo Creek landscape is of greatest interest because there are significant anomalies for four out of the five elements determined in the samples and because the areal extent of the anomalous area is relatively large. Unfortunately the variations in the plant-cover types may limit the suitability of the area for a Pilot Project. Pilot Projects have been completed or are planned for the Silvermine, Lucky Ship, Lornex as well as the Tuzo Creek area.

This discussion of the role of preliminary soil investigations in the selection of areas for plant prospecting methods research should end on a note of caution. It is clear that like the preparation of plant-cover type maps, soil sampling is only one indication of the suitability of a landscape for biogeochemical or geobotanical research. Although to begin with we have chosen only those landscapes where good geochemical indications are known, later, as the results of more Pilot Project become available, landscapes where less positive soil geochemistry occurs will almost certainly be chosen for research.

#### E 7 Summary of the findings of soil geochemical research

The chemical data obtained from analysis of nine site sets of B horizon (or equivalent) samples, each collected in the vicinity of a different mineral deposit, has been presented on a scan sheet and in tabular form. These results have been interpreted in relation to the suitability of each landscape for Pilot Project study.

It is clearly an advantage to obtain like batches of samples of the same (or similar) horizons of mineral soil from each deposit to which a Visit is made. The choice of the B horizon for study allows comparison of results from one area with those of another, although from the point of view of soil geochemistry these comparisons cannot be pressed too far owing to variations of the intensity of soil forming processes (i.e. climate, drainage vegetation type, maturity of the site etc.). A further advantage of the collection of soil samples during Visits is that it provides material for chemical analysis from each site thus enabling the difficulties in sample preparation or chemical analysis associated with a particular area to be solved prior to any Pilot Project study. In the case of one landscape the determination of elements not assumed to be of interest in the deposit (zinc at Tuzo Creek) resulted in unexpectedly favourable results. The plotting of chemical data obtained from like sets of samples on a scan sheet facilitated the interpretation of results.

#### E 8 General Conclusions

It is concluded that the geobotanical plant-cover type maps and the soil geochemical observations made as described in this report, together with the examination of the background geological geochemical and geophysical

information obtained from a company (when prepared in a form for easy comparison of results) provide a working basis for the assessment and selection of drilled, undisturbed mineral deposits for plant prospecting methods research. The purpose of the Visit is therefore well-founded as an essential preliminary to a Pilot Project.

#### E 9 References

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SECTION F TWO QUICK PROJECTS, ONE AT A MASSIVE  
SULPHIDE OREBODY NEAR TIMMINS, ONTARIO AND  
THE OTHER AT A COPPER DEPOSIT IN  
GASPÉ PARK, QUEBEC

J. A. C. Fortescue and E. H. W. Hornbrook

F 1 Introduction

The first Quick Project was carried out at the Kidd Creek orebody of the Texas Gulf Sulphur Company, near Timmins, Ontario (see Fig. 2) in May, 1964. This project was followed during February, March, and April, 1965 by a drilling program aimed at investigating the geochemistry of the deep layer of surficial material that covers the area near the ore deposit. Some results of these investigations have already been published in two short papers (Fortescue and Hughes, 1965) and (Fortescue and Hornbrook, 1967). The account of the investigation at Kidd Creek given here supplements the preliminary information given previously.

As the result of a suggestion made by Dr. Paul - E. Grenier,<sup>1</sup> in June, 1966, a Visit, closely followed by a Quick Project, was carried out at the Pekan Creek copper deposit of Terra Nova Explorations Ltd. in Gaspé Park, Quebec. The collection of samples of soil and plant material was completed three weeks later and a shallow seismic traverse completed along the cut line sampled by the end of August. Although the landscape conditions along the cut line were very favourable with respect to slope, soil cover, and vegetation cover, the results from the soil, and particularly the plant-geochemical investigations were disappointing. Consequently no further investigations are planned for this area at present.

F 2 The Quick Project at the Kidd Creek massive sulphide deposit

The Kidd Creek<sup>2</sup> copper-zinc massive sulphide orebody of the Texas Gulf Sulphur Company<sup>3</sup> is situated in Kidd Township north of Timmins, Ontario (Fig. 2). Vegetation cover above the orebody was stripped off before the removal of the layer of surficial material during late May and June, 1964

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<sup>1</sup>Directeur, Services Géologiques, Ministère des Richesses Naturelles du Québec.

<sup>2</sup>At the time the first paper was written (Fortescue and Hughes, 1965) the property was referred to as the 'Dragon Property'.

<sup>3</sup>The writers would like to thank the management of the Texas Gulf Sulphur Company for permitting our sample collection at a very busy time during the development of the deposit during the summer of 1964. Field investigations were greatly facilitated by Mr. H. Clayton at first and later on by Mr. B. Hester.

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(see Fig. F 1). The sample collection program involved in the Quick Project was carried out during the last week in May, just prior to the stripping operations. Soil samples were collected at 200-foot, and in some cases 100-foot, intervals along previously cut lines located 200 feet apart located at right angles to the strike of the suboutcropping ore. Vegetation samples were collected from five cut lines located within the most uniform plant-cover types. Over 500 samples were collected from 150 sample points included in the area shown on Figure F 9. Some of the soil samples, collected toward the side of the suboutcrop of the ore were collected after the Quick Project, later in the same summer.

The second part of the project involved a surficial material drilling program<sup>1</sup> which was planned in January, 1965 and completed in April. Samples of clay material and underlying lower till material were collected from nine boreholes located in the 'down-ice' direction from the mineral deposit. Two hundred samples were collected, each being analyzed for total copper, zinc, lead and nickel. The sampling was carried out by a Failing Drill (see Part I, Frontispiece) mounted on a truck which moved on winter roads prepared on the frozen muskeg surface.

(1) General description of the area. The Kidd Creek massive sulphide ore deposit lies at a north-trending contact in volcanic rocks of the Tisdale Group of Archean age. The Tisdale rocks are a typical interbedded sequence of volcanic and sedimentary rocks including rhyolite pyroclastics, which are found to the east of the deposit, and andesitic pillow lavas to the west. The mineral deposit tends to be rich in copper at the northeast, and, where it is narrow at the south end, high zinc values are found (Roscoe, 1967; personal communication). Details of the mineralogy of specimens of the ore are given in a report by Petruk and Owens (1965).

Kidd Township is in the Great Clay Belt of Northern Ontario. The nature of the layer of surficial material was described previously (Fortescue and Hughes, 1965). Briefly, the glacially paved bedrock surface (Fig. F 8) is overlain by a layer of lower till material of variable thickness (Fig. F 6) a part of which is locally derived. The lower till is covered by varved clay layers which are commonly tens of feet thick (Fig. F 5). The upper part of the clay layer was disturbed by a late, Cochrane, readvance of the ice that resulted in the formation of a clay till layer which is usually less than 30 feet thick (Fig. F 5). The upper surface of the clay is nearly flat (Fig. F 5) with a layer of peaty material lying directly on the clay (Fig. F 7). In the vicinity of rock outcrops, or in slightly higher parts of the area which are better drained, a mineral soil profile is developed which in some places includes an easily recognizable B horizon.

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<sup>1</sup>The writers acknowledge the cooperation of the Department of Public Works who made available a drill and crew at short notice to undertake the sampling program and in particular Mr. N. E. Laycraft, Chief of the Testing Laboratories Division who made the arrangements.

Figure F 1

Kidd Creek Quick Project;  
View south overlooking  
the suboutcrop area of  
the mineral deposit. Note  
the scrub prepared for  
burning in the foreground  
with mixed deciduous and  
coniferous forest in the  
background.



Figure F 2

Kidd Creek Quick Project;  
View southeast from the  
suboutcropping mineral  
deposit. Note the aspen  
stand in the background  
in which the camp is  
situated.



Figure F 3

Kidd Creek Quick Project:  
View from the north end  
of the campsite looking  
southeast. Note the  
aspen stand with mixed  
deciduous and coniferous  
forest in the background.

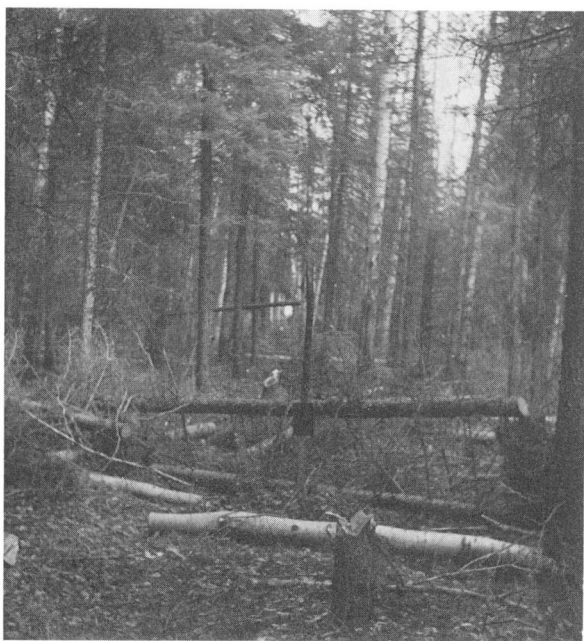


Figure F 4

Kidd Creek Quick Project:  
View looking west along  
Line 345 from coniferous  
into deciduous stand.

Figure F 5

Kidd Creek Quick Project:  
View of the face of a test  
pit dug to expose overburden  
section prior to stripping.  
Note the flat surface of the  
clay till with the remains  
of the organic soil layer,  
as well as the mixed decid-  
uous and coniferous stand  
in the background. In the  
foreground some twenty  
feet of clay till lie above  
varved clay, some of the  
varves are contorted.  
(Vertical lineaments are  
made during stripping  
operations.)



Figure F 6

Kidd Creek Quick Project:  
Lower till material resting  
on bedrock. The notebook  
is resting on outcrop with  
some 2 feet of lower till  
material below the varves.  
A large ice-rafted block  
rests on the lowermost  
varves.

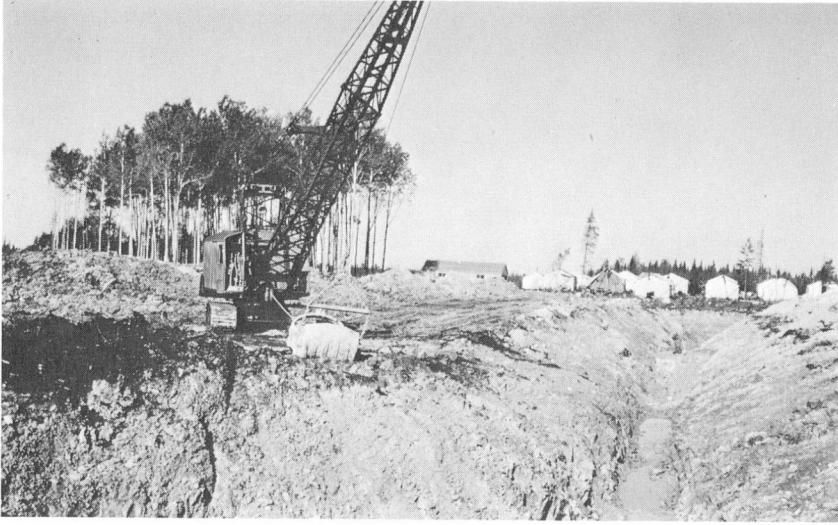


Figure F 7 Kidd Creek Quick Project: View looking west along Line 26S towards the tent camp. Note the aspen stand in the distance with the dark line of organic matter on the side of the trench closer to the camera and outcrops in the bottom of the trench in between the puddles of rainwater. (GSC 200390-A)



Figure F 8 Kidd Creek Quick Project: The bottom of trench on Line 26S at Kidd Creek showing the fresh glacially paved surface of the ore zone. (GSC 200390-B)



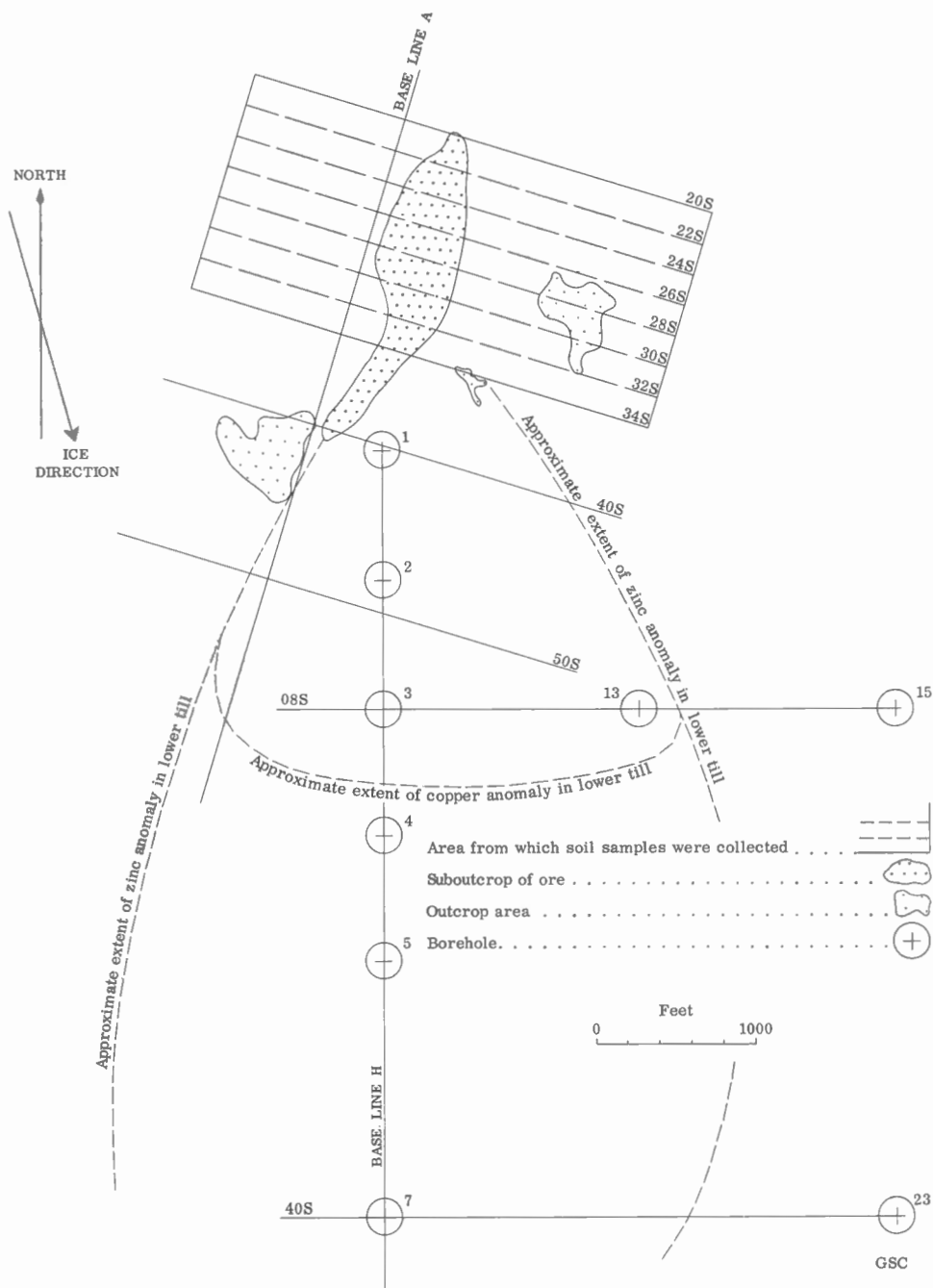


Figure F9. Kidd Creek Quick Project. Index map showing the location of the area from which soil and plant samples were collected and the location of the boreholes from which the samples of surficial material were collected in relation to suboutcrop area of the mineral deposit

The Great Clay Belt, which includes Kidd Township, is in the Northern Clay Section of the Boreal Forest, and is described by Rowe (1959) as follows:

