RELATIONSHIPS BETWEEN SOME ELEMENTS IN ROCKS, SOILS AND PLANTS OF SOME MINERALIZED AREAS OF BRITISH COLUMBIA

by

J. J. Barakso

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ABSTRACT

The distribution of trace elements in bedrock, soils and plants, was studied in twelve areas of British Columbia where mineralization was known to occur below different kinds and depths of overburden. Samples were taken from two soil profiles and the bedrock at each location, and second and third year twigs of the principal vegetation found within a radius of fifty feet of each profile were also collected. The bedrock, soil and plant samples were analysed. The soil samples were used for the determination of pH, organic matter content, percentage of material $<$80 mesh, cation exchange capacity, exchangeable heavy metals, and content of Cu, Mo, Zn, Pb, As, Co, Ni, Fe and Hg. The same elements were determined in the bedrock and vegetation samples.

The results were examined graphically for relationships between elemental contents of the bedrock, soil horizons and vegetation. The data were then statistically analysed.

(a) soil horizons and plant relationship with bedrock.

(b) inter-elemental relationship of individual horizons of soils and of plants, as well as all horizon relationships.

(c) multiple correlation study of cation exchange capacity, percentage of organic material and -80 mesh of element content of individual and all soil horizons.

These studies showed that, although most of the soil horizons were developed from transported materials, (glacial, alluvial, etc.), there was a highly significant correlation with B and C horizons and bedrock that confirmed the value of soil sampling in prospecting, since horizon development includes the upwards migration of the elements from bedrock.

The secondary dispersion of the halo elements (Mo, Zn, Pb, As, Co, Ni, Hg) proved useful as pathfinders where major economic elements may have been masked during the upward migration process. Secondary dispersion may also be in some degree, helpful in identifying the origin of soils and plants.

A great divergence in the affinity of various plants for different elements, and of the same species at different locations, was noted. It was also observed that plants have a closer relationship to the soils than to the bedrock itself, but even so, indicate mineralization.

The important relationships between elemental distributions in soil horizons and in plants with bedrock, indicated a logarithmic relationship.

The multiple correlation study indicated that some of the major factors of influencing the level of element content in soils developed on transported material-covered areas, are the size of the soil particles and frequently the pH of the soil.

In general, the study indicated that the distribution of trace elements is highly complex and that bedrock, soils, and plants, should all be combined into one study; since the study of one of these alone would be incomplete without the others.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES - cont'd

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1. INTRODUCTION

The rapidly growing demand for metals has led to prospecting for metallic orebodies on an unprecedented scale. Since earlier surveys, made by prospectors using conventional methods, located many of the exposed orebodies, new techniques of prospecting are needed to detect those which are buried by soil, organic debris, or other material.

Pedo-geochemical and bio-geochemical prospecting are methods which have recently been developed for this purpose. Pedo-geochemical and bio-geochemical prospecting refer to exploration based on systematic measurement of one or more elements occurring in soil or plant material. In order to use these methods effectively, it is necessary to have an understanding of the relationships that exist between the elements occurring in buried orebodies, in soil, and in vegetation. The purpose of this study was to obtain a better knowledge of these relationships.

In this study, 24 soils were examined, described, and sampled, at 12 locations where buried orebodies were known to occur in British Columbia. Samples of the vegetation and underlying bedrock were also collected and, along with the soil samples, analysed for their content of eight important micro-elements, along with some additional chemical properties.

The results of these studies and the relationships between the content of micro-elements in the bedrock, soils, and vegetation, are reported upon in the sections which follow.

2. LITERATURE REVIEW

Geochemical prospecting for minerals includes any method of mineral exploration based on systematic measurement of one or more chemical properties of naturally occurring material. The chemical property measured is most commonly the content of some trace element or group of elements; the naturally occurring material may be rock, soil, gossan, glacial debris, vegetation, stream sediment or water. The purpose of the measurement is the discovery of abnormal chemical patterns or geochemical anomalies related to mineralization (15).

Pedo-geochemical and bio-geochemical prospecting refer to the use of soil and vegetation respectively, and since the work reported here is concerned with these relationships, the review of literature will be restricted accordingly.

2.1 Soil and Vegetation Surveys

The use of plants as indicators of metallic elements dates back to 1753 when Urban Jerne (25), noted the frequent presence of a higher content of heavy metals including iron, copper, tin, lead, gold and arsenic, in plants growing in certain areas of Sweden.

In 1929, Linstow, mentioned by Malyuga (25), observed an affinity among plant species for certain elements when grown on different geological formations. He noted especially, the high content of zinc in the violets of Germany and Belgium.

Pedo-geochemical prospecting was begun about 1930. Goldsmith and his associates (26,33) were among the first to conduct trace element analysis of soils in order to identify the origin of transported soils in parts of Norway and Finland. During the same period, Fersman and Vernadsky (33,40) in Russia, did similar work to determine the occurrence of dispersion of elements in geochemical cycles. They were successful in using spectrographic analyses for trace elements in soils and plants as a prospecting method. Their work led to the initiation of "Metallometric Surveying" in the mid-1930's, which has since become a standard procedure of prospecting in Russia.

Palmquist and Brundin (25) working in Sweden in 1939, used bio-geochemical methods in routine spectrographic determinations of the ash of grassy plants and the fallen leaves of the forest. Occasionally, they also sampled the organic layers of soils in areas where there was a possibility of finding minerals. The occurrence of higher lead, zinc, and tungsten contents in some of their samples, led to the discovery of several mineralized zones. Although these deposits were found to be non-economical for mining, their observations proved the value of their method.

Tooms reported in 1961 (39) on latosol soil profiles developed over granitic bedrock in Northern Rhodesia and described soils with enrichments of copper, chromium, vanadium, manganese, and iron in the B horizon.

Beginning about 1945, Warren and his associates (41,42,46) in British Columbia, undertook an extensive research program on the metal content of vegetation, and reported the possibility of using different species of trees for geochemical prospecting for several elements. Their work pioneered this field and established background values for some rocks and plants as guide lines for prospecting.

During the last decade, a great deal more attention was given to geochemical prospecting. Russian scientists have done a great deal of work in the use of soil and vegetation in surveys. Among the Russian scientists working in this field, Vinogradov and Malyuga (40,25) have been outstanding. Vinogradov made a wide study of the distribution of "Rare" elements in soils. He examined more than 20 soil profiles from areas of the eastern European plains, and made a complete and detailed analysis of samples collected from there, summarizing his work in the text "The Geochemistry of Rare and Dispersed Chemical Elements in Soils" (40), published in 1959.

Malyuga studied the chemical composition of plants relative to geochemical prospecting, and gave a summary of different indicator plants. He reported experience in the U.S.S.R. of the use of plants for bio-geochemical prospecting. The account of his work is found in his book - "Bio-Geochemical Methods of Prospecting " (25), published in 1964.

In comparison, literature published in the western countries on this subject, especially in North America, is rather limited. Some indication of the use of soil sampling in mineral prospecting has been given by Hawkes and Lakin (15). Their earlier work was mostly on lead-zinc occurrences and only the cold extractable metal contents were used as a guide to further study. A more scientifically designed study was carried out by Byers in the Flin Flon area of Northern Saskatchewan (4), in which the extractable heavy metals were compared in different soil horizons at zinc-copper sulphate mineralized and unmineralized areas. It was noted that the exchangeable heavy metals are highest in the organic horizon and also enriched in the B horizon as compared with the parent material. A somewhat more elaborate investigation was carried out for copper and zinc by Ermergen (12) in Chibougamau in Northwestern Quebec. The samples were taken from known mineralized areas of different depths down to 15 feet; the metals were extracted with hot HNO_3 and determined colorimetrically. In his work, enrichment of the elements varied with depth and the highest results he obtained were in the Ao horizon. In British Columbia, Clark (9), analysed a number of soils from non-mineralized areas for total and available copper. He found the levels of exchangeable Cu ranged from 1 - 4 ppm and copper accumulation was indicated in some well developed B horizons.

Recently, Presant (29), analysed different horizons of Podzolic soils in New Brunswick and found that the concentration of elements varied in the different horizons represented. Warren and associates (47,48), worked on several of the pathfinder elements, and also began investigating the use of new pathfinder elements such as Hg and As in plants as indicators of mineralization.

Warren and Delavault defined the pathfinders in 1956 as follows:

> "Pathfinder elements may be defined as elements which, because of some particular property or properties, provide anomalies, or halos, more readily usable than the sought-after element with which they are associated." (43)

It is evident that since 1930, soil and vegetation surveys have been widely and effectively used in locating mineralized areas, but that much remains to be learned regarding the relationships and the levels of elements in anomalies, soil horizons, and vegetation.

2.2 Dispersion of Elements

Goldschmidt (26) noted that geochemistry is concerned with the determination of the relative and absolute abundance of the elements in the earth and the study of the distribution and migration of the individual elements in the various parts of the earth. Pressure, temperature, and the availability of the most abundant chemical components, are the parameters of the geochemical environment that determine which mineral phases are stable at any given point. On the basis of these variables, it is possible to classify all the natural environments of the earth into two major groups - primary and secondary (15).

(a) Primary environment - extends downward from the lower levels of circulating meteoric water to the deepest level at which normal rocks can be formed. This is the environment of high temperature and pressure, restricted circulation of fluids, and relatively low free oxygen content.

(b) Secondary environment - is the environment of weathering, erosion and sedimentation at the surface of the Earth. Characteristics are low temperature, nearly constant pressure, free movement of solutions, free oxygen, H_2O and CO_2 present.

The secondary environment is of most concern in this study, since it includes the secondary dispersion of the elements in weathering and soil formation.

The overall pattern of the geochemical distribution of elements in a given area will reflect the net effect of all the dynamic forces concerned; this pattern is referred to as the geochemical landscape (15). The normal abundance of an element in each material is known as the background value for that element (15). Background values have been given by several workers for rock (14,15) and a range of values for a number of important elements in soils is given by Hawkes and Webb (15). However, it should be noted that in some cases, background values have been reported to cover a wide range and therefore may be unsatisfactory for practical purposes.

The enrichment of elements may occur as a result of fractional recrystallization of magmas and represents the second geochemical differentiation of the Earth (30).

Rocks and soils where they are enriched above the normal contents of dispersed elements are termed anomalous.

Dispersion is generally the result of an inter-action of chemical and mechanical processes (15). Fundamentally, the dispersion of an element is governed by the mobility of that element and is dependent on its environment, and on the mechanical properties of the mobile phase. Mobility has a very important role in the primary and secondary dispersion of the elements, and relative mobilities have been given for several groups of elements under the most common circumstances so far encountered by several workers (15). Mobility of elements plays an important role in geochemical dispersion of elements, especially in the use of pathfinder elements (43). Pathfinder elements are often called "indicators" (14), or geochemical tracers. They may be distributed in the form of halos around mineralization.

These elements can play a major role in applied geochemistry, and their origins are very important. They can be classed as primary or secondary:

1. Primary dispersion - is concerned with the distribution of the elements that are preserved in rocks of different formations. In primary dispersion, the elements are distinguished as syngenetic patterns which were formed at the same time as the rock itself, or epigenetic patterns formed by the material introduced in some way into a pre-existing rock matrix.

2. Secondary dispersion - is concerned with the redistribution of the elements as rocks weather. The major factors of secondary dispersion are chemical, mechanical or biological (15).

Chemical factors important in secondary dispersion are the hydrogen ion concentration (pH), redox potential (Eh), chemical stability of the mineral, sorptive capacity of the solids, and the stability of the dispersed colloidal phase. The important mechanical factors are simple gravity movement, wind action, and with less significance, volcanism. Biological dispersion factors are vegetation and micro-organisms.

The nature of the statistical distribution of the elements has been the subject of study and some controversy. Thus, in 1954, Ahrens reported that most geochemical distributions in rocks appear to be more nearly log normal than normal (2). This has been questioned by Chayes, Aubrey and others (34), and the question has not been completely answered.

In a recent publication, Saw concluded that ....

> "It is essential to understand clearly the nature and limits of a given population, in geochemical terms, before trying to find a model to explain it." ...

In general, Saw concluded that log normal distributions existed, but no single law applies to all the situations (34). Hawkes and Webb (15), concerning the distribution problem, state it is certainly true that data collected during the course of geochemical surveys often appear to be distributed log-normally.

In review of the work done, it appears that for purposes of statistical treatment, the distribution of elements may, under some circumstances, be assumed to be log normal. In view of this, for purposes of the statistical treatment used in the present study, log normal distribution was assumed to occur in bedrock and soils.

2.3 Anomalies in Transported Materials

An anomaly is a deviation from the norm, and a geochemical anomaly is a departure from the geochemical patterns that are normal for a given area or geochemical landscape. Anomalies that are related to, or that can be used as guides in exploration are termed "significant" anomalies (15).

In order to define what constitutes an anomaly, it is necessary to determine upper limits of normal background fluctuation before establishing threshold value. The magnitude of anomalies may be expressed in terms of the contrast between the peak or highest values, and the threshold (14,15,26).

Hawkes and Webb (15) state that a fully dependable value from threshold can come only from an orientation survey of the area, and at this time there is no real substitute for a visual estimate of tentative threshold values, correlated with the known distribution of metal in the bedrock. They also noted that statistical methods should be used solely as a disciplinary guide and never as a replacement for qualitative appraisal. There has been considerable controversy in the geochemical literature relative to statistical distribution of elements in rocks. This has been discussed in some detail earlier with the dispersion of elements.

Pedo- and bio-geochemical prospecting are concerned with detecting anomalies where the overburden is either residual or transported (15). In British Columbia, as in many other areas of the earth, bedrock anomalies are often blanketed with recent deposits of glacial debris, alluvium, colluvium, peat, wind-blown material, or volcanic ash, all of which present special problems. It has been found that geochemical anomalies developed in transported material have some features in common, and that different patterns occur (15).

(a) Syngenetic patterns which are the effect of purely mechanical movement of solid particles.

(b) Epigenetic patterns that result from hydromorphic and biogenetic factors and appear to be the more important.

A syngenetic anomaly is formed at the same time as the deposit of transported material in which it occurs; while an epigenetic anomaly is a dispersion pattern introduced subsequent to the deposition of the matrix. The occurrence and nature of syngenetic and epigenetic patterns have been studied in such materials as glacial overburden, colluvium, alluvium, lake and marine sediments, and organic deposits (15). However, there appear to be few published studies made of these in relation to soil formation and horizon differentiation.

2.4 Soil Formation and Secondary Dispersion

Weathering and soil formation merge and often proceed simultaneously; weathering paving the way for soil development. During the weathering of rocks by physical, chemical and biological means, the elements are liberated. Minerals which are more resistant to weathering tend to be released from host rocks, while the less resistant ones provide constituents for new minerals of different composition, as well as solid-form aqueous solutions (15).

A great many studies have been made relating to soil formation and the behaviour of elements in the development of soil horizons. Hawkes and Webb (15), writing on soil formation in relation to geochemistry, point out that beginning with the work in Russia, it has been shown that soil formation and the development of horizons are primarily the result of circulation of solids and suspension of materials accompanied by a complex series of chemical reactions. Therefore, it is evident that secondary dispersion of elements will be affected by soil-forming processes. Jenny (20) discusses soil development at some length in relation to the five factors of soil formation -- time, parent material, topography, climate and organisms, and points out that a soil including the material of its horizons is a function of these factors. The secondary dispersion of elements, therefore, will also be affected by these factors and will be related to the soil, as noted by Vinogradov (40) in his studies of the soils of the plains of Eastern Europe. Ginsburg (14) and Hawkes and Webb (15) also provide rather complete reviews of the importance of soils and soil classification in relation to geochemistry. In spite of its importance, the secondary dispersion of elements in soils in relation to geochemistry, has not been thoroughly studied.

It can be said that the lack of this kind of study was due in part to the need for a precise descriptive soil classification based on evolution. This was provided recently in Canada by the National Soil Survey Committee. The reports of this committee for 1963, and 1965 (31,32), give a complete outline of the soil classification system designed for the Canadian environment. The soil descriptions and classification used in this study were made following this system.

3 MATERIALS AND METHODS

3.1 Sampling Sites and Methods

Twelve sample sites were chosen representing widely separated mineralized areas in British Columbia. The locations of these sites are shown in Figure 1. At each site, two soil profiles were located within the area of mineralization, as indicated in Figure 2. The profiles were located about 100 feet apart, and within a radius of 50 feet of each the principal vegetation was identified and the shrubs and trees sampled for analysis. To minimize seasonal variations, the second and third year growth, including the needles in the case of conifers, was collected.

At each site the general geology and physiography, including the slope, aspect, and drainage, were noted and recorded following the procedure outlined in U. S. Soil Survey Manual (38). The soil profiles were described and classified as to group and sub-group following the method of the National Soil Survey Committee (31,32,38). Approximately a two-pound sample of soil was taken from each major horizon. For this purpose, a small trowel was used to obtain a representative sample from the thickness of each major horizon. Material larger than 2 inches in diameter was discarded. One to six-pound samples of the underlying bed-

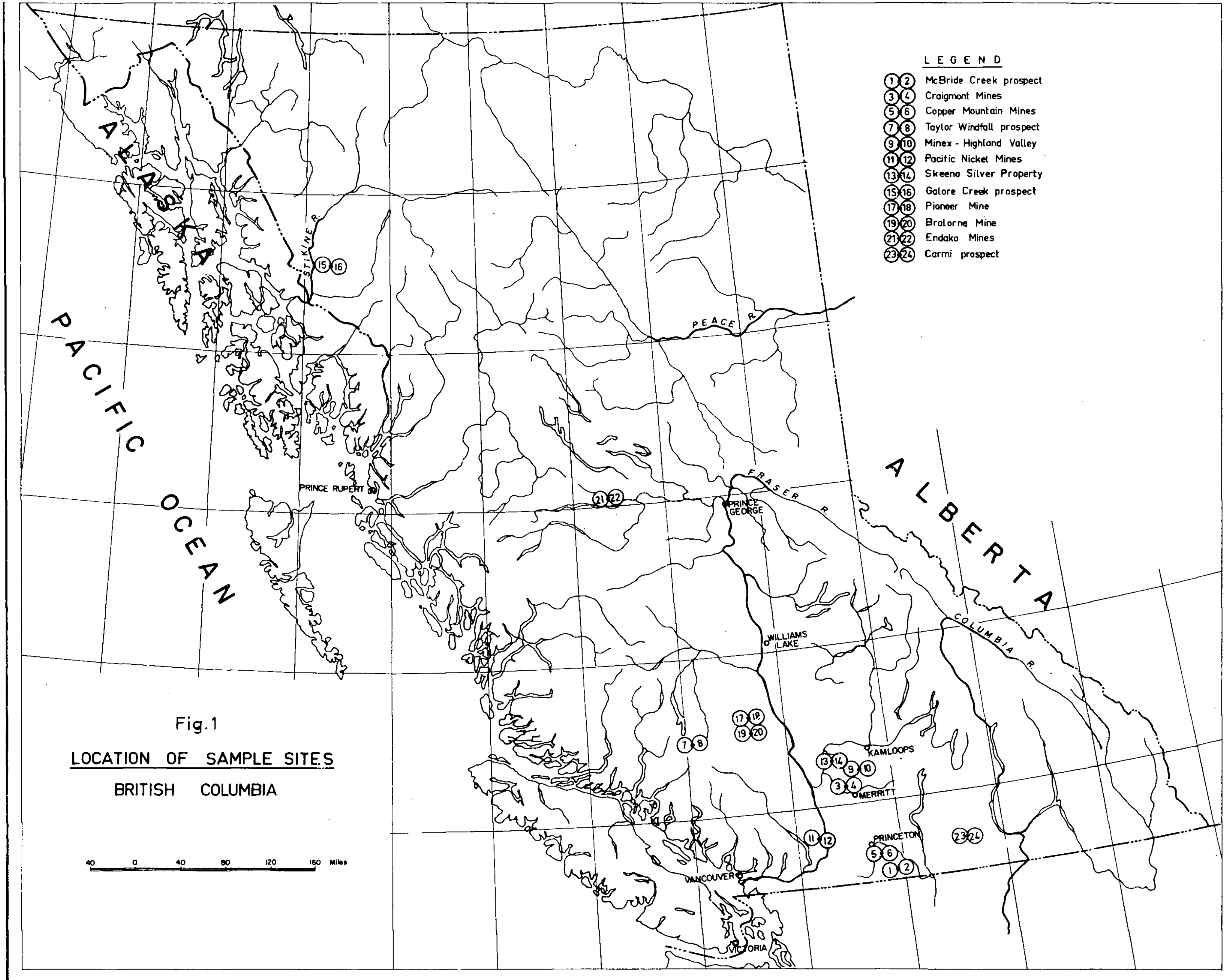


Fig. 1

LOCATION OF SAMPLE SITES

BRITISH COLUMBIA

rock were also taken at each profile by collecting rock chips from the oxidized but unbroken material.

3.2 Laboratory Methods

The laboratory methods used were a combination of those used in geochemistry (33,17), and in standard soil and plant analysis (36). The analysis was carried out in the laboratories of the Department of Soil Science, and in the geochemical laboratory of Kennco Explorations, (Western) Limited.

All the samples were taken to the laboratory and following mixing, a sub-sample was removed from each for the determination of mercury. These sub-samples were placed in plastic containers to prevent drying. The balance of each sample was dried in an electric oven by slowly raising the temperature to 100°C.

The samples of bedrock were crushed and pulverized using ceramic plates to pass a 100-mesh sieve (minus 0.16 mm).

The soil samples were pounded, mixed and quartered. One quarter was screened through a screen with 2 mm openings. The material passing was used for the determination of pH, cation exchange capacity, and percent organic material.

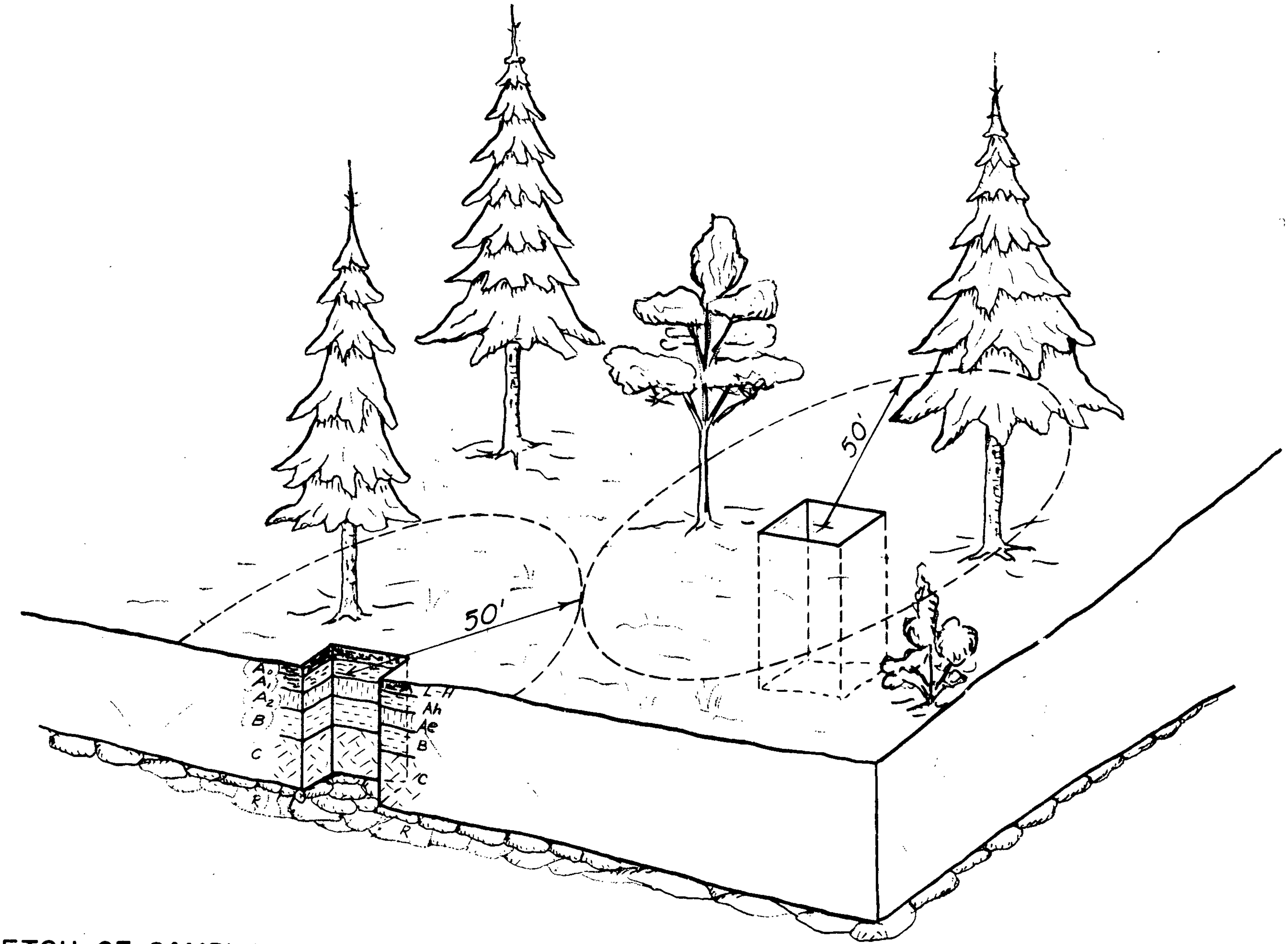


Fig.2 SKETCH OF SAMPLING METHOD

The remaining three-quarters were weighed and screened using an 80-mesh screen (minus 0.205 mm). The material passing was weighed also and its percentage of the total sample calculated ($>$80, mesh %). This material was used for the determination of the exchangeable and total element contents, as this is the size fraction generally used in geochemical work (15).

The plant samples were dried at 95°C, ground with a Wiley mill, and representative samples used for analyses.

The methods of analyses used were as follows:

Reaction: (pH) was measured using a 1:2 soil to water ratio and a Zeromatic pH meter.

Cation Exchange Capacity: (C.E.C. me/100 gms) was determined using 2.5 or 5-gram samples and Na^+ to replace the exchangeable ions (neutral normal sodium acetate). Centrifugal techniques were employed and for washing, ethanol was used; Na^+ was determined using a flame photometer (17).

Organic Matter Percentage: (O.M.%) of the samples was determined using 0.25 grams or less of samples and wet combustion using N. $K_2Cr_2O_7$ and back-titrating with 0.5N ferrous sulphate in the presence of orthophenonthroline indicator (17). Organic matter percentage was found by multiplying the organic carbon percentage by the factor 1.724.

Exchangeable Heavy Metals and Exchangeable Copper: (Exch. H.M. and Exch. Cu ppm). Blooms method (36,21) was followed for Exch. H.M. and Holman's method for Exch. Cu using NH_4 ions to exchange the metals.

Diphenyl-Dithiocarbazone (Dithizone) 0.001% was used as reagent in the presence of a weak acetate buffer.

