72-46

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 72-46

REGIONAL, LITHOLOGICAL, AND TEMPORAL VARIATION IN THE ABUNDANCES OF SOME TRACE ELEMENTS IN THE CANADIAN SHIELD

K. E. Eade and W. F. Fahrig

Price, $2.00

1973

[redacted]

CANADA

GEOLOGICAL SURVEY OF CANADA

PAPER 72-46

REGIONAL, LITHOLOGICAL, AND TEMPORAL VARIATION IN THE ABUNDANCES OF SOME TRACE ELEMENTS IN THE CANADIAN SHIELD

(Report, 20 tables and 3 figures)

K. E. Eade and W. F. Fahrig

DEPARTMENT OF ENERGY, MINES AND RESOURCES

Available by mail from *Information Canada*, Ottawa

from the Geological Survey of Canada
601 Booth St., Ottawa

and

Information Canada bookshops in

HALIFAX - 1687 Barrington Street
MONTREAL - 640 St. Catherine Street W.
OTTAWA - 171 Slater Street
TORONTO - 221 Yonge Street
WINNIPEG - 393 Portage Avenue
VANCOUVER - 800 Granville Street

or through your bookseller

Price: $2.00 Catalogue No. M44-72-46

Price subject to change without notice

Information Canada
Ottawa
1973

CONTENTS

Tables

Illustrations

ABSTRACT

Samples of rocks during reconnaissance geological mapping by Geological Survey of Canada field parties have been used to estimate the average abundance of some trace elements in the surface crystalline rocks of the Canadian Shield. The preferred values are as follows, in ppm: Ni, 19; Cu, 26; Zn, 60; Pb, 18; V, 59; Sc, 12; Y, 21; La, 71; Zr, 190.

Regional variations in trace element content of the rocks suggest that Pb is mobile under high grade regional metamorphism but that Ni, Co, Cu, Zn, V, and Sc are relatively immobile and tend to be concentrated in rocks of granulite facies. Ni is more abundant and Pb and Zn less abundant in Archean rocks than in Proterozoic rocks. Rocks of some of the sample areas show higher than average contents of some trace elements, for example, rocks of Fort Enterprise area are high in Ni and Cu and rocks of Battle Harbour - Cartwright are high in Zn.

RÉSUMÉ

Des échantillons de roches ramassés au cours de missions de cartographie géologique de reconnaissance par les équipes de la Commission géologique du Canada ont été utilisés pour évaluer la quantité moyenne d'éléments à l'état de traces à la surface des roches cristallines du Bouclier canadien. Les valeurs rencontrées sont les suivantes, en ppm: Ni, 19; Cu, 26; Zn, 60; Pb, 18; V, 59; Sc, 12; Y, 21; La, 71; Zr, 190.

Les variations régionales dans le contenu des roches en éléments à l'état de traces laissent à entendre que le Pb est mobile dans le cas d'un métamorphisme régional très élevé mais que le Ni, le Co, le Cu, le Zn, le V et le Sc sont relativement immobiles et ont tendance à se concentrer dans des roches à faciès de granulite. Le Ni est plus abondant dans les roches de l'Archéen que dans les roches du Protérozoïque alors que c'est le contraire pour le Pb et le Zn qui sont moins abondants dans les roches de l'Archéen que dans les roches du Protérozoïque. Des roches de certaines des régions d'échantillonnage ont une teneur plus élevée que la moyenne en certains éléments à l'état de traces, par exemple les roches de la région de Fort Enterprise ont une teneur élevée en Ni et en Cu, et les roches de Battle Harbour - Cartwright ont une teneur élevée en Zn.

REGIONAL, LITHOLOGICAL, AND TEMPORAL VARIATION IN THE ABUNDANCES OF SOME TRACE ELEMENTS IN THE CANADIAN SHIELD

INTRODUCTION

In a previous publication (Eade and Fahrig, 1971) concerning the chemical composition of surface crystalline rocks of parts of the Canadian Shield data were presented on the abundance of the major rock-forming elements and of some of the minor elements. The abundances of some additional trace elements in these same rocks and an interpretation of the results are presented in this report.

A detailed discussion of the collection and preparation of the samples and the processing of the results is given in the earlier report. Briefly, rock specimens collected in the course of reconnaissance geological mapping were used to prepare composite samples representing each major rock-type in each unit-area. The number of specimens used in each composite to determine the trace element abundance of each rock-type is listed in Tables 2 to 9, as well as the number of square miles represented by each analysis. As indicated in Figure 1, the investigation involved the study of 26 unit-areas. New Quebec was divided into 15 unit-areas and northern Keewatin into 5. The unit-areas of New Quebec and northern Keewatin were numbered for ease of reference. Each of the 6 remaining map-areas formed a unit-area in the investigation. The average abundance of each element in each unit-area was