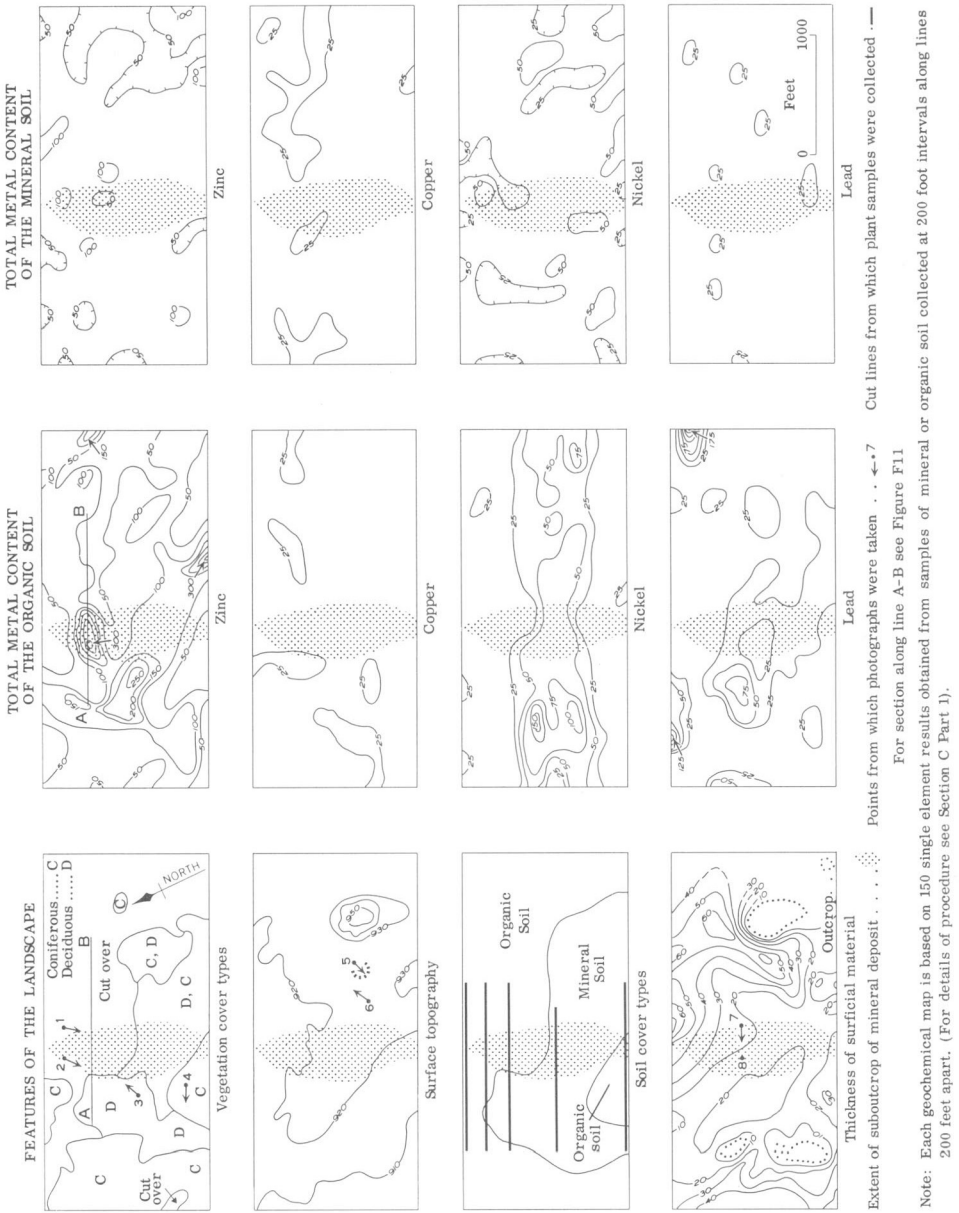
"The impressive characteristic of the "Clay Belt" is the seemingly endless stretches of stands of black spruce (Picea mariana) which cover the gently rising uplands as well as the lowland flats, alternating in the latter position with extensive sedge and heath bogs. Tamarack (Larix laricina) is an infrequent companion of the black spruce except in young stands. Extensive areas of spruce-cedar swamp occur but the latter species (Thuja occidentalis) reaches tree size only at the swamp borders. Improvement in drainage due either to slight changes in relief, to shallowly buried coarse drift or to position beside rivers and lakes, is reflected in fine hardwood or mixedwood stands of aspen (Populus tremuloides), balsam poplar (P. balsamifera), balsam fir (Abies balsames), white spruce (Picea glauca) and the black spruce. Jack pine (Pinus banksiana) has a dominant position on many of the dried sites such as outwash deposits, old beaches and eskers."

Both mineral and organic soil cover types are found in the vicinity of the suboutcrop of the ore (Fig. F 9). Several types of vegetation cover are found in the same area including coniferous, deciduous, and mixed forest. A part of the area, which had been logged over a few years ago, was covered with muskeg or alder. The complexity of the plant-cover types made the choice of cut lines from which vegetation samples were to be collected difficult (see Figs. F 1, F 2, F 3 and F 4).

(2) Biogeochemical and soil geochemical investigations. Data on the description of the landscape in which the Kidd Creek orebody occurs and on the geochemistry of the mineral and organic soil samples collected from the area have been brought together on Figure F 10. At the left of the figure small maps show, 1) the total thickness of the layer of surficial material; 2) the soil cover types; 3) the surface topography; and 4) the distribution of the vegetation cover types. The locations from which the photographs (Figs. F 1 to F 8) of surficial material and vegetation cover types were taken are also shown on these maps as well as the location of the cut lines from which the samples were collected.

The mineral soil samples were collected from small pits, whereas the organic soils were sampled by a 3-inch diameter Shelby Tube hand sample (see Part I, Section C for details). The methods by which the samples of soil and vegetation were collected, dried, subsampled and analyzed colorimetrically (or, in the case of most of the vegetation samples, spectrographically) for a number of minor elements, were also described in Part I, Section C.

The total amount of zinc, copper, lead and nickel in samples of mineral and organic soil has been plotted on contour maps in Figure F 10. In general these results were disappointing because no strong anomalies of



the type previously described (see Fig. E 16) near other base metal deposits were found for any of the four elements determined in either the mineral or the organic soil. The metal values obtained for all four elements in the mineral soil lying below the organic layer are typical of what might be expected in a landscape located away from mineral deposits. In the case of the organic soils more complicated patterns were obtained for nickel, lead and zinc although the results for copper were consistently low. The higher nickel values are found in a belt extending across the area from one outcrop area to another and, because they occur under different plant-cover types (i.e. one plant community does not preferentially cycle nickel), may be due in part to the proximity of outcrops. More detailed investigations of the nickel content of the organic layer of soil collected under similar landscape conditions might prove or disprove this assumption. The data obtained for lead in the organic soil (see Fig. F 10) appears to be influenced by the ridge of higher ground that trends northwest and is associated with the presence of mineral soil and deciduous and mixed deciduous and coniferous forest cover. The small high-lead anomaly in the northeast of the map-area is probably an erratic value. The most important distribution pattern for an element from the point of view of mineral exploration was found in the case of zinc in mineral soil (Fig. F 10). Although the distribution patterns for lead and zinc are generally similar, in the case of zinc two distinct anomalies are found one of which, on Line 24S is located almost directly above the suboutcrop of the mineral deposit in an area where the bedrock surface is less than 30 feet deep.

In Figure F 11, a section of the part of Line 24S coincident with the zinc anomaly is given showing the location of the ore in the bedrock in relation to the depth of the layer of surficial material, the nature of the soil cover, the surface relief and the vegetation cover types found in the vicinity. Results for the chemical analysis of the samples of mineral and organic soil collected at 100-foot intervals along the section have also been plotted on the same figure. Unfortunately details of the composition of the layer of surficial material along this line are not known at first hand. However, the layer of surficial material was studied in a trench parallel to Line 24S located 200 feet to the south (see Figs. F 7 and F 8) where a layer of varved clay lies directly on the glacially paved bedrock surface (see Frontispiece) containing fresh sulphide minerals in the ore zone. Although the rock surface had been polished smooth by the physical action of the moving ice no chemical weathering had subsequently occurred at the surface of the ore. It is likely that these physical and chemical features of the bedrock extend northwards under Line 24S. The geochemical data may be interpreted using the information collected on the landscape. First it is noted that the layer of surficial material (probably varved clay without significant amounts of underlying lower till) deepens towards the east, and that this deepening of the layer is associated with a slight, but uniform, increase in the zinc content of the mineral soil (from 100 to about 200 ppm). The zinc content in the organic layer provides the reverse pattern; in the vicinity of the shallow part of the layer of surficial material (where the mineral soil occurs and the aspen cover type is found) at

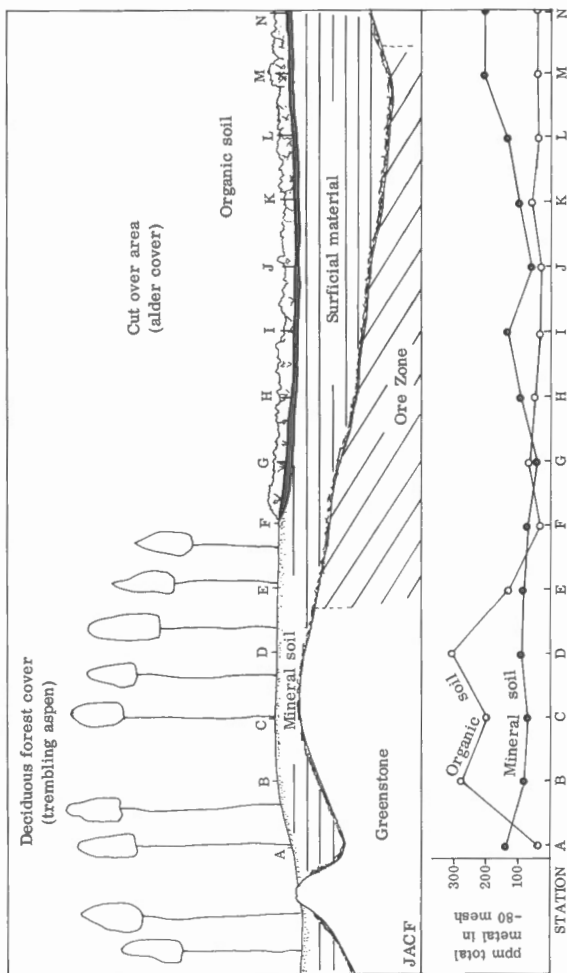


Figure F11. Kidd Creek Quick Project. Landscape section showing bedrock geology, surficial geology, soil cover types and plant cover types in the vicinity of a zinc anomaly in the soil on line 24 S.

the west end of the section, high zinc values occur. Towards the east, there are lower values in the area of organic soil with the alder plant-cover. Thus it seems very probable that the anomaly in the zinc content of the organic layer of the soil is due to the accumulation of zinc derived from decaying aspen leaves and not to zinc which has migrated upwards from the mineral deposit. The slight decrease in the amount of zinc found in the mineral soil under the aspen stand provides support for this interpretation. A second fact which supports this interpretation is that under parts of the aspen stand, located away from the suboutcrop of the mineral deposit (see Fig. F 9) similar concentrations of zinc are found.

The effectiveness of the varved clay layer in insulating the soil from relatively high concentrations of zinc in lower till is described below and it is logical to assume that where the bedrock is directly under the clay layers, the insulation is even more effective.

When the high zinc values in the organic soil were first discovered it was thought that they might be due to zinc derived from an exposure of lower till material, or from a seasonal flow of artesian waters that had been in contact with ore or lower till containing ore minerals. No evidence to support these suggested interpretations was found, but, as will be described below, lower till material may be extremely valuable in geochemical prospecting in the Clay Belt and exposures of this material should always be looked for and examined geochemically during routine geochemical prospecting in the area.

During the Quick Project numerous samples of vegetation of various kinds were collected from the five cut lines indicated on the soil-cover map (Fig. F 10). These samples were ashed and analyzed by the Scan Spectrographic method (see Part I, Section C) in the trailer laboratory during the summer of 1965. A close inspection of the results showed no significant variations in the concentration of any element that could be directly related to the presence of the mineral deposit. The spectrographic method was being modified slightly during the time when these samples were examined, and chemical data obtained for specific batches of different material, were subject to different amount of bias. This did not affect the precision of the data from any batch of samples although it did affect the accuracy of the data. For this reason none of these results are included to indicate background concentrations of the elements concerned in the different kinds of plant material. Results obtained colorimetrically for a typical site set of vegetation samples collected above the suboutcrop of the deposit were included in a previous paper (Fortescue and Hornbrook, 1967).

(3) The surficial material drilling project. In a previous report (Fortescue and Hughes, 1965) the importance of lower till material for geochemical prospecting in the vicinity of the Kidd Creek orebody was stressed. In particular the presence of an anomaly for zinc and copper in this material

in the 'down-ice' direction from the orebody was described, but, unfortunately these results were too few to give any indication of the extent of the geochemical anomaly in this direction, or the uniformity of the chemical composition of the lower till material. The winter drilling program was designed to provide more information of this kind. The program had two aims: 1) to provide systematic information on the nature and geochemistry of the layer of surficial material in the down-ice direction from the mineral deposit which would be of direct interest to all engaged in exploration in the Clay Belt of Northern Ontario or in other areas where similar landscape conditions obtain, and, 2) to provide information of use in developing techniques of use in areas where geochemical soil and plant methods have been unresponsive in the vicinity of a mineral deposit.

The location of the individual boreholes in relation to the suboutcrop of the orebody and the probable extent of the zinc and copper anomalies in the lower till material are shown on Figure F 9. The content of total zinc, copper, lead and nickel in the different layers of the surficial material is summarized on Table F 1 and illustrated on Figure F 13. Geological sections showing details of the vertical distribution of zinc in two boreholes are given on Figure F 13.

Details of the methods used to obtain the samples of different kinds of surficial material were given in Part I, Section C. Briefly, by means of a truck-mounted Failing Drill (see Part I, Frontispiece) the clay layers were sampled every 5 feet by 2-inch diameter Shelby tubes 24 inches long. An example of a sample of this type when freshly extruded from the Shelby tube, with a slice cut from the surface just prior to the collection of a channel sample for chemical analysis, is shown on Figure F 12. All samples for chemical analysis were taken from small, uniformly deep, channels cut from top of bottom of freshly extruded samples. The clay material was then oven dried at 110°C and prepared for chemical analysis for total zinc, copper, lead and nickel by methods described in Part I, Section C. Samples of lower till material were collected using a split spoon or hardwall sampler.

The results obtained for total copper and zinc in the lower till samples have been summarized by contours delineating the approximate extent of the anomalies for those metals on Figure F 9. This anomalous area is several times the area of the suboutcrop of the deposit and provides a relatively large target for geochemical prospecting based on the lower till material. The zinc anomaly is larger than that for copper, possibly due to the deposit being relatively zinc-rich at the south end, and not to the greater mobility of zinc ions relative to copper ions in the lower till. This finding is most important in planning prospecting in the Great Clay Belt.

More details of the results of the drilling program are given on the series of plans (Fig. F 13). The size of the dot at each borehole site indicates the average minor element content within a given layer of the surficial material. This method of plotting focuses attention on the abnormally high

Table F 1 Timmins Drilling Project: Summary of data obtained for minor element content of the surficial material.

|                 | Clay Till                        |        |      |      |        | Varved Clay                      |                  |      |      |        | Lower Till                       |        |      |      |        |                        |
|-----------------|----------------------------------|--------|------|------|--------|----------------------------------|------------------|------|------|--------|----------------------------------|--------|------|------|--------|------------------------|
| Borehole Number | Total metal content <sup>†</sup> |        |      |      |        | Total metal content <sup>†</sup> |                  |      |      |        | Total metal content <sup>†</sup> |        |      |      |        | Total depth to bedrock |
|                 | Footage                          | Copper | Zinc | Lead | Nickel | Footage                          | Copper           | Zinc | Lead | Nickel | Footage                          | Copper | Zinc | Lead | Nickel |                        |
| 1               | 5-27*                            | 10     | 100  | 10   | 50     | 27-51                            | <10 <sup>@</sup> | 50   | 10   | 50     | 51-52                            | 1000   | 2000 | 100  | 100    | 52                     |
| 2               | 5-42                             | 10     | 100  | 10   | 50     | 42-79                            | 10               | 100  | 10   | 50     | 79-107                           | 50     | 500  | 10   | 10     | 107                    |
| 3               | 5-52                             | 10     | 100  | 10   | 50     | 52-113                           | 10               | 50   | <10  | 50     | 113-121                          | 50     | 500  | <10  | 50     | 121                    |
| 4               | 5-47                             | 10     | 100  | 10   | 50     | 47-97                            | 10               | 50   | <10  | 50     | 97-123                           | 10     | 100  | <10  | 50     | 123                    |
| 5               | 5-37                             | 10     | 100  | <10  | 50     | 37-92                            | <10              | 50   | <10  | 10     | 92-98                            | 10     | 100  | <10  | 10     | 98                     |
| 7               | 5-47                             | 10     | 100  | 10   | 10     | 47-102                           | 10               | 50   | 10   | 10     | 102-206                          | 10     | 100  | 10   | 10     | 209                    |
| 13              | 5-32                             | 10     | 100  | 10   | 50     | 32-67                            | 10               | 50   | 10   | 50     | 67-72                            | 50     | 100  | <10  | 50     | 73                     |
| 15              | 5-42                             | 10     | 100  | 10   | 50     | 42-92                            | 10               | 50   | <10  | 50     | 92-96                            | 10     | 50   | <10  | 50     | 97                     |
| 23              | 5-52                             | 10     | 100  | <10  | 50     | 52-131                           | 10               | 100  | <10  | 50     | 121-137                          | 10     | 50   | 10   | 10     | 137                    |

<sup>†</sup> Arithmetic average values for parts per million in samples from a given footage.

\* First sample was always collected five feet below the ground surface.

@ Indicates less than ten parts per million metal.