Total Metals: (ppm) were determined following digestion of 1 gram of < 80-mesh soil or < 100-mesh rock in a beaker. The samples were first treated with concentrated HNO_3 and then digested with 71% $HClO_4$. To release metals from silica layers, a few drops of HF were added during digestion. The digested samples were made up to volume of 50 ml and aliquots taken for each element determination. Colorimetric methods were used as indicated below, using a "Spectronic 20" spectrophotometer.

Molybdenum: (Mo ppm) was determined by ammonium thiocyanate-stannous-chloride method (33,21).

Copper: (Cu ppm) 2'-2 biquinoline was used as reagent dissolved in iso-amyl alcohol and extracted from the buffered media at pH 4.5 (33,21).

Zinc: (Zn ppm) a mixed, coloured dithizone method was used where previously copper had been extracted from the sample solution to reduce interference (33,21).

Lead: (Pb ppm) after Zn and Bi interference eliminations by complexing with KCN, the monocolour dithizone method was employed (33,21).

Nickel: (Ni ppm) was determined with dimethyl-glyoxine as reagent in buffered media (33,21).

Cobalt: (Co ppm) was determined after it was buffered to 6.2 by the 2-Nitroso -1 -Naphtol method (33,21).

Arsenic: (As ppm) the modified Gutzeit method was followed and the highly sensitive silver-diphenyl-dithiocarbamate used as reagent in pyridine (9,47). Plants were set-ashed and followed with the same procedure.

Mercury: (Hg ppb) unscreened samples were used and 1-3 grams of soils and rocks, and 0.5-1.0 of plants were taken. After digestion, the mercury was amalgamated on copper and measured by a single beam U. V. instrument in the mercury vapour form (19,23,35).

Plant Analysis: 5 g samples were weighed into a porcelain crucible and ashed at 550°C for about two hours. After ashing, the treatment and procedure were the same as for soil and rock, with the exception of the determination of arsenic and mercury. These were wet-ashed before determination.

3.3 Statistical Methods

The data was statistically analysed using an I.B.M. 7040 computer at the University of British Columbia. The following tests were conducted:

1. Simple correlations were made of the elemental content in the bedrock with that of the major soil horizons. Both linear and logarithmic correlations were carried out.

2. Simple correlations between individual elements and between individual elements and the analytical soil data.

3. Multiple correlations were determined among cation exchange capacity, organic material percent, and minus 80 mesh percent with each element and with each recognized soil horizon.

4 RESULTS AND DISCUSSION

4.1 Discussion of Sample Sites

The locations of the 24 profiles studied are shown on the outline map of British Columbia, Figure 1. From this figure it may be noted that the locations are widely distributed from south to north.

Information relative to the locations, with respect to economic mineralization, bedrock parent material, and classification of the soils, is summarized in Table I.

From Table I it may be noted that the profiles were selected to represent different types of economic mineralization. Economic mineralization refers to mineralization in areas where minerals are being mined or may be mined at some future date. Seven of the sites selected for study contain copper as the major economic mineral (1,2; 3,4; 5,6; 7,8; 9,10; 13,14; 15,16). Two represent significant molybdenum major mineralization (21,22; 23,24). At three other sites, molybdenum occurs as an associated important element (1,2; 7,8; 9,10). Gold is represented by two sites (17,18; 19,20) and nickel by one at Pacific Nickel mine, at present the only producing nickel mine in British Columbia (11,12).

Bedrock in Table I refers to the sometimes oxidized but solid layer of consolidated rock which occurs under the overburden. The nature of this was determined by reference to geological and other reports (4,5, 8,9,23,33), and by observations at the sites.

Parent material is the unconsolidated mass from which the soil developed, and the terms used in Table I, refer to its mode of origin. From this table it may be noted that at all sites except 9-10, parent materials have been transported or moved to a greater or lesser extent. Thus, colluvium, refers to poorly sorted material near the base of steep slopes that has been moved by gravity, frost action, soil creep or local wash (38). Its nature, therefore, should be closely related to the material occurring above it on the slope. Glacial drift consists of all the material picked up, mixed, disintegrated, transported and deposited through the action of glacial ice or water resulting primarily from the melting of glaciers. Glacial till includes that part of the glacial drift deposited directly by the ice with little or no transportation by water (38). Alluvium consists of sediments moved and re-deposited by streams.

Residual parent materials can be defined as those which are formed in place through the disintegration and decomposition of country rocks (38). Of course, the above mentioned parent materials may occur in combinations, such as at Site 5,6 where a mixture of colluvium and

TABLE 1: Summary of Information Concerning Sample Sites

Sample Sites	Soil Order	Soil Subgroup	Parent Material	Bedrock	Economic Mineral
1,2 McBride Creek Prospect	Brunisolic	Degraded Acid Brown Wooded	Colluvium (some volcanic ash layers)	Granite Porphyry & Rhyolites	Pyrite Chalcopyrite Molybdenite
3,4 Craigmont Mines	Podzolic	Gleyed Gray Wooded	Glacial Drift	Nicola Volcanic Beds of Limestone	Chalcopyrite Magnetite Hematite
5,6 Copper Mountain Mines	Brunisolic	Orthic Acid Brown Wooded	Colluvium & Residual Mixed	Nicola Volcanics (Tuffaceous)	Chalcopyrite Magnetite Hematite
7,8 Taylor Windfall Prospect	Brunisolic	Degraded Acid Brown Wooded	Alluvium & Colluvium	Granite Intr. & Silicified Tuffs	Pyrite Chalcopyrite Molybdenite
9,10 Minex Highland Valley	Brunisolic	Orthic Acid Brown Forest	Residual & Colluvium	Hornblende Granodiorite	Chalcopyrite Pyrite Molybdenite
11,12 Pacific Nickel Mines	Brunisolic	Orthic Concretionary Brown	Glacial Drift & Colluvium	Ultrabasic (Dunite, Norite, and Diorite)	Ni Sulphide Chalcopyrite
13,14 Skeena Silver Property	Brunisolic	Degraded Brown Wooded	Glacial Till	Skeena Granodiorite	Chalcopyrite Pyrite

cont'd

TABLE 1: cont'd

Sample Sites	Soil Order	Soil Subgroup	Parent Material	Bedrock	Economic Mineral
15,16 Galore Creek Prospect	Brunisolic	Orthic Acid Brown Wooded	Glacial Drift	Volcanic & Sediments with Syenite Intrus.	Chalcopyrite Bornite Pyrite
17,18 Pioneer Mine	Podzolic	Dark Gray Wooded	Glacial Drift	Granodiorite Quartz vein	Gold Arsenopyrite Pyrite
19,20 Bralorne Mines	Brunisolic	Orthic Brown Forest	Glacial Drift	Granodiorite Quartz veins	Gold Arsenopyrite Pyrite
21,22 Endako Mines	Brunisolic	Degraded Acid Brown Forest	Glacial Drift	Topley Granodiorite	Molybdenite Pyrite
23,24 Carmi Prospect	Brunisolic	Orthic Acid Brown Wooded	Glacial Till	Granodiorite Gneiss	Molybdenite Pyrite

residual material was found, and at Site 11,12 where a mixture of glacial drift with colluvial material from the steep mountain slopes occurred.

The soils were classified according to the latest report of the National Soil Survey Committee of Canada (32) into the following categories - "order", "great group", and "subgroup". From Table 1 it may be noted that with the exception of profiles 3,4 and 17,18, the soils were classed as belonging to the Brunisolic order. These are well to imperfectly drained soils developed under forest, mixed forest and grass, grass and fern, or heath and tundra vegetation, with brownish-coloured sola and without marked eluvial horizons (N.S.S.C. p.51). In regard to this group, it is important to note that they are all soils without marked eluvial horizons, and therefore a major re-distribution of elements within the profile would not be expected.

Profiles 3,4 and 17,18 are classed in the Podzolic order, which are well and imperfectly drained soils developed under forest or heath, having under virgin conditions organic surface horizons (L-H), light coloured eluviated horizons (Ae) and illuvial (B) horizons with accumulations of organic matter, sesquioxides or clay, or any combinations of these (N.S.S.C., p.38). Due to the greater horizon differentiation in these soils, more marked re-distribution of micro-elements would be expected.

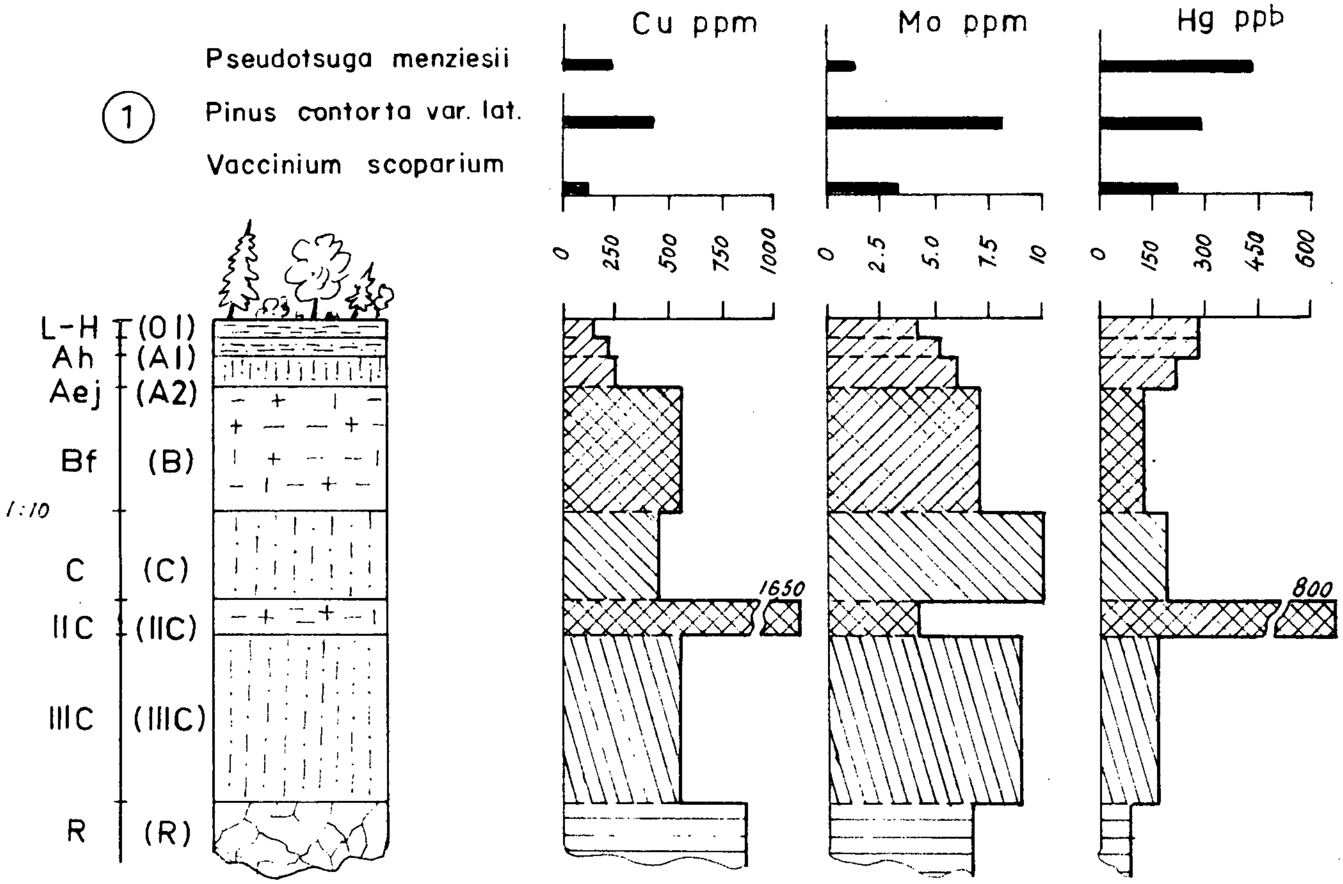
In the taxonomic system of soil classification, the next level is the "great group" which includes groups of soils having certain morphological features in common that reflect a similar pedogenic environment. The subgroup which is given for each soil in Table 1 defines the central concept of the "great group" and variations from this central concept. The number of subgroups in the above mentioned two orders in this survey, is nine; almost as many as the sample sites.

Diagrams identifying the major horizons present in each profile are given in Figures 3 - 14. The horizon nomenclature used is that accepted by the National Soil Survey Committee of Canada (1965) on the left, and the U.S.D.A. (1951) on the right. These figures also show the distribution, in the soil horizons and the plants, of elements considered to be most significant at each location. With reference to these figures, Tables A1 to A12 in the Appendix should be used concomitantly.

Each location is described individually in the sections that follow.

4.1.1 McBride Creek Prospect, Profiles 1,2

These profiles, located about 35 miles southeast of Princeton on a low grade porphyry copper-type mineralization, occur at an elevation of 5200 feet on a normal convex slope of 28-29° to the southeast. Both profiles are classed as Degraded Acid Brown Wooded soils, of sandy



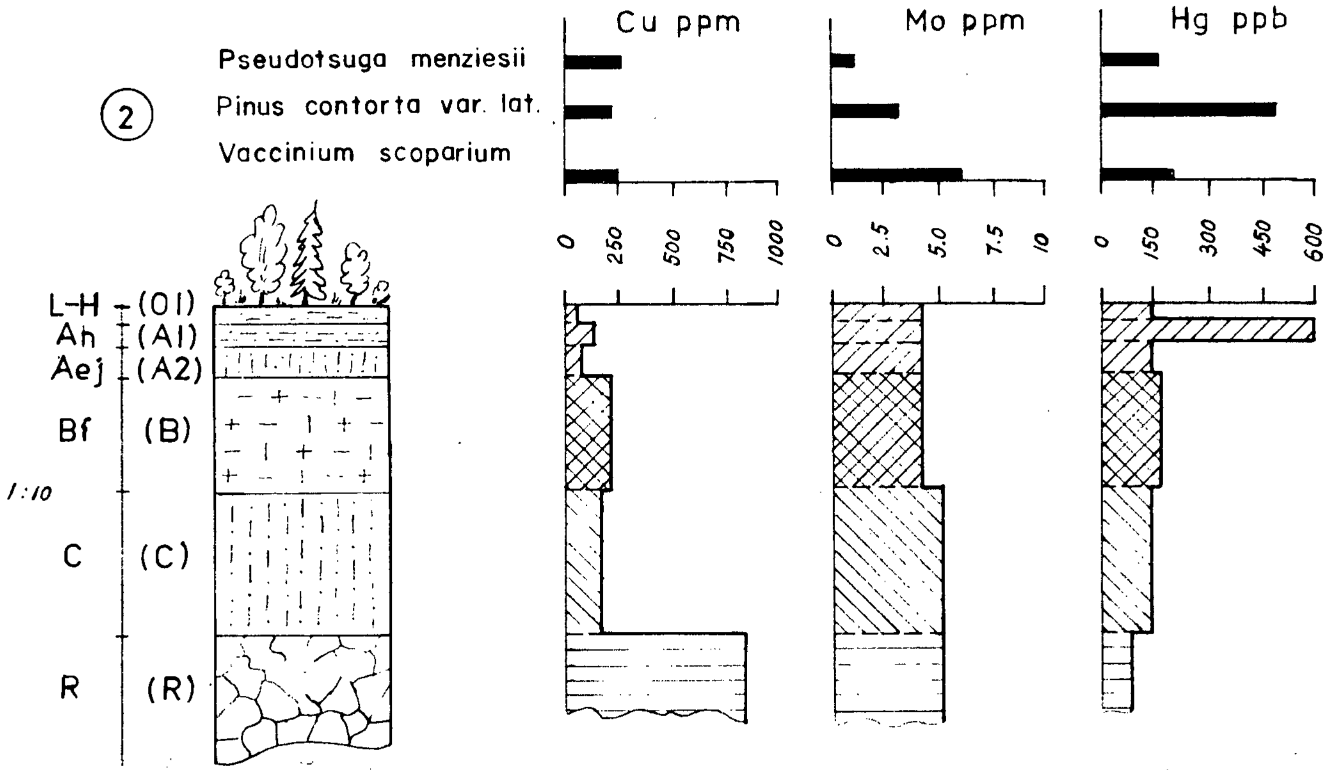


Fig.3 Selected Data for Mc Bride Creek Prospect Profiles 1,2

loam texture and friable to firm consistency, developed from colluvial material. There is some evidence of erosion and profile 1 is considered to have buried Bf and C horizons. It is also thought that the Aej horizon has been influenced by volcanic ash which is known to occur in the area.

The analytical data indicate a high correlation between Cu in the bedrock and the soil horizons, and the pathfinder elements Mo, As and Hg in the soil horizons also provide good evidence of the mineralization due to secondary dispersion.

The plant samples indicate the Pinus contorta has noticeably collected Cu, Zn, Pb, Ni and Co, while Pseudotsuga menziesii has 20 to 25 times the concentration of As, than do the other two species. Anomalous amounts of As and Mo are indicated by Vaccinium scoparium.

4.1.2 Craigmont Mines, Profiles 3,4

Craigmont Mine is a major operating copper mine in British Columbia, located about 7 miles northwest from Merritt in the Nicola volcanic rock formations of Upper Triassic age.

The sample sites are located at the edge of the orebody and are of possibly lower grade, but similar in nature and environment to the orebody.

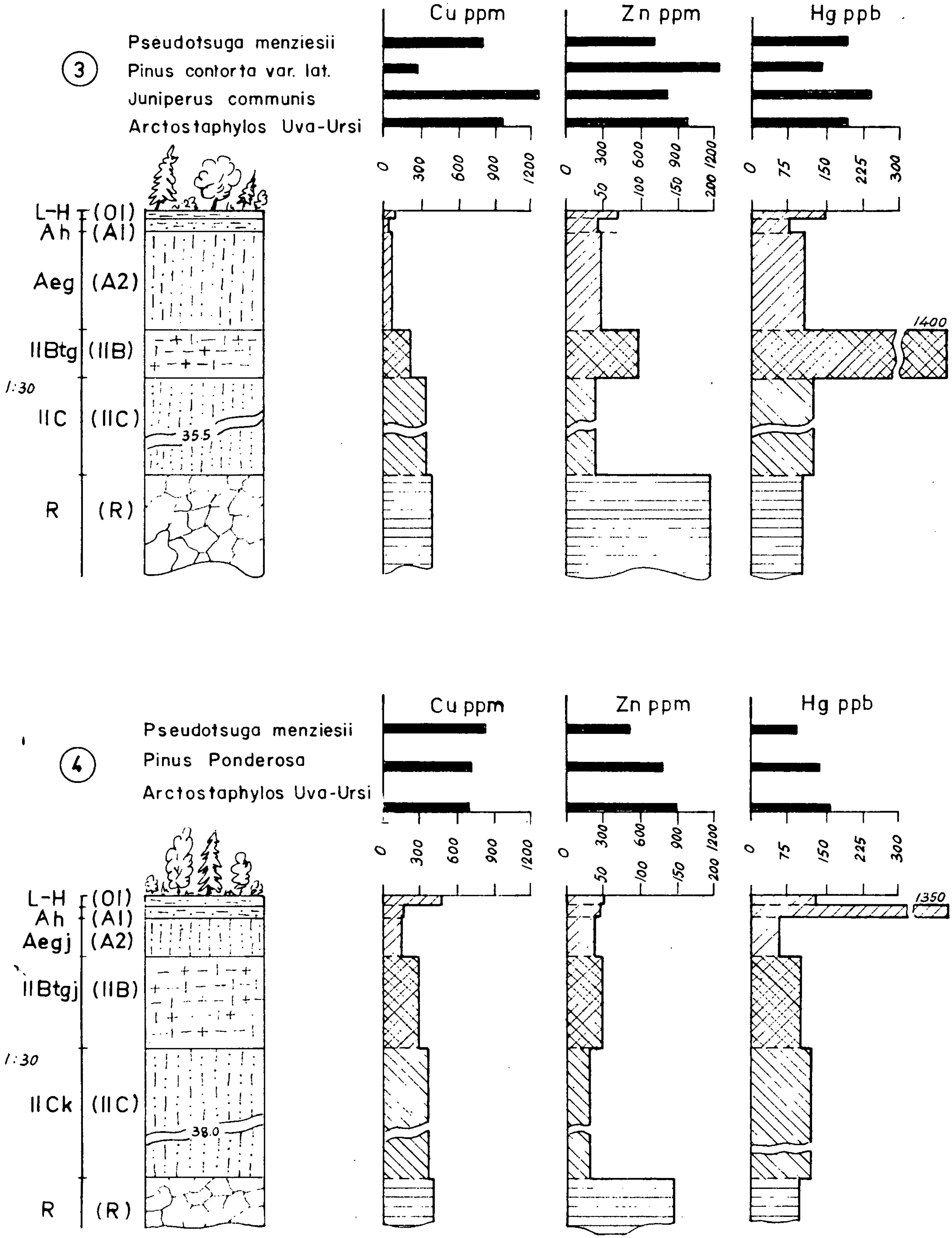


Fig.4 Selected Data for Craigmont Mines Profiles 3,4

The bedrock is covered by several feet of glacial drift and till but soil horizon differentiation is quite noticeable. The soil is classified as Gleyed Gray Wooded and has a firm, silty clay Btg horizon. The texture of the horizons varies from sandy loam in the surface to silty clay loam texture in the Btg, with 10 - 25% stones above one inch in diameter.

The analytical results are quite striking in these soils, and particularly so for profile 3. This soil has a strongly developed textural Btg horizon, which apparently has trapped the upward and downward movement of elements such as Zn and Hg. This effect is not as noticeable in profile 4, in which the Btg horizon is not as well developed. In this soil the highest amount of Hg is in the Ah horizon while in the former it is in the Btg. Some contamination by copper and other elements of the L-H horizons may have occurred as a result of the open pit operations of the nearby mine.

The analyses of the plants, whose roots penetrated the Btg horizons, show indications of mineralization.

Figure 4 suggests that mercury and possibly zinc are pathfinders for copper.

4.1.3 Copper Mountain Mines, Profiles 5,6

This is another major copper orebody in the vicinity of the Nicola volcanic group, situated about 15 miles southeast of Princeton. The majority of the known orebodies have been mined.

The sample site was chosen near the underground operated mine to avoid problems of contamination. It has a depressional relief with 7° slopes at an elevation of 4000 feet. The soils are developed from a mixture of colluvial and residual material, and were classified as Orthic Acid Brown Wooded. The profiles are of a sandy loam texture with friable consistency. The most common plants at the site are Lodgepole pine and Douglas fir.

Analytical data indicate a correlation between the orebody and soil horizons, as indicated by Figure 5. It is also noted in profile 5 that the L-H horizon shows abnormal amounts of copper, possibly due to contamination.

The indicative pathfinders, Zn and Hg, were chosen to demonstrate the vertical secondary dispersion of halo elements.

Plants again, gave a good clue to the presence of mineralization in the bedrock.

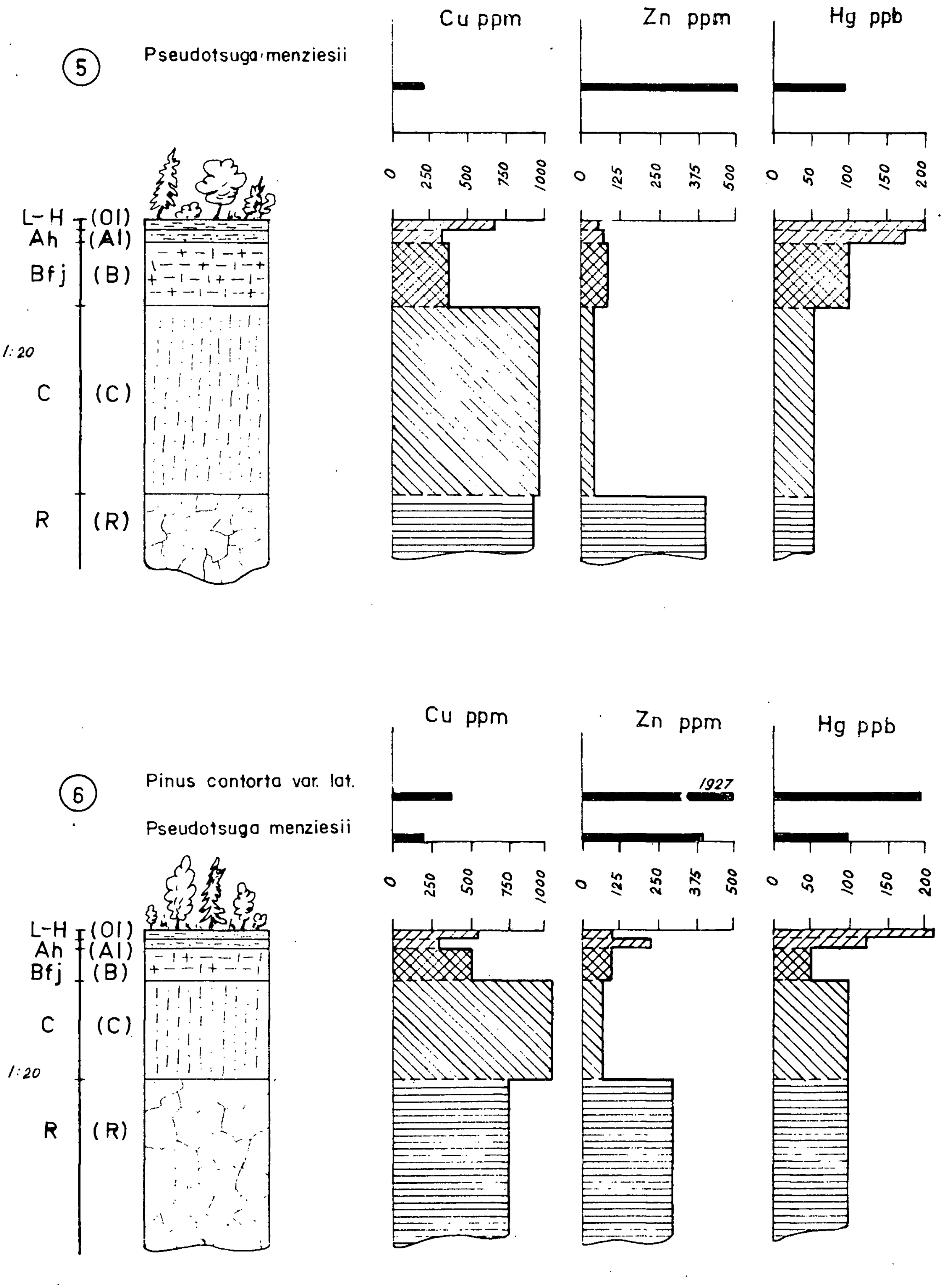


Fig.5 Selected Data for <u>Copper Mountain Mines</u> Profiles 5,6

4.1.4 Taylor Windfall Prospect, Profiles 7,8

Near an old gold mine on the southern side of Taseko River, there is a small copper prospect. It is located about 75 miles southwest of Williams Lake. The gold mine, which was a small producer of eluvial material, is on the southeast side of Battlement Creek Canyon. The bedrock formation is volcanic tuff. The copper mineralization occurs with granodiorite intrusions.