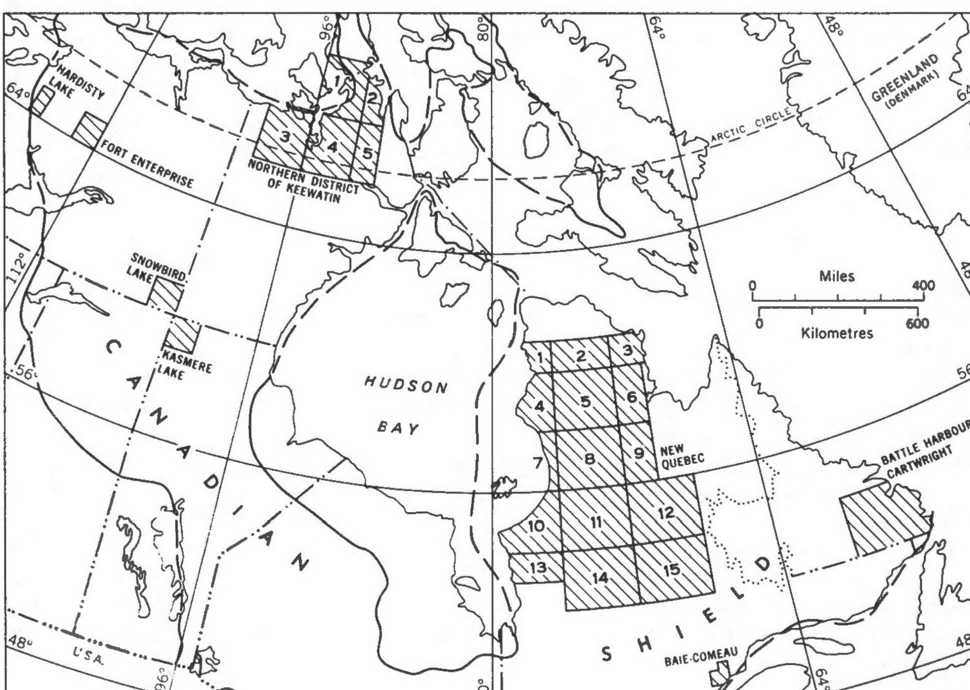

Figure 1. Location map of areas sampled.

Original manuscript submitted: September 29, 1972
Final version approved for publication: October 6, 1972

determined by weighting each rock-type in proportion to its exposed area and overall averages for the map-areas were determined by the same process of weighting according to the size of the unit-areas.

The rock-types of this report are the same as those of the previous report (Eade and Fahrig, 1971) and they are defined in the simplified legend, Table 1. Distribution of the rock-types in each map-area is as shown on the previously published standardized rock distribution maps (Fig. 3 op. cit.). For more detailed information on the geology of the areas the reader is referred to the original published maps and reports.

Pb, Zn, Ag, Ni, Co, and Cu were determined in all samples by the Spectrographic Laboratory of the Geological Survey of Canada (G.S.C.) by quantitative emission spectrographic methods. Results for Pb, Zn, and Ag are expected to be accurate within ±30 per cent of the value reported and Ni, Co, and Cu to be within ±15 per cent of the value reported. It should be noted that Ni was previously determined in all samples and Co in some of the samples (see Eade and Fahrig, op. cit.) using a slightly different laboratory method. The new results are considered to be the more accurate.

Ni, Co, Cu, V, Sc, Y, La, and Zr were determined in samples from New Quebec, Battle Harbour - Cartwright, Baie Comeau, and northern District of Keewatin areas in the Spectroscopic Laboratory of the Bureau of Mineral Resources (B.M.R.), Canberra, Australia. These analyses were carried out by optical emission spectroscopy using a method adapted from Ahrens and Taylor (1961). Both internal and rock standard controls were used. From previous experience with this method for the analysis of similar material, it is estimated that the values given for the elements are within 10 per cent of the true value.

Duplicate results (B.M.R. and G.S.C.) for Ni, Co, and Cu are given for comparison. In general the agreement is good and the few cases where large differences exist may be due to a modification in final sample preparation; the B.M.R. aliquots of the samples were reground to pass 120 mesh sieve and homogenized before analysis.

Although the abundance in crystalline Shield rocks of such economically important elements as Pb, Zn, Ag, Ni, Co, and Cu may not be directly applicable to ore finding, the values give the order of magnitude of abundance of these metals in these parts of the earth's continental crust. The interpretation of the results relative to lithology, age, and metamorphism may provide clues in the continuing search for the concentrations of the elements that constitute economic mineral deposits. The value of knowing the natural abundances of metals in the crust when attempting long-range forecasts of the supply and price of metals is emphasized by Booth (1971).

W.H. Champ and K.A. Church, Spectroscopic Laboratory, Geological Survey of Canada, and K.R. Walker, T.I. Slezak and R.E. Moon of the Spectrographic Laboratory, Bureau of Mineral Resources, Canberra, carried out or assisted with the analytical work. J.A. Fraser, W.W. Heywood, I.M. Stevenson and F.C. Taylor made available specimen collections. Discussion of the results with K.R. Walker and D.F. Sangster assisted us in the interpretation.

THE AVERAGE ABUNDANCE OF TRACE ELEMENTS IN THE SURFACE CRYSTALLINE ROCKS OF THE CANADIAN SHIELD

Three averages were calculated (Tables 11 and 12); one average gives map-areas unit weight (although they are not all the same size); a second was calculated by weighting the average composition of each map-area according to the size of the map-area; and in the third, the average compositions of the map-areas were used to calculate an average for the structural province within which they lie and an overall average was then calculated from the structural province averages by weighting according to the size of the structural province. In determining the average composition of structural provinces (Table 12), in those where only one map-area was studied the average consists of the average composition calculated for that one map-area. For those structural provinces in which two or more areas were studied, an average for the province was calculated by weighting the chemical averages of each map-area according to its size. The last average (Table 12), for reasons discussed in the earlier report (Eade and Fahrig, op. cit.), is considered to be more meaningful than the other two as it takes some account of the crust's systematic geochemical variation with geological time and tectonic history. The Superior Province is represented by only the New Quebec area. Since the New Quebec region is considered to represent a deeper crustal level than that exposed in much of the remainder of the Superior Province, the values may not be truly representative. Other structural provinces are not adequately represented by the sample areas but the values obtained are considered to be suitable for determining a preliminary value of the surface composition of North American Precambrian continental crust. This overall surface crystalline average provides a background with which regional values should be compared.

TRACE ELEMENTS IN SOME MAJOR ROCK-TYPES

The average trace element content of the major rock-types in the areas studied and the weighted overall average in these rock-types is presented in Tables 15 to 20. Published analyses of similar rock-types are included for comparison.