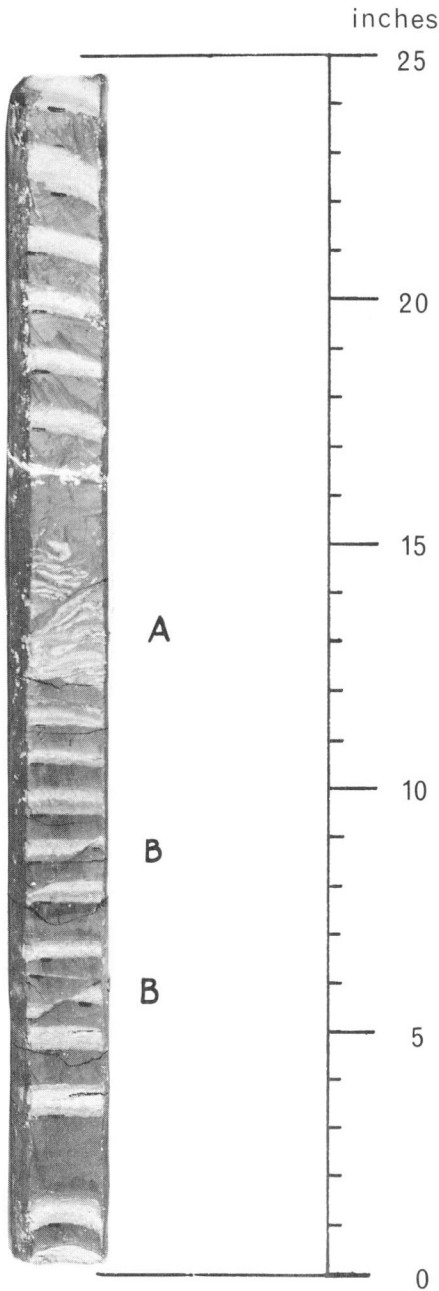


Figure F 12

Drilling Project: Typical varve clay core sample from borehole No. 4 (depth 80 feet). A face has been cut on the sample to facilitate description. Note the marks designating each varve, details of contorted varves (at A) and displacement of a varve along a fault (at B). (GSC 11229-A)

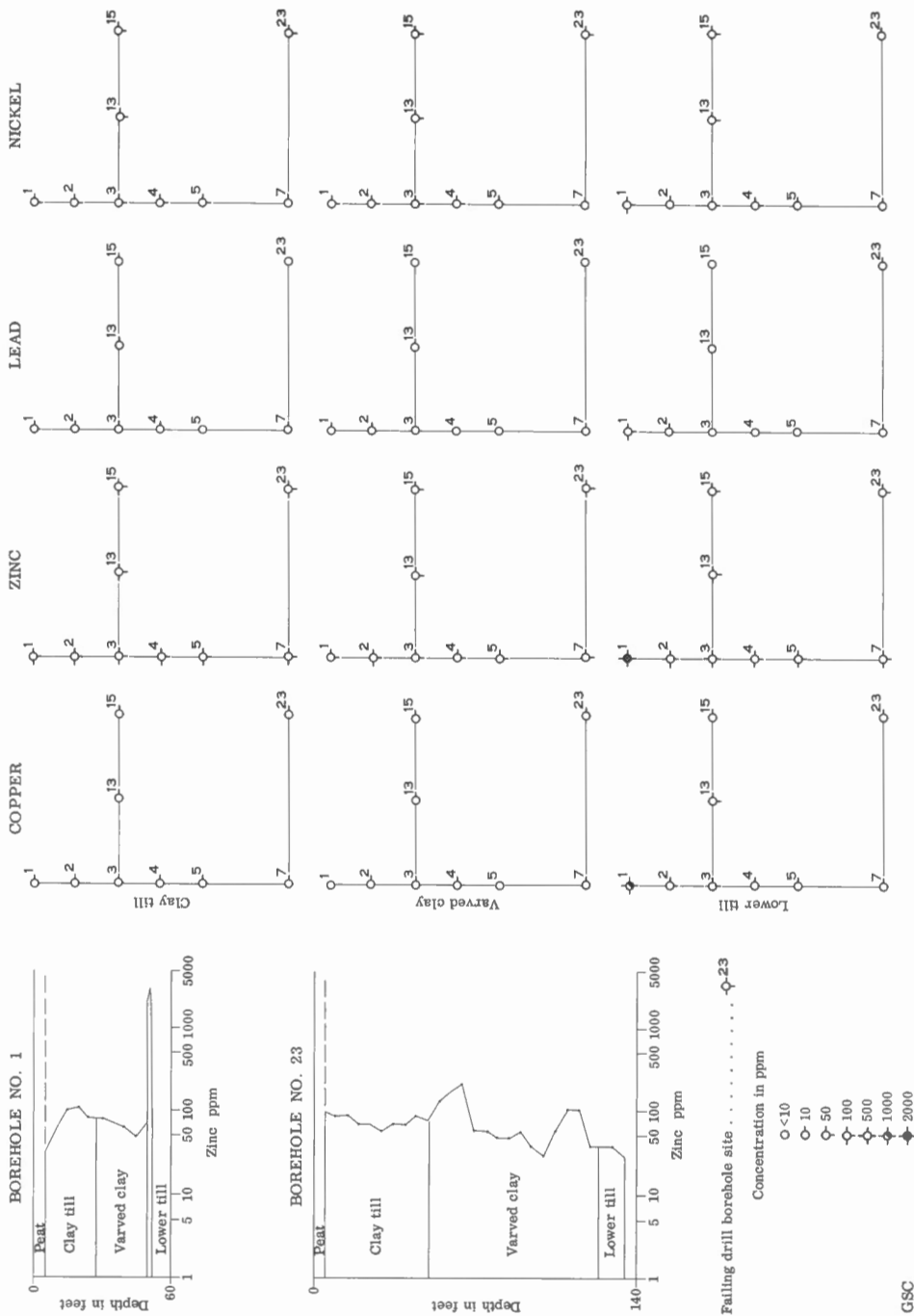


Figure F13. Kidd Creek Drilling Project. The distribution of total minor element content in three layers of surficial material.

amounts of zinc and copper in the lower till material just down-ice from the mineral deposit compared with the content of these elements in the overlying clay layers. The results for lead are uniform and relatively low in all materials except in the case of lower till material collected from borehole No. 1. The results for nickel in the different clay layers are exactly the same and relatively high for material of this kind. In the lower till the distribution pattern for nickel is similar to that in the clays except for the anomalous results in borehole No. 1. These data are also tabulated in Table F1. Briefly, in the case of borehole No. 1, copper values 100 times background (i.e. 1,000 ppm) were obtained for lower till samples, and five-fold anomalies in boreholes No. 2, No. 3, and No. 13 (see Fig. F13) which together indicate a persistent geochemical anomaly of five times background values. This pattern of high values is also present in the case of zinc where 2,000 ppm is found at borehole No. 1, 500 ppm at boreholes No. 2 and No. 3 and 100 ppm at boreholes No. 4, No. 5, No. 7, and No. 13. Again the anomalous values are consistently high and, when plotted indicate a target area for prospecting purposes.

The details of the vertical distribution of zinc in two boreholes, one located above the lower till anomaly (No. 1), and the other in a control area (No. 23) are shown in Figure F13. These sections show in detail the generalized results described above. Perhaps the most important information on Figure F13 is that samples from clay layers directly above the lower till in borehole No. 1 have background concentrations of zinc, even though the underlying lower till contains 100 times the background concentration.

(4) Summary and conclusions. The Kidd Creek orebody was exceptionally favourable for geochemical prospecting research in the Great Clay Belt of Northern Ontario because, although there are no outcrops of the ore, the ore zone is large in extent and suboutcrops over a large area of bedrock surface under a relatively thin cover of surficial material. Investigations showed that this layer is typical, with regard to geological section and lithological composition, of the glacial material found in the Great Clay Belt. The soil cover and the vegetation cover found in the area of the suboutcrop of the mineral deposit are also typical of the Boreal Forest cover of the area.

Geochemical investigation of the coarse-textured lower till material found lying on the glacially paved bedrock surface showed strong anomalies for zinc and copper in this material collected above the orebody and for some distance in the down-ice direction from the orebody. This finding is important in planning geochemical prospecting in the Clay Belt area because the area of the geochemical anomaly in the lower till is several times that of the suboutcrop of the deposit, so providing a considerably larger exploration target.

In contrast to the positive geochemical results found in the lower till, negative results were found consistently in the overlying layers of varved clays and clay till. Similarly, negative results were found in the case of the soil geochemical investigations and in the biogeochemical investigations

associated with them. Some significant variations were found in the zinc, lead, or nickel content of the soil organic material, and, in one case, a small zinc anomaly was found directly above the suboutcrop of the ore (less than 30 feet below the daylight surface). Detailed examination of this small anomaly in relation to the features of the landscape in which it occurred provided a reasonable explanation for its existence without reference to zinc derived from the mineral deposit.

In conclusion, the results of the Kidd Creek Project focus attention on the effect of varved clays in restricting the scope of geochemical prospecting in the Great Clay Belt area of Northern Ontario based on mineral or organic soils, or on vegetation samples, which have been collected and analyzed by the methods used in this investigation. The present results indicate that the lower till material is the only reliable material for successful geochemical prospecting in the immediate vicinity of the Kidd Creek ore deposit.

### F 3 The Quick Project at the Pekan Creek copper deposit

In June, 1966 a Visit was made to the Pekan Creek property of Terra Nova Explorations Ltd.<sup>1</sup> in Lesseps Township, Gaspé Park, Quebec (for location see Fig. 2). On the advice of the Company representatives and as a result of field investigations, 30 sample points (see Fig. F 14) were selected for inclusion in a Quick Project which commenced directly after the Visit and lasted ten days. During this period a field crew of three men collected samples of mineral and organic soils, and bark, twig, needle and current growth material from individuals of balsam fir (Abies balsamea) at each of the thirty stations. Sample preparation and colorimetric chemical analysis of the soil and plant material was carried out by methods described in Part I, Section C, as a result of which data for the total copper, zinc, lead and nickel content of the samples was obtained. Results for 600 single element determinations have been brought together on a scan sheet (Fig. F 17).

A shallow seismic survey was carried out in August along the cut line from which the soil and plant samples had been collected. The results of this survey, which are discussed below, are summarized on the small topographic sections which appear at the bottom of each column of panels on Figure F 17.

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<sup>1</sup>The writers would like to thank the management of Terra Nova Explorations Ltd. for allowing this research to be carried out at a busy time during the exploration of the Pekan Creek deposit and in particular Mr. Goldsmith who provided important advice regarding the location of our sampling program. The writers would like to thank Dr. P. E. Grenier and the staff of the Services Géologiques Ministère des Richesses Naturelles du Québec for assistance during the project.

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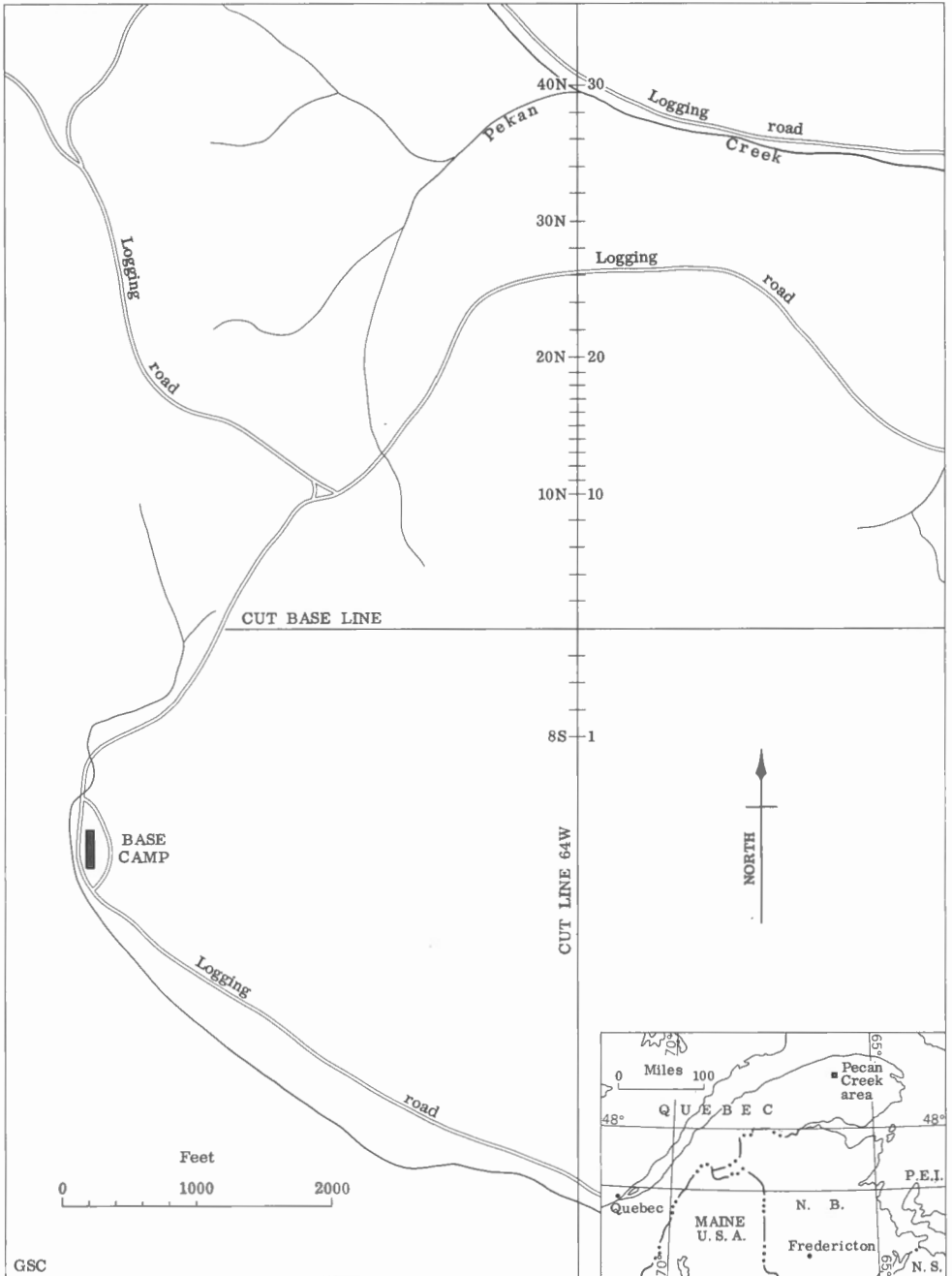


Figure F14. Pekan Creek Quick Project. Index map showing the location of the cut line from which samples were collected

(1) General description of the area. The Pekan Creek copper deposit occurs in an area underlain by sedimentary rocks of Silurian or Devonian age. According to Robert (1966) the mineral deposit is in the central part of an alteration zone in Silurian rocks. Very few outcrops occur in the area of the mineral deposit, and, in many Robert observed small amounts of pyrite, pyrrhotite and chalcopyrite although not within half a mile of the deposit. No information was available on the details of the glacial history of the Pekan Creek area. The soils and vegetation cover of the Gaspé Park area were described by Rowe (1959) as part of the Gaspé Section of the Boreal Forest as follows:

"The major forest cover types are dominated by conifers, though mixed conifer-hardwood stands are not uncommon. Balsam fir (Abies balsamea), black spruce (Picea mariana) and white spruce (P. glauca), often in combination with white birch (Betula papyrifera), form the characteristic cover types. In addition to pure stands of fir and of black spruce, mixed stands of fir-spruce often with cedar (Thuja occidentalis) are common. Forest cover is continuous except on the exposed portions of the plateaux where climate-induced barrens occur, and where both fir and spruce show strong wind effects. On the lower slopes of the section, and in the river valleys at its edges, there are local representations of species such as white pine (Pinus strobus), sugar maple (Acer saccharum), and yellow birch (Betula lutea) from the adjacent Great Lakes-St. Lawrence Region.

"Elevations on the irregular, rugged plateaux range up to an average of 3,000 feet, with Mount Jacques Cartier reaching an altitude of 4,160 feet. Numerous small streams, deeply cut into the underlying soft sedimentary rocks, radiate outward in all directions from the uplands. Thin podzol profiles, with rather heavy but poorly-structured B horizons, are common in the well-drained positions, while acid peats are developed in areas of poor drainage."

(2) Description of the traverse line from which the samples were collected. No rock samples were examined or collected during the project, and no sampling of the layer of surficial material, which blankets the area in which the traverse line was located, was undertaken. However, data obtained from the shallow seismic survey, conducted under the direction of G. D. Hobson of the Geophysics Division, provided data on the nature and thickness of the layer. Briefly, the surficial layer is between 5 and 20 feet thick along the whole sampled line except in two places where it is deeper. At the first five stations at the top of the hill (Fig. F 14) the sandy layer at the surface is underlain by a gravel layer, which is also present in the area of the suboutcrop of the mineral deposit. In the latter case the gravel layer varied between 10 and 30 feet thick under a few feet of sandy material at the surface.

The cut line chosen for sampling passes through a relatively uniform forest in which balsam fir is dominant with minor spruce and occasional young birch or aspen. The balsam fir vary in height between 30 and 50 feet and are generally about 70 years old. The old, dead, birch trees which are common in the forest belong to a previous cycle of vegetation, as do rotten trunks of deadfall which are common along the cut line from which the samples were collected (Figs. F 15, F 16). Some organic soils were found at the bottom of the hill near the creek; at other places the soil profiles examined were typical podzol soils with a well-defined A<sub>2</sub> layer. In better drained areas at the top of the hill the A<sub>2</sub> layer is less well-defined than further down the slope.

(3) Discussion of biogeochemical and soil geochemical results. The data for total copper, zinc, lead and nickel in the B horizon material, soil humus, bark, third year twigs and current growth are plotted on the scan sheet, Figure F 17. This scan sheet differs from Figure E 16 in that a log scale, instead of an arithmetic scale, was used to plot the content of metal in each panel. On Figure F 17 the columns of panels contain data for the same element and the rows of panels refer to the different elements in the same type of samples.

The data for copper in the B horizon reveals an anomaly of up to a maximum of twelve times background in the samples collected above the sub-outcrop of the mineral deposit. The background for copper in the area is relatively high (50 ppm). This copper anomaly is comparable in magnitude and extent with those for other elements found during Visits described in Section E above. For some unexplained reason this copper anomaly in the B horizon is not present in the overlying humus layer or in the tree bark twig, or current growth material collected at the same stations as the anomalous B horizon samples. It should be noted that the apparent increase in the background noise in the copper data obtained in the vicinity of the deposit is due to the location of sample stations at 100-foot instead of 200-foot intervals immediately above the mineral deposit.