The Degraded Acid Brown Wooded soil is developed mostly on alluvial deposits of the Taseko River, and some colluvial material is mixed in at some places from the mountain sides.

The general relief consists of complex slopes with little erosion at the sample sites. Profile 7 has a 2.0 inch thick buried Ah horizon. The soil consists of well developed horizons of sand and silty sand with 2 - 3% stones above one inch in diameter, and a distinct B horizon.

Analytical data indicate a relationship between soil horizons and bedrock mineralization, especially with the B horizon. The data from L-H and Ah horizons are very erratic and they do not give clear anomalous results, particularly with copper. It is evident from Figure 6, that if the B or C horizons were not sampled for copper, the mineralization could be missed. Molybdenum, possibly due to its higher mobility, shows a more even distribution.

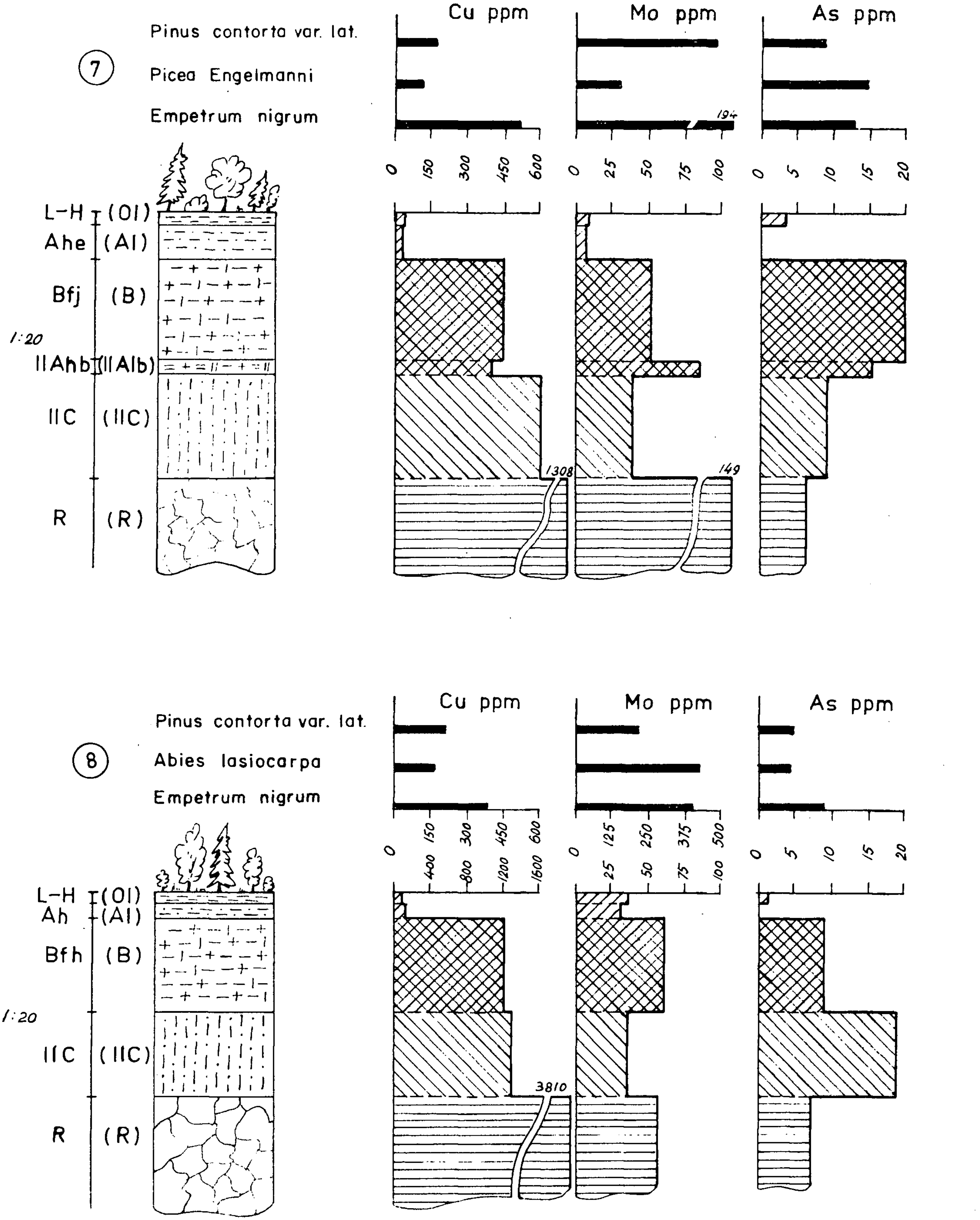


Fig.6 Selected Data for Taylor Windfall Prospect Profiles 7,8

The distribution of As in the profile shows it to be a good pathfinder for Cu, as well as Co and Ni, which can also be indicative but at a somewhat lower scale.

In plant sampling, all the noted elements show anomalous amounts indicating the presence of mineralization.

The complete analytical data for the site are given in Figure A-2.

4.1.5 Minex-Highland Valley, Profiles 9,10

Minex property is located on the southern side of Highland Valley, along the side of Gnawed Mountain, as shown on Figure 1. It is a low grade copper mineralized area with minor amounts of molybdenum and gold.

The bedrock is of the Bethsaida-type granodiorite with some introduced quartz veins, especially along fractures.

The economical mineralization consists mostly of chalcopyrite, bornite and pyrite. Molybdenum occurs as MoS_2.

The soil has developed from decomposition of bedrock, and some colluvial material covers the surface. The surface has been planed down by glacial movement from the higher elevations which left behind practically no glacial debris on the mountain slopes and tops.

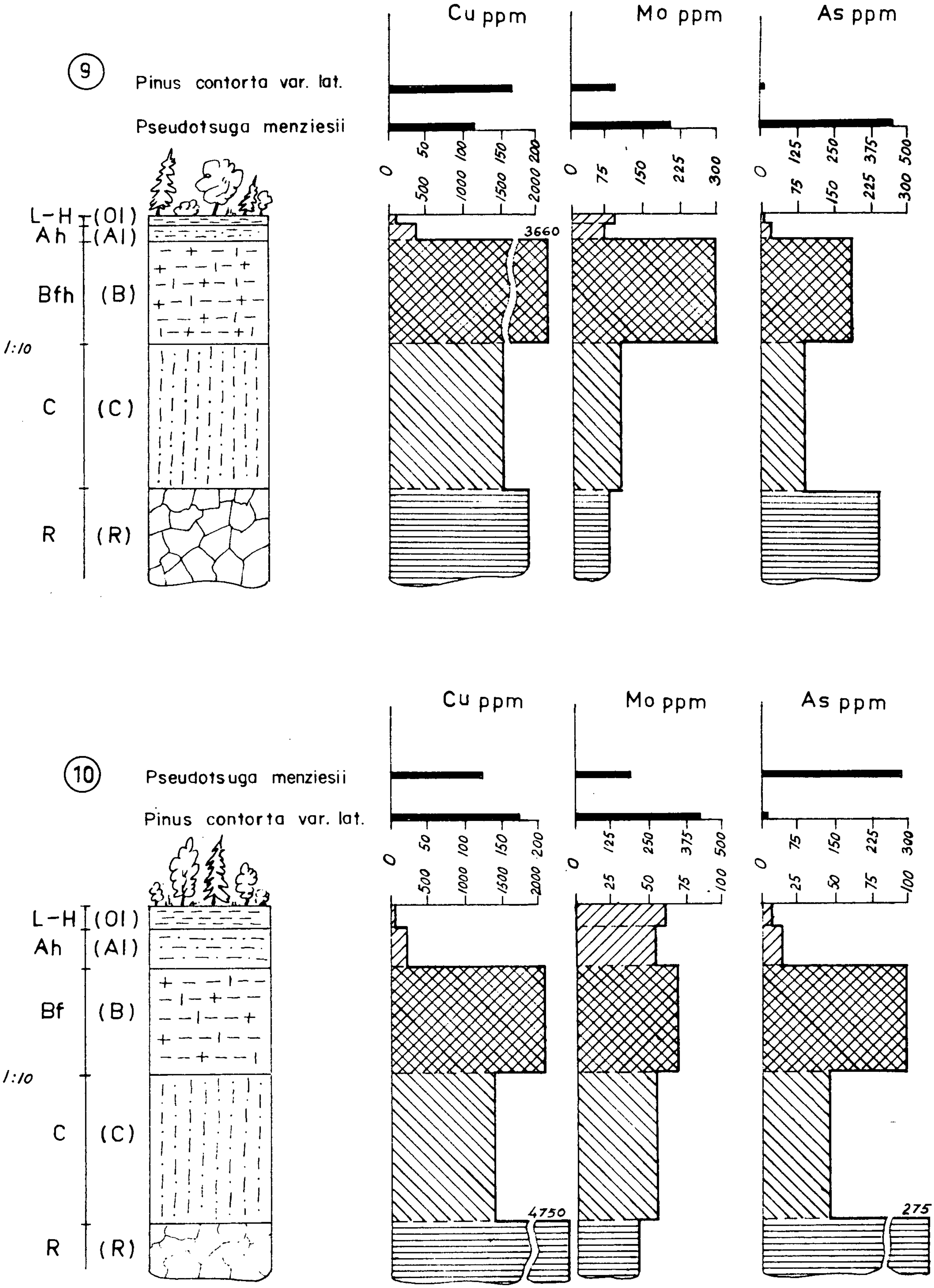


Fig.7 Selected Data for Minex-Highland Valley Profiles 9,10

The sampling area has an 8^{o} slope, a southwest aspect with slight erosion, medium drainage, and moderate permeability of the profile. The profiles have a sandy loam to loamy sand texture with a medium, granular to subangular blocky structure in the lower horizons with moderately soft consistency. The soil is classed as Orthic Acid Brown Wooded.

The analytical data for this site is particularly interesting and indicates that the B horizon is markedly enriched with elements as shown in Figure 7. From this figure it is evident that the B horizon has a higher content of micro-elements than any other horizon, including the C horizon. This distribution is thought to be associated with the residual nature of the soil.

Similar relationships can be noted with exchangeable heavy metals and exchangeable copper (Table A-V). It is believed that these effects are related to the well developed B horizon (10YR 5/4 dry) of this residual soil, where accumulations of the elements take place on a higher scale.

As pathfinder elements in vertical dispersion, Mo, As, Hg, and Zn may be significant.

Outstanding anomalous results can be observed by the sampled trees (Douglas fir and Lodgepole pine) for molybdenum, zinc and copper. Douglas fir is again much higher in arsenic than the other plant species studied.

4.1.6 Pacific Nickel Mines, Profiles 11,12

Pacific Nickel Mines are located about 7 miles northeast of Hope in the rugged mountain areas of ultrabasic intrusives.

The Orthic Concretionary Brown soil has developed in the thick colluvial deposits which originate from the steep mountain slopes.

The soil profiles indicate fairly good development, but the thickness of the profiles and horizons can vary a great deal because of lithological changes.

The sample site has an 11° slope with a normal convex relief. The soil contains about 5% stones over on inch in diameter and the gravelly sandy loam texture in the Bfh and C horizons exhibits a blocky structure with firm consistency. Root distribution is down to the C horizon.

The laboratory data show that in order to detect the mineralization, all soil sampling must be from B or C horizons, especially for copper. The metal values plotted in Figure 8 show a typical example of micro-elemental distribution in transported soils; as one can observe a decreasing metal value from bedrock upwards.

The observed pathfinders for Ni appear to be Co and Zn which generally follow the pattern of the major mineral elements, with characteristic higher mobility. In this case, the use of mercury as a pathfinder appears somewhat doubtful.

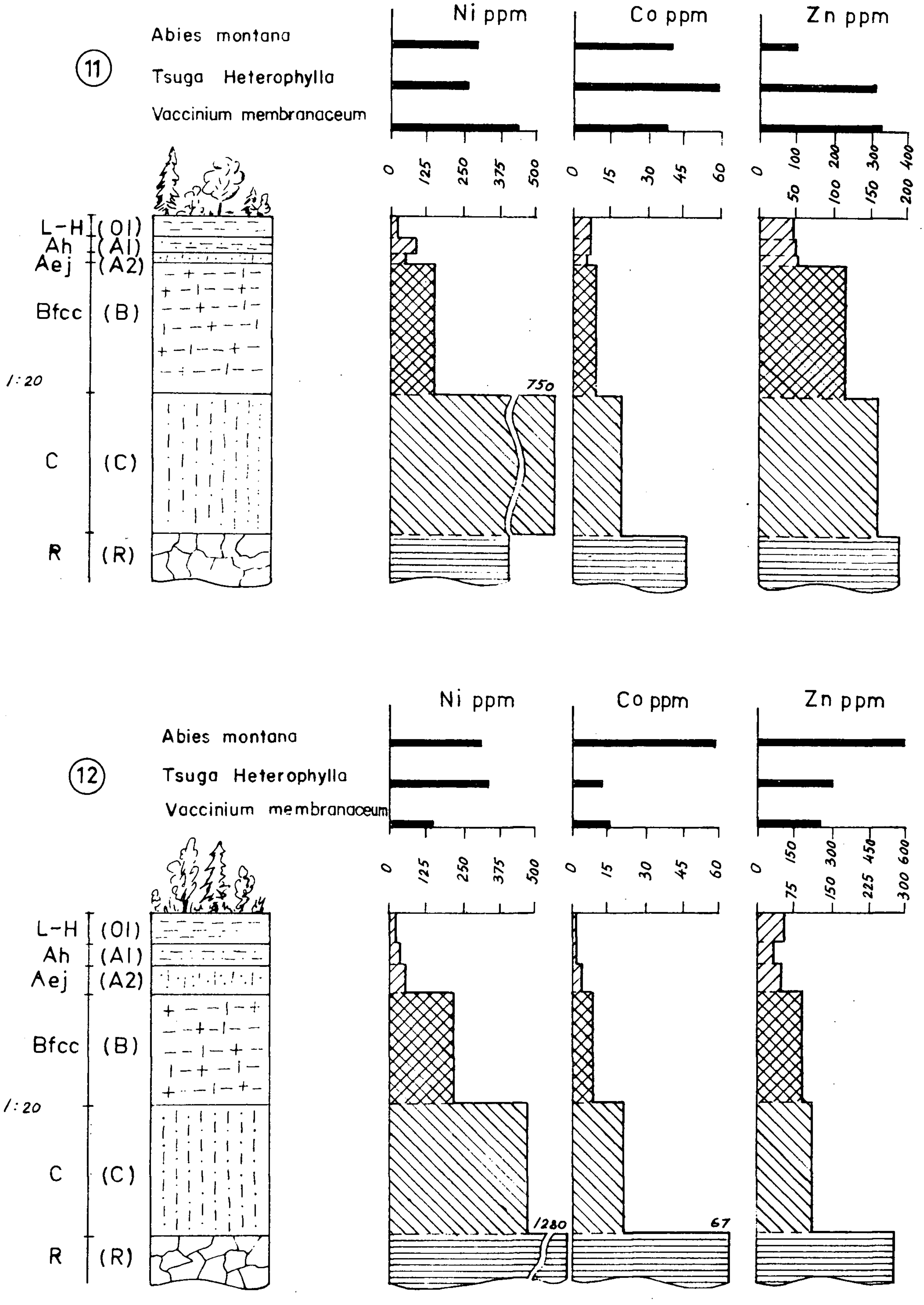


Fig.8 Selected Data for Pacific Nickel Mines Profiles 11,12

The plants gave very high variations in metal content by different species, but some of them indicated mineralization, such as Abies montana (which has the deep hart root system). The other species can also be useful to indicate the major elements, such as Cu, Ni and Co. This is well presented in Figure 8 and Table A-VI.

4.1.7 Skeena Silver Property-Highland Valley, Profiles 13,14

This site is located on the southwest side of Highland Valley opposite to Bethlehem Copper, as shown in Figure 1.

The surrounding bedrock is Guichon quartz diorite and the area, where the mineralization occurs, is known as Skeena Granodiorite, a phase of the Guichon quartz diorite.

The Degraded Brown Wooded soil is developed from thick glacial drift and till which cover the bedrock. The relief has a convex slope with a northwest aspect. Permeability and drainage are moderate. The texture varies from loamy sand to loamy coarse sand, with some layers of silty clay material (glacial origin). The plant coverage consists mostly of trees and some shrubs.

The laboratory data show Cu as the main element, which is high in each horizon, and is anomalous in B and C horizons. In profile 13 the high copper content of the L-H horizon is thought to be the result of contaminations caused by some drilling and trenching in the vicinity of the sampling area.

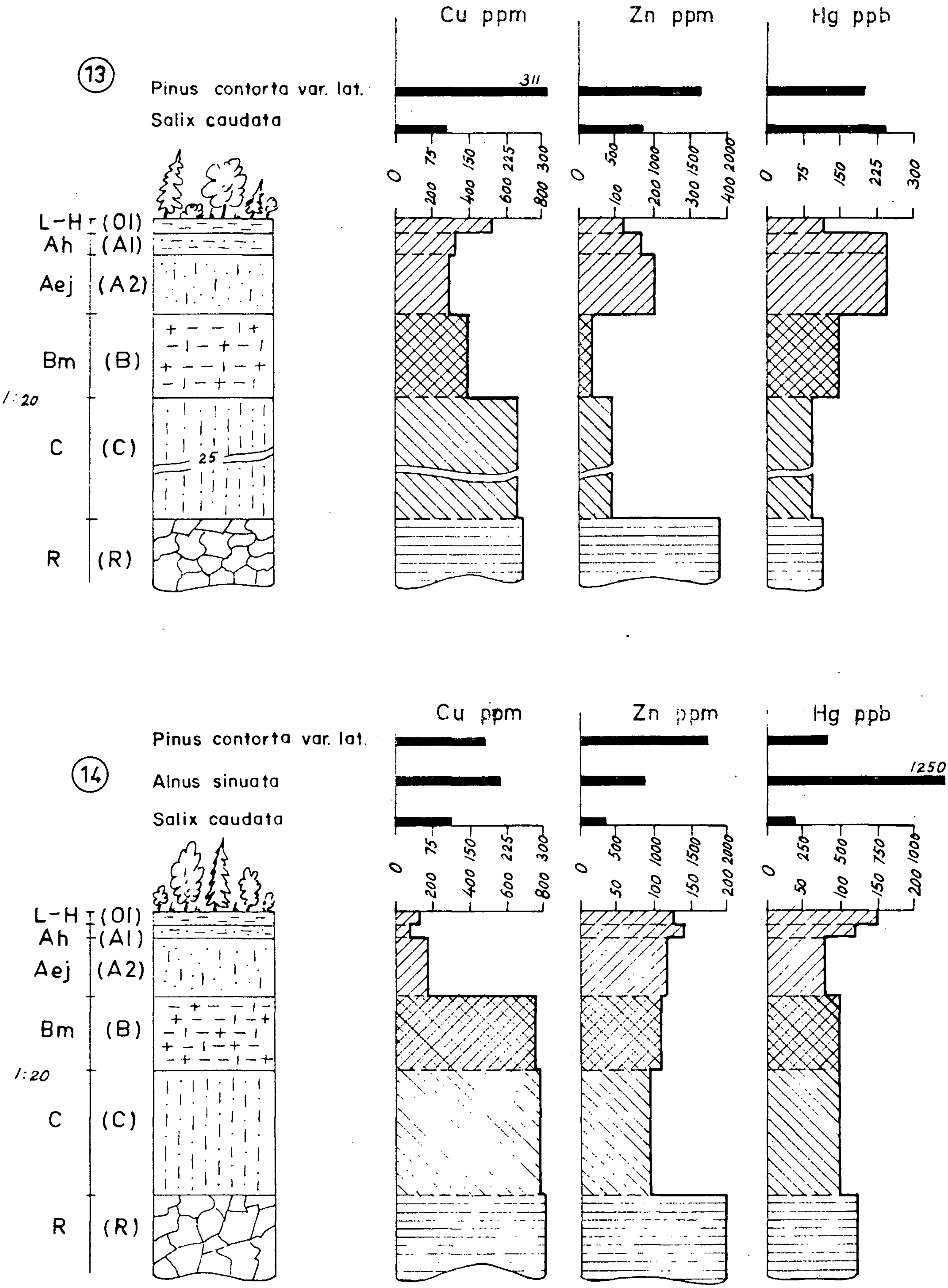


Fig.9 Selected Data for Skeena Silver Property - Highland Valley Profiles 13,14

The observed pathfinders, Zn and Hg, of the mineralized zones, again define very well vertical dispersion of a secondary nature of the halo elements.

Similarly, plants exhibit the projections of mineralization but the element content varies with the species. The plants also show the occurrences of molybdenum veins, which were not indicated by the soil sampling. Alnus sinuata (Sitka alder) yielded very high mercury values as compared to other species (see Table A-VIII), which indicate it may have a high affinity for mercury.

4.1.8 Galore Creek Prospect, Profiles 15,16

This site is located in the northwest part of British Columbia close to the Alaskan border, about 10 miles east of the Stikine River, as shown in Figure 1.

The bedrock consists of volcanic and sedimentary rocks of presumed Triassic age, with a complex of small syenite porphyry intrusions.

The soils are developed from one of the youngest glacial tills of the sampled areas. The soil is classified as Orthic Acid Brown Wooded. It must be pointed out that the soil cover of the area is not very uniform because of sudden topographical and lithological changes, and its closeness to the timberline.

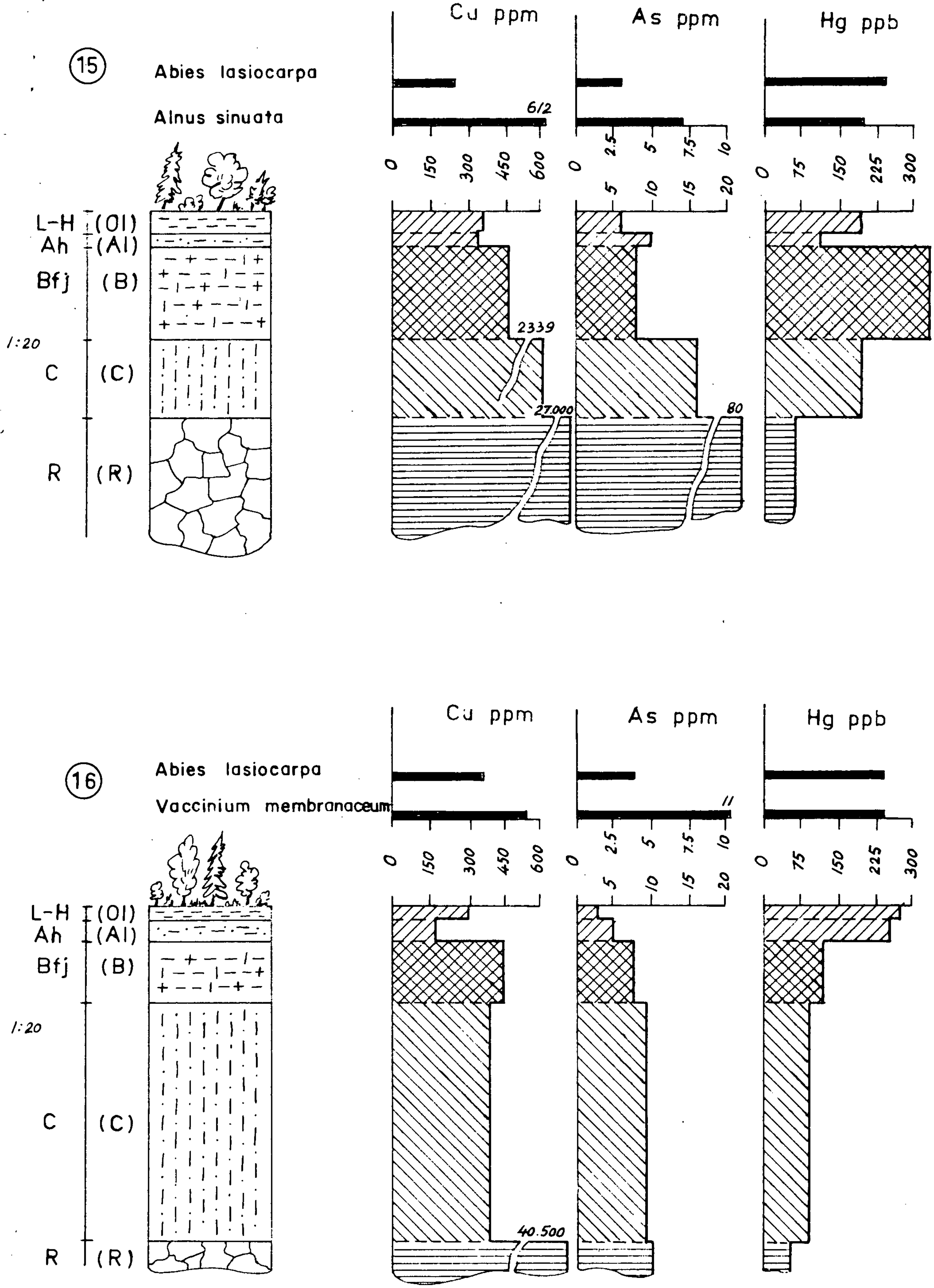


Fig.10 Selected Data for Galore Creek Prospect Profiles 15,16

The area has a complex relief with till foot slope physiography and an elevation of 2500 feet. The sampled area has 21^{o} slopes on the northeast aspect of Galore Creek.

Some frozen lenses were seen in June; however, the root distribution is satisfactory throughout the profile. The profiles have a loamy texture, although stony clay loam is indicated by the minus 80 mesh fractions in the B and C horizons, which originate from glacial deposition. Structure increased in strength with depth from granular to blocky in the C horizon.

In contrast to the youthfulness of the soil profile, the horizons indicated a very interesting distribution of micro-elements. Copper is the main element of the mineralized bedrock and this anomaly is shown by the results for each horizon, and a very sharp increase in Cu with depth. Exchangeable heavy metals also show some increase with depth, although not so distinctive, and also show the presence of the anomaly.

The distribution of pathfinders As and Hg are plotted on Figure 10. Zinc, and possibly cobalt and nickel, may also be given some consideration as pathfinder elements, as results indicate their presence. (See Table A-VIII).

All the plants gave indications of the major elements and pathfinders, but the individual species gave considerable variations;

i.e., Abies lasiocarpa (Mountain fir) had only one-third as much copper as was present in Alnus sinuata (Scrub alder).