Rock-Type 1: Volcanic and metavolcanic, minor sedimentary and metasedimentary rocks:

Rocks of this type have the highest average contents of Ni, Co, Cu, Zn, and Ag. Distribution of the rock-type is restricted to Fort Enterprise, Snowbird Lake and New Quebec. In New Quebec this rock-type is present in five of the fifteen unit-areas (10, 12, 13, 14, and 15). Ni and Co in areas 10 and 12 of New Quebec are much lower than in the other three unit-areas and the quantity of Zn in this rock-type differs from area to area throughout New Quebec. Cu is low in area 10 and high in area 15 compared to areas 12, 13 and 14. Zn is high in areas 10, 12, and 13 and Pb in areas 10 and 12. High Ag values are present in areas 10, 13, and 14.

The variations in trace element content probably reflect variation in the amount of metasedimentary rocks included with the predominantly metavolcanic type. The Ni and Co values in area 12 suggest some basic and ultrabasic rocks, probably intrusive, have been included with the metavolcanic rocks.

The trace element abundances in rock-type 1 from the Fort Enterprise area are similar to the average values found in this rock-type in New Quebec. Rock-type 1 in Snowbird Lake area contains less of all these elements, but rock-type 4 (amphibolite) has a trace element content very similar to that of rock-type 1 in Fort Enterprise and the average of rock-type 1 for New Quebec. The inclusion of metamorphosed basic intrusive rocks in type 1 in Fort Enterprise and New Quebec areas and their inclusion in type 4 of Snowbird Lake may account for the variation.

The contents of Ni, Co, Cu, and Zn are higher and Pb and Ag contents lower in type 1 than in either the amphibolite facies or epidote-amphibolite facies greenstones of the Yellowknife volcanic belt (Boyle, 1961). The Ni and Co values in particular are markedly higher. The metavolcanic rocks of the Red Lake - Lansdowne House area (Reilly and Shaw, 1967; Holman, 1963) are lower in Ni, Cu, and Zn than the rocks of rock-type 1.

Rock-Type 5: Paragneiss, paraschist; minor amphibolite:

Rocks of this type have the highest average Pb content of any of the major rock-types indicating the preference of the element for sedimentary and metasedimentary rocks. The average Ni content of this rock in northern District of Keewatin is anomalously high, again suggesting that specimens of amphibolite derived from basic intrusive rocks, containing abundant Ni, were included in the composite sample in unit-area 2, one of the two unit-areas of northern District of Keewatin in which rock-type 5 is present. Rock-type 5 in the Fort Enterprise area contains relatively large amounts of Ni.

The Cu content (11 ppm) of this rock in the Baie Comeau area is much lower than that of the other areas which have a range of 36 to 46 ppm and the overall average (44 ppm). This Shield-wide average is double the average Cu value in the metasedimentary rocks of the Red Lake – Lansdowne House area (Reilly and Shaw, 1967). Similarly the Zn in rock-type 5, which ranges from 50 to 85 ppm and has a Shield-wide average of 56 ppm, is much higher than the 30 ppm average Zn reported from metasedimentary rocks of the Red Lake – Lansdowne House area (Holman, 1963).

Rock-Type 6: Undifferentiated gneisses and schists derived from sedimentary and volcanic rocks:

The higher average content of Ni and lower content of Pb in the gneisses and schists of rock-type 6 as compared to 5 is thought due to the notably greater amount of metamorphosed volcanic rocks within this type.

Rock-Type 7: Banded gneisses, migmatites, granitic gneisses: minor amphibolite inclusions:

Rocks of this type generally have very low Ni content the one exception being rocks of Fort Enterprise which are anomalously high in Ni and Cu. Cu in rocks of Fort Enterprise is, for example, more than four times the average content for all other rocks of this type. Cu is also slightly above the average in the Battle Harbour - Cartwright area. This rock-type in the 15 unit-areas of New Quebec exhibits relatively constant Cu values but Zn, Pb, and Ag all vary from unit-area to unit-area. The Battle Harbour - Cartwright area has Zn, Pb, and Ag values much above average values. The high Zn content is probably related to the very high Zn value obtained from the high level granite, unit 10, in this area. The inclusion of some calc-silicate rock specimens in the composite sample of these gneisses may have increased the Zn, Pb, and Ag content.

Rock-Type 9: Massive to slightly foliated deep level granitic rocks:

The content of Ni and Co in rocks of this type is largely below the level of detection by the methods used. The average Cu content in all areas is much above the Cu average for massive granites in the Red Lake - Lansdowne House area (Reilly and Shaw, 1967). Rock-type 9 in Hardisty Lake area and in several unit-areas in New Quebec give particularly high Cu values. The Zn content ranges from 49 to 66 ppm with the exception of that in the Snowbird Lake area (35 ppm). These values are all higher than average granite values given for Zn in Red Lake - Lansdowne House area (27 to 29 ppm) (Holman, 1963).

Rock-Type 10: High level granite, quartz monzonite to monzonite:

This rock-type in the Fort Enterprise area has an anomalously high Ni content and, to a lesser extent, Cu. In all other areas the Ni content of rocks in this unit is below the limits of detection of the analytical method. The Zn content of this rock in the Battle Harbour - Cartwright area (170 ppm) is much greater than the range of 40 to 64 ppm found in this rock-type in all other areas. The Shield-wide average Zn content of rock-type 10 may be exaggerated (81 ppm) because of the inclusion of data from Battle Harbour - Cartwright area.

The Pb content is much below average (13 ppm) in the Fort Enterprise area whereas in unit-area 13 of New Quebec the Pb is abnormally high at 40 ppm. In most other areas Pb values are reasonably consistent, between 20 and 30 ppm.

It is interesting that the Ag content in rock-type 10 of Battle Harbour - Cartwright area is high, as is Zn, yet the Pb value is close to average.

METAMORPHISM AND FRACTIONATION

The sampling of widespread granulite facies rocks in the New Quebec area provided material suitable for an examination of possible fractionating effects of regional metamorphism on trace element distribution. The distribution and character of the granulite rocks and their relationship to adjacent rocks of amphibolite facies have been discussed previously (Eade, et al., 1966; Eade and Fahrig, 1971). Table 14 gives the average abundances of the trace elements in rocks of the amphibolite and granulite facies of each unit-area, and the mean abundance in all amphibolite and in all granulite facies rocks. The mean facies compositions of New Quebec, calculated on the basis of the areal extent of the two facies, do not necessarily indicate whether fractionation of trace elements occurs under conditions of high grade regional metamorphism. It is necessary in examining this question to compare the values for the two facies in the twelve unit-areas where both are present.