The zinc content of all five materials examined (Fig. F 17) does not include a significant anomaly above the mineral deposit, although, as in the case of copper, the greatest variation in concentration is in the B horizon material. The concentration of lead in all materials shows a consistent decrease from the top of the hill downwards. In the case of the B horizon samples this trend is shown by amounts of over 100 ppm at the top of the hill and below 40 ppm lower down. The trend is even more marked in the case of humus material where values as high as 500 ppm were found at the top of the hill and as low as 30 ppm at the bottom. The trend is also present in the plant samples, for example in the case of the current growth where a combination of the log plotting scale and poor precision of the analytical method at the extreme low concentration of metal tends to accentuate the importance of the trend. This variation in the lead content of all types of samples from top to bottom of the hill is not related to the presence of the



Figure F 15 Pekan Creek Quick Project: View along Line 64W from station 20+00N looking south. Note the widely spaced trees and deadfall in the foreground with moss and fern ground vegetation.



Figure F 16 Pekan Creek Quick Project: View along Line 64W from station 18+00N looking south. Note the deadfall with fern and moss ground vegetation.



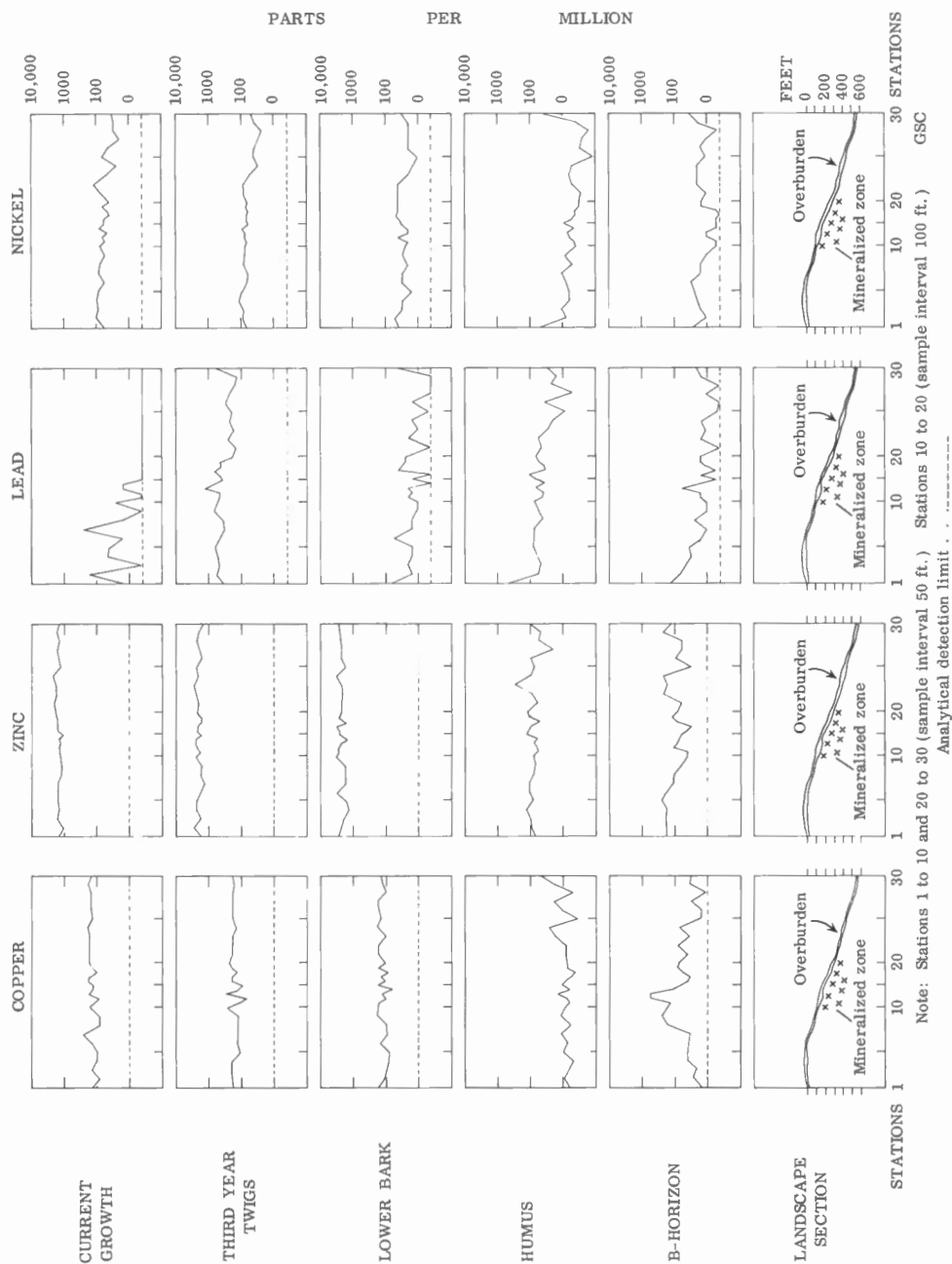


Figure F17. Pekan Creek Quick Project. Scan sheet showing total minor element content of soil and vegetation and landscape section.

copper deposit and its cause is unknown. The trend might be due to variations in the lead content of the bedrock, or the layer of surficial material, but, most probably, it is due to a systematic variation in the intensity of the factors of soil formation from the bottom to the top of the hillslope. More detailed investigations would be needed to establish the validity of the assertion. The data for nickel is generally similar to that obtained for zinc and variations in the concentration of this element cannot easily be correlated with the presence of the deposit. The low nickel content in the B horizon samples in the area of the suboutcrop of the deposit should be noted. The high values for nickel in humus at stations 1 and 30 is due in part to a significant variation in the ash per cent.

(4) Summary and conclusions. Biogeochemical prospecting by the methods described above would have failed to locate the copper deposit which suboutcrops on the hillside above Pekan Creek. Geochemical prospecting based on the chemical analysis for total metal content of the B horizon soil, but not the humus layer, would have been successful.

Details of the geology of the mineral deposit, or the rocks in which it occurs, were not studied during this Quick Project because of lack of access to the bedrock in outcrop or in trenches. Evidence from the results of the shallow seismic survey indicated that the layer of surficial material along the cut line samples was generally less than 20 feet thick in control areas and slightly deeper in the mineralized zone, where a gravel layer occurs between the bedrock surface and an overlying sand layer. No samples of the surficial material were collected during the project. Evidence from chemical analysis of the B horizon samples indicated a strong copper anomaly in the area of the suboutcrop of the copper deposit. This anomaly was not detected in the overlying organic soil layer or in the samples of bark, twigs, needles or current growth which were collected from the most common species of tree, balsam fir, taken from the same sample points as the soil.

It is concluded that, in landscapes of the type in which the Pekan Creek deposit occurs, the B horizon of the soil is a reliable guide to the location of copper mineralization in the bedrock. The reasons for the failure to find anomalies for copper in the organic materials analyzed are not known.

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## SECTION G A PILOT PROJECT AT THE SILVERMINE LEAD DEPOSIT, CAPE BRETON ISLAND, NOVA SCOTIA

E. H. W. Hornbrook

### G 1 Introduction

The object of a Pilot Project investigation of a landscape is to produce a set of botanical and chemical results that indicate the scope and limits of geobotanical and biogeochemical prospecting methods. These results can be compared with similar sets of results obtained for other landscapes. This involves the application of several methods which are described in detail in Part I, Section C of this progress report.

The biogeochemical aspect is emphasized in this section and consists of analyses of soil and vegetation samples collected along a cut line from that part of a landscape in which an undisturbed mineral deposit occurs. During investigations, lithology and structure of the surficial material and soils is recorded and the configuration of the bedrock surface is determined by a shallow seismic method.

A Pilot Project investigation was carried out at the Silvermine property primarily to demonstrate the scope and effectiveness of biogeochemical prospecting, but partly to evaluate the performance of the scan spectrographic method of analysis, and to refine the various techniques involved in sample collection and preparation methods.

The Silvermine property of Yava Mines Limited is situated near the village of Silvermine in the Salmon River Basin, southeast Cape Breton Island, about 24 miles southwest of the city of Sydney (see Fig. G 1). Access is provided by a road from Sydney through the village of Marion Bridge, and through the property to the east coast.

The Silvermine property was chosen for a Pilot Project investigation primarily because it is a drilled, but otherwise undisturbed, single element deposit located in a landscape that has a relatively simple topography. The surficial material cover is relatively thin and of uniform thickness. However, its complexity, due to two periods of ice movement in opposite directions, created unexpected difficulties in the interpretation of the chemical results. The area examined straddles a thin band of Windsor sediments along the Mississippian-Pennsylvanian contact. Galena mineralization occurs in the basal sandstone horizons of the Pennsylvanian Morien group with little or no sulphides observed in the upper beds of the Mississippian Windsor group. Samples of soil and vegetation were collected from a cut traverse line oriented at right angles to the contact. The property was first sampled in 1963 by the Geological Survey as part of an orientation

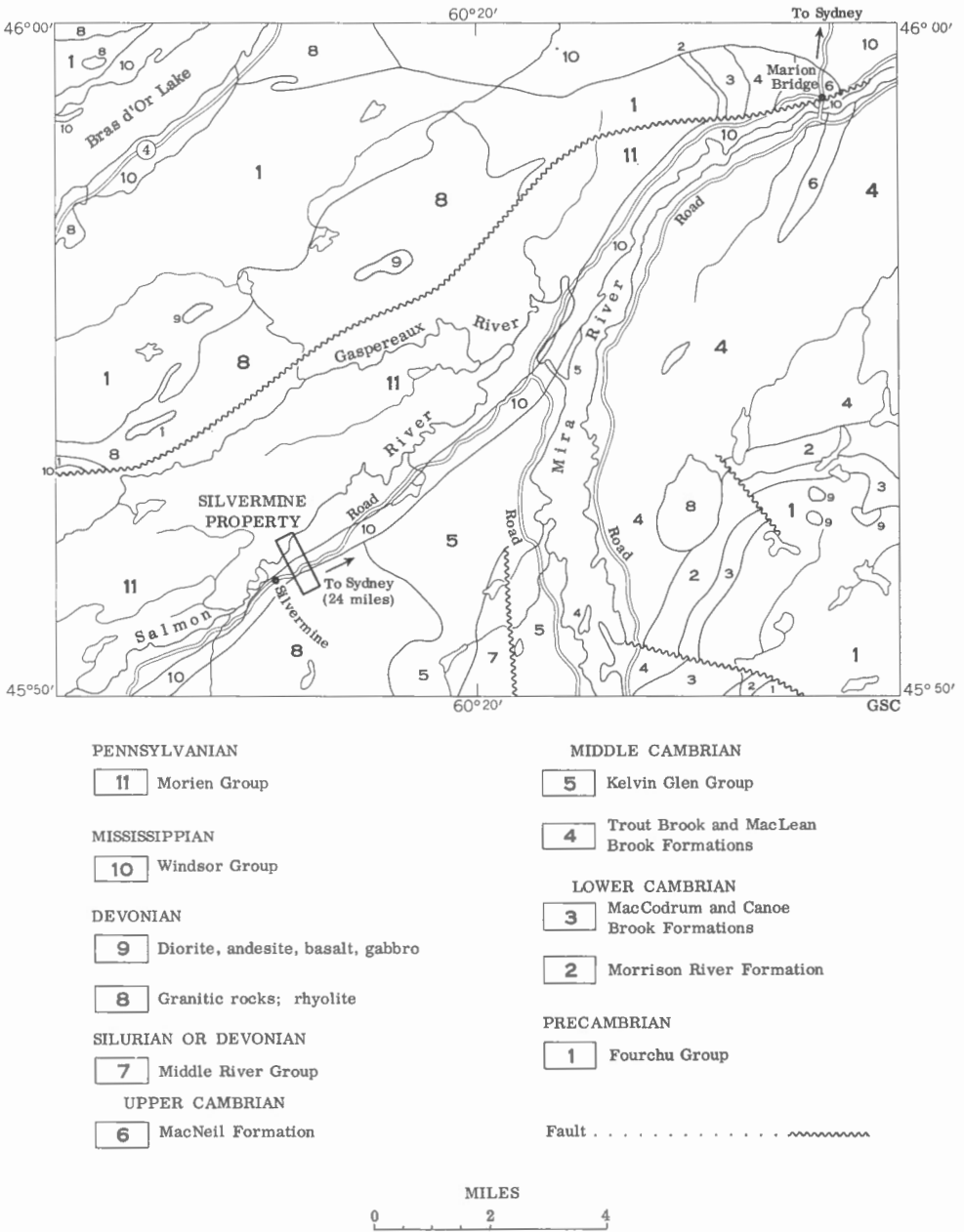


Figure G1. Geology of the Salmon River Area and location of Silvermine property (after L. J. Weeks, 1954)

survey in experimental sampling techniques. The results of this survey as described by Carter (1965) and Fortescue and Hornbrook (1967) provided part of the background information for this Pilot Project.

Briefly, the history of the lead deposits in the Silvermine area began in the early 1900s when prospect pits near the village of Silvermine disclosed lead mineralization in the limestones along a strike length of several miles. In 1953, diamond drilling by Minda Scotia Mines Limited revealed the presence of galena and sphalerite in rhyolite near its contact with carboniferous limestones. Later, geological, geophysical, and geochemical studies and diamond drilling were carried out by interested companies now represented by Yava Mines Limited. These studies showed that lead and zinc mineralization was present in varying amounts in the Mississippian and Pennsylvanian rocks and along the contact between them.

A shallow seismic investigation was carried out under the direction of G.D. Hobson of the Geological Survey to determine the depth of surficial material at each station. A profile levelling survey by the sampling crew established the relative elevations of each station.

During the month of June, 1966, a crew of three men collected 494 samples of soil and vegetation from a single line of 45 stations. Where possible samples were collected at each station of current growth, second and third year twigs and needles, lower, middle, and upper bark; humus; A<sub>2</sub>, B, and C zones soils. The samples were transported to the mobile sample preparation and spectrographic trailer laboratories in Ottawa. The trailers were described in Part I, Section C of this report. In the laboratories all samples were prepared for analyses, and the plant material and organic soil analyzed spectrographically. Colorimetric analyses of the prepared mineral soils and some organic material were completed under the direction of J.J. Lynch in the Geological Survey laboratories.

Mineral and organic soils, lower bark, third year twigs and needles, second year twigs and current growth were analyzed colorimetrically for lead, zinc, copper, and nickel. All plant organs and organic soil were analyzed spectrographically for lead, zinc, copper, nickel, barium, strontium, manganese, titanium, silver, and indium. Attention is drawn to the fact that some plant organs as well as humus were analyzed colorimetrically and spectrographically. This replicate analysis permits the comparison of the analytical techniques to evaluate the performance of the scan spectrographic method of analyses with the established colorimetric method of analyses.

## G 2 Acknowledgments

The writer was aided in his field work and laboratory analyses by E.A. Debock and K.D. Wollin to whom he is indebted for their able assistance and excellent companionship. Thanks are due to Yava Mines Limited

who gave permission to carry out the Pilot Project investigation at the Silvermine property. Information concerning the property in this report has been reviewed by officials of that organization.

The writer would also like to express his appreciation to J. A. C. Fortescue and Lily Usik who have read this report and offered many suggestions for its improvement.

### G 3 General description of the landscape

The geology of southeast Cape Breton Island has been described by Weeks (1954). The predominantly sedimentary rocks, that underlie the region range in age from Precambrian to Pennsylvanian and have undergone several periods of intense folding and deformation. They have been intruded by granite in Devonian time and by gabbro in late Mississippian.

In the Salmon River Basin a thin band of Mississippian Windsor group sediments, striking northeasterly with a shallow dip to the northwest, are flanked by Pennsylvanian sediments on the north and Devonian rhyolite on the south (see Fig. G 1). Recent drilling has revealed that galena and minor sphalerite occur in the basal sandstone of the Pennsylvanian rocks at the contact and there is evidence of lead and zinc mineralization for several thousand feet along the contact. Mineralization was not observed in the few outcrops that are present in the area.

Surficial material covering the region is till. A profile of the traverse line (see Fig. G 3), shows a relatively thin layer of surficial material which varies locally in thickness but never exceeds 35 feet in depth. A few depressions in the suboutcrop surface at stations 20, 24, 29, 33, and 39 were possibly caused by ice erosion on mineralized bedrock. The Salmon River must be postglacial in origin because there is no depression in the bedrock surface corresponding to the Salmon River valley. The glacial history of the region is complex and includes two periods of ice advance in opposite directions, both of which were parallel to the dominant northeasterly trend of the ridges and valleys. Bedrock material gouged from the mineralized bedrock was dispersed northeast and southwest throughout the surficial material in the valley. Hence the surficial material probably contains mineralized bedrock as wedges or lenses of mineralized till.

The orthic podzol soils of the region have been described by Cann et al. (1963). Two soil series occur at the Silvermine property and their contact is approximately northeasterly along the base of the ridge intersecting the traverse line at about station 17 (see Fig. G 2). The Thom soil series occurs southeast of the contact on the ridge and the Shulie soil series extends to the northwest of the contact in the valley. Both soil series have a common parent material which is a pale brown to greyish brown sandy loam and till. Typical profiles of the Thom and Shulie series are described in Appendix GA.