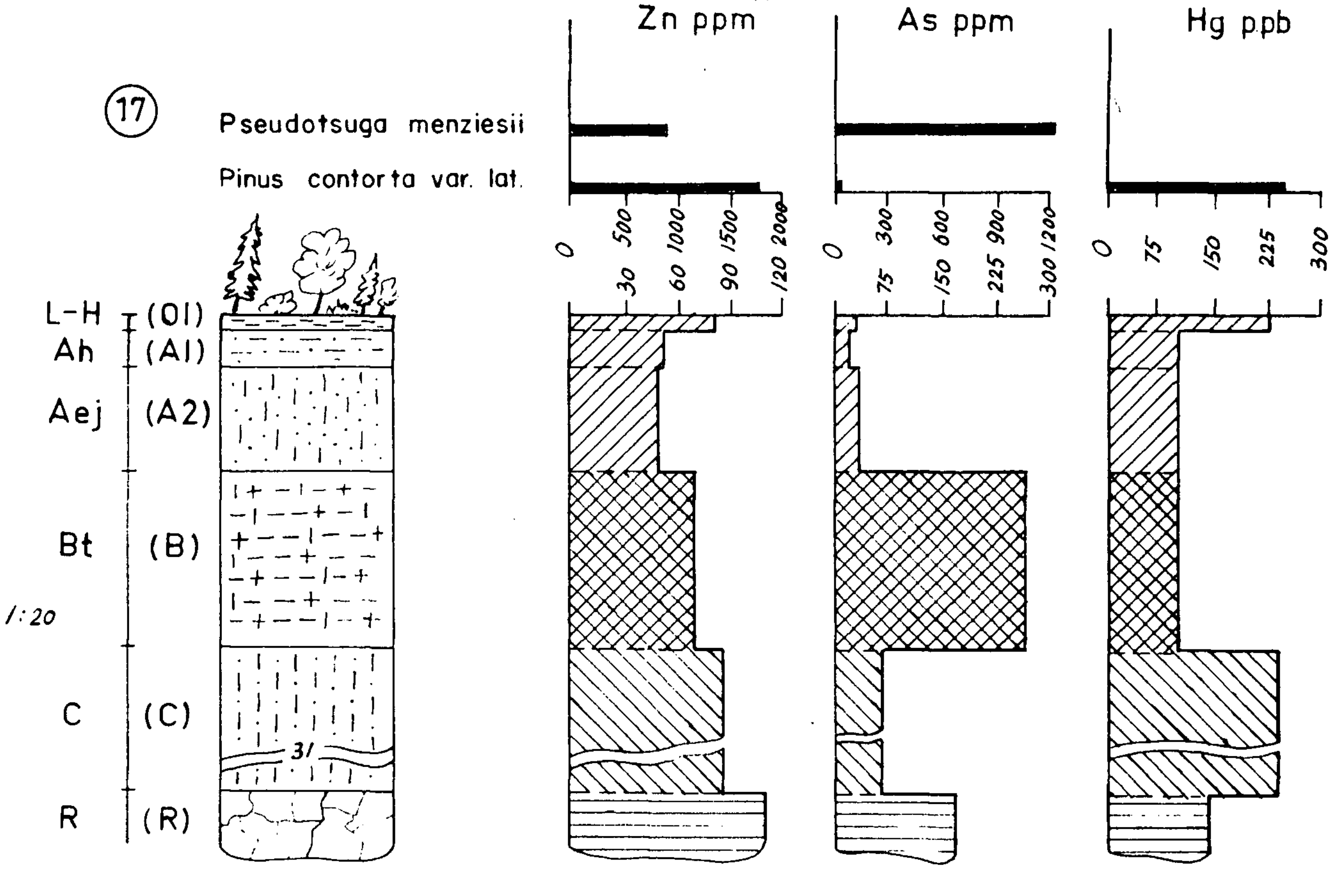
4.1.9 Pioneer Mine, Profiles 17,18

Pioneer gold mine is located in southern British Columbia, about 125 miles northwest of Vancouver, as indicated on Figure 1. The site location is near numerous veins of quartz with some gold mineralization. Besides being a sample site of gold mineralization, the area serves as one to study pathfinders giving secondary dispersion halos for other elements.

The bedrock consists of intrusive masses of augite diorite-soda granite. The gold-quartz fissure veins are related to and developed within the intrusive masses.

The Dark Gray Wooded soil is developed in glacial drift on the southwest slopes. The quartz veins are on a mountainside at an elevation of 4200 feet. Erosion is noticeable on slopes and in exposed gullies.

The soils contain 5 - 8% stony material over one inch in size. Soil texture is loamy and gravelly sandy loam with a medium granular to blocky structure. The consistency varies with depth from friable, through loose, to firm.



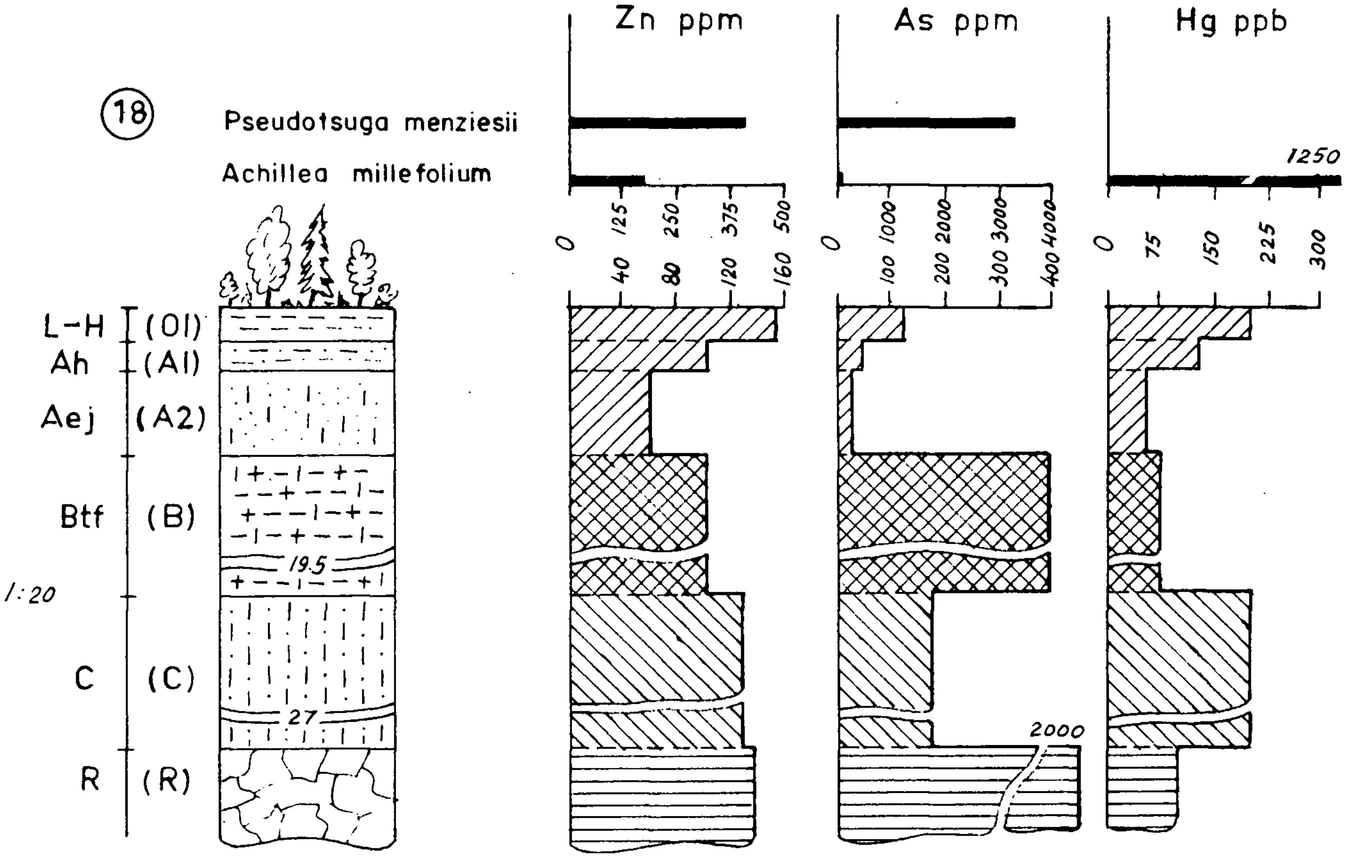


Fig.11 Selected Data for Pioneer Mines Profiles 17,18

The micro-elemental results shown in Figure 11 and Table A-9 are particularly useful to study possible pathfinders for gold in the vein-structured bedrock and the presence of primary and secondary halos. They indicated that some of the pathfinder elements can be very useful in prospecting for gold deposits, even in transported soils. The soil horizons show that dispersion of halo elements of the bedrock is more widely dispersed in the secondary halo than in the primary halo as indicated by the Cu, Zn, As and Hg in Table A-9. Although Hg is only moderately promising, it may also be considered as a halo element.

Plants were also useful indicators at this site. The high concentration of arsenic in Pseudotsuga menziesii (Douglas fir), which collects about 100 times more arsenic than the other sampled plants, is very noticeable.

4.1.10 Bralorne Mine, Profiles 19,20

Bralorne Mine is at present the producing part of Pioneer-Bralorne Gold Mines. It is about 120 miles from Vancouver, as indicated on Figure 1. The sample sites are in the vicinity of Ida-May veins.

The bedrock is similar to that at the Pioneer Mine, intrusive masses of augite-diorite-soda granite, containing gold-quartz fissure veins. The veins vary in width from a few inches up to 10 feet.

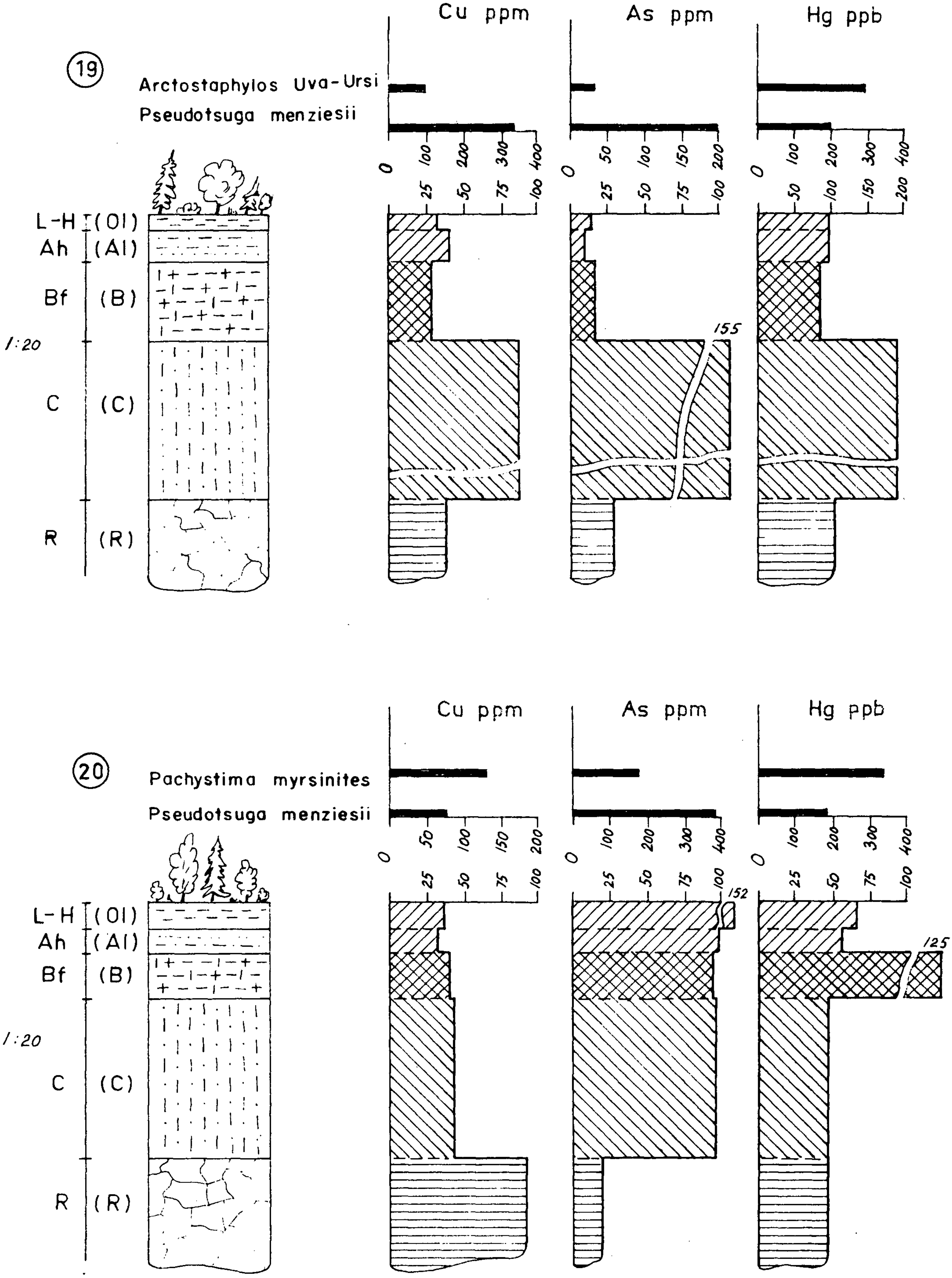


Fig.12 Selected Data for Bralorne Mines Profiles 19,20

The Orthic Brown Forest soil was developed from glacial drift at the sites. Well developed Ah (A_1) and Bf horizons are noticeable on the northeast single mountain slope relief, at an elevation of 4100 feet.

Root distribution is down to bedrock. The texture of the horizons varies from sandy loam to gravelly sand, with estimated 6 - 8% pebbles, above one inch in size. The most massive looking horizon is the B, which exhibits the hardest consistency.

Plant coverage is satisfactory for sampling over this logged area where second growth timber with some shrubs are found.

The analytical data indicated, as they did at sites 17 and 18, that pathfinder elements occur which indicate the mineralized zones in soil and plant samples. Those plotted in Figure 12 are Cu, As, and Hg. The variation of lead content in the horizons indicated that it must have originated from glacial till rather than from the bedrock. The results indicate that As is the most promising pathfinder in the area, but the use of the others would assist in confirming the presence of a mineralization.

At this location of gold mineralization, plants are very indicative of the soil's element content. With regard to arsenic values, it can be noted that not only Pseudotsuga menziesii (Douglas fir), but Pachystima myrsinites (False Box) show high affinity for arsenic.

4.1.11 Endako Mine, Profiles 21,22

Endako mine is the largest producing molybdenum mine in British Columbia. It is located about 115 miles northeast of Prince George, as shown on Figure 1.

The bedrock of the mineralized zone consists of Topley Granite of early Jurassic age. Pre-ore aplites and quartz feldspar porphyry dykes, as well as post-ore lamprophyre dykes are found in the vicinity.

The Degraded Brown Forest soil is developed from glacial drift. The sample site was on a mountain side with a single mountain slope relief bearing southwest 8° at an elevation of 3000 feet. Profile 21 had a very thin layer of gray-brown (10YR 5/2 dry) Aej horizon, but it was not measureable at profile 22. The texture of the soil is sandy loam with a mixture of gravels. Lithologic discontinuations were noted in both profiles. The structures in the B and II-C horizons are prismatic with firm consistency. Material above one inch in size amounted to 7 - 9%.

The elemental analytical data clearly indicated molybdenum as the most important element of mineralization well above the background level in each horizon.

Populus tremuloides (Trembling aspen) was sampled. It gave an excellent indication of the molybdenum mineralization, and it also showed a high affinity for zinc, mercury and lead, as well as molybdenum.

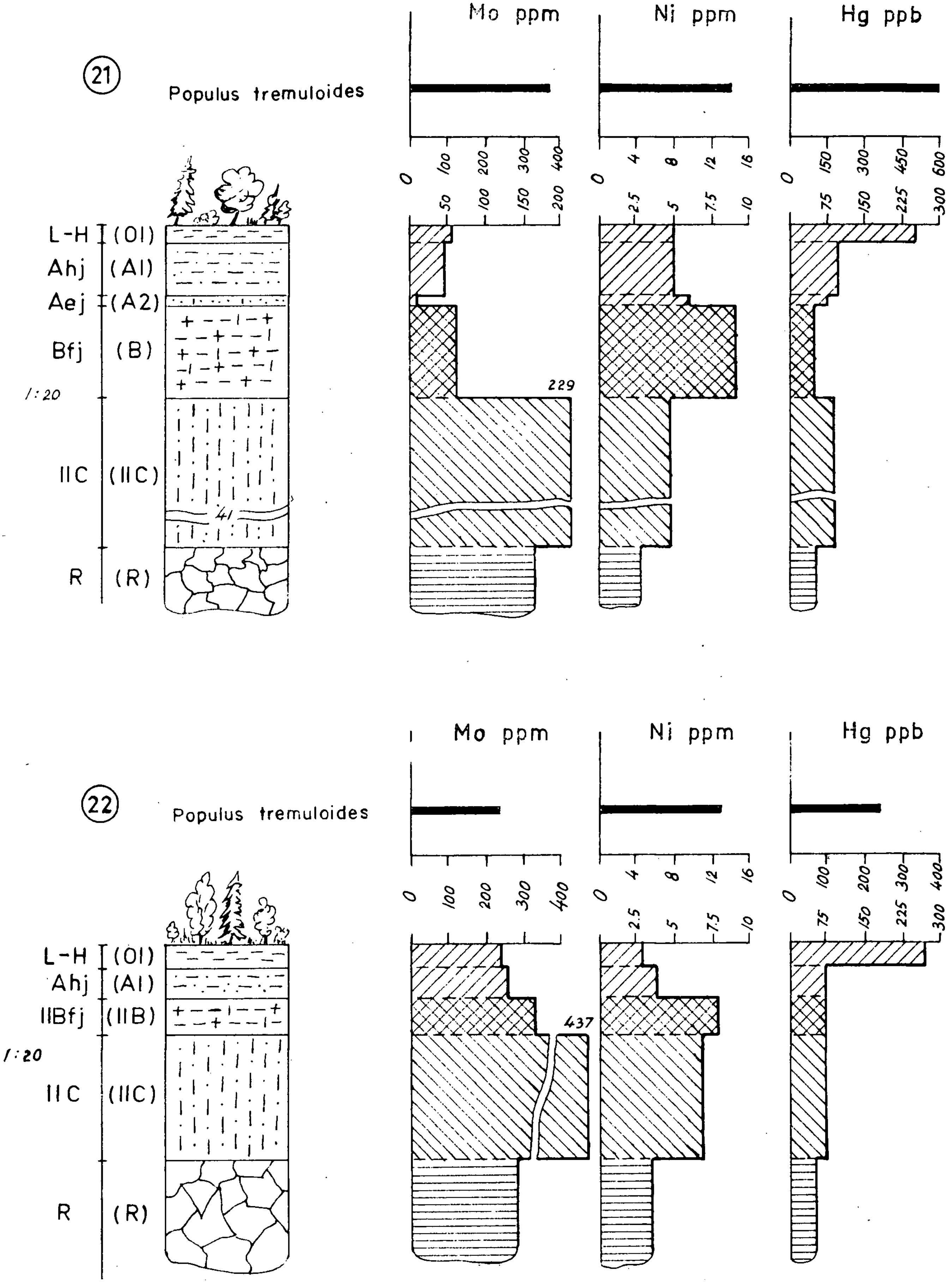


Fig.13 Selected Data for Endako Mines Profiles 21,22

4.1.12 Carmi Prospect, Profiles 23,24

This molybdenum prospect is located in the southeast part of British Columbia, about 30 miles north of the U. S. Border and about 5 miles northwest from Carmi, as indicated on Figure 1.

The bedrock of this site is breccia of granodiorite gneiss cemented by quartz and by minor pegmatitic material.

The Orthic Acid Brown Wooded soil was developed from glacial till and varies greatly in thickness with topography. The sample site was on a mountain slope physiography with 14° northeast slope at an elevation of 4100 feet. The profiles had 5 - 10% particles coarser than one inch in size. At profile 23, the bedrock was not reached by digging, so that samples were not obtained for R (bedrock).

The analytical data for both soils and plants for profile 24 clearly indicated the presence of mineralization. However, the results of profile 23 were inconclusive because bedrock was not found, as this site is probably located in a blind gully which has been filled by glacial material. It is evident in this profile that secondary dispersion of the molybdenum and also the halo elements such as zinc, nickel, and mercury, etc. have not been noticeably affected vertically from the bedrock.

The sampled plants are all indicative of the presence of molybdenum mineralization. Similarly, the halo elements are indicative of an anomaly, even though they vary a great deal in the different species.

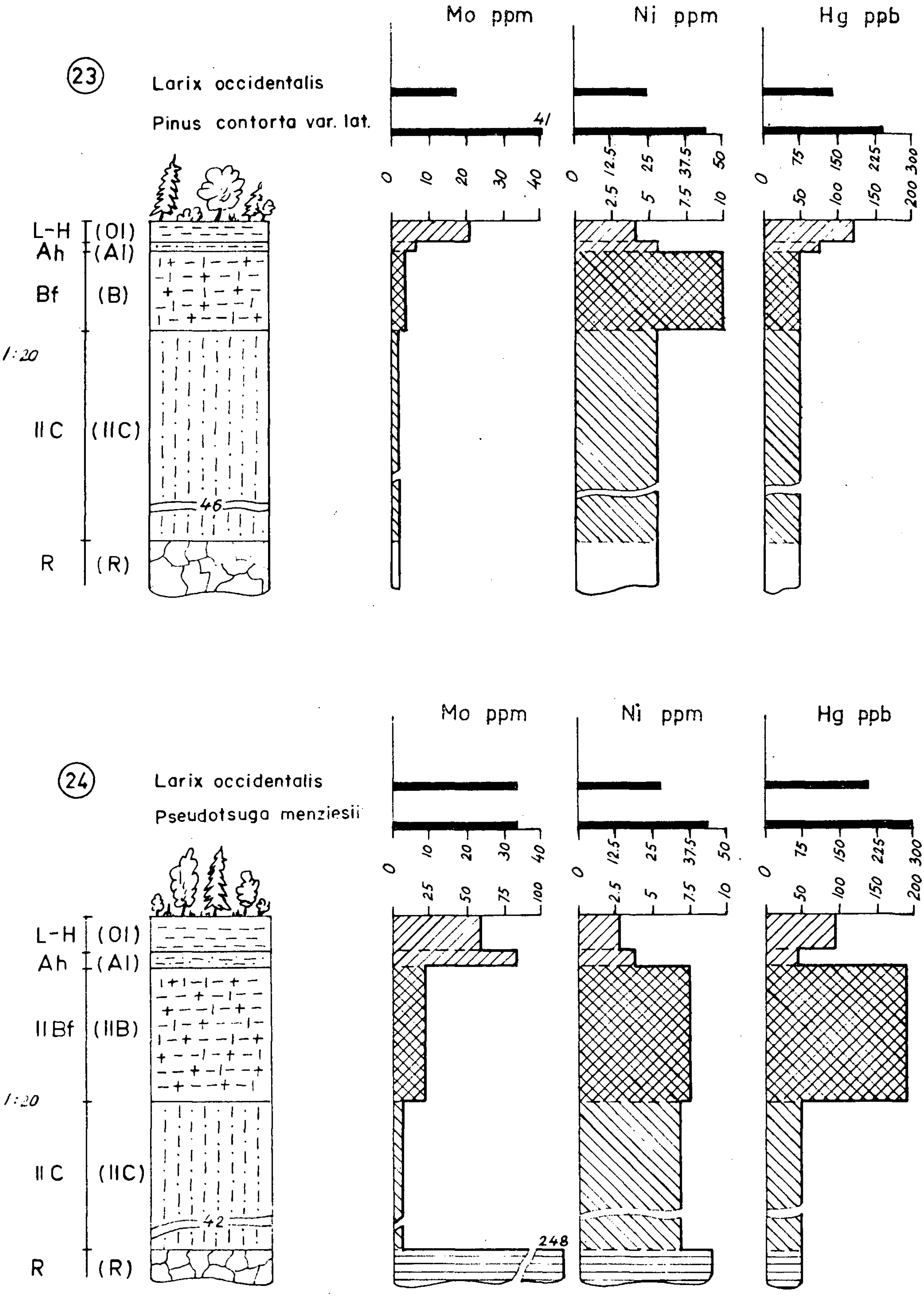


Fig.14 Selected Data for Carmi Prospect Profiles 23,24

In the previous section, the analytical results were discussed briefly for each location, and they will now be considered collectively for all locations. To facilitate comparison and establish relationships, Figures 15 to 23 were prepared showing the amount of each element present in the bedrock and the major soil horizons at all locations. The results of the soil and micro-elemental analyses were also treated statistically with the aid of computer programming and the results are shown in Tables 2 to 5.

In Figures 15 to 23, the sample locations are arranged on the horizontal axis in order of the increasing amount of the element found in the bedrock and the amount of each element found in the major soil horizons is shown on the vertical axis. In these figures, each point represents the average elemental content of the two sites sampled at each location.

Figures 15 to 23 also suggested background values of each element for bedrock and soils. These values were estimated using background values given in literature (14,15), the results obtained in this study and the author's experience gained in other studies. Values obtained above background for each element indicate mineralization, and in general the higher the values are above background, the more positive is the evidence that mineralization is present at a location.

Background values for vegetation are not suggested, as it was felt that the information available was not sufficient for this purpose. However, it is thought that the background values for vegetation would be somewhat lower than those indicated elsewhere (25,46), as the results in the present study were obtained following ashing at 450°C for three hours, and not directly comparable to other published results. The amount of elements in vegetation is generally reported in ash and the weight of ash depends on the temperature and time of ignition.

In Figures 15 to 23, the correlation coefficients for the amount of each element found in the bedrock and in each major horizon at all sites, is also given.

In the statistical treatment, individual profile values rather than the averages of the two profiles at the same location, were used. This was done after comparisons had been made using both individual and average results in which it was found that using averages increased the correlations noted between the elemental content of the bedrock and major soil horizons, but at the same time reduced the degrees of freedom. Therefore, it was assumed each profile represents a random sample, because the profiles were selected in a random manner at known mineralized areas.

The statistical treatments were of the following types:

1. Simple correlations of the elemental content of the bedrock with that of the major soil horizons. For this study, four major horizons were used - - L-H(O-1), Ah(A-1), B and C, and the plants were considered as a fifth "bio-horizon" without separation as to species.

First, no significant correlation was found between the elemental content of the bedrock and some major horizons. (See Table 2 and A-13). After that, the data were subjected to partial correlations, and repeated several times, for the mineralized and unmineralized sites, for the individual elements. The results, however, were still insignificant and therefore it was decided to use the logarithm of the elemental values. In this case, using copper first significant correlations were obtained. After that, logarithmic values were used for the other elements as well. Levels of significance of correlation values were obtained. From this, it was assumed the distribution of trace elements are not just log normal (12,30), but the relationship exists between bedrock, soils and plants, which are also logarithmic rather than linear.

The results of the simple correlations are shown in Table 2. It should be noted that these were obtained using single logarithmic values of the elements. These correlations coefficients are also shown in Figures 15 to 23.

TABLE 2: Elemental Correlations of Soil Horizons and Plants to Bedrock (Logarithmic Values used, df = 22).