The Metallic Elements

There is no sharp contrast in the abundance of Ni in granulite vs. amphibolite facies rocks although our data suggest somewhat larger quantities of Ni in the granulite facies relative to the amphibolite facies. The Geological Survey of Canada analyses show higher Ni values in granulite facies than in the amphibolite facies in six unit-areas, higher values in the amphibolite facies than in the granulite facies in four unit-areas, and in two unit-areas there is no significant difference. Bureau of Mineral Resources analyses show higher Ni values in the granulite facies than in the amphibolite facies in seven of the twelve unit-areas, and six of these correspond with Geological Survey analytical results.

It should be pointed out here that if an element is not mobilized under conditions of high grade metamorphism, its abundance in the granulites will be increased relative to, let us say neighbouring rocks of amphibolite facies, only by the percentage total loss of mobile material from the granulite zone during its elevation to this facies. On the other hand the decrease in the abundance of a mobile element during increased metamorphism may approach 100 per cent and its percentage in the zone of fixation may be very materially increased.

The amount of Co present in most samples is too close to the detection limits of the Geological Survey analysis for the determinations to be significant. The Bureau of Mineral Resources results however indicate enrichment of Co in the granulite rocks relative to rocks of amphibolite facies in six of the twelve unit-areas, with six unit-areas showing no significant difference. There is no significant difference in the average, but as already pointed out the overall average does not necessarily resolve the question of the fractionation of elements under high grade conditions.

An enrichment of Cu in rocks of granulite facies as compared to those of amphibolite facies is indicated by the analyses from both laboratories. This is confirmed by results of both laboratories in eight of twelve unit-areas but in four unit-areas they conflict.

Values for Zn in rocks of the two facies do not have a marked spread but in four of the twelve areas values in rock of granulite facies are higher and in seven areas are virtually the same. This seems to indicate relative enrichment of the element in the granulite facies rocks despite the fact that overall average value for rocks of the two facies show the amphibolite facies very slightly (1 ppm) richer in Zn than is the granulite facies. This results from determining the averages by weighting according to areas.

Pb shows relative enrichment in the amphibolite facies of ten of the twelve unit-areas. In four of the ten areas however the differences are probably too small to be significant but an overall trend does seem to be suggested.

A very pronounced trend of relative enrichment of V in the granulite facies is evident. In some unit-areas the difference is not great but the trend is indicated in eleven of the twelve areas where both rock facies are present.

The amount of Ag present in many of the samples is so close to the detection limit of the analytical method used that no trend can be established for this element.

In summary, in the twelve unit-areas of New Quebec where both granulite facies and amphibolite facies rocks are present, Ni, Co, Cu, Zn, and V seem to be enriched in the granulite facies relative to the amphibolite facies; Pb is enriched in the amphibolite facies relative to the granulite facies; on the basis of present data, no variation is evident for Ag.

Discussion

The results suggest that Pb is mobile under conditions of temperature and pressure accompanying high grade regional metamorphism in New Quebec but that Ni, Co, Cu, Zn, and V are relatively immobile and tend to be relatively concentrated in the granulite facies rocks. The granulite facies rocks in New Quebec are hornblende granulites, i.e. in the lower part of the granulite facies. It is possible that under still higher grade metamorphism, for example in pyroxene granulites, some of the other elements mentioned, in addition to Pb, may become mobile. In this regard, the experimental work of Walker and Buchanan (1969) on metal transport in the gas phase at high temperatures, is of interest. For sulphide minerals reacting with gaseous HCl, they determined an order of mobility of Pb>Zn>Cu. It is possible then that in pyroxene granulite rocks Zn as well as Pb may be depleted. The apparent mobility of Pb, whether in the gas or liquid phase and whatever the mechanism, has economic implications in the zoning of trace element contents under conditions of high grade metamorphism.

The relative enrichment of Pb in amphibolite facies rocks may in part be related to the fractionation of U and Th due to a regional metamorphism (Fahrig, et al., 1967). If fractionation has enriched the amphibolite facies rocks in U and Th, their radioactive decay would result in Pb enrichment as well.

The zinc to lead ratio (Table 14) is consistently higher in the granulite facies rocks with the exception of unit-areas 12 and 14. The plot of the Zn/ Zn+Pb ratio, Figure 2, shows some consistency of trend between the amphibolite and granulite rocks in each unit-area with the exception of the two areas mentioned. The granulite facies rocks in areas 12 and 14 appear to be anomalously high in Pb and it is noteworthy that these same rocks are also high in Ag (Table 14).

The manner of occurrence of the metals enriched in the granulite facies is not known. Wilson (1969) stated that preliminary data showed that high concentrations of Cu, Ni, and other metals are common in orthopyroxene of granulite facies rocks, the metal ions apparently substituting in the lattices of the mineral under high pressure - temperature conditions. In an investigation of the Cu content of biotites from the Boulder Batholith of Montana, Al-Hashimi and Brownlow (1970) found that biotite without sulphide inclusions can accommodate up to 200 ppm Cu. Generally however, much of the Cu in biotites is probably present in fine chalcopyrite inclusions. No data are available on the content or state of Cu in the biotites of rocks of New Quebec. Whether metal ions are present in the granulite rocks as fine sulphide inclusions or as substitutes in the lattices of silicate minerals has some economic bearing because it governs their susceptibility to solution and transport and possible concentration in deposits. Sulphides are relatively stable in "hot water" solutions such as may develop during retrograde metamorphism but silicates are not. However, sulphides are more susceptible than silicates to tectonic (physical) remobilization and concentration. Deformation, in the form of isoclinal folding, the selective remobilization that often accompanies isoclinal folding, and recrystallization, can transform an uneconomic sulphide layer into an economic orebody as pointed out by Sangster (1971).