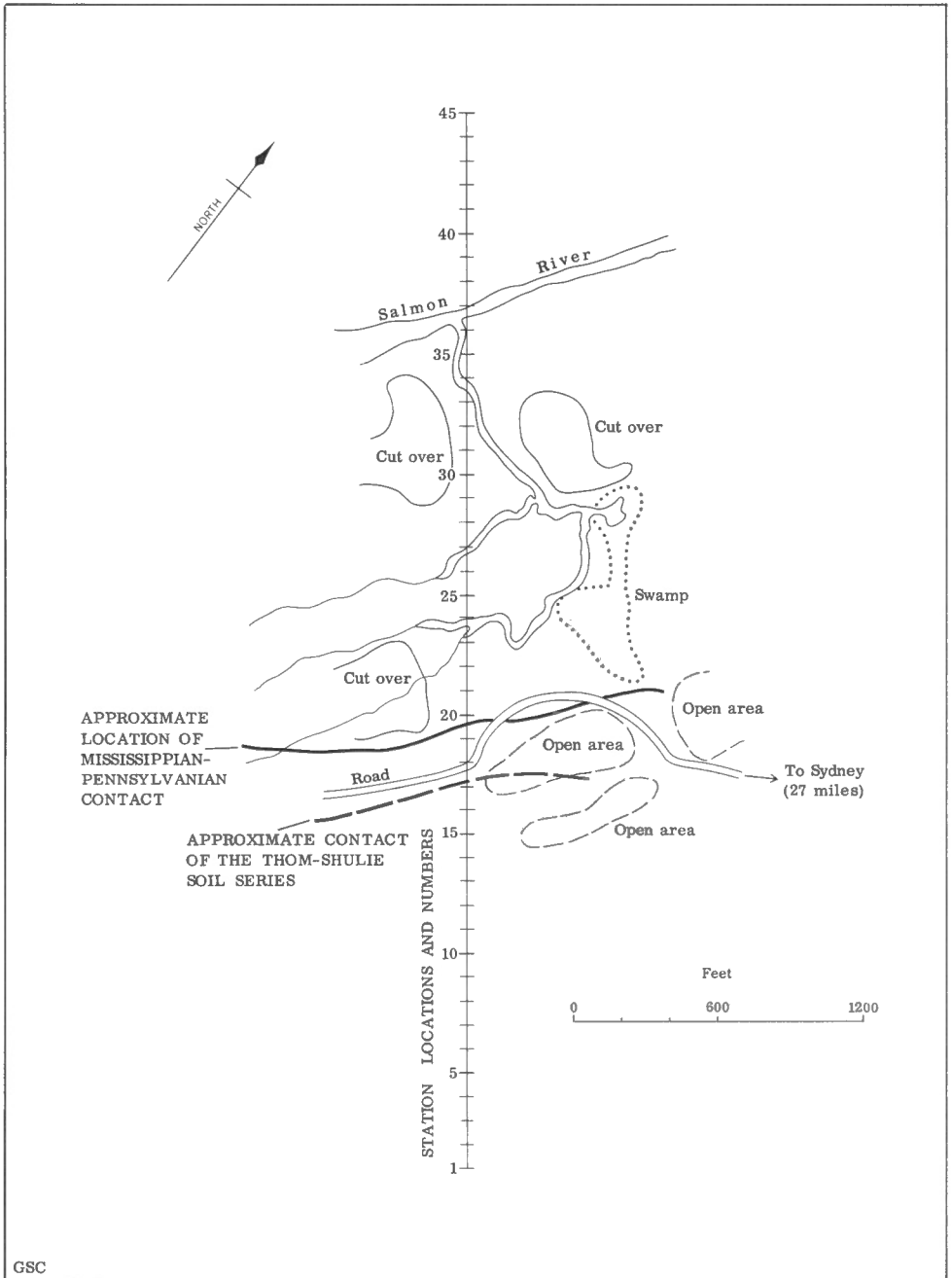


Figure G2. Yava Mines Ltd. Silvermine property, plan of traverse line

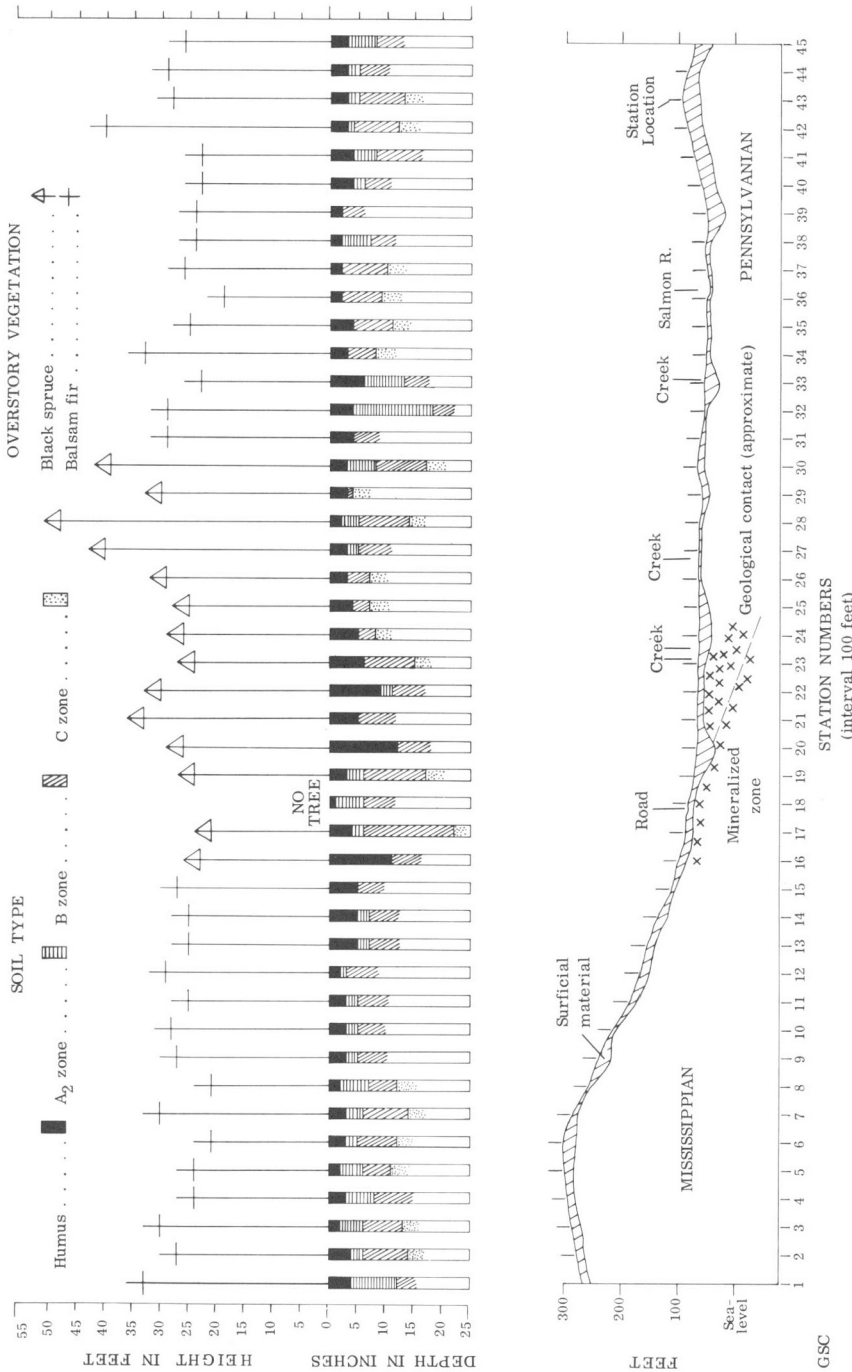


Figure G3. Geological section of the traverse sampled at Silvermine property, showing tree species, soil profile, surficial material thickness and bedrock.

Locally the soil shows well-developed, easily distinguishable A, B, and C horizons (see Fig. G 3). Between the road and the Salmon River on the lower, poorer drained part of the traverse line, the A<sub>2</sub> horizon, is not always present and the depth of organic soil increases.

Southeast Cape Breton Island is a tilted and probably warped plateau that emerges from the Atlantic Ocean on the southeast and rises inland to the northwest. The hills, valleys, and drainage system have a dominant north-east orientation that is in part, related to both the bedrock geology and the glacial history of the region. Locally the traverse line begins on the top of a ridge and descends approximately 200 feet to the Salmon River valley (see Fig. G 3). The Salmon River and its major tributary, the Gaspereau River, flows northeastward in the valley to the Mira River. A few small streams that are parallel to, and bisect the traverse line flow into the Salmon River (see Fig. G 2).

The forest cover of the region has been described by Rowe (1959). Locally balsam fir (Abies balsamea) and black spruce (Picea mariana) are predominant forest species. The former is dominant on better drained soils on the ridges and the latter is dominant on poorer drained soils in the valleys. There is the occasional white pine (Pinus strobus), white and yellow birches (Betula papyrifera, B. lutea), red maple (Acer rubrum), hemlock (Tsuga canadensis) and trembling aspen (Populus tremuloides) in the vicinity of the traverse line. Deciduous trees are more common on the ridges. Low brush grows in the cut-over areas near the traverse line with willows and alder associated with the swamps in the low lying areas of the valley (see Fig. G 2).

The first fifteen stations at the southeast end of the traverse line were sampled for balsam fir. This was followed by black spruce for the next fifteen stations in the lower poorer drained sections of the line; and, when better drained sample sites became available, balsam fir was again sampled for the last fifteen stations (see Fig. G 3).

Data on the climate of southeast Cape Breton Island has been recorded for several years at Sydney which is situated 24 miles northeast of Silvermine. Appendix GB after Cann et al. (1963) tabulates the average monthly and seasonal temperature and precipitation at Sydney.

Contamination from local sources such as road dust, old drill sites, and logging operations were assumed to have an insignificant effect on the analytical results.

#### G 4 Discussion of methods

The methods that have been applied to the Silvermine project including those briefly discussed below are described in detail in Part I, Section C of this progress report.

(1) Methods of establishing traverse line. The 4,400-foot traverse line established at the Silvermine deposit is an extension of one of the 1,700-foot lines used in the 1963 orientation survey. The results of that survey and information from mining companies showed that this extended line was the most suitable for the following reasons: (1) The traverse line is situated over a lead deposit that was indicated by previous soil geochemistry and diamond drilling (see Geisler, 1963); it is oriented at right angles to the mineralized Mississippian-Pennsylvanian contact as shown on Figures G 1, 2; and (2) the line does not pass through swamps or cleared and cut-over areas. A total of 45 stations were established at 100-foot intervals and a sample tree and soil pit located selected at each station (see Fig. G 3).

(2) Shallow seismic investigation. Shallow seismic investigations carried out in conjunction with this project have been made under the direction of G.D. Hobson of the Geological Survey. A two-man crew using a portable hammer seismograph completed the survey in one week. The depth of surficial material was calculated at each station. During the period the samples were collected, a levelling survey was carried out to establish the elevation of each station relative to a selected benchmark. The above information was used in constructing the profile on Figure G 3.

(3) Methods of collection and preparation of material. The sample tree at each station was cut down and the following samples collected: lower, middle, and upper bark; current, second, and third year growth of needle and twig organs; humus, C, B, and A<sub>2</sub> zone organic and mineral soils, in this order, where possible from the soil pit to minimize contamination. After second and third year growth was subsampled to separate needle and twig organs, all samples were cabinet dried, and, except for mineral soils, oven dried in the sample preparation trailer. The sieved minus 80 mesh portion of the cabinet dried mineral soils was retained for colorimetric analyses. After oven drying the organic soil was sieved to obtain the minus 10 plus 80 mesh fraction. A 2 g and a 10 g oven dried sample for spectrographic and colorimetric analyses respectively, was taken from the organic soil and plant organ samples for ashing. All samples were dry ashed in a muffle furnace on a time-temperature controlled cycle in which the temperature slowly increases to 435° C and then remains constant for the remainder of the 10 hour cycle. The ash was thoroughly mixed and temporarily stored in sealed plastic vials.

(4) Scan spectrographic method of analyses. A 10 mg portion of ash, held in suspension in a sugar solution, was placed on top of a sugar impregnated 1/2-inch graphite platrode and dried to a thin cake under a heat lamp. The sugar solution contains indium as an internal reference standard for control of the analytical precision. The sample platrode was rotated at 10 rpm and excited by means of a high voltage spark source. The spectrogram was recorded on 35 mm film with a 20 second exposure in a Jarrell-Ash 1.5 metre Wadsworth grating spectrograph. By matching the sample film

with a standard film in the densitometer-comparator, visual estimations were made of the concentration of the elements; these were recorded on special data recording sheets. These sheets were forwarded to the computer centre for data processing. Concentrations on an oven dry and ash basis with statistical information for each element is printed out on a special form as previously described in Part I, Section C.

A detailed description of the precision and accuracy of the scan spectrographic method is also given in Part I, Section C. A bias exists between the relative spectrographic and colorimetric concentration average for some elements such as copper in third year twigs as shown in a comparison of Figures G 4, 5 (in pocket). This bias is introduced particularly by the synthetic plant ash base used in making the spectrographic standard film. However, it does not interfere with the comparison of the element distribution patterns of the plotted colorimetric and spectrographic results for a given element. The following materials were analyzed spectrographically: organic soil (humus); lower, middle, and upper bark; second and third year needle and twig organs; and current growth (combined needle and twig organs), (see Fig. G 5).

(5) Colorimetric method of analyses. Plant ash samples, and mineral and organic soils were analyzed colorimetrically after an HF, HNO<sub>3</sub>, and HClO<sub>4</sub> decomposition and total extraction in the Geological Survey chemical laboratories under the direction of J. J. Lynch. Standard methods for the colorimetric determination of lead, zinc, copper and nickel were used as described in Appendix GC.

The following materials were analyzed colorimetrically: mineral soil (A<sub>2</sub>, B, and C zones); organic soil (humus); lower bark; third year twigs and needles; second year twigs; and current growth (combined needle and twig organs) (see Fig. G 4).

Unfortunately an error was made in the published description of the reagents used for the digestion of organic material, ash, and soil material in Part I, Section C, Appendix GC. The present operational procedure for colorimetric analyses of soils and organic material ash is summarized in Appendix GC because copper is presently determined by a different method than previously reported and to correct the above error.

(6) Scan sheets. Spectrographic and colorimetric analytical results for biogeochemical investigations are displayed on scan sheets for comparison and interpretation. Use of the scan sheets allows a rapid assessment of the element distribution, relative concentration, and the comparison between sets of results for the same material by different analytical methods.

All scan sheets are constructed with several panels, each panel representing a graph showing the configuration of the distribution profile for one element's concentration in samples of the same material. The horizontal

scale for the traverse line and the vertical scale for the concentration in ppm are adjusted according to the requirements of individual Pilot Projects. For convenience in presentation, all concentrations for one element are shown in a vertical column of panels, each panel representing a different material analyzed in the sequence from C zone soil through to current growth. The results for one material for two or more elements is presented in a horizontal row of panels, each panel for a different element. The format of the complete scan sheet shows the materials in sequence on the left side of the sheet, elements analyzed across the top, and a simplified soil and surficial material profile repeated at the bottom of each column of element results.

#### G 5 Discussion of results

(1) Description of the presentation of the results. To display colorimetric and spectrographic analytical results for interpretation and comparison, scan sheets of the type shown in Figures G 4, 5 were constructed. Each panel shows the configuration of the distribution profile for an element's concentration in 45 samples of the same material collected from 45 stations on the traverse line across the mineralized contact. The profile reveals graphically the magnitude of the ratio of anomalous to background element concentrations. In Figures G 4 and 5 the concentration of an element is shown on the vertical axis of a panel on a four cycle log scale from 1 to 10,000 ppm, and the station locations on 100-foot centres are shown horizontally on a scale of 1 inch to 800 feet. By scanning a column of panels, a single element response across the contact can be examined in different materials; or by scanning a row of panels, the response for several elements in the same material can be examined.

The detailed characteristics and variations in the soil profile, tree species, and geology as shown on Figure G 3 should be used in conjunction with the scan sheets for interpretation of the analytical results. Figure G 2 should also be used because it shows the relationship between sample stations and drainage pattern and also some features of the topography.

All analytical results for plant material are plotted on an ash basis; organic soil is plotted on an oven dry basis because of its large variation in ash percentage. An exception is the humus results for the indium reference standard which are plotted on an ash basis.

The dashed horizontal line across all panels, except those in the humus row, indicates the detection limit for a given element. The detection limit for an element in humus is the same as that shown in other materials in that element's column in the same figure. On the colorimetric scan sheets, (see Fig. G 4), for the A<sub>2</sub> and C zone rows, the thick broken line below the detection limit indicates that samples were collected where the line is present and not collected where the line is absent. Where there is a gap in the distribution curve in the colorimetric results, there was no corresponding sample collected; in the spectrographic results, the gaps correspond to an analysis

where the concentration of an element in a given material was below the detection limit for that element. When the element concentration at a station is shown as a dot, because there are no results for adjacent stations, it was found necessary to circle it for visual emphasis.

The variation in concentration of the indium reference standard for the analyses of 45 samples of the same material collected from the traverse line is shown by its distribution pattern in the indium panel in the appropriate material row. The apparent concentration of indium has a direct relationship with the sample matrix. For example, the complex matrix of humus and its variation in physical composition between samples, results in an erratic distribution curve for the reference standard. This shows that the precision of the analytical results are relatively poor as compared with other materials such as needles or twigs (see Fig. G 5).

The background concentration level selected in each panel for estimating the magnitude of an element anomaly was not necessarily the lowest concentration level shown. At station 18 the gap in all plotted analytical results, which should correspond to the absence of a sample tree as shown in Figure G 3, was drafted solid by joining results from adjacent stations to avoid unnecessary complications in the distribution patterns. The results for cobalt, chromium, and molybdenum were not presented with the above results because most of the 1,215 single element analyses failed to detect the presence of these elements.

(2) Evaluation of the scan spectrographic method of analysis. The following materials have been analyzed both spectrographically and colorimetrically for lead, copper, zinc and nickel; organic soil; lower bark; third year twigs and needles; second year twigs; and needle and twig organs of current growth. These (similar) results are shown in the appropriate material rows in Figures G 4 and 5.