Horizon	L-H	Ah	B	C	Plants
Element	Corr. Coeff.(r)	Corr. Coeff.(r)	Corr. Coeff. (r)	Corr. Coeff.(r)	Corr. Coeff (r)
Cu	0.56**	0.63**	0.78**	0.81**	0.38
Mo	0.85**	0.85**	0.76**	0.87**	0.66**
Zn	0.06	0.09	-0.10	0.20	0.22
Pb	0.46*	0.59**	0.58**	0.45*	0.12
As	0.84**	0.89**	0.86**	0.89**	0.87**
Co	0.46*	0.43*	0.80**	0.83**	0.40
Ni	0.44*	0.66**	0.88**	0.90**	0.83**
Fe	-0.11	< 0.01	-0.16	0.11	0.20
Hg	0.05	0.25	0.01	0.57**	0.39

* Significant Correlation > 0.40 ($p \leq 0.05$)

** Highly Significant Correlation ≥ 0.52 ($p \leq 0.01$)

2. Simple correlations were also determined between individual elements and between the elements and the soil analytical data. These are presented in Tables 3 and 4. This study provided useful information on pathfinders in general, and showed that Cu-Zn, Cu-Pb, Cu-Co, Mo-Zn, Pb-Zn, Co-Zn, Pb-Fe(negative), Co-Ni and Ni-Fe are correlated and therefore could be used as pathfinders.

3. Multiple correlation was made of C.E.C., O.M.% and -80 mesh %, with each element separately and with each horizon. The results are given in Table 5. Generally, it can be concluded that the most important controlling factor is -80 mesh % and the elemental content of the soil samples.

TABLE 3: Inter-Elemental Simple Correlations over all Soil Horizons, Bedrocks, and Soil Data (df = 130)

Correlation	Between	Corr. Coeff. (r)
pH	MESH	0.72**
pH	H.M.	0.34**
pH	Cu	-0.28**
pH	Zn	-0.35**
pH	As	-0.23**
pH	Co	-0.29**
-80 MESH%	C.E.C.	0.28**
-80 MESH%	O.M.	0.18*
-80 MESH%	Cu	-0.24**
-80 MESH%	Zn	-0.33**
-80 MESH%	As	-0.20*
-80 MESH%	Co	-0.22*
-80 MESH%	Fe	-0.23*
C.E.C.	O.M.	0.83**
C.E.C.	Zn	-0.22*
C.E.C.	Pb	0.24**
C.E.C.	Fe	-0.36**
O.M.	Pb	0.28**
O.M.	Co	-0.19*
O.M.	Fe	-0.45**
Ex.Cu	H.M.	0.93**
Cu	Zn	0.32**
Cu	Pb	0.49**
Cu	Co	0.50**
Mo	Zn	0.25**
Zn	Pb	0.30**
Zn	Co	0.25**
Pb	Fe	-0.25**
Co	Ni	0.52**
Ni	Fe	0.62**

* Significant ($p \leq 0.05$)

** Highly significant ($p \leq 0.01$)

TABLE 4: Simple Correlations in Individual Horizons and Plants

Correlations	Between	Corr. Coeff.(r)
		L-H (Ol) Horizon
pH	C.E.C.	-0.69**
pH	O.M.	-0.78**
pH	Zn	0.46*
pH	Pb	-0.43*
C.E.C.	O.M.	0.60**
C.E.C.	H.M.	-0.46*
C.E.C.	Zn	-0.44*
Ex.Cu	H.M.	0.87**
Ex.Cu	Cu	0.75**
H.M.	Cu	0.49*
Mo	Zn	0.68**
As	Ni	0.42*
		$Ah(A_1)$ Horizon¾
pH	O.M.	-0.53**
-80 MESH%	H.M.	0.43*
-80 MESH%	Co	0.43*
H.M.	Ex.Cu	0.80**
H.M.	Cu	0.60**
H.M.	Pb	0.61**
H.M.	Co	0.48*
Mo	Zn	0.79**
Co	Ni	0.67**
		$Ae(A_2)$ Horizon
pH	-80 MESH%	0.67*
pH	C.E.C.	-0.63*
pH	O.M.	-0.74**
-80 MESH%	O.M.	-0.58*
-80 MESH%	As	0.83**
C.E.C.	Ni	0.71*
H.M.	Ex.Cu	0.97**
H.M.	Cu	0.63*
Zn	Pb	0.65*
		Ae Horizon
Zn	Hg	0.79**
Fe	Pb	-0.74**

TABLE 4 - cont'd

Correlations	Between	Corr. Coeff.(r)
		In "B" Horizon
O.M.	C.E.C.	0.64**
C.E.C.	Ni	0.44*
C.E.C.	Fe	0.53**
O.M.	Ex.Cu	0.48*
O.M.	Mo	0.48*
H.M.	Ex.Cu	0.97**
Cu	H.M.	0.82**
Ex.Cu	Cu	0.75**
Mo	Cu	0.53**
Mo	Zn	0.40*
Zn	Pb	0.57**
Co	Ni	0.42*
Ni	Fe	0.52**
		In "C" Horizon
pH	Ni	-0.59*
pH	Fe	-0.51*
C.E.C.	O.M.	0.49*
C.E.C.	Fe	0.53*
O.M.	Mo	0.74**
H.M.	Ex.Cu	0.97**
H.M.	Cu	0.64**
Ex.Cu	Cu	0.68**
Ex.Cu	Co	-0.53*
Ex.Cu	Fe	-0.50*
Cu	Mo	0.50*
Cu	Zn	0.68**
Cu	Pb	0.58*
Mo	Co	-0.50*
Zn	Pb	0.88**
As	Hg	0.50*
Co	Ni	0.53*
Co	Fe	0.62**
Ni	Fe	0.87**
		In II-C Horizons
pH	Fe	0.65*
-80 MESH%	Mo	-0.74*
H.M.	Ex.Cu	0.87**
H.M.	Hg	0.66*
Ex.Cu	Zn	0.65*
Cu	As	0.98**
Cu	Mo	0.79**
Mo	Zn	0.75*
As	Hg	0.75*

TABLE 4 - cont'd

Correlations	Between	Corr. Coeff.(r)
		In "R" Bedrock
Cu	Pb	0.76**
Cu	Co	0.54**
Hg	Mo	0.46*
Co	Ni	0.61**
Co	Fe	0.52**
Ni	Fe	0.76**
		In Plants
Pb	As	0.47**
Co	Ni	0.78**

TABLE 5: The Highest Significant Independent Variable for the Multiple Correlations of Mesh Size C.E.C. and O.M. with the Elements and Horizons

	Horizons						
Elements	L-H	Ah	Ae	B	C	II-C	All Horizons
H.M.	C.E.C.	MESH	MESH	MESH	MESH	MESH	MESH
X Cu	C.E.C.	MESH	MESH	MESH	MESH	O.M.	O.M.
Cu	MESH	MESH	MESH	O.M.	C.E.C.	O.M.	MESH
Mo	MESH	MESH	C.E.C.	O.M.	O.M.	MESH	MESH
Zn	C.E.C.	C.E.C.	C.E.C.	MESH	C.E.C.	O.M.	MESH
Pb	O.M.	MESH	O.M.	C.E.C.	O.M.	MESH	O.M.
As	O.M.	O.M.	MESH	MESH	O.M.	O.M.	MESH
Co	MESH	MESH	O.M.	O.M.	O.M.	O.M.	MESH
Ni	O.M.	C.E.C.	C.E.C.	C.E.C.	MESH	MESH	MESH
Fe	C.E.C.	O.M.	C.E.C.	C.E.C.	C.E.C.	O.M.	O.M.
Hg	MESH	MESH	MESH	O.M.	C.E.C.	O.M.	MESH

C.E.C. : Cation Exchange Capacity
MESH : Minus 80 Mesh %
O.M. : Organic Material %
X Cu : Exchangeable Copper

4.2 Discussion by Elements

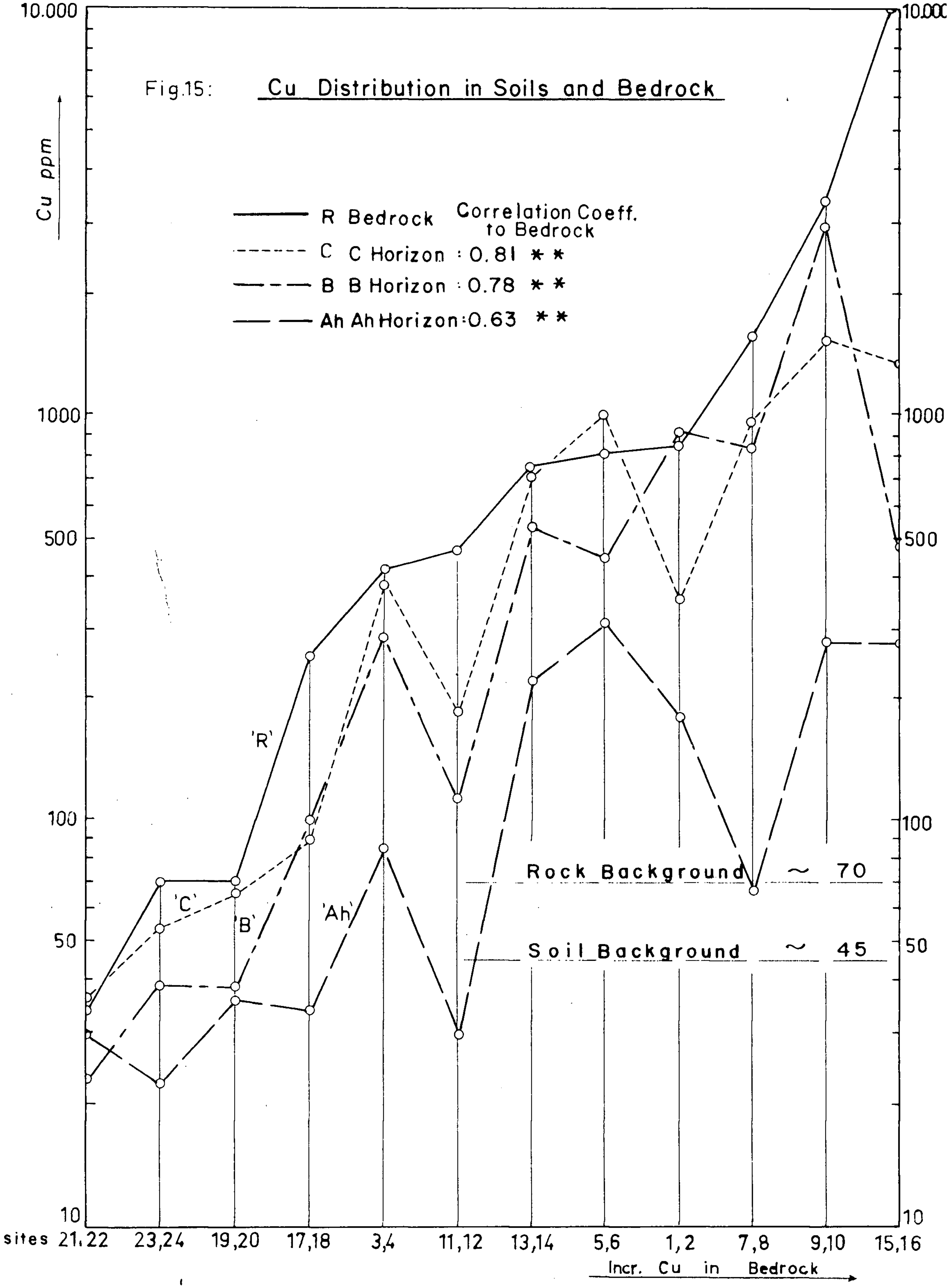
Copper: The distribution of copper in the bedrock and the major soil horizons is shown in Figure 15. It may be noted from this figure that the background values suggested are 40 ppm for soil and 60 ppm for bedrock. These values may be affected by the fact that the non-economic mineralized areas sampled were somewhat higher in copper than would be typical of completely unmineralized areas.

Figure 15 and the correlation values show that the content of copper in all the horizons is highly correlated with that in the bedrock and the correlations are highest for the B and C horizons.

Copper in almost every case is lower in the soil horizons than in the bedrock, the exception being sites 5, 6 and 9, 10, in which modified residual material exists, and where copper accumulation is very high in the B horizon.

Molybdenum: The background values for molybdenum, 1.0 ppm for soil and 1.5 ppm for rock, are suggested. Molybdenum is a highly mobile element in the upward migration in the soils and plants. Figure 16 indicates high correlation between bedrock content with that in each horizon and plant.

Fig.15: Cu Distribution in Soils and Bedrock



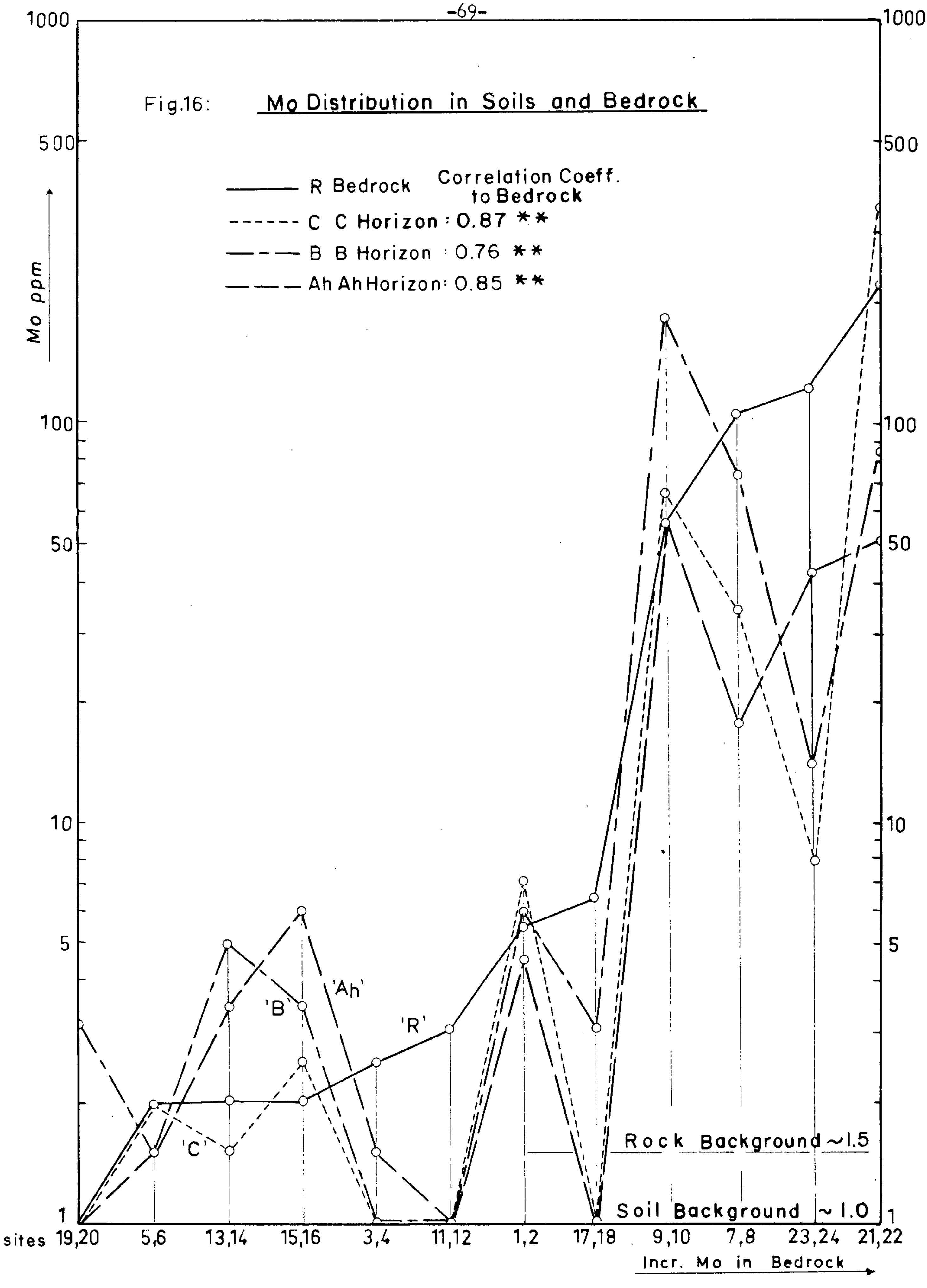


Fig.16: Mo Distribution in Soils and Bedrock
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon : 0.87 **
B B Horizon : 0.76 **
Ah Ah Horizon : 0.85 **
Mo ppm
1000
500
100
50
10
5
1
'Ah'
'B'
'R'
'C'
Rock Background ~1.5
Soil Background ~1.0
sites 19,20 5,6 13,14 15,16 3,4 11,12 1,2 17,18 9,10 7,8 23,24 21,22
Incr. Mo in Bedrock

The persistent good correlations of molybdenum with soils and plants is principally due to its mobility and consequent distribution, in general, similar to copper in British Columbia soils.

It is interesting to note that mercury gave significant correlation with Mo in bedrock. (See Table 4).

Zinc: In Figure 17 the background values are indicated as 50 ppm for soil and 70 ppm for bedrock. Zinc was included in this study as a good pathfinder, because it provides a good secondary halo.

Zinc accumulation is noticeable in the organic horizons L-H and Ah, which is probably due to plant uptake. Plants show high affinity for zinc, especially the common tree of the area, Pinus contorta, var. latifolia.

Zinc showed negative correlation with pH and -80 mesh %, but was highly correlative with Cu, Mo, Pb, and Co (see Tables 3 and 4).

Lead: Lead was also considered as a pathfinder or halo element in this study, since none of the mineralizations contained economical lead minerals. Background values for soil were set at 1.0 ppm and for bedrock at 1.5 ppm. Lead gave significant correlation in most of the soil horizons and showed high contents in organic horizons giving highly significant correlation with O.M.% (Table 3), which relates to the plants' affinity for lead. In addition, lead was positively correlated with Cu and Zn, but gave a negative correlation with Fe.

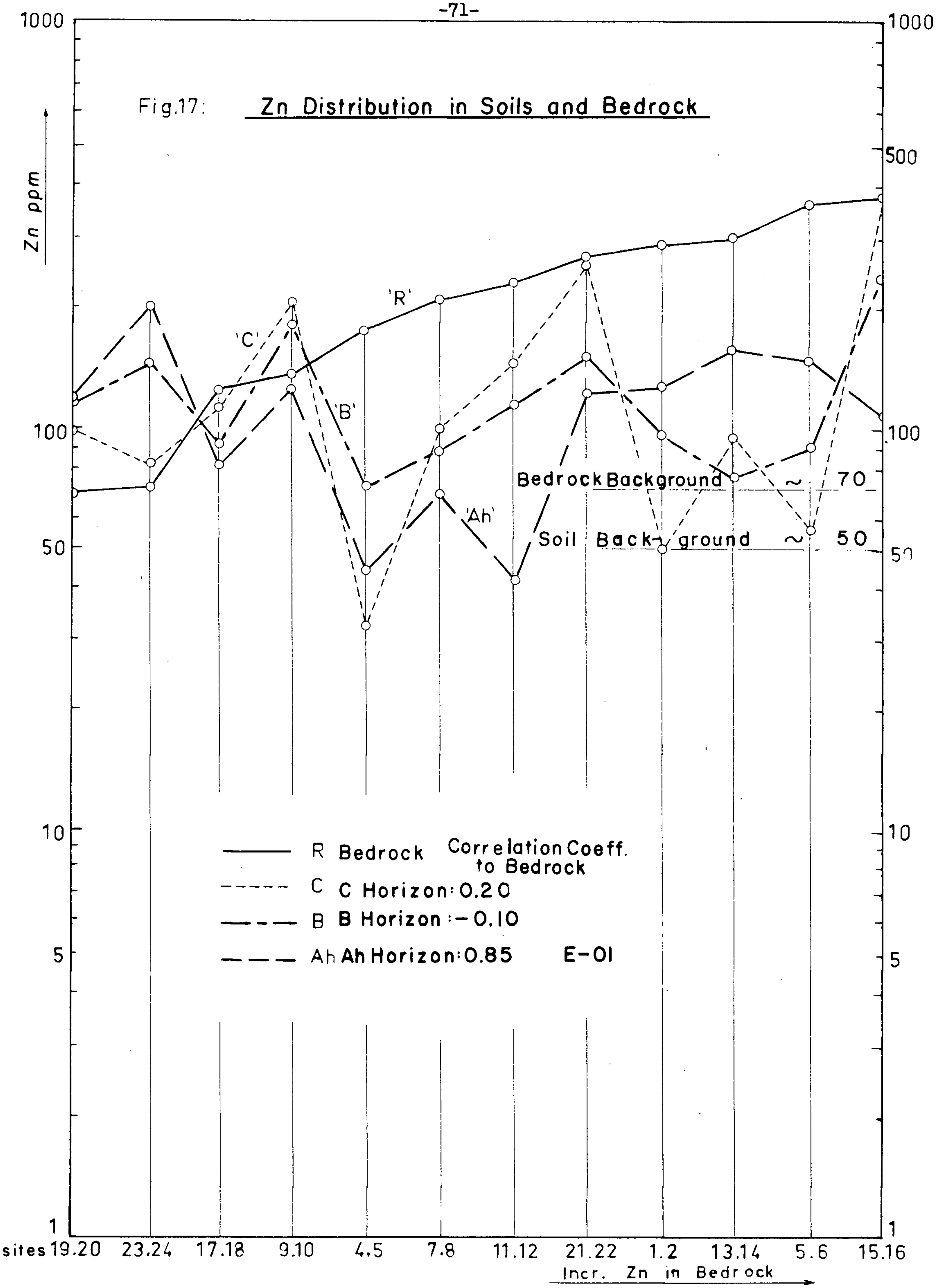


Fig.17: Zn Distribution in Soils and Bedrock
Zn ppm
1000
500
100
50
10
5
1
'R'
'C'
'B'
'Ah'
Bedrock Background ~ 70
Soil Back-ground ~ 50
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon: 0.20
B B Horizon: −0.10
Ah Ah Horizon: 0.85
E-01
sites 19.20 23.24 17.18 9.10 4.5 7.8 11.12 21.22 1.2 13.14 5.6 15.16
Incr. Zn in Bedrock

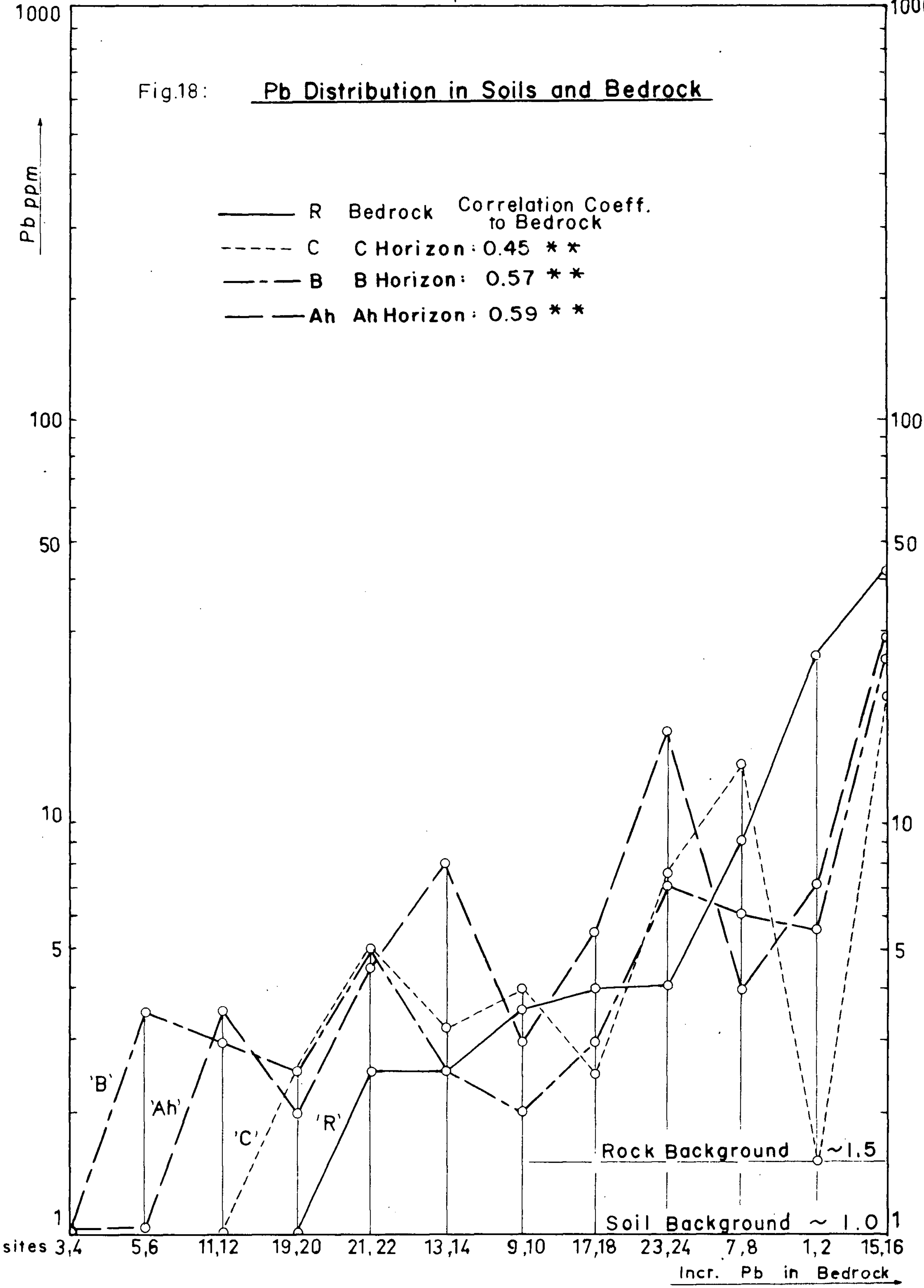


Fig.18: Pb Distribution in Soils and Bedrock
Pb ppm
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon: 0.45 * *
B B Horizon: 0.57 * *
Ah Ah Horizon: 0.59 * *
1000
100
50
10
5
1
'B'
'Ah'
'C'
'R'
Rock Background ~1.5
Soil Background ~ 1.0
sites 3,4
5,6
11,12
19,20
21,22
13,14
9,10
17,18
23,24
7,8
1,2
15,16
Incr. Pb in Bedrock

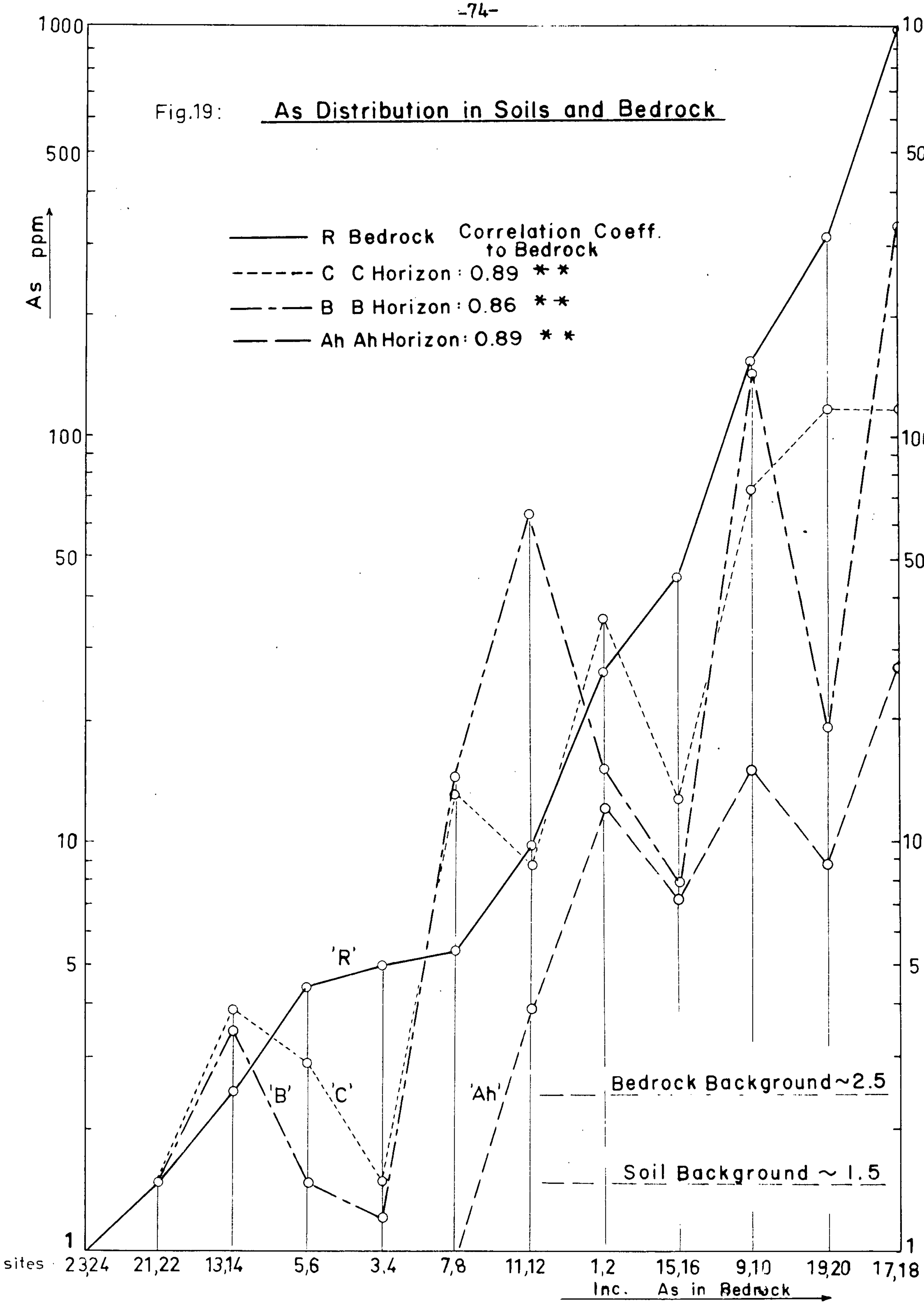
Arsenic: Arsenic is one of the most important gold pathfinders, since it gave good indications of mineralization at sites 17, 18 and 19, 20, but it is present in other mineralized areas such as sites 1, 2; 15, 16; and 9, 10; as an indication of copper mineralization, where minor amounts of silver and gold are also present.