During retrograde metamorphism of granulite facies rocks, pyroxenes are converted to amphiboles or phyllosilicates and trace element metals are released. They may be either incorporated into new minerals or transported elsewhere to be deposited in favourable locations as concentrations if at some stage sufficient sulphur is available. Wilson (1969) suggested that the "volatiles" for the hydrous minerals formed in retrograde metamorphism are of deep-seated origin and that some mineralization may be derived from this juvenile material although it is likely that the greater part of the metal content is scavenged from the granulites themselves. Saha et al. (1968) suggested that in the case of granitizing solutions passing through rock, the trace elements and the major elements in the granitizing solution would compete for substitution in crystal lattices mainly on the basis of geometry; i.e. ionic size, while bonding properties like ionic charge and electronegativity are less important. In crystallizing melts where major and trace elements compete

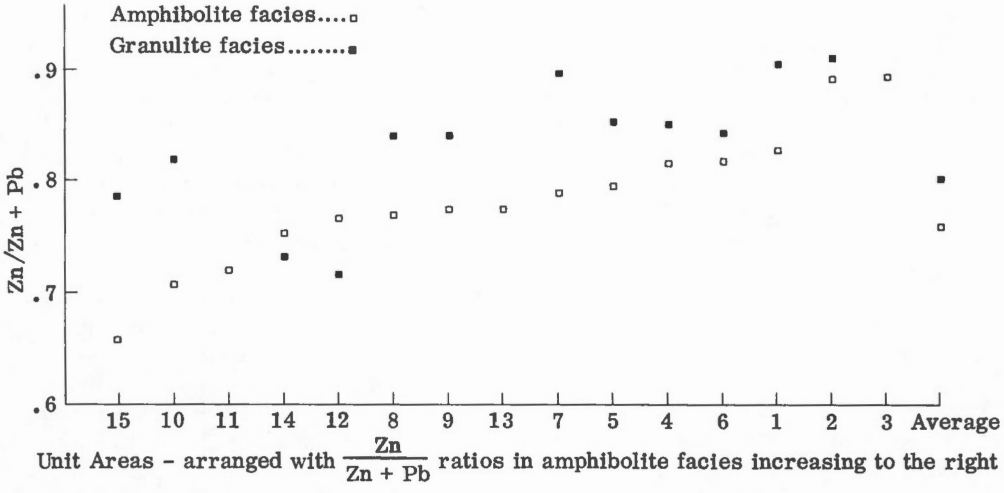

Figure 2. Zn/ Zn + Pb ratios in amphibolite and granulite facies rocks, New Quebec.

to form the growing crystals, ionic charge and electronegativity are more important factors. In the case of the solutions producing retrograde metamorphism, ionic size would be a factor in determining whether substitution of trace elements in the lattices of new-forming minerals or transportation of the elements takes place.

The basification of granulites resulting from the loss by upward movement of more volatile constituents in response to regional metamorphism, may in part account for the depletion of Pb. Potassium is one of the volatile elements that moves from the granulite rocks and as Pb tends to be concentrated in K feldspar, where it substitutes for K, the breakdown of the K feldspar would leave Pb ions more susceptible to transport.

The relative enrichment of vanadium in the granulite rocks as compared to the amphibolite rocks is predictable. Vanadium is geochemically similar to Ti which is concentrated in the granulite facies (Eade and Fahrig, 1971). In general there is a basification of the granulite facies compared to the amphibolite facies and vanadium shows a strong affinity for the more basic rock-forming minerals (Rankhama and Sahama, 1950).

Scandium, Yttrium, Lanthanum, and Zirconium

The abundance of Sc, Y, La, and Zr were determined in the amphibolite and granulite facies rocks of New Quebec (Table 13). Values obtained for Zr show no trend whatever indicating enrichment or depletion during high grade metamorphism. Sc, however, appears to be slightly enriched and Y and La even less so in the granulite facies relative to amphibolite facies rocks.

Although in many respects, scandium resembles thorium chemically (Rankhama and Sahama, 1950), the reactions of the two elements are reversed under conditions of regional metamorphism. The ability of scandium to replace bivalent iron in silicate minerals under certain conditions may account for its relative concentration in the granulite facies rocks of New Quebec with enrichment and concentration of scandium in ferromagnesian minerals in concert with the apparent trend to basification of granulite facies rocks. In the progressive metamorphism of pelitic rocks, Shaw (1954) found a slight trend toward increasing Sc content with increasing metamorphism.

Our data for Y, La, and Zr are equivocal in regard to their reaction to high grade regional metamorphism. Rankhama and Sahama (1950) stated that Y is enriched in the garnets and hypersthene of granulites in Finland and La enriched in the feldspars of the granulites. The data of Shaw (1954) suggest increasing Y content with increasing metamorphism of pelitic rocks.

ABUNDANCES OF ELEMENTS AND EVOLUTION OF THE CANADIAN SHIELD

A progressive change in composition of new non-orogenic material added to the Shield during Precambrian time was suggested in an earlier paper (Fahrig and Eade, 1968). The average abundances of trace elements in the various areas in terms of the ages of the major rock units of which they are composed (Fig. 3) offers some additional data in regard to possible chemical evolution of the Shield. It should be noted that values for V, Sc, Y, La, and Zr are available in only four sample areas, New Quebec, northern District of Keewatin, Battle Harbour - Cartwright, and Baie Comeau. For the other trace elements, Ni, Co, Cu, Zn, Pb, and Ag, two averages have been calculated (Table 13), one the average of those areas composed entirely of Archean rocks, the other an average of those areas that are entirely Proterozoic plus those that are mixed Proterozoic and Archean. These two weighted averages indicate some significant differences. Ni is definitely higher and Pb and Zn significantly lower in the Archean rocks. According to Table 13, Cu too is much higher in the Archean rocks but this is due in large part to the New Quebec average of 32 ppm (G.S.C. analyses). As indicated in Figure 3, the New Quebec average derived from B.M.R. analyses is 23 ppm Cu. The use of this figure would reduce the Archean average (Table 13) to within 20 per cent of the Proterozoic average. As stated previously, determinations of Ag and Co are not regarded as interpretable since the values obtained are at or near the limit of detection of the analytical method.