To evaluate the performance of the semiquantitative scan spectrographic method of analysis, it was necessary to determine if the method was capable of detecting anomalous results that had a satisfactory similarity to anomalous colorimetric results for the same samples. In a comparison of similar results, the spectrographic pattern for a given element and material must reflect closely the relative variations in concentrations that are developed in the colorimetric pattern for the same element and material. The anomalous results for spectrographic and colorimetric analyses of humus and lower bark are reproduced and superposed in Figure G 6 to facilitate comparison. The comparison shows that the patterns are similar; significant anomalous concentrations of lead in the colorimetric pattern are also shown in the spectrographic pattern. The lead patterns obtained from both analytical methods on third year twigs and current growth in Figures G 4 and 5 also show a satisfactory relationship to each other. There is a relatively poor comparison between lead patterns for third year needles. However, the

spectrographic method of analyses is capable of producing results that will define anomalous concentrations of lead comparable to the colorimetric method.

There is a satisfactory relationship between the patterns of element distribution derived from both methods when the same type of comparison is carried out for similar copper, zinc, and nickel results in Figures G 4 and 5. The comparison also shows that a difference in average concentration exists between the similar results for some elements, such as is shown in the case of copper. Fortunately this difference does not affect the comparison of similar results as previously explained in Part I, Section C.

For lead, zinc, copper, and nickel the performance of the scan spectrographic method of analysis is satisfactory for biogeochemical investigations because the anomalous spectrographic results compare well with similar anomalous colorimetric results. The assumption has been made that the spectrographic results are also satisfactory for barium, strontium, manganese, titanium, silver, and indium which have only been analyzed by the scan spectrographic method.

(3) Interpretation of the analytical results. A biogeochemical anomaly in organic material can be caused by a combination of biological activity and mobilization of dissolved elements in groundwater. Anomalies may develop directly over the source of mineralization or some distance from the source by the action of such agencies as aqueous dispersion. An anomaly in the vicinity of a mineral deposit is recognized by an element being present in relatively high concentrations as compared to low background concentrations. The background concentrations are established by the regional element content of similar material remote from mineralized areas. The magnitude of the high or anomalous concentrations with respect to background concentrations that may be considered significant in interpretation varies depending on the element or material being examined. For this project, a magnitude in excess of three or four times background concentrations may generally be considered significantly anomalous.

Interpretation of the analytical results is discussed under the following headings: mineral soil, organic soil, and plant material. The headings are discussed in the ascending order of their relative position in a landscape because the element response is very strong in the mineral soil, particularly in the B zone; and geochemical soil results are probably more familiar than are those of organic soil, and certainly those of plant material. Throughout the interpretation, emphasis is placed on the relationship of the results of all elements in all materials to that of the lead results in mineral soils. Where similar colorimetric and spectrographic results are available for a given element in the same material, the interpretation for both is discussed simultaneously. Only marked differences in their results are noted.



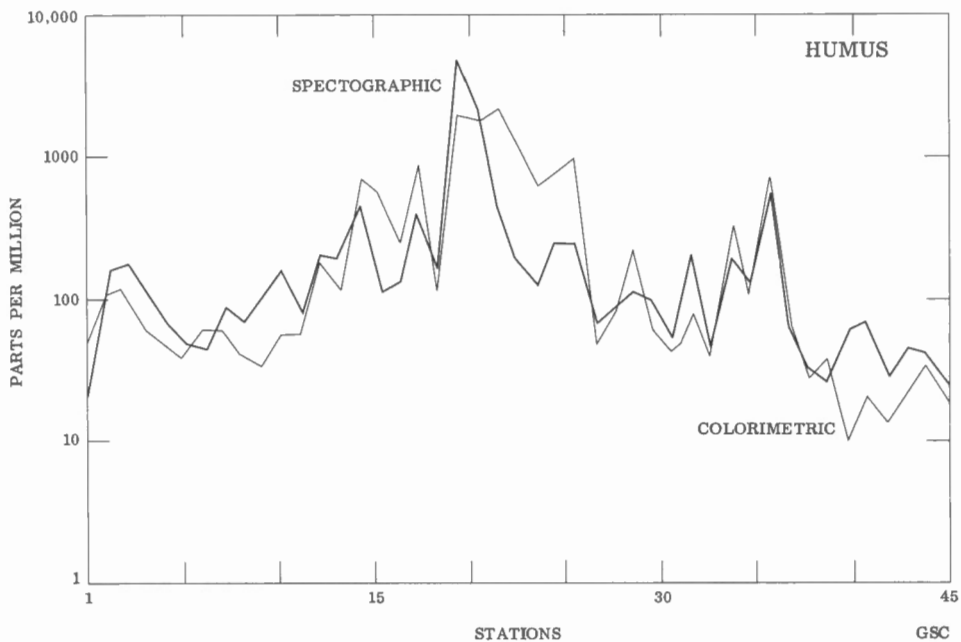
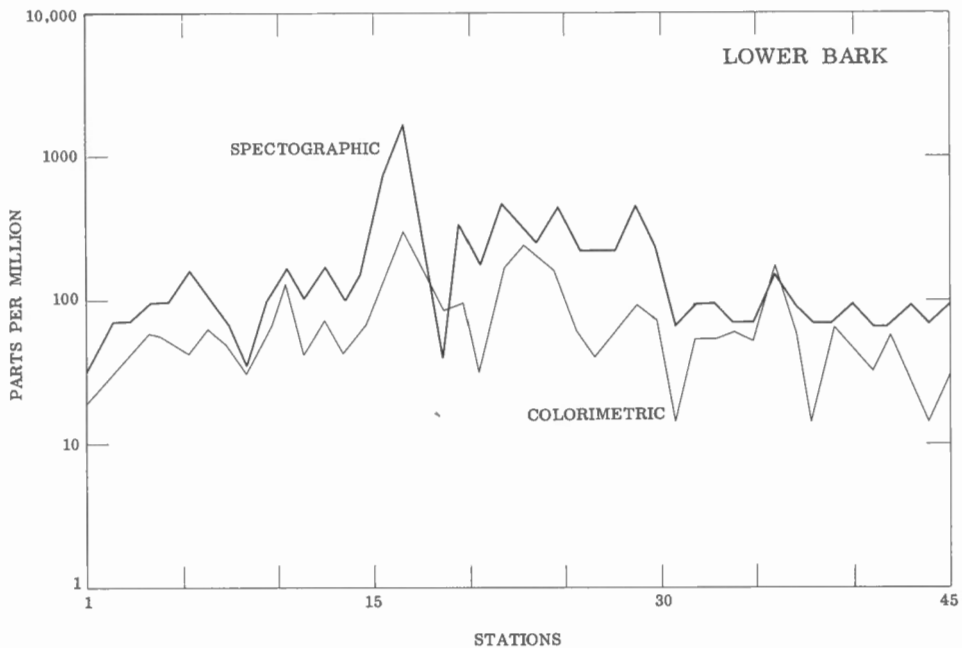


Figure G6. Comparison of lead concentration in ppm as shown by colorimetric and spectrographic analyses of bark and humus samples

The order in which elements are selected for discussion within a heading depends upon their response or to what degree the mineral deposit has affected their variation in distribution in the landscape. When examining an element's panel illustrating analytical results from 45 samples collected from the traverse line across the deposit the contrast between anomalous and background concentrations was considered more important than the absolute element content. Therefore, elements showing good contrast in the configuration of their distribution pattern are discussed before those simply showing a high absolute element content. In each heading, a detailed discussion of lead is followed by a general discussion of the most responsive elements in a decreasing order of their response. Those elements with little response or variation in concentration shown in their column of panels are discussed together as a group.

Table G 1 was constructed to provide a useful reference which shows the cut line length and magnitude of the anomalous concentrations of lead in all materials. The mineral soil results are obtained from the colorimetric results in Figure G 4, and the organic soil and plant material results are obtained from the spectrographic results in Figure G 5. Zone (1) occurs between stations 15 and 29 and Zone (2) occurs between stations 34 and 36. The cut line lengths marked with an asterisk indicate that what is considered the anomaly, is actually a composite of two or more peaks of adjacent anomalies.

(4) Mineral soil results. Mineral soils were analyzed colorimetrically for lead, zinc, copper, and nickel.

Lead. Anomalous concentrations of lead are present at several stations along the traverse line as shown in the colorimetric results for mineral soils in Figure G 4. The largest lead anomaly occurs more or less symmetrically from stations 15 to 29 over the Mississippian -Pennsylvanian contact and is approximately centred about stations 20 and 21. This anomaly is a composite, consisting of four peaks at stations 15, 19, 24, and 29. Most of the anomaly has a 100-fold magnitude in the B and C zone soil results. A relatively minor part of the anomaly at station 29 has a 20-fold magnitude. The location of the mineral deposit at the contact is very well defined by the largest peak of this anomaly and it also conforms with a large depression in the suboutcrop surface at station 20 (see Fig. G 3). This depression was probably caused by the erosion of soft weathered mineralized bedrock during the two periods of ice advance. The peaks at stations 24 and 29 also conform to slight depressions in the bedrock surface. For convenience in further interpretation of the results, the location of this anomaly will be referred to as Zone (1), as indicated on all panels showing the traverse section (see Figs. G 4 and 5), and on the B zone panel in the lead column of results (see Fig. G 4). Although there are not sufficient results from the analyses of the A<sub>2</sub> zone soil for adequate interpretation, it is probable that the single high concentration at station 22 is part of the Zone (1) lead anomaly.

Table G 1 Summary of Magnitude and Extent of Anomalous Lead Results

| Method of Analyses | Material analyzed   | Zone number | Cut line length   | Lead background | Zone number | Cut line length | Lead background |
|--------------------|---------------------|-------------|-------------------|-----------------|-------------|-----------------|-----------------|
| Colorimetric       | C Zone              | (1)         | 1100 <sup>Ⓔ</sup> | 100             | (2)         | 200             | 50              |
|                    | B <sup>Ⓔ</sup> Zone | (1)         | 1400 <sup>Ⓔ</sup> | 100             | (2)         | 300             | 60              |
|                    | A <sub>2</sub> Zone | (1)         | 100               | 10              | (2)         | ---             | ---             |
|                    | Humus               | (1)         | 300               | 120             | (2)         | 300             | 15              |
|                    | Lower bark          | (1)         | 300               | 23              | (2)         | 200             | 2               |
|                    | Middle bark         | (1)         | 1000 <sup>Ⓔ</sup> | 10              | (2)         | 300             | 5               |
| Spectrographic     | Upper bark          | (1)         | 300               | 5               | (2)         | 200             | 4               |
|                    | 3 yr. twigs         | (1)         | 1400 <sup>Ⓔ</sup> | 4               | (2)         | ---             | ---             |
|                    | 2 yr. twigs         | (1)         | 1000 <sup>Ⓔ</sup> | 6               | (2)         | ---             | ---             |
|                    | 3 yr. needles       | (1)         | 1500 <sup>Ⓔ</sup> | 3               | (2)         | ---             | ---             |
|                    | 2 yr. needles       | (1)         | ---               | ---             | (2)         | ---             | ---             |
|                    | Current growth      | (1)         | 200               | 5               | (2)         | 100             | 2               |

--- No anomalous concentrations

<sup>Ⓔ</sup> Composite anomaly composed of two or more peaks

Another lead anomaly of interest is at stations 34, 35, and 36 immediately southeast of the Salmon River. The contrast of this anomaly is 50- and 60-fold in the C and B zone mineral soil results respectively. Although its magnitude is not as great as for the Zone (1) lead anomaly, its distribution profile shows a much sharper contrast relative to that of adjacent stations. There is a corresponding depression in the bedrock surface at station 34 below this anomaly (see Fig. G 3), which also suggests the possibility of mineralization in the bedrock as in the case of Zone (1). The anomaly could however be developed as a result of the redeposition of lead that has migrated from the vicinity of the mineralized contact down the stream system that parallels and bisects the traverse line (see Fig. G 2). A third contributing factor to the development of this anomaly may be the influence of transported lead mineralization in the till underlying Zone (2). The location of this anomaly in further interpretation will be referred to as Zone (2) and shown on the figures in the same manner as Zone (1).

The colorimetric results for lead in mineral soils define two separate anomalous locations that are related to lead mineralization at the Silvermine property. The source of the Zone (1) lead anomaly is almost certainly the mineralized contact at station 20. The northwest section of the anomaly may be due partly to mineralized lenses of till locally dispersed by ice movement. A previous geochemical survey also showed a strong lead anomaly in the mineral soils at station 20 (see Geisler, 1963). The extent of mineralization in the lead deposit at the Mississippian-Pennsylvanian contact was subsequently outlined by diamond drilling (see Carter, 1965). The occurrence of the Zone (2) lead anomaly at station 35 is probably due to a contribution of one or several of the following factors: underlying mineralized bedrock; mineralized till; redeposition of lead from the stream or groundwater system. The location of the Zone (2) lead anomaly lies outside the area investigated by previous workers.

Zinc. There are two significant zinc anomalies in the results for the mineral soils. The pattern of zinc distribution compares very well with that of lead particularly for the locations of Zones (1) and (2). The relative magnitude of the zinc anomalies is less than that of the lead, but they show good contrast at both Zones. Development of the anomalies is probably due to sphalerite which is known to be associated with the lead mineralization.

Copper and nickel. The colorimetric results for copper and nickel in the mineral soils have no anomalous concentrations or relationship with the lead results at Zones (1) and (2). This is expected because there is no evidence of copper or nickel mineralization at this location in the history of the property. The copper has one erratic, high, concentration in the B zone results at station 26 and the nickel concentrations are too near the sensitivity limit for valid interpretation.

(5) Organic soil results. The organic samples were analyzed for lead, zinc, copper, and nickel colorimetrically and spectrographically, and by the last method only, for barium, strontium, manganese, titanium, silver, and indium.

Lead. Over Zones (1) and (2) the pattern of anomalous lead distribution in the humus analytical results has an excellent comparison with the pattern in the mineral soil results. In the humus results, the magnitude of the Zone (1) lead anomaly is similar, whereas that of the Zone (2) lead anomaly is smaller in comparison to their respective magnitudes in the mineral soil results. The pattern of the Zone (1) lead anomaly as shown in the spectrographic results has a shorter apparent extent along the traverse line, which has the advantage that the contrast in the configuration of the pattern is emphasized.

Manganese. The magnitude of the Zone (1) manganese anomaly is about 100-fold and Zone (2) about 20-fold. Zones (1) and (2) are as well defined by manganese as by lead in the patterns for the organic soil results. The manganese and lead patterns in humus and mineral soil have an excellent comparison.

Barium. Barium spectrographic results in humus show several anomalies. The largest, with a 40-fold magnitude, is at station 19 and another separate one is at station 25. These barium anomalies occur within the cut line extent of Zone (1). Southeast of Zone (1), there is a significant barium anomaly at station 12 that can be related to one in the lead results for mineral soil, although the anomaly is not particularly significant in the soil. At Zone (2) there are no anomalous barium concentrations. The barium pattern compares well with the lead pattern in the mineral soils for Zone (1).

Zinc. There is a different relationship between the colorimetric and spectrographic zinc results in organic soil when compared to that of lead in the mineral soil. In the case of the former results, there are significant anomalies that compare very well with the lead anomalies in Zones (1) and (2). In the latter results the significance of possible anomalous results is difficult to estimate because the background concentrations cannot be definitely established. The complex composition of humus, and its ash percentage and matrix variation from sample to sample create difficulties in obtaining accurate and reliable results from the spectrographic method of analyses. The high concentration of zinc at station 20 can be tentatively related to the Zone (1) lead anomaly in the mineral soil.

For the purposes of this discussion, the interpretation of the following elements can be grouped together: titanium, strontium, silver, nickel, and copper. An examination of the configuration of the distribution patterns of these elements reveals no significant anomalies.

The pattern of distribution for lead, barium, and zinc have an excellent comparison to the lead pattern in the mineral soils. Sufficient concentrations of all nine elements were detected in humus to permit reliable interpretation. Humus is a special case in that its preparation and analyses are rather difficult in comparison to those of the plant materials. To provide reliable results, humus must be plotted on an oven dry basis because of its large variation in ash percentage. The humus horizon frequently gives better results than the B horizon in soil sampling surveys as shown by Boyle et al. (1967); and therefore, will continue to be sampled and analyzed during Pilot Project investigations.

Variation of the internal reference standard, indium, during the humus analyses is shown in the indium panel in Figure G 5. The spectro-graphic results have relatively poor precision for humus as compared to the precision of analyses for some of the other plant organs.

(6) Plant material results. Lower, middle, and upper bark; second and third year needles and twigs; and combined organs of current growth were analyzed spectrographically for lead, copper, nickel, barium, strontium, manganese, titanium, silver, and indium (see Fig. G 5). Lower bark, third year needles and twigs, and current growth were analyzed colorimetrically for lead, zinc, copper, and nickel (see Fig. G 4). Table G 1 shows a summary of anomalous concentrations of lead in plant material.

Lead. There is a good comparison at Zones (1) and (2) between the lead distribution patterns of bark and mineral soils. This is evident even though in all bark panels the magnitude of the Zone (1) lead anomaly has decreased to between 5- and 23-fold and the Zone (2) lead anomaly decreased to between 2- and 5-fold (see Table G 1). The lower and middle bark from the spectrographic results, and the lower bark from the colorimetric results have developed two distinct peaks at stations 17 and 24 representing the Zone (1) lead anomaly. Spectrographic results from the lower bark show the Zone (1) lead anomaly most effectively with a magnitude of 23-fold and very good contrast. For unknown reasons this lower bark does not as significantly show the Zone (2) lead anomaly as well as all other bark results.