The inter-elemental correlation (Table 3) indicated highly negative correlations with pH and -80 mesh %. A high correlation is noticeable in the C horizons between As and Hg (Table 4).

The plant relationship is quite fascinating. Looking at the individual plants, the species are very selective about arsenic, but for some unexplained reason, *Pseudotsuga menziesii* has more than 100 times the amount of this element than other plants at the same site. Inter-elemental correlation in plants indicated that Pb and As are highly correlative. (Table 3).

Cobalt: Cobalt is another element which has not been considered as an economical element in this work, but it is rather surprising that it is found in the field of halo elements, with high pathfinder characteristics.

The striking correlation of bedrock and the B and C horizons can be noted in Figure 21, with the soil background value of 3.0 and bedrock 4.0 ppm.



1000
500
100
50
10
5
1
As ppm
Fig.19: As Distribution in Soils and Bedrock
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon: 0.89 **
B B Horizon: 0.86 **
Ah Ah Horizon: 0.89 **
'R'
'B'
'C'
'Ah'
Bedrock Background ~2.5
Soil Background ~ 1.5
sites
23,24
21,22
13,14
5,6
3,4
7,8
11,12
1,2
15,16
9,10
19,20
17,18
Inc. As in Bedrock

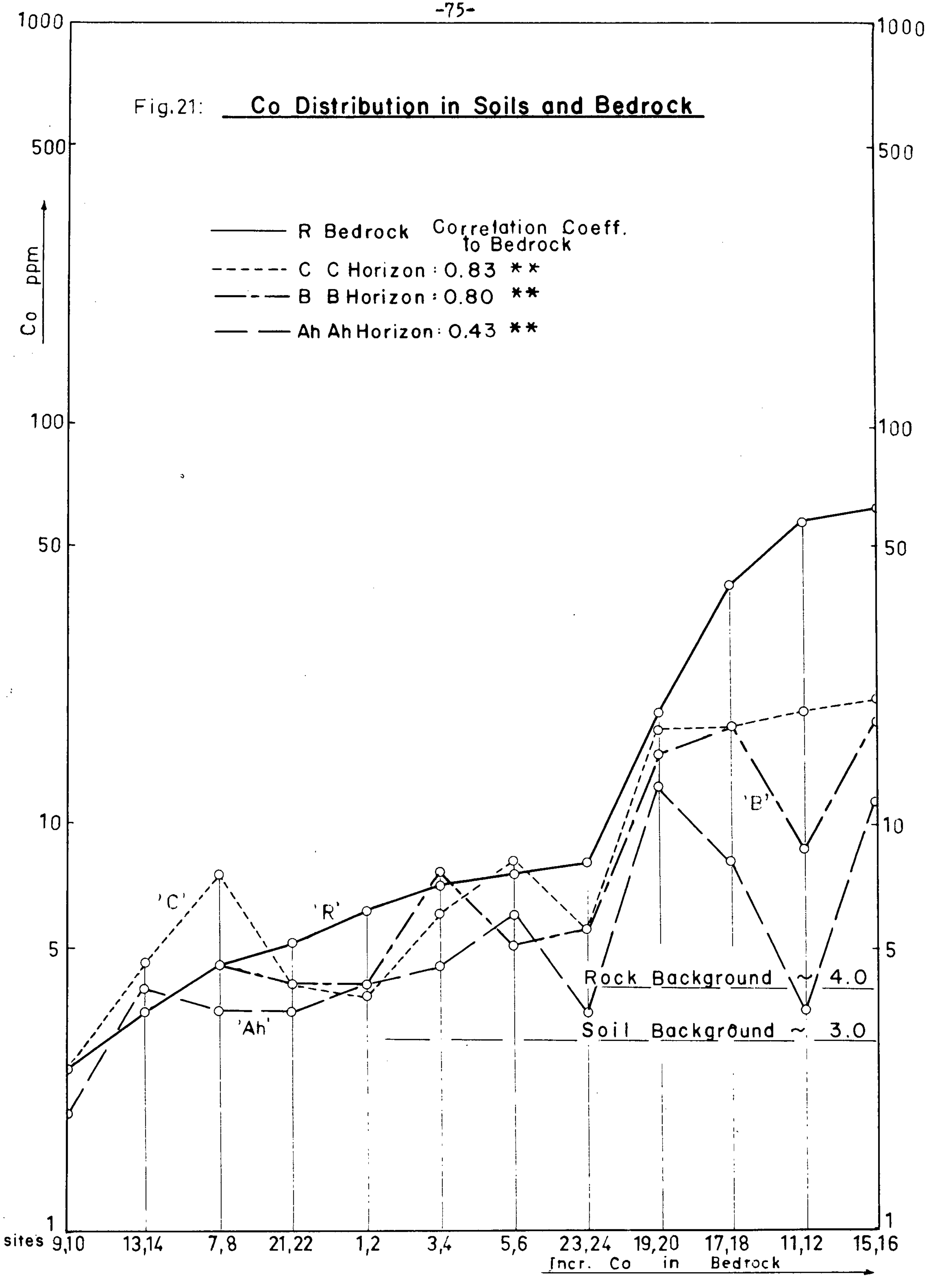


Fig.21: Co Distribution in Soils and Bedrock
Co ppm
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon : 0.83 **
B B Horizon : 0.80 **
Ah Ah Horizon : 0.43 **
'C'
'R'
'Ah'
'B'
Rock Background ~ 4.0
Soil Background ~ 3.0
1000
500
100
50
10
5
1
sites 9,10
13,14
7,8
21,22
1,2
3,4
5,6
23,24
19,20
17,18
11,12
15,16
Incr. Co in Bedrock

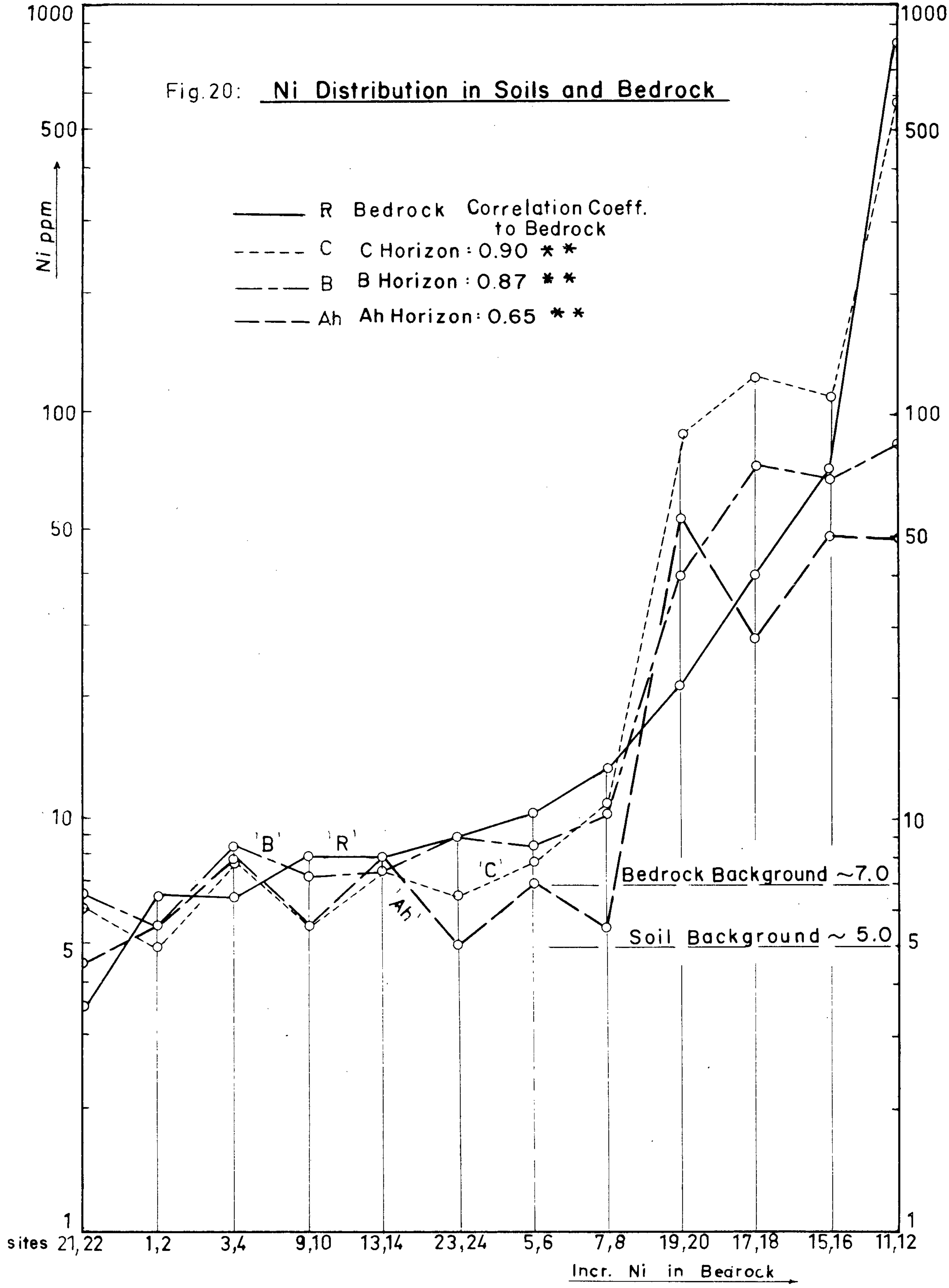
In inter-elemental correlations, pH, -80 mesh %, Cu, Zn, and Ni are found to be highly correlative with cobalt. Also it is noticeable that a very similar pattern is obtained with nickel, not only at nickel-bearing deposits (Pacific Nickel Mines 11,12), but also at other sites as well.

Plants absorb cobalt without apparent difficulty, and the high mobility of the element encourages this uptake; however, the correlations between bedrock and plants did not give significant values but were highly correlated with soil horizons, which act as suppliers of the element to the plants.

This element should be given more attention as a pathfinder in geochemical applications.

Nickel: Nickel is of high economic importance at Pacific Nickel Mines 11, 12, but like cobalt, it can be considered on a somewhat lower level as a pathfinder, at sites 15,16; 17,18; and 19,20. However it must be noted that to make use of it in transported material, one should be careful because a glacial deposit originating from nearby volcanic-covered areas could have a higher nickel content than the bedrock itself.

Nickel is highly correlated with all major soil horizons and plants in relation to bedrock (Table 2). Also, the inter-elemental correlation was highly significant between Co and Fe (Table 3).


1000
500
100
50
10
5
1
Ni ppm
Fig. 20: Ni Distribution in Soils and Bedrock
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon : 0.90 * *
B B Horizon : 0.87 * *
Ah Ah Horizon : 0.65 * *
'B'
'R'
'C'
'Ah'
Bedrock Background ~7.0
Soil Background ~ 5.0
sites 21,22
1,2
3,4
9,10
13,14
23,24
5,6
7,8
19,20
17,18
15,16
11,12
Incr. Ni in Bedrock

Plants can be good indicators of nickel, as this limited work indicates. In a sense, plants vary by species in nickel content, but all of them are indicative at a specific site (see Tables A-I to A-XII).

Iron: The analytical data on iron was used as a guiding factor in soil classification, but did not give any geochemical information. However, it is interesting that Fe gave a highly significant negative correlation with C.E.C. and O.M.% (Table 3).

Mercury: Mercury was one of the most interesting elements included in this work, since its pathfinder behavior is not yet scientifically established.

Some observations have been given in the discussion of the individual sites, but it is difficult to generalize or to give final conclusions. Mercury shows a very complex distribution in nature, and in elemental studies Hg demonstrates the meaning of the dynamic complexion of trace elements in dispersion studies.

In the correlation studies (Figure 23, Tables 3,4,5), it is seen that mercury differs a great deal from other elements. Since bedrock generally shows the lowest amounts present in the profiles, this illustrates well the fact of vertical migration of mercury. In some cases, the Ah(A_1) horizon is enriched, except when other absorbing

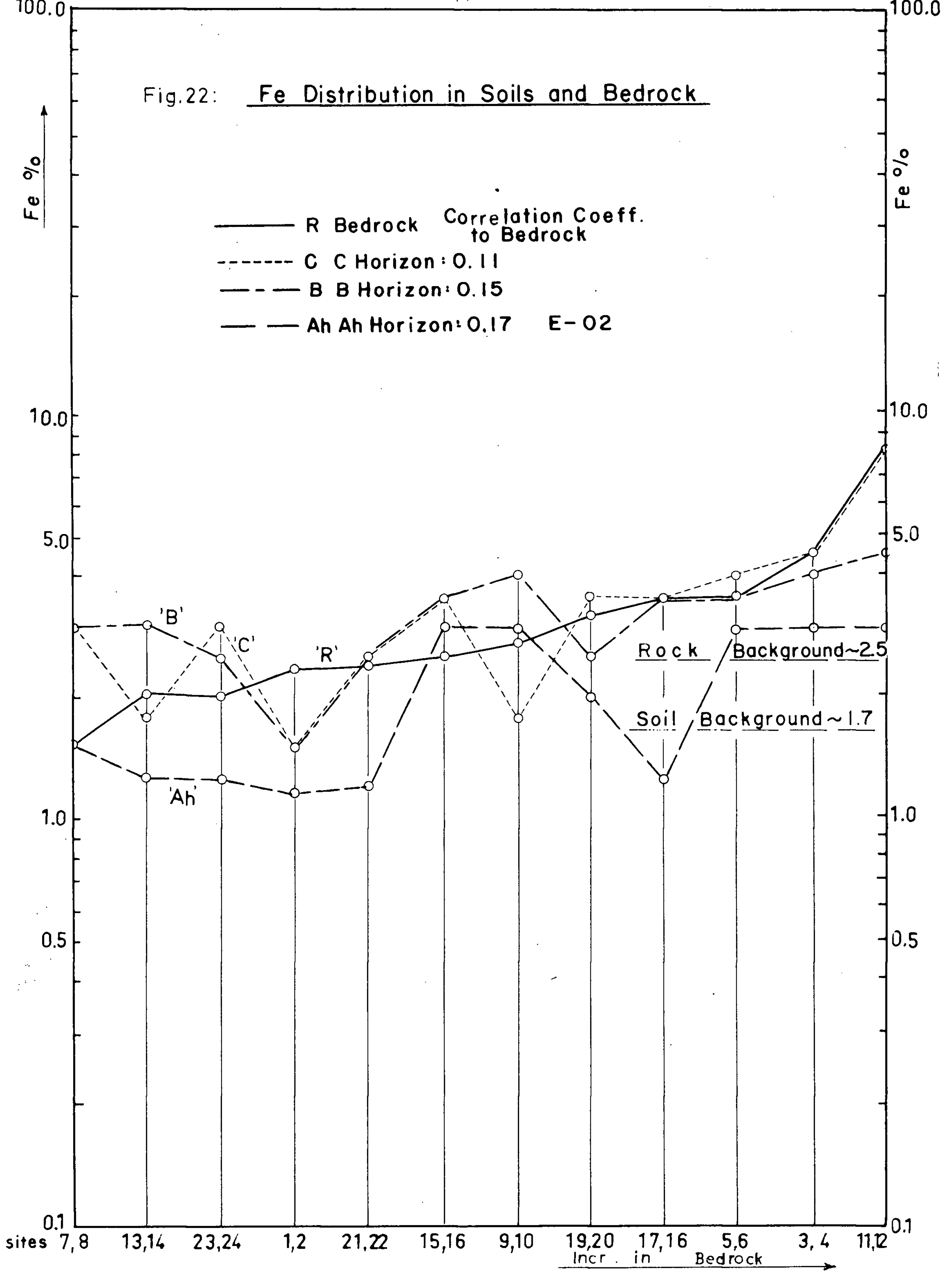


Fig. 22: Fe Distribution in Soils and Bedrock
Fe %
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon: 0.11
B B Horizon: 0.15
Ah Ah Horizon: 0.17
E-02
'B'
'C'
'R'
'Ah'
Rock Background ~ 2.5
Soil Background ~ 1.7
100.0
10.0
5.0
1.0
0.5
0.1
sites 7,8 13,14 23,24 1,2 21,22 15,16 9,10 19,20 17,16 5,6 3,4 11,12
Incr. in Bedrock

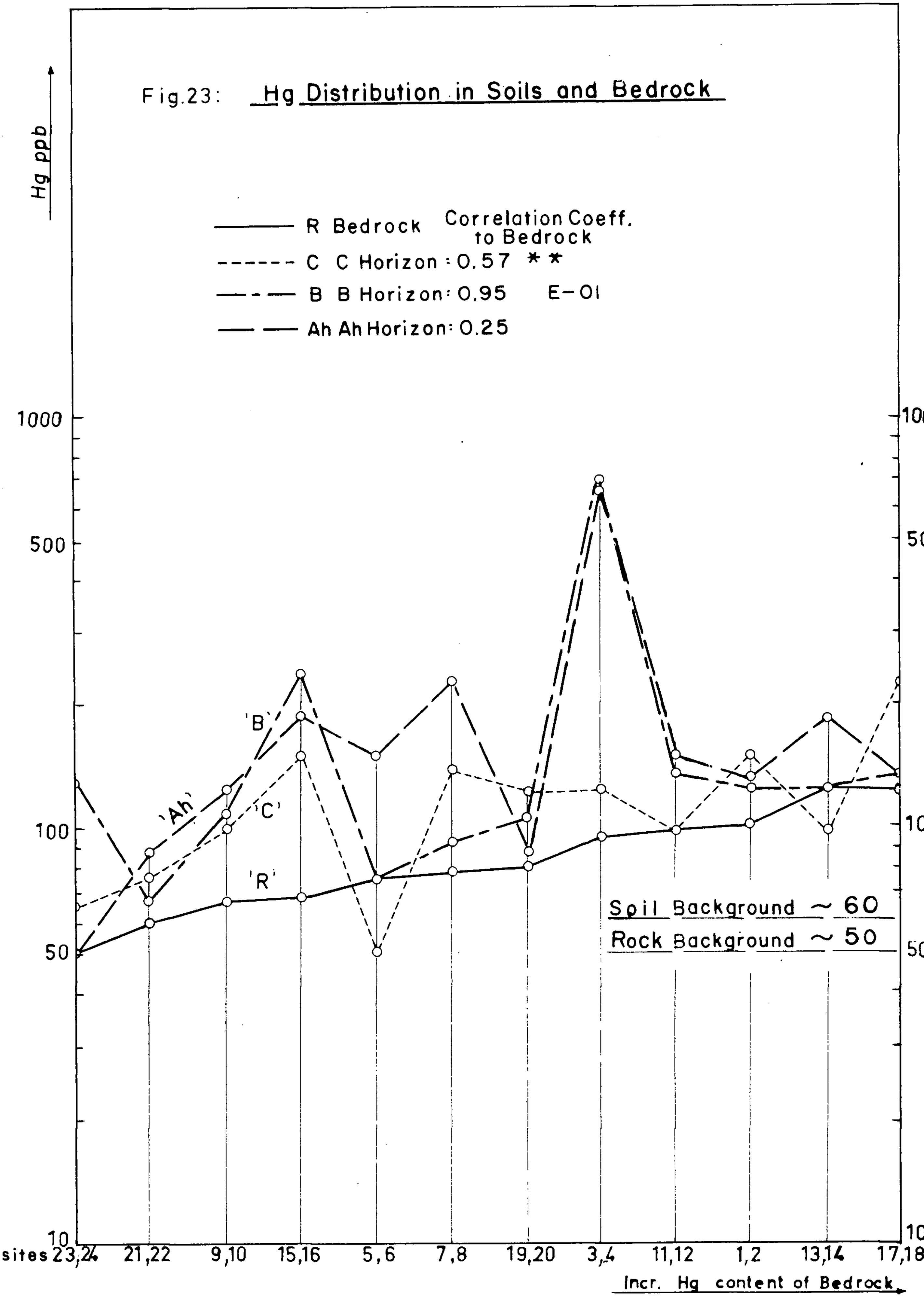


Fig.23: Hg Distribution in Soils and Bedrock
Hg ppb
R Bedrock
Correlation Coeff. to Bedrock
C C Horizon : 0.57 * *
B B Horizon : 0.95 E-01
Ah Ah Horizon : 0.25
'Ah'
'B'
'C'
'R'
Soil Background ~ 60
Rock Background ~ 50
1000
500
100
50
10
sites 23,24 21,22 9,10 15,16 5,6 7,8 19,20 3,4 11,12 1,2 13,14 17,18
Incr. Hg content of Bedrock

substances, such as clay, restrict it to the lower horizons. An outstanding example is seen at the Craigmont site (3,4). If not much clay is present in the lower horizons, the mercury enrichment is found in the Ah horizon.

The elemental correlation of horizons and bedrock gave significant correlation only between bedrock and the C horizon, which are also of a similar low level in Hg content.

Plants show Hg accumulation as their background is generally higher than the soils which support their growth. Plants can also solve sampling and sample preparation problems which are present with soils, since mercury in plants is generally in unvarying fixed forms. Some plant species show a higher affinity for Hg than others, but general conclusions cannot be reached at this stage because frequency of sampling of species were insufficient (see Tables A-I to A-XIII).

5 SUMMARY AND CONCLUSIONS

One of the main objectives of the study was to determine whether or not levels of certain elements in soils formed from transported materials, could be used as a practical basis for detecting mineralized areas covered by overburden. When the field observations and laboratory data are considered, in relation to the known mineralization at the 12 sites studied, it is concluded that this has been shown to be possible. However, the study has also demonstrated that soil samples must be carefully taken from specific horizons, and that samples taken arbitrarily by depth would not be satisfactory for this purpose.

For all the elements studied the correlations between the amounts present in the different horizons and the bedrock, it is concluded that, in general, the most suitable horizon to use for locating mineralization is the B horizon. The results also show that the C horizon is quite satisfactory, especially where the soil is fairly shallow, and in soils where there is no B horizon, or where it is difficult to recognize. In these latter cases the C horizon should be used.

There are exceptions to this general conclusion, and when there is doubt, pilot sampling and analysis should be done. This is true especially in the case of Hg. Use of L-H, Ah, or Ae horizons was shown to give erratic results. Also, predictions based upon Ae horizons may be incorrect because of eluviation of elements and the susceptibility of this horizon to erosion and/or deposition.

As would be expected in soils formed from transported materials, the micro-elemental content of the soils was in general lower than that of the bedrock in the mineralized areas. This was reflected in background values which, with the exception of Hg, were lower in the soils than the bedrock.

In a considerable number of cases, elemental content of soil horizons was higher than that of the bedrock. The results suggested that upward migration of elements through glacial, colluvial and alluvial materials is important. This migration can be the result of four factors.

(a) Water table fluctuations.
(b) Capillary action.
(c) Plant action (biocycling).
(d) Diffusion of elements and physical mixing.

These factors were not studied in relation to movement of elements, but it is believed that their relative importance varies considerably in different soils.

Dispersion upward into soils is most common in the case of pathfinder elements (Mo, As, Co and Hg), as these elements are relatively greater in amount in the upper section of the profiles than the other elements which have less mobility (Figures 5, 9, 10). This suggests that in transported materials, pathfinder elements can play an important role in locating areas of mineralization. In the case of upward migration of elements in soils, the pathfinders may act differently, which can be used in locating the orebodies. For example, the major element can undergo several transformations by different reactions, such as precipitation, inter-actions, chelation, etc., and never indicate anomalous amounts. At the same time, the pathfinders may not go through the same processes, or will show completely different behavior in the same environment. For example, copper will precipitate in basic media in lower horizons, while molybdenum's mobility will increase; or in the case of an acidic media, molybdenum can have inter-actions with iron and thereby lose mobility, while zinc and cobalt may be highly mobile, or mercury may diffuse through the soil without any major difficulties.