Many authors have noted the marked concentration of Pb and Zn deposits in Phanerozoic rocks and of Ni deposits in the Archean rocks. Petrascheck (1969) noted a concentration of Pb, Zn, and Cu deposits in the Proterozoic as compared to the Archean. It is however still a moot point whether or not these differences reflect a temporal change in composition of mantle material added to the crust or whether they were caused largely by the evolution of crustal material through migration and concentration of the elements resulting from repeated cycles of orogeny, sedimentation, and palingenesis.

SUMMARY

The problem of discussing data is complicated by differences in the precision and accuracy of methods used to obtain them, by possible inhomogeneity arising from sample preparation, as well as by limited statistical control on sampling procedure. However, the samples are considered to be reasonably broadly representative of the areas outlined although large Shield areas are unrepresented. The samples representing the unit-areas, and the procedures followed in evaluating the data are considered adequate to reliably establish trends of element variations between amphibolite and granulite rocks in the New Quebec areas studied.

Our data indicate the following average abundances for crystalline rocks of the Canadian Shield: Ni-19 ppm, Cu-26 ppm, Zn-60 ppm, and Pb-18 ppm. The abundances of other elements, based on less comprehensive samplings are as follows: V-59 ppm, Sc-12 ppm, Y-21 ppm, La-71 ppm, and Zr-190 ppm. These values differ considerably from the average continental crustal abundances of Taylor (1964) and of Tan and Chi-lung (1970) (see Table 12).

The trace element content of the major rock-types (Tables 15 to 20) show much variation from area to area. Noteworthy are the high Ni, and to a lesser extent, Cu content, in most rock units of the Fort Enterprise area. The gneisses, rock-type 7, in this area contain 130 ppm Cu and the high level granite, rock-type 10, 45 ppm Cu. These high average values in the two most abundant rock-types in the area suggest that it is part of a copper metallogenic province with possible economic potential. Similarly, the high Zn content of the high level granite to monzonite (rock-type 10) in the Battle Harbour - Cartwright area is of some interest.

Comparison of trace element contents in rocks of granulite facies and amphibolite facies in New Quebec suggests relative enrichment of Co, Cu, Zn, V, and Sc and possibly also Ni, La, and Y, in the granulite facies rocks but Pb is relatively enriched in the amphibolite facies rocks.

In considering the possible chemical evolution of the Canadian Shield, our data show higher average Ni content and lower average Pb and Zn content in Archean rocks as compared to Proterozoic and combined Proterozoic and Archean rocks. However, there is no evidence to show whether these differences are due to changes in composition of mantle material added to the crust or if they result from the re-cycling processes of repeated orogeny and sedimentation.

REFERENCES

Ahrens, L.H., and Taylor, S.R.
1961: Spectrochemical analysis, 2nd ed. Addison-Wesley Publishing Company, Inc., Reading, Mass., 545 p.

Al-Hashimi, A.R.K., and Brownlow, A.H.
1970: Copper content of biotites from the Boulder Batholith, Montana; Econ. Geol., v. 65, p. 985-992.

Booth, J.K.B.
1971: The influence of the natural abundance of metals on exploration; Can. Mining Met. Bull., v. 64, p. 128-133.

Boyle, R.W.
1961: The geology, geochemistry and origin of the gold deposits of the Yellowknife district; Geol. Surv. Can., Mem. 310.

Eade, K.E., and Fahrig, W.F.
1971: Geochemical evolutionary trends of continental plates - preliminary study of the Canadian Shield; Geol. Surv. Can., Bull. 179.

Eade, K.E., Fahrig, W.F., and Maxwell, J.A.
1966: Composition of crystalline Shield rocks and fractionating effect of regional metamorphism; Nature, v. 211, p. 1245-1249.

Fahrig, W.F., and Eade, K.E.
1968: The chemical evolution of the Canadian Shield; Can. J. Earth Sci., v. 5, p. 1247-1252.

Fahrig, W.F., Eade, K.E., and Adams, J.A.S.
1967: Abundance of radioactive elements in crystalline Shield rocks; Nature, v. 214, p. 1002-1003.

Holman, R.H.L.
1963: A regional geochemical reconnaissance of bedrock in the Red Lake - Lansdowne House area of Ontario, Canada; in eight papers on regional geochemistry in Canada; Geol. Surv. Can., Paper 63-23, p. 28-39.

Petrascheck, W. E.
1969: Ore metals from the crust or mantle; Econ. Geol., v. 64, p. 576-577.

Rankama, Kalervo, and Sahama, Th.G.
1950: Geochemistry; Univ. Chicago Press, Chicago, 912 p.

Reilly, G. A., and Shaw, D. M.
1967: An estimate of the composition of part of the Canadian Shield; Can. J. Earth Sci., v. 4, p. 725-739.

Saha, A. K., Sankaran, A. V., and Bhattacharyya, T. K.
1968: Trace element distribution in the magmatic and metasomatic granites of Singhbhum region, eastern India; Neves Jahrb Mineral Abh., v. 103, p. 247-270.

Sangster, D. F.
1971: Metamorphism as an ore-forming process; Econ. Geol., v. 66, p. 499-500.

Shaw, D. M.
1954: Trace elements in pelitic rocks; Geol. Soc. Am. Bull., v. 65, p. 1151-1183.

Shaw, D. M., Reilly, G. A., Muysson, J. R., Pattenden, G. E., and Campbell, F. E.
1967: An estimate of the chemical composition of the Canadian Precambrian Shield; Can. J. Earth Sci., v. 4, p. 829-853.