The Zone (1) lead anomaly in the colorimetric results for twigs appears as a single peak at station 20, and in the spectrographic results as two peaks at stations 20 and 27. Accompanying the change in plant organs, there is a change in the location of the above two peaks to 300 feet northwest from their respective peaks in the bark results. There is a good comparison between the twig and mineral soil results particularly at station 20. No comparison is possible for the Zone (2) lead anomaly which did not develop in the plotted twig results.

There are no significant anomalies in the analytical results for needles. However, third year needles do show a high concentration of lead from station 16 to 30 in the spectrographic results.

A comparison exists between the lead results in the current growth and mineral soils for Zone (1) and possibly Zone (2). However, lead concentrations are approaching the sensitivity limit and may not be reliable for interpretation.

The lead distribution pattern for most plant organs, with the exception of needles, compares very well with the anomalous patterns of lead distribution for Zones (1) and (2) in the mineral soils. Particularly in Zone (1), there are one or more lead anomalies developed whose peak station location in various organs changes slightly throughout most of the sequence from lower bark to current growth. This change is only between different plant organs and not between different age samples of the same plant organ. The peak at station 17 remains constant for lower, middle, and upper bark samples but changes to station 20 for the twig samples. Therefore, the results from one sample of a plant organ can be considered representative of all samples of that organ. Results from all plant organs show that twigs, specifically third year twigs, contain more lead than bark, needles, or current growth. However, the pattern of lead distribution in Zones (1) and (2) is best defined in bark, particularly the lower bark (see Table G 1 and Figs. G 4 and 5). The most effective organ to sample for lead analyses in this case is not necessarily the one that contains the most lead, but the one (e.g. lower bark) that shows the greatest variation in lead concentration and therefore the best contrast.

Barium and strontium. The similar distribution patterns of barium and strontium are discussed together. The configuration of their distribution patterns is strongly maintained with a proportionately decreasing concentration and increasing contrast in the pattern for each different plant organ throughout the sequence from lower bark to current growth. This relationship is obvious for each different plant organ in the column of barium panels at stations 34, 35, and 36 where the Zone (2) barium anomaly develops in magnitude and contrast up the material sequence. This observation suggests a possible relationship between the age of the needles and twigs and the relative height of the bark sample collected to the barium concentration in the plant organs. Although there is more barium concentrated in the older and lower parts of the tree, the anomalous concentrations are best shown in the younger and upper parts of the tree. In all cases the strontium results have less concentration and contrast than the barium results. Over Zones (1) and (2) the barium and strontium results show an excellent comparison with the lead results in the mineral soils. In fact, the barium has a higher concentration in all plant organs than the lead and its anomalies have a greater magnitude and contrast. This suggests the use of barium as a pathfinder element in biogeochemical investigations for lead deposits in similar landscapes. Unfortunately the 10,000 ppm upper limit of the standard film as shown on the plotted spectrographic results, obscures the variation in the barium concentration that is present in the bark limiting that organ's full potential for interpretation.

Titanium. The distribution pattern of titanium is erratic and only a few possible similarities with the lead results in the mineral soils can be suggested. In Zone (1) similarities occur at stations 19 and 20 in the second and third year twigs; and at stations 17 and 24 in the lower and middle bark. The titanium content decreases proportionately in the younger needle and twig organs and remains more or less constant in the lower, middle, and upper bark.

Silver. Interpretation of the silver results is inconclusive because concentrations are approaching the detection limit. However, there appear to be similarities to the lead results for Zone (1) but not Zone (2). Less silver is concentrated in the needles and current growth than in the twigs and bark.

Results for the remaining elements. Nickel, copper, and zinc do not have any significant similarities to the lead results in the mineral soils at Zones (1) and (2). Manganese and zinc are concentrated in the bark and nickel in twigs and current growth. The concentration of copper in current growth is not substantiated by colorimetric results.

Variation in the indium reference standard indicates that the required precision was maintained for the analyses of all plant material. The relatively poorer precision indicated for the analyses at the central portion of the lower and middle bark was not sufficient to interfere with the reliability of the analytical results.

## G 6 Summary

An orientation survey carried out in 1963 indicated that the landscape in which the Silvermine property was located was suitable for Pilot Project investigation. Subsequent examination of the landscape and the Silvermine lead deposit disclosed other advantages which were as follows: (1) a single element, lead, predominated in the mineralization of the deposit; (2) the deposit was drilled, but otherwise undisturbed; (3) trees could be sampled at all but one station; (4) the landscape had a relatively thin surficial cover; (5) the property was readily accessible; (6) results of previous geochemical, and biogeochemical surveys and diamond drilling programs were available; (7) there was an element response in the vegetation as well as the soil. Disadvantages disclosed in the examination of the landscape included: (1) one species of tree could not be sampled throughout the investigation; (2) the surficial material, although thin, was extremely complex; (3) the existing stream system may have had some effect on the element distribution in the landscape; (4) the road bisecting the cut traverse line was a possible source of contamination.

During a working period of three weeks by a three-man crew, the traverse line was established, station elevations obtained, and 494 samples collected from 44 trees and 45 soil pits. Sample preparation and



spectrographic analyses completed in three weeks by the same crew provided data comprised of 4,050 single element determinations for organic soil and plant material. Processing of the analytical results at the computer centre required 47 minutes. A total of 1,468 single element determinations were obtained for the colorimetric analyses of plant material, organic and mineral soils.

Biogeochemical methods that have been applied to the Silvermine Project were described in detail in Part I, Section C of the report and were referred to when required. Construction and use of the scan sheets which represent a convenient method of presenting several thousand determinations for rapid evaluation and interpretation was described.

A comparison was made between spectrographic and colorimetric analyses of the same materials to evaluate the effectiveness of the scan spectrographic method. The presentation and interpretation of the analytical results were discussed to demonstrate the scope and effectiveness of biogeochemical prospecting methods. Specifically it has been shown that using these methods, lead and associated element anomalies have been developed that were used to determine the source and extent of lead mineralization at the Silvermine property.

Mineral soil colorimetric results were discussed before organic soil and plant material results in order to define the zones of anomalous lead concentrations by results which are generally more familiar.

To determine if the element response in the vegetation was sufficient to produce significant concentrations, the spectrographic and colorimetric results for all plant organs were compared throughout the interpretation to the colorimetric results for the mineral soils.

The magnitude and pattern of anomalies in all plant organ samples for nine elements were mutually compared in order to: (1) attempt to select the most effective plant organ to sample and analyze for lead response; and (2) determine if any of the associated elements which showed a greater response than lead could be used as a pathfinder element.

A comparison was also made among different samples of the same plant organ to determine if the age of the twigs or needles, or the position of the bark sample on the stem of the tree, had any significant relationship to the degree of element response. This comparison was carried out to select the most effective sample to be collected and analyzed as representative of all samples from a given plant organ.

The average concentration of a given element in each organic material was compared to determine if any material specifically concentrated that element.

Results for the colorimetric analyses of the mineral soils from the A<sub>2</sub>, B and C horizons were examined to determine if the B zone analytical results could be considered representative of all zones.

All spectrographic and colorimetric results were carefully examined to see if any characteristic of the distribution pattern could be related to the effect of one or more of several variables which include the following: tree age, height and species; thickness of the humus horizon; presence or absence of soil zones; thickness and development of soil zones; and thickness of the surficial material.

## G 7 Conclusions

The landscape in which the Silvermine property is situated was suitable for Pilot Project investigation except for the unexpected complexity of the surficial material cover. Thickness of the cover did not become a limiting factor in the analytical response of the plant material because it never exceeded 35 feet.

Sample collection and preparation methods described in Part I, Section C of the progress report, and briefly mentioned here were generally found to be satisfactory for the purposes of this investigation. The 100-foot interval between sample locations on the traverse line provided satisfactory sampling density to determine the element distribution in the landscape. The designed capabilities of the analytical facilities can be maintained because the rate at which samples can be collected, prepared, and supplied to the trailer laboratories exceeds the rate of sample analyses.

Many points of similarity between spectrographic and colorimetric results for plant and humus material, and between plant and humus results to the mineral soils results, indicate that the scan spectrographic method of analyses does provide precise and relatively accurate results for biogeochemical investigations. An examination of all results showed that the spectrographic results were sensitive enough to distinguish among the response in different plant organs as well as the response among different samples of the same plant organ.

All methods of biogeochemical prospecting that have been applied at the Silvermine property were successful in detecting the previously known lead deposit overlain by till. Interpretation of the lead and other associated element anomalies developed by the investigation, verified previously known sources of mineralization in and adjacent to the contact of the Mississippian-Pennsylvanian rocks at Zone (1) as well as suggested another possible source at Zone (2).

A major difficulty in the interpretation of the probable sources of the anomalies was the complex glacial history in the Salmon River valley. Two periods of ice advance, from opposite directions, but parallel to the

northeast trend of the ridges and valleys have undoubtedly gouged material from mineralized bedrock and dispersed it erratically throughout the surficial material. The assumption can be made that the mineralized bedrock material is probably scattered as wedges or lenses in the thin layer of surficial material. This mineralized material could, by aqueous dispersion close to the ground surface, cause anomalous concentrations of lead and zinc to develop in all sample materials over barren bedrock, or could modify anomalous concentrations that have developed over mineralized bedrock. Previous investigations have shown that the source of the Zone (1) lead anomaly is the mineralized contact but the anomaly has probably been modified as a result of glacial action. Possible factors probably contributing to the development of the Zone (2) lead anomaly are: mineralization in the bedrock; transported mineralized till; and redeposition of lead that has migrated in solution from the vicinity of the mineralized contact. The more extensive scope of a Main Project, which includes a drilling program, as described in Part I, Section C of the report would resolve many of the difficulties encountered in this Pilot Project investigation. Analyses of surficial and bedrock samples would resolve problems associated with the complex glacial history and determine if mineralization was associated with the depressions shown in the suboutcrop surface as shown in Figure G 3. Analyses of stream sediment samples along the stream drainage system would determine whether there was migration of elements downstream from the vicinity of the mineralized contact.

Colorimetric results for mineral soils define Zones (1) and (2) which can be related to lead mineralization at the Silvermine property. Analytical results for humus show an excellent relationship to the lead results for mineral soils particularly at Zones (1) and (2).

Anomalous concentrations of lead and associated elements in plant organs, such as bark or twigs, detected by scan spectrographic analyses were sufficient to outline the extent of the known lead mineralization at Zone (1), and indicate the possible presence of a further area of mineralization in Zone (2).

A comparison of the magnitude and pattern contrasts of all lead anomalies in various plant organs, and an examination of their average lead content showed that although twigs contained more lead than bark, the results from bark provided a more reliable basis for interpretation. Therefore, bark should be used in future biogeochemical investigations as the most effective plant organ to sample and analyze for lead because its analytical results show the Zone (1) and (2) anomalies with better magnitude and pattern contrast than twigs or needles. However, the above comparison also shows that the anomalies of an associated element, barium, have a greater magnitude and pattern contrast than lead in all plant organs. This suggests that barium be used as a pathfinder element in biogeochemical prospecting for lead deposits in similar landscapes.

A careful study of the magnitude and pattern contrast of anomalies among lower, middle and upper bark analytical results show that there is little difference in the element response with the possible exception of lower bark. Except possibly for nickel, all the required elements can be detected in bark by the scan spectrographic method of analysis. The lower bark, which best defines the Zone (I) lead anomaly, can be collected and analyzed as a representative of all the barks. Numerous samples of lower bark can be collected quickly and to collect them it is not necessary to fell the tree as is the case with middle and upper bark. Bark is accessible for collection in winter when growth is dormant, and when it is not possible to collect organic or mineral soils. For the purpose of 'Visits' as described in Part I, Section C, and because bark has been shown to contain most elements required, it may be necessary only to collect and analyze lower bark to determine the presence and degree of element response in plant material. This element response in several bark samples provides a measure of the suitability of the landscape vegetation for Pilot Project investigations.

Analytical results for second and third year plant organ samples showed an appreciable difference in concentration of most elements between needles and twigs. However, there was little difference in concentration between samples of different ages of needles or twigs. Current needles and twig organs were combined for analysis, hence, their individual concentrations cannot be compared. The relative concentration of most elements into needles and twig organs was shown by the following elements: lead, barium, strontium, titanium, and silver are concentrated in the twigs; nickel, in twigs and organs of current growth; and copper possibly in organs of current growth. Manganese and zinc are apparently not affected by the age or type of organ. Current needle and twig organs change radically during even a short period of the growing season in their physiological processes and are therefore considered unsuitable for collection and analyses. Because second year needle and twig organs are simpler and quicker to collect than third year organs and their element response has been shown to be similar to third year organs, they can be collected and analyzed as representative of all needle and twig organs.

When the relative concentrations of all elements in all plant organs was compared it was found that bark contained a greater amount of barium and strontium than twigs and also concentrated manganese and zinc.

Therefore, the selected representatives of plant organs that will be routinely collected and analyzed for future biogeochemical investigations are: lower bark, second year twigs and needles.

Examination of the colorimetric results for the mineral soils showed that the B zone soil, which was relatively simple to collect, provided a strong signal for most elements. Therefore, the various characteristics of all mineral soil zones will be recorded to provide information on soil profiles but only the B zone material will be routinely collected and analyzed together with any organic soils.

A careful examination of all the analytical results did not reveal any features of the element distribution patterns that could be related to tree age or height variation. Similarly there were no features that could be related to the variation in thickness and development of organic and mineral soil zones. There appears to be no significant relationship between the tree species (i.e. balsam fir compared to black spruce) and element concentration in this landscape.

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APPENDIX GA

Typical soil profiles of the Thom and Shulie Series  
after D. B. Cann et al. (1963)

Thom Series

| Horizon          | Depth<br>inches | Description                                                                                               |
|------------------|-----------------|-----------------------------------------------------------------------------------------------------------|
| L-H              | 2- 0            | Dark reddish brown (5 YR 2/2), partly decomposed organic matter; fibrous and felty <u>mor</u> ; pH 3.6.   |
| Ae               | 0- 2            | Light reddish brown (5 YR 6/2) sandy loam; fine crumb structure; porous; friable; numerous roots; pH 3.9. |
| Bfh <sub>1</sub> | 2-12            | Strong-brown (7.5 YR 5/6) sandy loam; fine crumb structure; numerous roots; some stones; friable; pH 5.1. |
| Bfh <sub>2</sub> | 12-20           | Dark-brown (7.5 YR 4/3) sandy loam; structureless; gravelly; slightly firm; very stony; pH 5.2.           |
| C                | 20+             | Dark-brown (10 YR 4/3) gravelly sandy loam; firm; very stony; pH 5.4.                                     |

A dark-coloured B horizon is characteristic of the Thom soils and indicates movement and accumulation of organic matter in the horizon. In some places the upper B horizon is thin and the lower B is yellowish brown, grading to olive grey in the parent material. The L-H horizon is often only 1 inch thick. On some of the steeper slopes the parent material has a reddish cast and has probably been mixed with other material. In a few locations the B horizon is a silt loam where finer material has been mixed with the till. The stones are sharply angular metamorphic rocks 1 to 3 inches in size. Where moisture accumulates, the B horizon is greyish brown with darker brown patches, and the soil grades into the imperfectly drained Mira series.

Shulie Series

| Horizon          | Depth<br>inches | Description                                                                                                                   |
|------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------|
| L-H              | 2- 0            | Dark brown, semidecomposed organic matter; felty and fibrous; pH 3.5                                                          |
| Ae               | 0- 3            | Light grey (10 YR 7/2) sandy loam; loose; porous; structureless; numerous roots; a few stones; pH 4.4.                        |
| Bfh <sub>1</sub> | 3-10            | Yellowish brown (10 YR 5/6) loam; fine crumb structure; friable; porous; some roots; some stones; pH 4.5.                     |
| Bfh <sub>2</sub> | 10-16           | Yellowish brown (10 YR 5/4) loam; fine crumb structure; friable; some stones; pH 5.1.                                         |
| Bf               | 16-22           | Light olive(2.5 YR 5/4) sandy loam; slightly firm; structureless; porous; fragments of grey sandstone; pH 5.0.                |
| C                | 22+             | Dark greyish brown (10 YR 4/2) sandy loam; moderately firm to compact; brittle; numerous angular sandstone fragments; pH 4.7. |

The cultivated soil is a light-brown sandy loam. Some of the soils have a reddish cast and the upper B horizon may be yellowish red. The parent material is then a dull reddish brown and the soils resemble the Folly series in Colchester County. Tree roots go well down into the B horizon in this porous soil. There are a few areas where the B horizon may be sandier than that described above.

APPENDIX GB

Average Monthly and Seasonal Temperatures and  
Precipitation at Sydney, Cape Breton Island<sup>1</sup>

| Sydney (67 years) |                   |                          |
|-------------------|-------------------|--------------------------|
|                   | Temperature<br>°F | Precipitation<br>inches  |
| December          | 29                | 5.45 (17.6) <sup>2</sup> |
| January           | 22                | 5.16 (23.8)              |
| February          | 20                | 4.42 (24.9)              |
| Winter            | 24                | 15.03 (66.5)             |
| March             | 27                | 4.45 (17.4)              |
| April             | 36                | 4.03 (8.8)               |
| May               | 46                | 3.44 (0.5)               |
| Spring            | 36                | 11.92 (26.7)             |
| June              | 56                | 2.84                     |
| July              | 64                | 3.37                     |
| August            | 64                | 3.75                     |
| Summer            | 61                | 9.96                     |
| September         | 57                | 3.46                     |
| October           | 48                | 4.70 (0.2)               |
| November          | 38                | 5.17 (4.5)               |
| Fall              | 48                | 13.33 (4.7)              |
| Year              | 42                | 50.24 (97.9)             |

<sup>1</sup>From reports of the Meteorological Branch, Air Services, Department of Transport, Ottawa.