The upward migration of Hg was particularly noticeable and it is thought that this may have been largely the result of diffusion.

In general, background values for the elements in soils were lower than those suggested for bedrock.

In this study, consideration was given to the possibility of correlation between soil development and the elemental content of the major horizons; e.g. of the B horizon. However, the range of development in the soils studied appeared to be too limited, because with the exception of two soils, all of them belong to the Brunisolic order, and therefore did not give wide enough range to work with. Also, for this type of correlation, each soil-forming factor should be considered in the statistical treatment and should be statistically weighed according to its importance in soil development at any particular site.

It should be noted, however, that the development of a soil profile may give the first clue as to what can be expected from soil sampling as an indication of mineralization. The more strongly developed B horizons will normally show much higher accumulations of the elements, as a result of greater migration. Sampling and analysis of the vegetation at the 12 sites showed that the occurrence of elements in the vegetation was more closely correlated with the amount in the soils than it was with amounts in the bedrock. This substantiates the obvious fact that soil horizons are the major source of plant nutrients, rather than the bedrock.

The fact that Hg and Pb in the L-H horizons are highly correlated with the amounts in the vegetation (higher than with other horizons), shows the importance of vegetation in bio-geochemical cycling, as the main source of Hg and Pb in these horizons. This likely occurs by plant residues falling on the soil surface. A similar effect is noted in the case of Zn in the Ah horizons. This also indicates the general higher affinity of plants for Hg, Pb and Zn.

The results confirmed that elemental content of vegetation varied a great deal with the different species studied, and in different environments the uptake by any one species may also vary. However, the results also showed that vegetation can be very useful in locating mineralized areas, as none of the mineralized areas included in the study would have been missed, if all species at each site had been sampled and analysed.

The conclusions above indicate that elemental distributions in transported soil and plants growing in this soil, are most dynamic "compexum", and without a complete cross-section study, including bed-rock, soils, and plants, the complicated laws which may apply to locate mineralization will not be understood.

The major conclusions are:

1. The levels of certain elements, in soils and plants from transported materials (glacial, alluvial, colluvial), can be used as guides for detecting mineralized areas in British Columbia.

2. In soil sampling for geochemical prospecting, the most satisfactory horizon to sample is generally the B, or in cases of weaker developed horizons, the C. These horizons give the best correlation of element content with bedrock.

3. Soil development in transported material includes vertical migration of elements. The processes thought to be involved are capillary action, water table fluctuations, biocycling, and diffusion. These phenomena make it possible to use soil horizons for indication of mineralized bedrock.

4. The stage of soil development can always give the first clue as to what we can expect to find from soil sampling as an indicator of mineralization under transported parent materials.

5. Pathfinders and their study have greater importance in soils developed from transported material, than in soils developed from residual material; since pathfinders may not suffer transformations in the upward movement.

6. Plants are generally good indicators of mineralization, but they vary widely in element content by species - special indicator plants should be sought in each area. Element content of vegetation correlates with soil horizons more than with bedrock.

7. In soils and plants, the relation to bedrock content of the elements was found to be more correlative using logarithmic than linear values. This is an indication of the relationship not being linear, but logarithmic similarly to the trace element distributions reported elsewhere.

8. In the transported soils studied, the most correlative factor of element content was found to be Mesh size and pH.

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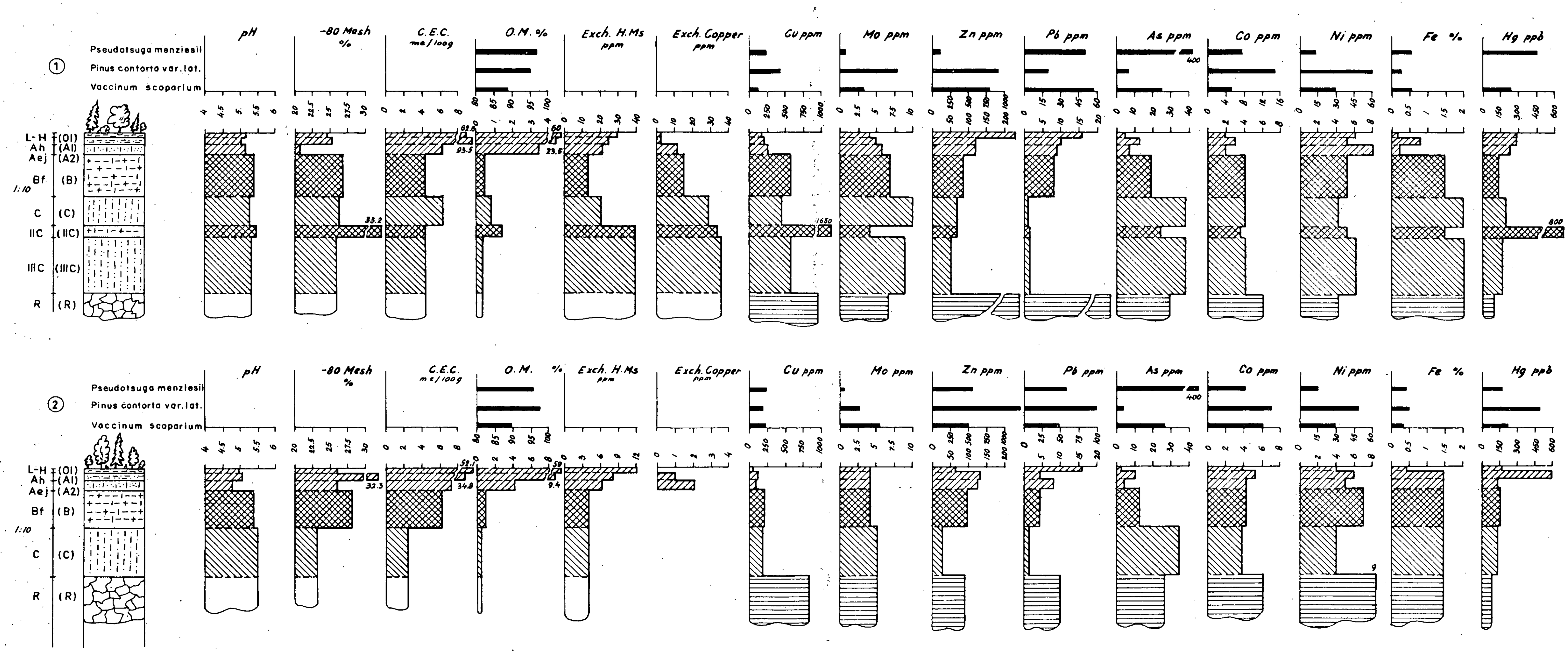

Fig.A-1 Analytical Data for Mc Bride Creek Prospect

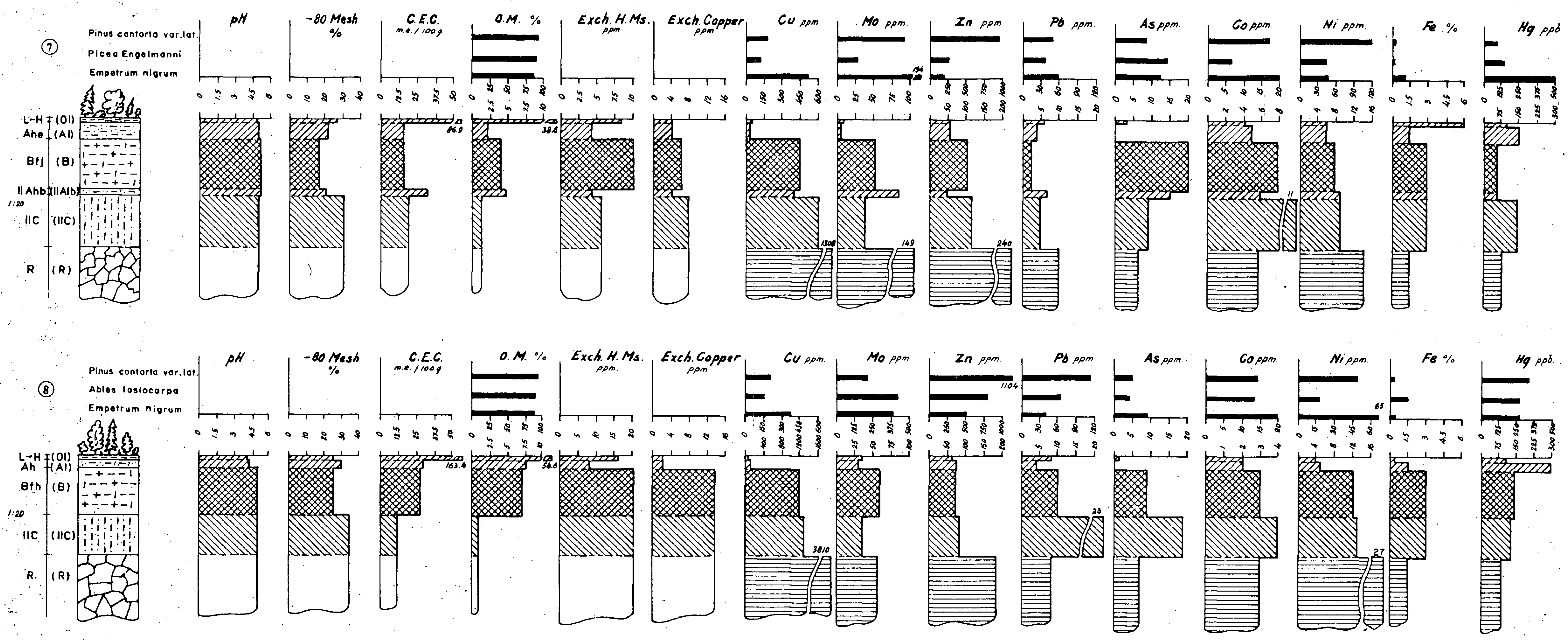

Fig. A-2 Analytical Data for Taylor Windfall Prospect

Fig. A-2

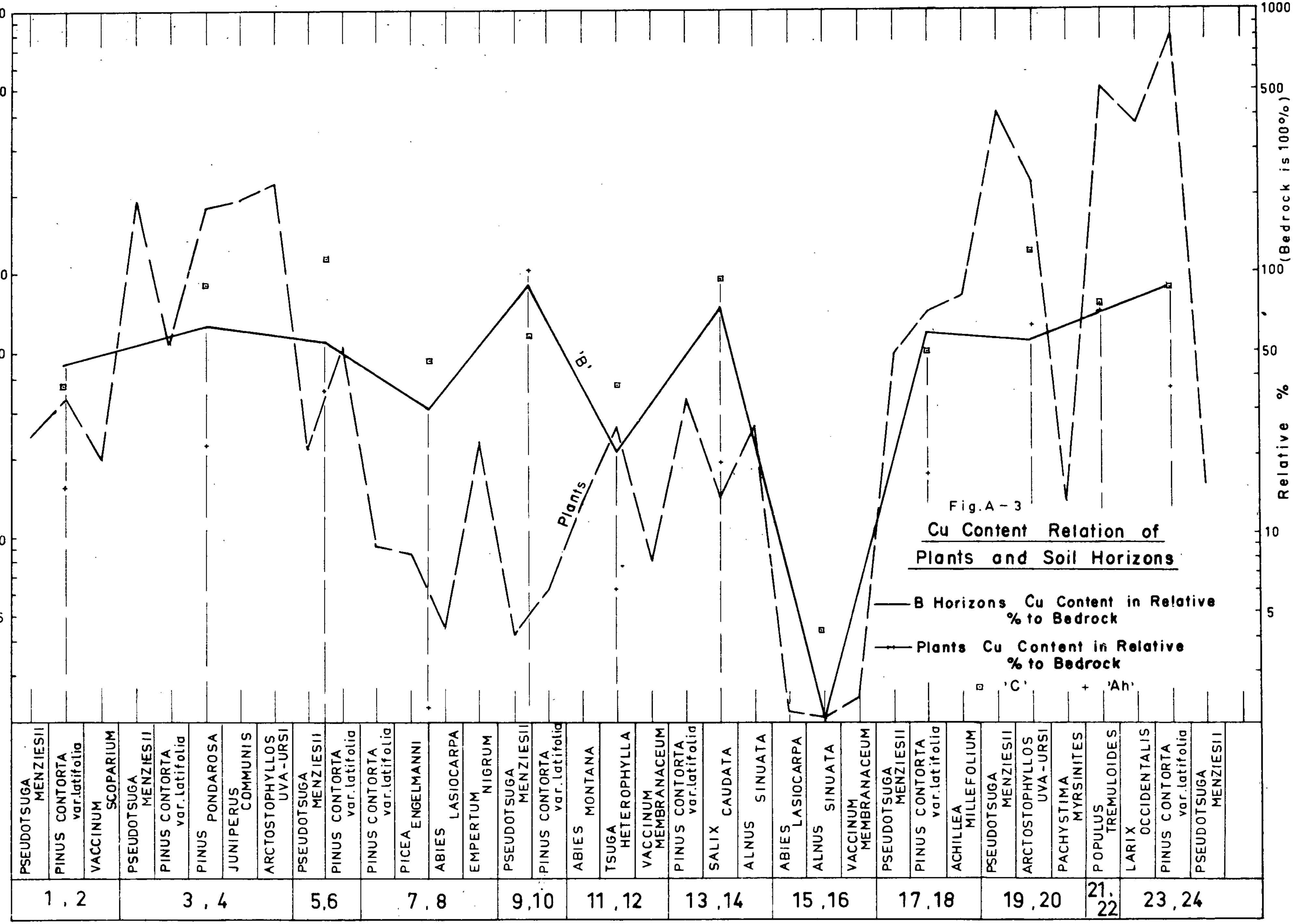
Fig. A – 3
Cu Content Relation of Plants and Soil Horizons
B Horizons Cu Content in Relative % to Bedrock
Plants Cu Content in Relative % to Bedrock
'C'
'Ah'
'B'
Plants
Relative % (Bedrock is 100%)
1000
500
100
50
10
5
PSEUDOTSUGA MENZIESII
PINUS CONTORTA var. latifolia
VACCINUM SCOPARIUM
PSEUDOTSUGA MENZIESII
PINUS CONTORTA var. latifolia
PINUS PONDAROSA
JUNIPERUS COMMUNIS
ARCTOSTOPHYLLOS UVA-URSI
PSEUDOTSUGA MENZIESII
PINUS CONTORTA var. latifolia
PINUS CONTORTA var. latifolia
PICEA ENGELMANNI
ABIES LASIOCARPA
EMPERTUM NIGRUM
PSEUDOTSUGA MENZIESII
PINUS CONTORTA var. latifolia
ABIES MONTANA
TSUGA HETEROPHYLLA
VACCINUM MEMBRANACEUM
PINUS CONTORTA var. latifolia
SALIX CAUDATA
ALNUS SINUATA
ABIES LASIOCARPA
ALNUS SINUATA
VACCINUM MEMBRANACEUM
PSEUDOTSUGA MENZIESII
PINUS CONTORTA var. latifolia
ACHILLEA MILLEFOLIUM
PSEUDOTSUGA MENZIESII
ARCTOSTOPHYLLOS UVA-URSI
PACHYSTIMA MYRSINITES
POPULUS TREMULOIDES
LARIX OCCIDENTALIS
PINUS CONTORTA var. latifolia
PSEUDOTSUGA MENZIESII
1 , 2
3 , 4
5,6
7 , 8
9,10
11 , 12
13 , 14
15 , 16
17 , 18
19 , 20
21, 22
23 , 24

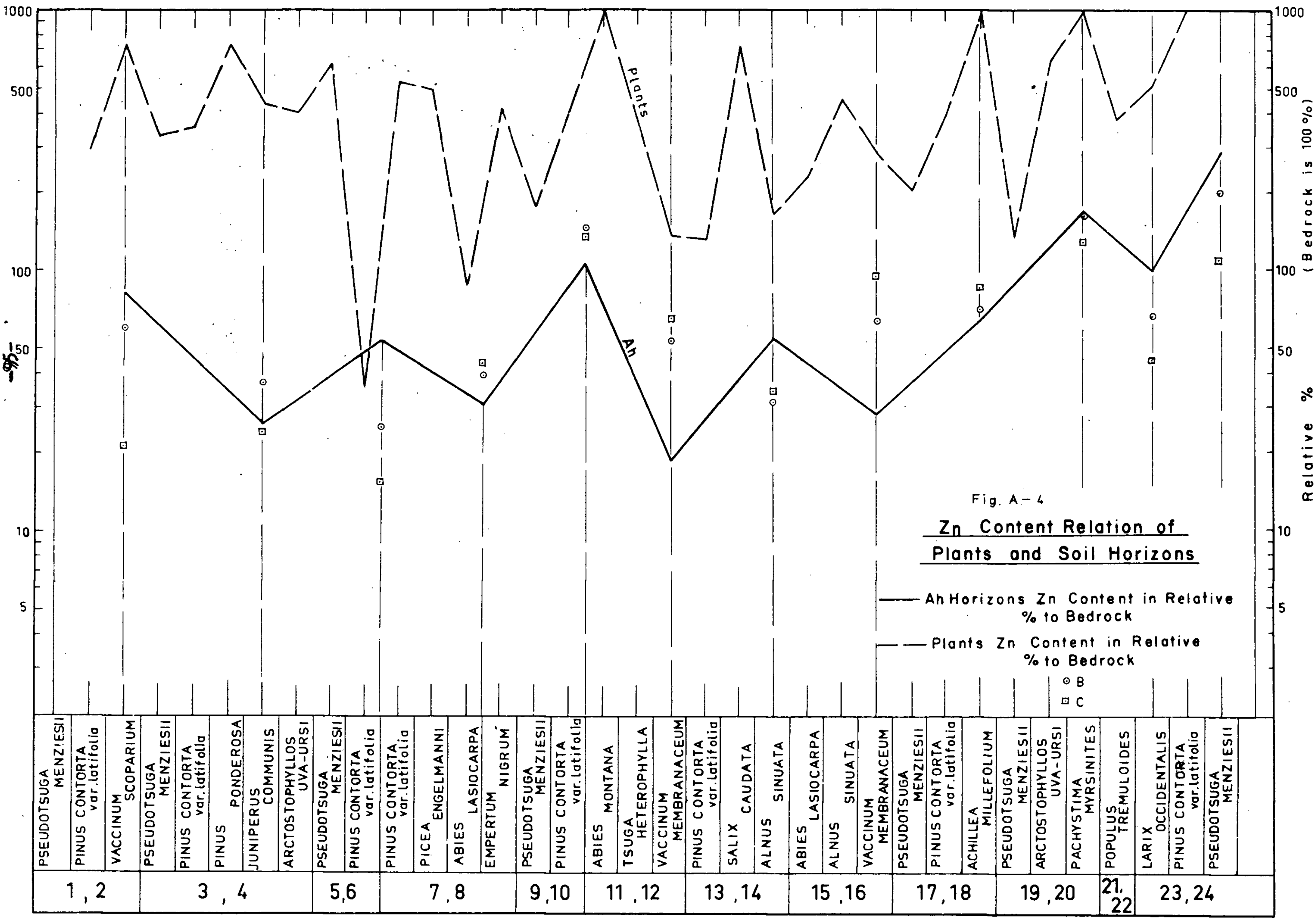

Fig. A-4

Zn Content Relation of Plants and Soil Horizons

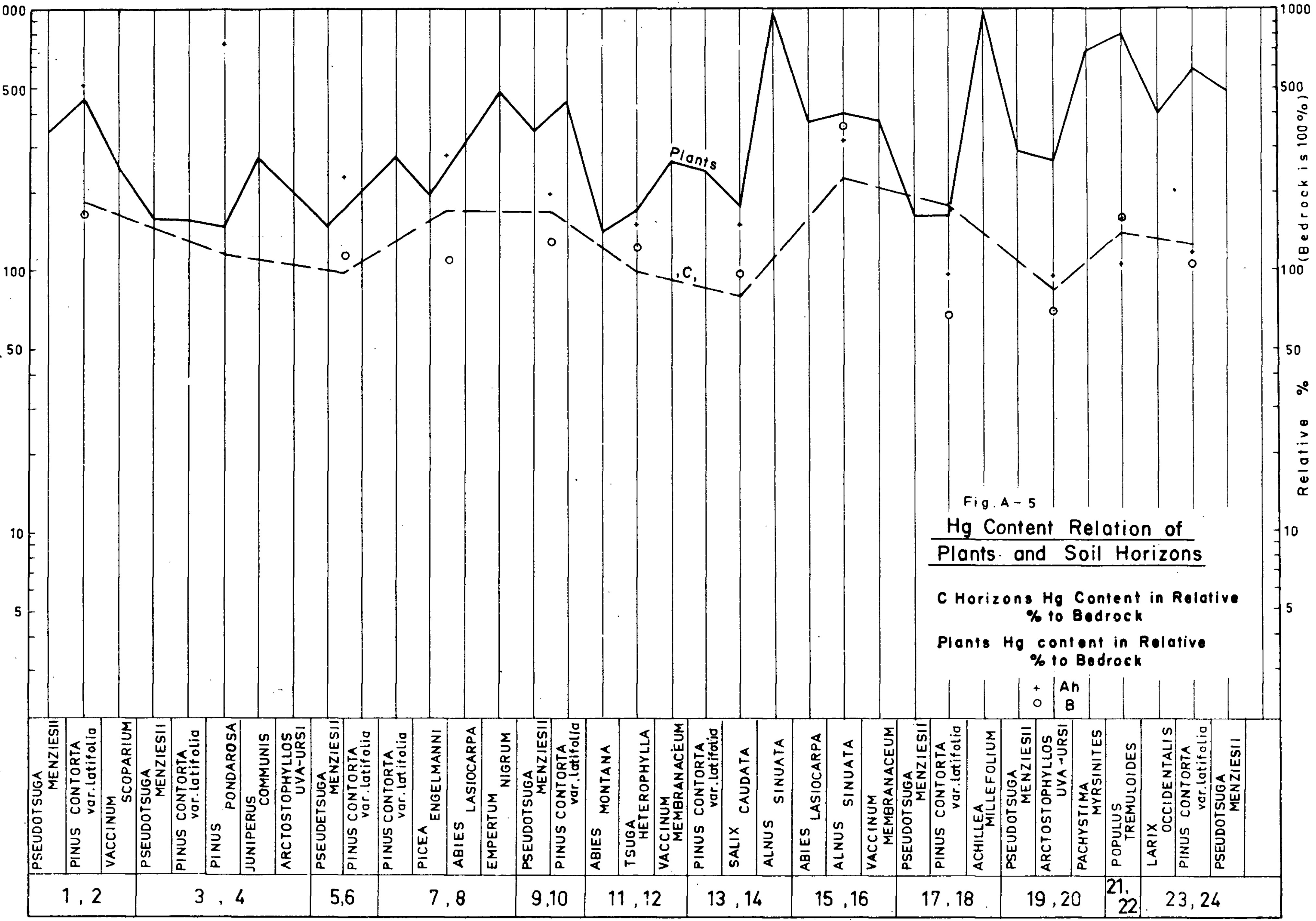

Fig. A-5

Hg Content Relation of Plants and Soil Horizons

Analytical Data for McBride Creek Prospect PROFILE No. 1 & 2

Sample No.	Horizon	Soil Type or Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C. m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe o/o	Hg * ppb
B- 1	L-H (01)	(1) Degraded Acid Brown Wooded	0.8"	5.2	24.7	62.6	60.0	28	1	121	4	214	16	3	2	6	0.15	250
B-2	Ah (A1)	Brunisolic soil	1.0"	5.1	25.3	93.9	23.5	24	2	176	5	115	10	13	3	5	0.80	250
B- 3	Aej (A2)	Developed on	1.7"	5.2	20.4	6.1	3.6	20	12	224	6	115	8	5	2	8	0.20	200
B- 4	Bf (B)	colluvial deposits	7.0"	5.4	27.0	4.3	0.4	14	16	588	7	90	7	17	4	5	1.50	108
B- 5	C (C)	with a buried B and	4.6"	5.3	26.0	6.1	0.9	20	28	422	10	70	1	37	4	4	2.00	175
B- 6	II-C(B)	C horizon.	1.9"	5.5	33.2	4.3	1.6	40	32	1650	3	70	2	22	3.5	5	1.50	800
B- 7	III-C(C)		8.7"	5.4	25.8	4.3	0.3	40	36	530	9	50	2	37	4	6	2.00	150
B- 7A	R		24.0"	-	-	-	-	-	-	900	6	470	42	26	6	4	3.0	83*
1		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	97.25	-	-	200	1	173	52	500	8	12	0.60	400
2		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	95.2	-	-	404	8	935	21	5	15	60	0.30	250
3		Vaccinium scoparium (Red Alpine Blueberry)	-	-	-	-	89.1	-	-	101	3	763	58	23	5	30	0.60	200
B- 8	L-H (01)	(2) Degraded Acid Brown Wooded	0.8"	5.0	26.4	52.1	59.3	12	0	41	4	69	16	2	3.5	4	0.50	150
B- 9	Ah (A1)	Brunisolic soil	1.2"	5.1	32.3	34.8	9.4	8	1	95	4	136	4	11	5	6	1.50	550
B-10	Aej (A2)	Developed on	1.8"	4.7	25.8	7.8	4.1	6	2	69	4	130	8	5	4	5	1.50	125
B-11	Bf (B)	colluvial deposits	6.0"	5.4	27.9	6.1	0.8	4	0	236	4	100	4	13	4	7	1.50	150
B-12	C (C)	without buried horizons.	8.0"	5.6	23.0	2.6	0.2	4	0	178	5	28	1	35	3.5	4	1.50	125
B-12A	R		17.0"	-	-	-	-	-	-	784	5	96	10	26	6	9	2.70	75
4		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	95.2	-	-	204	1	546	60	400	4	15	0.50	150
5		Pinus contorta var.latifolia (Lodgepole Pine)	-	-	-	-	97.3	-	-	189	3	1243	100	3	7	50	0.60	450
6		Vaccinium scoparium (Red Alpine Blueberry)	-	-	-	-	89.3	-	-	229	6	502	50	27	6	30	0.40	200

* Plants are ppm in ash, except mercury ppb in oven dry plants.