Tan, Lee, and Chi-lung, Yao.
1970: Abundance of chemical elements in the earth's crust and its major tectonic units; Int. Geol. Rev., v. 12, p. 778-786. Translated from Acta Geologica Sinica, v. 45, p. 82-91, 1965.

Taylor, S. R.
1964: The abundance of chemical elements in the continental crust - a new table; Geochim. Cosmochim. Acta, v. 28, p. 1273-1285.

Walker, A. L., and Buchanan, A. S.
1969: Geochemical processes in ore formation, Pt. II, Kinetics of high temperature gas phase metal transport and the relation of the model systems to the natural environment; Econ. Geol., v. 64, p. 923-931.

Wilson, A. F.
1969: The mineral potential of granulite terrains; Austr. Inst. Mining Met. Proc., v. 231, p. 41-46.

Table 1

SIMPLIFIED CLASSIFICATION OF ROCK-TYPES

Rock-Type	
12	Gabbro, diorite, anorthositic gabbro
12a	Ultrabasic rocks, pyroxenite, peridotite, dunite
12b	Gabbro dykes
12c	Gabbro sills
12d	Metagabbro
11	Anorthosite
10	Granite, quartz monzonite to monzonite – high level
9	Granite to granodiorite, foliated to massive, may be porphyritic – deep level
8	Pyroxene-bearing granite to granodiorite gneisses and granulite
7	Banded gneisses, migmatite, granitic gneisses; minor amphibolitic inclusions
7a	Undivided granite and granitic gneiss
7b	Mixed gneisses
6	Undifferentiated gneisses and schists derived from sedimentary and volcanic rocks
5	Paragneiss, paraschist; minor amphibolite
5a	Garnetiferous gneiss
4	Amphibolite, amphibolite gneiss, greenschist; minor sedimentary schists and gneisses
3	Intercalated volcanic and sedimentary rocks
2	Sedimentary and metasedimentary rocks
2a	Conglomerate
2b	Arkose, quartzite, sandstone
2c	Argillite, siltstone, greywacke
2d	Carbonates
1	Volcanic and metavolcanic rocks; minor sedimentary and metasedimentary rocks
1a	Dacite, andesite, basalt, quartz latite
1b	Quartz feldspar porphyry

In the following tables Ni(1), Co(1), Cu(1), Pb, Zn, and Ag were determined in the Spectrographic Laboratory of the Geological Survey of Canada; Ni(2), Co(2), Cu(2), V, Sc, Y, La, and Zr were determined in the Spectroscopic Laboratory of the Bureau of Mineral Resources, Canberra, Australia.

Table 2. Analyses of Rock-types and Average Composition, by Unit-areas, New Quebec

Unit-area 1, New Quebec (NTS 35SW, part)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	47	38	32	14	32	25	57	42	9.0	<.05	11	16	51	185	2947	73
7A	29	32	43	18	43	36	93	41	8.0	<.05	15	16	<50	127	369	9
8	66	35	40	26	40	23	125	42	4.2	<.05	18	19	71	138	256	6
AV A(ALL TYPES)	47	37	33	15	33	26	66	42	8.9	<.05	12	16	52	175	3572	88
AV B(7, 7A)	45	37	33	14	33	26	61	42	8.7	<.05	12	16	48	178		

Unit-area 2, New Quebec (NTS 35SE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
6	77	70	ND	37	58	28	120	62	4.2	<.05	24	42	115	140	100	11
7	36	30	ND	17	42	20	38	38	4.2	<.05	13	19	62	165	5852	133
7A	ND	24	ND	13	39	25	50	46	6.1	<.05	10	15	62	155	1713	32
8	<20	21	<20	15	23	30	62	43	4.1	<.05	10	17	82	133	673	21
9	ND	18	ND	16	65	29	87	24	3.8	<.05	13	17	78	140	1062	21
AV A(ALL TYPES)	24	27	--	15	43	23	48	38	4.5	<.05	12	18	66	158	9400	218
AV B(6, 7, 7A, 9)	25	28	--	15	44	22	47	38	4.5	<.05	13	18	65	160		

Unit-area 3, New Quebec (NTS 25SW, part)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	32	38	<20	18	28	29	71	44	5.4	.05	14	18	<50	105	3430	85
7A	33	30	ND	13	21	18	48	42	4.2	<.05	<10	15	<50	110	934	8
AV A(7, 7A)	32	36	<20	17	27	27	66	44	5.1	.045	12	17	<50	106	4364	93

Unit-area 4, New Quebec (NTS 34NW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
6	ND	66	25	25	76	79	70	54	7.7	<.05	20	22	<50	105	41	1
7	63	42	<20	18	48	24	76	35	7.5	<.05	15	17	50	135	6723	154
7A	36	42	<20	15	41	34	57	36	10	<.05	11	15	<50	125	591	15
8	110	30	ND	17	54	33	86	44	7.5	<.05	15	18	69	150	2033	43
9	29	30	<20	19	41	40	115	47	6.9	<.05	16	21	79	170	151	6
AV A(ALL TYPES)	70	39	<20	18	49	27	78	37	7.6	<.05	15	17	53	138	9539	219
AV B(6, 7, 7A, 9)	60	42	<20	18	47	25	75	35	7.7	<.05	15	17	48	135		

Unit-area 5, New Quebec (NTS 34NE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	29	27	ND	13	42	16	57	71	17	.113	11	18	56	156	10693	237
7A	ND	13	ND	10	170	22	42	69	19	.075	10	20	94	215	701	16
8	30	29	ND	17	27	27	78	65	11	.062	15	20	65	148	4634	103
9	30	28	ND	16	26	29	69	76	19	.11	15	23	85	165	3205	61
12	140	151	ND	43	110	80	160	83	7.7	.18	26	22	60	120	15	4
AV A(ALL TYPES)	28	27	--	14	41	21	63	70	16	.099	13	20	65	158	19248	421
AV B(7, 7A, 9, 12)	21	20	--	10	45	15	45	55	14	.084	9	15	49	122		