<sup>2</sup>Snowfall (10 inches of snow equals 1 inch of rain).



## APPENDIX GC

### Operational Procedure for Colorimetric Analyses on Soils and Organic Material Ash

These analyses were carried out in the Chemical Laboratory of the Geochemical Section of the Geological Survey of Canada under the direction of J.J. Lynch.

Procedure: (summary only)

- (1) One hundred mg of minus 80 mesh soil material or organic material ash is placed in a platinum dish and treated with 5 ml of concentrated HF, 5 ml concentrated HNO<sub>3</sub> and 2 ml of 70 per cent HClO<sub>4</sub> and allowed to digest overnight.
- (2) The mixture is evaporated to fumes of HClO<sub>4</sub> and then the sides of the dish washed with metal free water. Fuming and washing are repeated four more times before evaporating to dryness.
- (3) Residue dissolved in 5 ml of 1 N HCl and diluted to 10 ml with metal free water.
- (4) Aliquots of this solution are removed as required for zinc, lead, copper, and nickel tests. These elements were determined by methods due to Gilbert (1959) in the case of lead and zinc, Almond (1955) in the case of copper, and Stanton and Coope (1962) in the case of nickel. The method for zinc was slightly modified by the addition of sodium fluoride to the acetate buffer to suppress any interference due to aluminum, Stanton (1962).
- (5) The performance of these methods in the normal working range (20 - 1,000 ppm) is within 25 per cent of the total amount of metal present.
- (6) Molybdenum was determined by a method described in North (1956). This method involves a fusion with modified Na<sub>2</sub>CO<sub>3</sub> flux, leaching with water, and a final determination of molybdenum with zinc dithiol rather than dithiol as described by North. The performance of this method is similar to that of the other four.

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## A BIOGEOCHEMICAL INVESTIGATION AT MER BLEUE BOG

J.A.C. Fortescue and Lily Usik

### H 1 Introduction

Biogeochemical prospecting in areas of Canada variously known as bog, muskeg, and swamp, that are uniquely characterized by the presence of an accumulation of peat, or partially decomposed plant material, and by wet conditions, has received little attention in Canada. This has been true although not only does organic terrain cover approximately 500,000 square miles of Canada but most of it occurs in areas such as the Shield that are known to be potentially mineral rich but where standard prospecting methods have found limited success.

In Canada only two reports have appeared in the past decade that may be considered as serious contributions to the investigation of the problem of prospecting methods in peat areas (Gleeson, 1960; Gleeson and Coope, 1967). In Finland, which is third after the U.S.S.R. and Canada in its acreage of peatlands (Tibbets, 1963), Salmi has described a number of investigations utilizing the peat (1950, 1955), vegetation (1956) and physico-chemical factors, such as the pH (1958), of bogs to indicate the presence of ore minerals. According to the results of his studies biogeochemical investigation is a feasible method of prospecting in peatlands.

Part of the biogeochemical research at the Geological Survey of Canada is to develop methods for the systematic investigation of the content and distribution of the elements in bogs and muskeg for prospecting purposes. This paper reports on a preliminary investigation carried out to establish and test field and laboratory techniques and to examine the characteristics of a number of elements in the peat profile of a confined area of peatland, or bog.

### H 2 Area of investigation

The Mer Bleue bog was selected for investigation because it is a typical example of the peat bogs found in eastern Canada. Furthermore, it has been relatively undisturbed by man and is also readily accessible. Mer Bleue occupies a depression of about 8 square miles which was once a river delta (MacFarlane, 1964). The bog has a convex topography with the centre being slightly higher in elevation than the edges and may, therefore, be designated as a 'highmoor' type bog. A wet margin known as the 'lagg' and characterized by deciduous shrubs, rushes, sedges and herbs surrounds most of the bog. The bog proper within the 'lagg' supports the typical bog vegetation species of sphagnum mosses, ericaceous shrubs, sedges and larch. The most common species present and their typical associations are shown in Figure H 2, which depicts a selected traverse line across the South Arm of the bog (Fig. H 1).

### H 3 Peat sampling and analysis

The sampling procedure for biogeochemical investigation in peat areas is relatively simple. Briefly, the peat samples are collected from boreholes put down at specified intervals along a selected traverse line across the area of study. At each hole the samples are collected at selected intervals of depth to the substrate. For Mer Bleue, peat samples were collected from 10 stations situated at 200-foot intervals along a line across the South Arm. At each station the peat profile was sampled with a 3-inch diameter Shelby tube sampler. Two-foot peat cores were taken down the profile from the surface to the underlying clay. The peat cores were immediately wrapped in plastic sheets and taken to the laboratory for preparation and chemical analysis.

After air drying in the laboratory, 10 grams of material were taken from each core section and then oven dried at 110°C. The sample was dry ashed and the manganese, strontium, barium, titanium, copper, zinc, lead, chromium, and nickel contents determined in the ash by a semiquantitative spark spectrographic method (Fortescue and Hornbrook, 1967).

### H 4 Results

The results of the analysis were plotted for each element showing their vertical distribution within each of the ten profiles (Fig. H 3). For prospecting purposes the analytical results would be interpreted in relation to the possible presence of a mineral deposit below or near the bog. For Mer Bleue, however, interpretation of the chemical data involved only the examination of distribution patterns for each of the elements in each of the ten profiles in relation to depth, peat type, and surface vegetation.

Several observations can be made about the distribution patterns of the elements. Zinc, chromium, and lead have similar patterns in all profiles, and in the deeper ones, for example, II, III, V (Fig. H 3) the metal content increases with depth. This trend is not as evident in the shallower holes where there are fewer observations in relation to the total depth of the hole. The patterns for copper, nickel, and titanium are similar to each other and differ from those of the elements described above in having higher values in the centre of the profile. The similarity of titanium and zinc in the shallower holes, i. e., VII, VIII, and IX (Fig. H 3) should be noted. The distribution patterns for manganese, barium, and strontium are generally similar with almost constant concentrations of the elements along the profile. For manganese, but not for barium or strontium, very low values were obtained in the topmost layers of peat.

Some relationships between the vertical distribution patterns and the peat type may be observed. For example, the high zinc, lead, and chromium values in the surface samples (holes II and III) could be associated with the sphagnum peat at this level and the lower values of these elements

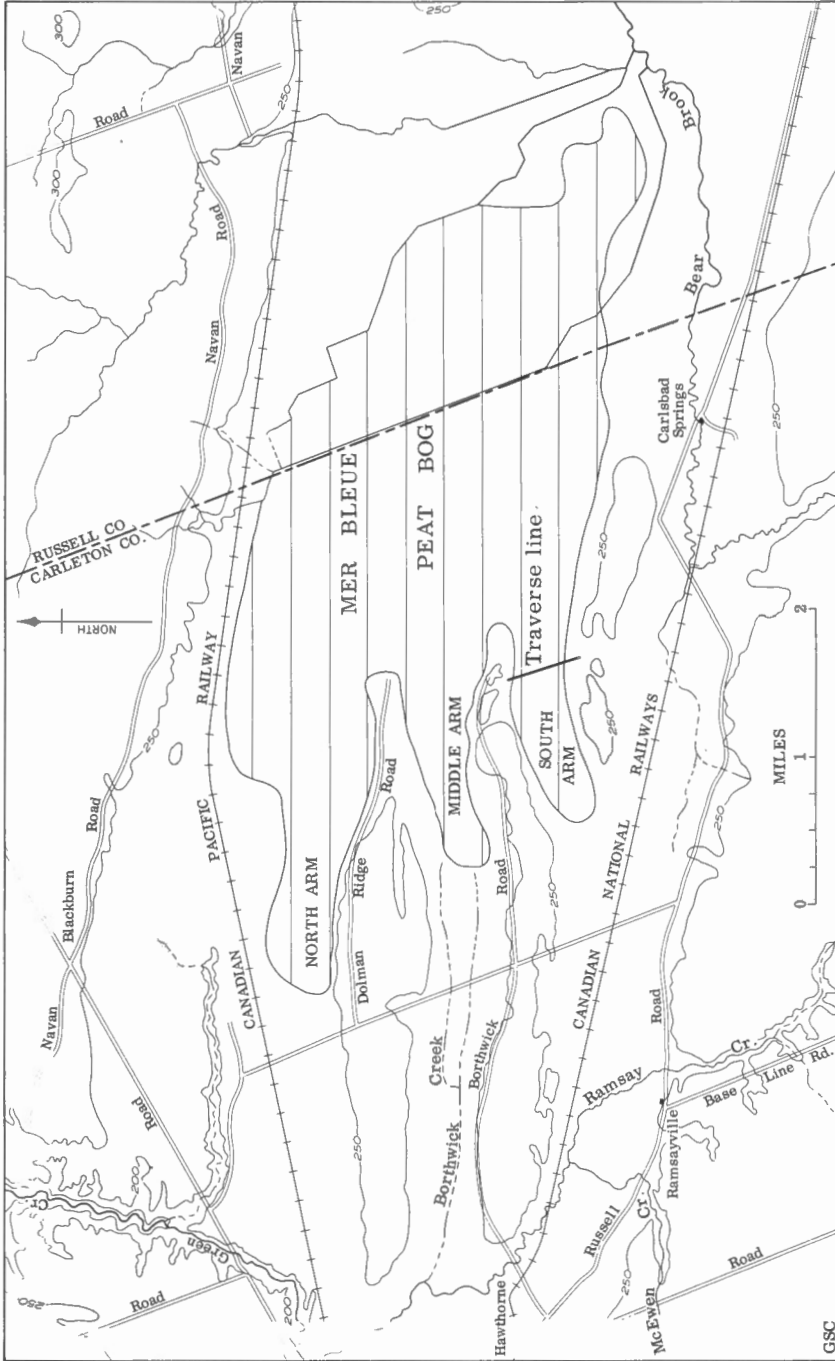


Figure H1. Mer Bleue peat bog, Ottawa, showing approximate location of traverse line across South Arm.

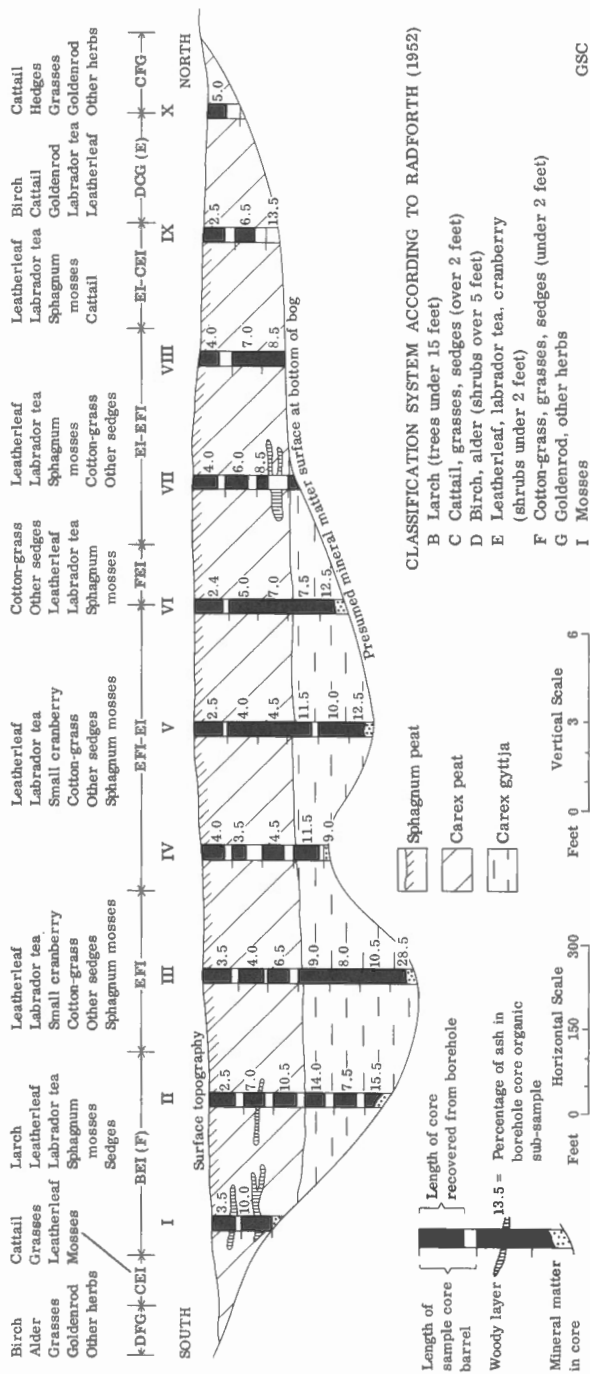


Figure H2. Section across the Mer Bleu peat bog showing vegetation cover types and stratification of peat material.

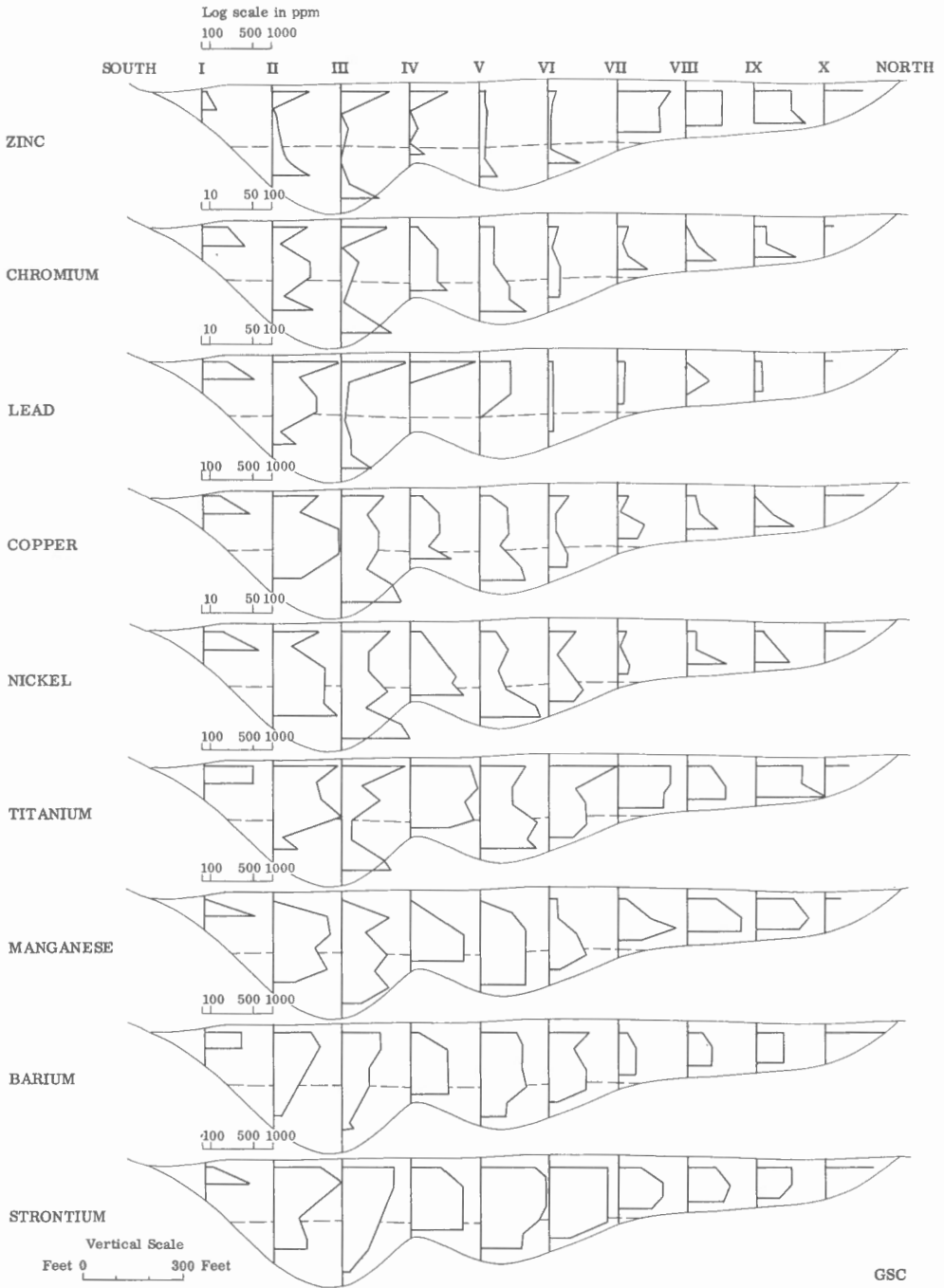


Figure H3. Vertical distribution of minor elements in ash of peat material collected from boreholes located along a traverse across the South Arm of Mer Bleue peat bog

with the underlying carex peat. More detailed investigations are required to fully interpret these observations. No apparent relationship could be found between the surface vegetation types and the element distribution patterns.

#### H 5 Summary

The results of the biogeochemical investigation at Mer Bleue bog demonstrated that using a relatively simple sampling method it was possible to obtain vertical distribution patterns for several elements in the peat of a bog unassociated with any known mineralization. When one considers the relatively few samples used and the low density of sampling (10 profiles at 200-foot intervals) it is interesting to note that similar distribution patterns for different combinations of elements were obtained.

It may be concluded that the procedures described for the collection, preparation, and analysis of peat are suitable for preliminary biogeochemical prospecting research of peat bogs in the vicinity of known, undisturbed mineral deposits.



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