TABLE A-1

Profiles No. 1 & 2

TABLE A-1

Analytical Data for CRAIGMONT MINES PROFILE No. 3 & 4

Sample No.	Horizon	Soil Type or Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C. m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe o/o	Hg ppb
B-13	L-H (01)	(3) Gleyed Graywooded	1.5"	6.1	35.3	38.3	6.3	16	1	86	0	68	2	0	2	6	2.00	150
B-14	Ah (A1)	Podzolic Soil	3.5"	5.2	33.0	8.7	0.4	4	0	46	1	40	1	0	3	8	2.00	75
B-15	Aeg (A2)	Developed from	23.0"	5.5	36.2	6.9	0.3	2	0	64	0	46	0	0	2	5	4.00	100
B-16	II-Btg (B)	Glacial Drift	11.0"	6.1	16.9	18.2	0.2	20	20	240	1	90	2	1	4	8	4.00	1400
B-17	II-C(C)		35.5"	6.5	16.9	19.9	0.7	28	36	396	1	35	0	2	3	5	4.00	125
B-18	R.		75.0"	-	-	-	-	-	-	432	3	195	1	5	7	6	4.00	95
7		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	95.5	-	-	825	2	700	66	15	14	30	2.00	200
8		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	96.5	-	-	248	2	1470	84	0	20	30	4.00	150
9		Juniperus communis (Dwarf Juniper)	-	-	-	-	93.7	-	-	1264	50	816	41	2	10	37	3.00	250
10		Arctostaphylos uva-ursi (Kinnikinnick)	-	-	-	-	95.0	-	-	966	12	960	54	1	6	27	0.90	200
B-19	L-H (01)	(4) Gleyed Graywooded	1.7"	6.7	43.0	64.3	11.3	24	20	477	2	50	5	0	5	5	3.00	125
B-20	Ah (A1)	Podzolic Soil - a lot	4.3"	6.6	32.4	17.4	3.3	20	8	142	2	47	0	0	6	8	4.00	1350
B-21	Aegj (A2)	thinner gley zone	9.2"	6.5	28.4	16.5	0.8	16	12	137	0	39	0	0	8	9	4.00	62
B-22	II-Btgj (B)	in profile.	22.5"	8.1	14.6	26.9	3.2	30	28	342	0	50	0	1	11	9	3.00	100
B-23	II-Ck (C)		38.0"	8.7	17.4	8.6	0.1	28	42	391	0	28	1	2	9	11	5.00	120
B-24	R.		74.0"	-	-	-	-	-	-	412	2	150	1	2	7	9	5.00	100
11		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	96.4	-	-	850	6	580	100	12	10	20	2.00	100
12		Pinus ponderosa (Pondersoa Pine)	-	-	-	-	96.4	-	-	750	6	832	113	1	12	60	1.50	150
13		Arctostaphylos uva-ursi (Kinnikinnick)	-	-	-	-	96.0	-	-	744	25	930	60	1	14	40	2.00	200

Profiles 3 & 4

TABLE A-2

TABLE A-2

Analytical Data for COPPER MOUNTAIN MINES

PROFILE No. 5 & 6

Profiles 5 & 6

Sample No.	Horizon	Soil Type or Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C. m.e./ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
		(5)																
B-25	L-H (01)	Orthic Acid Brown Wooded	1.5"	5.2	49.9	139.1	22.6	32	28	608	2	40	10	1	6	7	1.00	200
B-26	Ah (A1)	Brunisolic Soil	2.0"	5.9	55.2	59.1	24.3	28	20	304	2	50	2	0	4	6	2.00	170
B-27	Bfj (B)	Developed from mixture	9.0"	5.7	42.1	26.1	1.8	36	2	362	0	75	3	1	3	8	3.00	100
B-28	C (C)	of colluvial and	27.5"	6.1	32.3	18.2	1.0	4	46	966	2	40	1	3	9	9	4.00	50
B-29	R	residual materials.	35.5"	-	-	-	-	-	-	934	2	410	1	5	8	9	3.00	50
14		Pseudotsuga menziezii (Douglas Fir)	-	-	-	-	96.0	-	-	188	3	503	75	15	9	22	0.30	100
		(6)																
B-30	L-H (01)	Orthic Acid Brown Wooded	1.0"	5.2	43.0	187.8	37.3	28	28	568	2	100	16	0	6	9	1.00	225
B-31	Ah (A1)	Brunosolic Soil	1.5"	5.9	56.4	53.5	10.8	36	28	312	1	240	4	0	8	8	4.00	125
B-32	Bfj (B)	Developed same as #5	5.0"	6.3	42.1	28.7	1.2	12	12	553	3	100	4	2	7	9	4.00	50
B-33	C (C)		14.5"	6.2	35.1	26.1	1.2	36	50	1028	2	70	0	3	7	7	4.00	100
B-34	R		21.0"	-	-	-	-	-	-	762	1	300	1	4	7	12	4.00	100
15		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.7	-	-	409	5	1927	172	1	10	40	0.60	200
16		Pseudotsuga menziezii (Douglas Fir)	-	-	-	-	95.8	-	-	193	3	400	69	19	8	31	0.40	100

TABLE A-3

TABLE A-3

Analytical Data for TAYLOR WINDFALL PROSPECT PROFILE No. 7 & 8

Sample No.	Horizon	Soil Type or Names of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C. m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-35	L-H (01)	⑦ Degraded Acid Brown Wooded	1.5"	4.8	27.1	86.9	38.6	8	4	33	8	57	6	3	4	6	6.00	100
B-36	Ahe (A1)	soil. Developed from	5.5"	5.0	22.6	15.6	2.1	4	4	19	5	57	4	0	5	6	1.50	150
B-37	Bf (B)	alluvial deposition and	15.5"	5.1	17.0	15.6	3.7	10	6	453	51	100	2	20	8	8	3.00	50
B-39	II Ahb(Alb)	collubial material in	2.0"	5.2	21.3	32.1	4.2	4	4	402	84	45	7	15	6	9	3.00	50
B-38	II C (C)	places.	16.0"	5.1	30.3	19.1	1.1	6	8	606	36	115	5	9	11	9	3.00	150
B-40	R		37.0"	-	-	-	-	-	-	1308	149	240	10	6	6	14	1.50	75
17		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.5	-	-	168	96	960	48	9	18	120	0.30	100
18		Picea Engelmanni (Engelmann Spruce)	-	-	-	-	95.9	-	-	115	29	274	36	15	7	45	0.15	150
19		Empertum nigrum (Crowberry)	-	-	-	-	92.3	-	-	497	194	220	58	13	21	50	1.00	500
B-41	L-H (01)	⑧ Degraded Acid Brown Wooded	1.2"	4.1	25.1	163.4	54.6	16	2	89	36	61	8	1	2	4	0.15	112
B-42	Ah (A1)	soil. Developed from	2.3"	4.3	30.0	31.3	8.3	8	2	109	32	77	4	0	2	5	1.50	300
B-43	Bfh (B)	alluvial deposition.	15.2"	5.0	25.0	30.4	7.6	20	14	1216	62	70	10	9	3	12	3.00	133
B-44	II C (C)		13.5"	5.0	33.2	12.1	1.0	20	14	1304	33	80	23	19	4	13	3.00	125
B-45	R		31.0"	-	-	-	-	-	-	3810	59	180	8	7	3	13	1.50	80
20		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.8	-	-	235	235	1104	110	5	15	50	0.40	350
21		Abies lasiocarpa (Alpine Fir)	-	-	-	-	96.2	-	-	179	437	780	62	4	14	18	0.15	250
22		Empertum nigrum (Crowberry)	-	-	-	-	93.1	-	-	379	408	504	43	9	20	65	1.50	250

Profiles 7 & 8

TABLE A-4

TABLE A-4

Sample No.	Horizon	Soil Type or Name of Species	Thick-ness of Horizon	pH	-80 Mesh %	C.E.C. m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-46	L-H (01)	(9) Orthic Acid Brown Forest	1.0"	4.1	28.4	168.7	60.7	12	2	90	78	77	12	2	3	3	0.30	125
B-47	Ah (A1)	soil Developed from granodiorite,	1.5"	4.3	25.3	36.5	21.5	10	4	360	62	140	3	16	2	6	3.00	150
B-48	Bfh (B)	modified residual soil	7.5"	6.1	20.4	37.4	6.7	140	140	3660	295	190	4	185	3	12	4.00	125
B-49	C (C)	mixed with some colluvial debris on places.	10.0"	6.0	24.0	25.2	2.4	90	100	1590	82	320	8	100	4	8	2.00	100
B-50	R		19.0"	-	-	-	-	-	-	1900	70	190	3	235	2	8	1.50	75
23		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	96.7	-	-	171	80	1620	99	12	25	68	0.75	250
24		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	95.6	-	-	117	200	476	83	470	7	30	0.50	150
B-51	L-H (01)	(10) Orthic Acid Brown Forest	2.0"	4.1	26.5	173.9	43.5	12	1	90	64	66	9	6	1	8	0.50	150
B-52	Ah (A1)	soil modified residual soil	3.0"	4.4	33.2	52.2	10.8	10	2	196	55	115	3	14	2	5	3.00	100
B-53	Bf (B)	on granodiorite.	8.0"	5.9	25.8	36.5	2.1	100	100	2170	71	170	0	100	2	3	4.00	50
B-54	C (C)		11.0"	5.8	19.9	30.4	2.1	100	100	1408	54	100	0	45	1	3	1.50	100
B-55	R		22.0"	-	-	-	-	-	-	4750	44	84	4	275	3	8	4.00	50
25		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	95.3	-	-	126	183	397	107	280	4	20	6.00	250
26		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.1	-	-	173	428	1101	92	9	20	63	5.00	300

TABLE A-5

Analytical Data for PACIFIC NICKEL MINES

Profile No. 11 & 12

Sample No.	Horizon	Soil Type or Names of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-56	L-H (01)	(11) Orthic concretionary	3.5"	3.5	18.9	253.8	62.1	2	1	78	2	50	24	0	6	17	0.50	150
B-57	Ah (A1)	brown soil. Developed	2.0"	3.6	25.1	135.6	18.5	4	1	44	0	52	4	6	6	82	3.00	175
B-58	Aej (A2)	on colluvial deposits	1.5"	4.1	22.5	49.5	2.6	2	0	16	0	54	4	2	5	57	4.00	125
B-59	Bfcc (B)	from mountain sides	19.5"	4.8	17.1	70.4	5.4	1	1	80	1	126	4	19	9	144	4.00	150
B-60	C (C)	ultrabasic rocks.	30.0"	4.8	12.7	25.2	0.4	0	0	178	1	175	0	8	19	750	8.00	75
B-61	R		53.0"	-	-	-	-	-	-	430	3	195	1	13	47	420	8.00	100
27		Abies montana (Alpine Fir)	-	-	-	-	96.6	-	-	30	0	102	29	15	40	300	2.0	150
28		Vaccinium membraneceum (Black Mountain Huckleberry)	-	-	-	-	97.1	-	-	40	0	343	106	9	37	449	1.5	250
29		Tsuga heterophylla (Western Hemlock)	-	-	-	-	98.8	-	-	166	0	324	66	3	60	274	1.0	100
B-62	L-H (01)	(12) Orthic concretionary	4.2"	3.4	14.9	188.6	65.5	2	0	18	0	55	17	0	1	9	0.10	150
B-63	Ah (A1)	brown soil. Developed	3.5"	3.4	22.6	96.1	62.1	2	0	15	0	30	5	0	1	18	0.10	125
B-64	Aej (A2)	on colluvial deposits.	4.5"	3.8	21.7	30.8	4.0	2	0	23	0	51	8	2	4	39	3.00	100
B-65	Bfcc (B)	Same as #11	16.0"	4.6	20.7	42.6	4.5	2	1	135	1	98	2	14	8	220	5.00	125
B-66	C (C)		33.0"	4.9	17.7	32.1	0.8	1	0	190	1	112	1	10	19	450	8.0	125
B-67	R		59.0"	-	-	-	-	-	-	500	3	275	1	7	67	1280	8.0	100
30		Abies montana (Alpine Fir)	-	-	-	-	97.0	-	-	109	0	604	89	3	61	317	2.0	130
31		Tsuga heterophylla (Western Hemlock)	-	-	-	-	97.2	-	-	84	0	315	119	4	14	336	1.50	250
32		Vaccinium membraneceum (Black Mountain Huckleberry)	-	-	-	-	98.7	-	-	30	0	280	170	11	16	150	0.5	275

TABLE A-6

TABLE A-6

Analytical Data for SKEENA SILVER PROPERTY - HIGHLAND VALLEY

PROFILE No. 13 & 14

Profiles 13 & 14

Sample No.	Horizon	Soil Type or Name of Species	Thick-ness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Excha. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-68	L-H (01)	(13) Degraded Brown Wooded	1.5"	5.9	20.5	14.4	34.2	160	120	572	3	115	9	0	3	7	1.0	125
B-69	Ah (A1)	soil developed on	3.0"	6.0	23.8	12.8	9.4	40	36	354	2	170	10	0	4	8	1.5	250
B-70	Aej (A2)	glacial till setting	9.0"	5.7	20.4	5.4	0.3	6	0	318	1	215	8	1	8	20	2.00	250
B-71	Bm (B)	on Skeena granodiorite	13.0"	6.3	8.4	4.9	0.4	16	12	416	6	35	4	3	4	9	4.00	150
B-72	C (C)		25.0"	6.8	29.1	10.6	0.4	160	140	680	1	95	2	2	6	15	2.0	100
B-73	R		52.0"	-	-	-	-	-	-	700	2	390	2	2	4	8	2.0	125
33		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	96.5	-	-	311	34	1646	84	5	6	18	0.3	200
34		Salix caudata (Whiplash Willow)	-	-	-	-	92.8	-	-	109	16	780	8	7	8	12	0.5	250
B-74	L-H (01)	(14) Degraded Brown Wooded	2.0"	5.2	28.0	53.9	31.7	20	0	130	10	128	10	0	3	3	2.0	150
B-75	Ah (A1)	soil. Same as	2.0"	5.9	22.8	13.6	3.3	20	0	92	5	144	7	1	4	8	1.0	125
B-76	Aej (A2)	#13.	9.0"	6.0	33.3	9.6	0.8	16	8	160	1	121	8	2	5	10	2.0	81
B-77	Bm (B)		11.0"	6.3	12.6	11.7	0.5	120	160	766	4	115	1	4	3	6	2.0	100
B-78	C (C)		19.0"	6.6	14.7	11.6	0.5	160	160	786	2	95	4	6	3	7	1.5	100
B-79	R		43.0"	-	-	-	-	-	-	800	2	200	3	3	3	8	2.0	125
35		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.3	-	-	184	11	1760	119	4	6	23	0.2	400
36		Alnus sinuata (Sitka Alder)	-	-	-	-	94.1	-	-	216	77	854	43	9	6	20	0.1	1250
37		Salix caudata (Whiplash Willow)	-	-	-	-	91.1	-	-	112	20	277	23	3	12	21	0.4	200

TABLE A-7

TABLE A-7

Analytical Data for GALORE CREEK PROSPECT

PROFILE No. 15 & 16

Sample No.	Horizon	Soil Type or Name of Species	Thick-ness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-80	L-H (01)	(15) Orthic Acid Brown Wooded	3.0"	4.9	22.7	53.9	25.7	40	32	384	3	175	24	6	4	20	0.9	200
B-81	Ah (A1)	soil. Developed on	2.1"	5.0	42.5	36.5	6.4	60	40	375	3	115	20	10	15	60	3.0	125
B-82	Bfj (B)	glacial till with	13.9"	5.8	38.5	12.2	0.8	60	60	500	3	195	25	8	15	80	3.0	350
B-83	C (C)	underlying bedrock of	12.0"	6.4	23.2	18.8	0.4	120	100	2339	3	520	25	16	20	70	4.0	200
B-84	R	syenite porph. intrus.	27.0"	-	-	-	-	-	-	27000	2	420	13	80	60	24	3.0	70
38		Abies lasiocarpa (Mountain Fir)	-	-	-	-	96.9	-	-	260	2	3534	65	3	10	167	0.5	250
39		Alnus sinuata (Scrab Alder)	-	-	-	-	98.1	-	-	612	109	1224	153	7	43	398	0.2	280
B-85	L-H (01)	(16) Orthic Acid Brown Wooded	2.0"	4.2	36.3	60.8	36.4	36	20	310	6	160	32	3	7	7	4.0	275
B-86	Ah (A1)	soil. Same as	3.5"	4.3	42.4	45.2	12.7	40	20	180	9	100	35	5	7	40	3.0	250
B-87	Bfj (B)	#15.	9.5"	5.0	24.5	11.3	1.2	40	36	462	4	280	24	8	20	60	4.0	125
B-88	C (C)		36.0"	6.7	37.5	10.8	0.4	40	44	398	2	220	16	10	20	150	3.0	100
B-89	R		49.0"	-	-	-	-	-	-	40500	2	325	70	11	60	120	2.0	65
40		Abies lasiocarpa (Mountain Fir)	-	-	-	-	96.7	-	-	400	19	1079	102	4	21	170	0.6	250
41		Vaccinium membraneceum (Black Mountain Huckleberry)	-	-	-	-	93.7	-	-	558	72	666	117	11	8	117	0.2	250

TABLE A-8

TABLE A-8

Analytical Data for PIONEER MINES

PROFILE No. 17 & 18

Sample No.	Horizon	Soil Type or Names of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppb	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-90	L-H (01)	(17) Dark Gray Wooded	2.5"	6.5	44.4	79.1	28.4	12	0	57	0	85	12	19	60	15	0.6	225
B-91	Ah (A1)	Podzolic soil, developed	4.3"	6.8	30.2	27.8	7.2	6	0	31	1	57	7	12	8	7	1.0	100
B-92	Aej (A2)	from glacial drift.	11.2"	6.8	49.7	10.9	0.8	4	0	17	0	55	4	21	7	40	2.0	100
B-93	Bt (B)	Bedrock augite diorite.	18.3"	6.6	24.4	13.9	0.4	6	4	79	3	77	4	270	20	60	3.0	100
B-94	C (C)		31.0"	6.6	22.4	13.4	0.8	8	8	83	0	92	4	65	20	150	3.0	250
B-95	R		65.0"	- -	-	-	-	-	-	400	12	114	4	170	60	40	4.0	150
42		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	96.4	-	-	113	2	948	138	1250	9	73	0.4	200
43		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.7	-	-	290	5	1789	164	19	8	69	0.3	250
B-96	L-H (01)	(18) Dark Gray Wooded	3.7"	6.6	33.9	48.7	18.5	60	0	45	0	155	15	110	5	30	1.0	200
B-97	Ah (A1)	Podzolic soil.	3.5"	7.0	40.5	34.8	5.8	24	0	34	0	104	4	40	8	50	1.5	125
B-98	Aej (A2)	Same as #17	9.0"	6.8	43.2	7.3	0.3	2	0	17	0	65	3	23	9	40	3.0	50
B-99	Btf (B)		19.5"	6.8	41.5	20.8	0.8	12	12	119	3	104	2	400	15	90	4.0	75
B-100	C (C)		27.0"	6.8	32.3	12.9	0.7	4	6	102	0	134	1	175	15	100	4.0	200
B-101	R		59.0"	-	-	-	-	-	-	116	1	139	4	2000	20	40	3.0	100
44		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	96.0	-	-	90	3	443	263	3500	9	53	0.3	200
45		Achillea millefolium (Yarrow)	-	-	-	-	91.9	-	-	101	25	194	36	15	5	29	0.1	1250

TABLE A-9

TABLE A-9

Analytical Data for BRALORNE MINES

PROFILE No. 19 & 20

Sample No.	Horizon	Soil Type to Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-102	L-H (01)	(19) Orthic Brown Forest	2.7"	6.6	30.6	42.5	14.9	16	0	34	0	112	4	12	7	60	1.5	100
B-103	Ah (A1)	soil developed from	5.2"	6.7	49.6	14.3	4.1	8	0	45	0	135	1	10	10	60	2.0	100
B-104	Bf (B)	glacial drifts on augite	11.9"	6.8	46.2	9.9	1.8	2	0	31	6	139	1	18	15	30	2.0	92
B-105	C (C)	diorite with gold-quartz	45.9"	6.7	25.7	13.1	1.6	4	4	90	1	100	2	155	20	90	4.0	200
B-106	R	fissure veins.	63.0"	-	-	-	-	-	-	45	1	69	1	30	19	19	3.5	110
46		Arctostaphylos uva-ursi (Kinnikinnick)	-	-	-	-	91.9	-	-	104	15	1296	36	22	4	14	0.4	300
47		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	98.1	-	-	352	1	414	45	200	5	72	0.5	200
B-107	L-H (01)	(20) Orthic Brown Forest	4.5"	6.7	41.4	70.4	24.3	36	0	37	0	152	7	8	5	30	0.8	68
B-108	Ah (A1)	soil, developed from	4.0"	6.7	49.7	43.5	7.5	24	0	32	1	104	4	8	15	50	2.0	62
B-109	Bf (B)	glacial drift.	7.0"	6.5	36.1	10.9	0.9	2	0	40	0	98	4	20	15	50	3.0	125
B-110	C (C)		23.0"	6.3	30.9	17.4	1.7	4	2	42	1	100	2	85	15	90	3.0	50
B-111	R		34.0"	-	-	-	-	-	-	93	1	69	1	700	19	23	3.0	50
48		Pachystima myrsinites (False Box)	-	-	-	-	91.7	-	-	137	22	270	32	200	5	25	1.0	350
49		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	97.6	-	-	80	3	465	42	400	6	30	0.3	200

Profiles 19 & 20

TABLE A-10

TABLE A-10

Analytical Data for ENDAKO MINES

PROFILE No. 21 & 22

Sample No.	Horizon	Soil Type or Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-112	L-H (01)	(21) Degraded Brown Forest	2.5"	6.8	29.9	75.6	26.5	40	0	18	56	173	9	0	3	5	0.3	250
B-113	Ahj (A1)	soil developed	7.8"	6.9	39.4	50.4	11.3	8	0	19	48	80	8	0	3	4	0.9	100
B-114	Aej (A2)	from glacial drifts	1.1"	6.7	29.2	8.9	1.8	2	0	6	20	53	6	1	3	6	1.5	75
B-115	Bfj (B)	on the Topley	14.1"	6.5	25.7	7.3	0.7	0	0	25	65	88	6	2	4	9	2.0	50
B-116	II-C (C)	Granite.	41.0"	6.7	12.9	6.8	0.8	0	0	44	229	67	8	2	3	5	2.0	75
B-117	R		64.0"	-	-	-	-	-	-	28	176	290	1	1	7	3	2.1	60
50		Populus tremuloides (Trembling Aspen)	-	-	-	-	91.5	-	-	215	373	1373	33	4	4	14	0.4	600
B-118	L-H (01)	(22) Degraded Brown Forest	3.7"	7.2	22.4	53.0	20.1	20	0	40	230	382	6	1	2	3	0.7	275
B-119	Aej (A1)	soil. Same as	4.5"	6.4	22.4	52.1	9.1	20	0	39	253	432	1	1	4	4	1.5	75
B-120	II-Bfj (B)	#21	4.4"	6.3	9.2	27.8	3.5	8	0	21	315	212	4	1	6	8	3.0	75
B-121	II-C (C)		18.1"	6.2	6.4	21.7	1.5	2	0	30	437	174	2	1	5	7	3.0	75
B-122D	R		27.0"	-	-	-	-	-	-	37	288	250	4	2	3	4	2.7	58
51		Populus tremuloides (Trembling Aspen)	-	-	-	-	90.3	-	-	90	240	1290	24	3	5	13	0.2	350

TABLE A-11

Analytical Data for CARMI PROSPECT

PROFILE No. 23 & 24

Sample No.	Horizon	Soil Type or Name of Species	Thickness of Horizon	pH	-80 Mesh %	C.E.C m.e/ /100g	O.M. %	Exch. Heavy Metals ppm	Exch. Copper ppm	Cu ppm	Mo ppm	Zn ppm	Pb ppm	As ppm	Co ppm	Ni ppm	Fe p/o	Hg ppb
B-123	L-H (01)	(23) Orthic Acid Brown Wooded	3.7"	5.2	39.2	114.7	28.7	20	0	28	21	105	41	1	2	4	0.3	125
B-124	Ah (A1)	soil developed from	1.5"	5.4	49.2	38.2	9.1	28	0	7	6	138	18	1	3	6	1.0	75
B-125	Bf (B)	glacial till on grano-	11.7"	6.2	60.6	25.2	1.7	4	0	34	4	176	8	1	5	10	2.0	50
B-126	II-C (C)	diorite gneiss.	46.0"	6.2	35.9	6.4	0.3	4	2	27	2	62	6	1	6	6	3.0	50
52		Larix occidentalis (Western Larch)	-	-	-	-	96.9	-	-	221	19	1152	125	2	4	24	0.15	150
53		Pinus contorta var. latifolia (Lodgepole Pine)	-	-	-	-	97.8	-	-	276	41	2305	193	1	6	43	0.5	250
B-127	L-H (01)	(24) Orthic Acid Brown	5.5"	5.3	24.8	78.2	25.4	40	0	28	58	208	20	1	2	3	0.9	100
B-128	Ah (A1)	Wooded soil developed	2.5"	5.7	57.2	35.6	3.2	28	0	28	83	204	16	1	4	4	1.5	50
B-129	Bf (B)	from two different	20.5"	6.4	48.8	37.4	0.4	4	0	40	23	147	6	1	6	8	3.0	200
B-130	II-C (C)	layers of glacia tills	42.0"	6.0	34.5	7.6	0.1	20	8	64	8	80	9	1	5	7	3.0	50
B-131	R	on granodiorite gneiss.	65.0"	-	-	-	-	-	-	71	248	70	4	1	8	9	2.0	50
54		Larix occidentalis (Western Larch)	-	-	-	-	96.5	-	-	277	34	874	126	2	12	30	0.5	200
55		Pseudotsuga menziesii (Douglas Fir)	-	-	-	-	95.7	-	-	117	35	725	110	7	14	45	0.2	300

TABLE A-12

TABLE A-12

TABLE A-13: Elemental Correlations of Soil Horizons and Plants to Bedrock (Assuming Linear Distributions)

	- Correlation Coefficient - Single					Partial				
Element	L-H	Ah	B	C & II-C	Plants	L-H	Ah	B	C & II-C	Plants
Cu	0.25	0.34	0.06	0.37	.31	-0.26	0.27	-0.32	0.18	0.32
Mo	0.80**	0.82**	0.61**	0.76**	0.53**	-0.59**	0.65**	0.41*	0.26	0.59**
Zn	0.18	0.02	0.01	0.29	0.32	0.24	-0.15	-0.23	0.23	0.13
Pb	0.60**	0.78**	0.67**	0.36	0.06	0.04	0.48*	0.25	-0.33	-0.18
As	0.94**	0.85**	0.79	0.72**	0.94*	0.21	0.14	-0.39	0.06	0.42*
Co	0.43*	0.38	0.71**	0.86**	0.58**	0.28	-0.29	0.21	0.45*	0.55**
Ni	0.01	0.25	0.89**	0.77**	0.70**	0.26	-0.65**	0.80**	0.45*	0.17
Fe	-0.16	0.10	0.43*	0.85**	0.37	-0.41*	-0.17	-0.32	0.92**	0.71**
Hg	-0.11	0.09	0.07	0.38	0.05	0.09	0.08	0.04	0.36	0.03