Unit-area 6, New Quebec (NTS 24NW, part)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	23	33	ND	14	16	20	52	59	13	<.05	12	18	51	180	4964	70
8	ND	37	ND	17	68	23	66	61	11	<.05	14	20	58	200	3320	59
9	35	35	20	19	31	21	96	69	17	<.05	15	24	105	188	763	11
12	42	58	21	29	34	31	125	74	7.2	.08	26	22	<50	100	64	5
AV A(7, 8, 9, 12)	16	35	<20	16	36	21	61	60	13	.03	13	19	59	187	9111	145
AV B(7, 9, 12)	24	33	<20	15	18	20	58	60	13	.033	12	19	59	180		
12B	64	98	42	62	170	160	270	86	2.0	.07	40	33	64	160		

Unit-area 7, New Quebec (NTS 34SW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	29	16	ND	13	42	20	67	43	11	<.05	11	16	71	163	1485	38
7A	47	32	ND	13	32	17	52	31	6.0	<.05	30	16	<50	133	691	17
8	<20	26	<20	21	250	26	79	43	4.7	<.05	17	20	<50	110	49	5
9	ND	10	ND	10	21	16	47	31	11	<.05	<10	21	168	215	532	12
AV A(ALL TYPES)	28	19	--	13	39	19	60	38	10	<.05	15	17	78	166	2757	72
AV B(7, 7A, 9)	28	19	--	12	35	18	59	38	10	<.05	15	17	77	167		

Unit-area 8, New Quebec (NTS 34SE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	23	20	<20	13	36	20	56	61	18	.072	10	17	92	140	7977	344
7A	ND	13	ND	13	30	22	61	47	17	.055	12	19	61	188	1492	45
8	36	30	<20	17	29	24	79	43	8	<.05	13	18	60	191	3791	197
9	ND	14	ND	11	28	19	59	63	18	<.05	11	16	63	138	6876	179
12	110	100	69	60	80	64	165	46	3.3	<.05	35	23	<50	105	33	27
AV A(ALL TYPES)	<20	19	<20	13	32	21	62	58	16	.046	11	17	74	153	20169	792
AV B(7, 7A, 9, 12)	<20	17	--	12	32	20	58	61	18	.051	11	17	77	144		

Unit-area 9, New Quebec (NTS 24SW, part)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
7	<20	24	ND	13	15	22	56	56	18	.11	11	17	59	140	5094	84
7A	<20	20	ND	11	19	21	53	63	18	.12	<10	18	65	205	922	15
8	<20	35	ND	15	19	28	78	65	12	.10	10	18	56	154	998	20
9	ND	14	ND	<10	13	18	43	73	18	<.05	<10	18	59	150	3023	53
12A	450	780	59	71	12	15	95	60	4.0	.12	24	25	80	100	26	1
AV A(7, 8, 9, 12A)	8.73	24	--	11	15	21	54	63	17	.084	8	17	59	150	10063	173
AV B(7, 9, 12A)	7.64	22	--	10	15	20	51	63	18	.083	8	17	60	150		
12B	310	620	ND	80	74	49	98	39	1.0	<.05	33	32	97	120		2

Unit-area 10, New Quebec (NTS 33NW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
1	48	84	<20	23	29	36	97	100	23	.28	18	19	<50	110	13	12
7	21	28	<20	14	18	19	64	63	25	.15	11	16	<50	133	7955	44
8	140	200	20	23	28	27	60	86	19	.20	14	16	<50	138	1229	13
9	ND	16	ND	<10	11	13	46	57	26	.19	<10	15	56	200	4764	36
AV A (1, 7, 8, 9)	24	39	7.5	12	17	18	58	63	25	.17	9	16	36	156	13961	105
AV B (1, 7, 9)	13	23	6.3	11	15	17	57	61	25	.16	9	16	37	158		
1A	56	77	45	66	57	80	250	94	5.0	.23	39	27	74	130		4
2B	ND	12	ND	<10	ND	10	37	19	10.0	.22	<10	18	<50	280		6
2	ND	16	ND	12	ND	13	20	ND	6.0	.18	<10	30	76	370		9
12A	210	>1000	80	105	31	26	43	32	2.0	.42	12	15	<50	<100		1
12B	24	42	<20	25	38	37	90	130	35	.33	17	18	66	180		2

Unit-area 11, New Quebec (NTS 33NE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
6	46	42	47	41	80	37	183	66	8.0	.070	23	20	<50	120	32	6
7	<20	33	ND	16	29	32	60	68	25	.10	12	17	57	158	7980	103
9	ND	20	ND	13	51	25	65	66	27	.20	11	16	<50	163	13475	128
AV A (6, 7, 9)	4	25	ND	14	43	28	63	67	26	.162	11	16	37	161	21487	237
2B	ND	12	ND	10	8.4	10	46	36	17	<.05	<10	<15	<50	170		4
12B	120	170	43	55	84	74	270	77	5.7	.080	33	23	74	100		7

Unit-area 12, New Quebec (NTS 23NW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
1	620	1000	48	74	66	78	100	87	27	.085	27	24	56	100	47	21
6	63	103	ND	24	43	37	86	52	13	.090	23	20	52	150	931	14
7	57	70	ND	17	24	33	59	50	11	.090	12	17	53	165	8452	72
8	<20	28	ND	12	35	36	54	48	19	.25	10	15	57	120	5674	60
9	ND	23	ND	<10	12	16	44	39	17	<.05	<10	15	52	143	5997	63
AV A(1,6,7,8,9)	30	49	-	13	24	29	55	46	15	.115	10	16	54	146	21101	230
AV B(1,6,7,9)	37	57	-	13	21	27	55	46	14	.065	10	16	53	155		
2B	ND	12	ND	<10	ND	32	14	ND	4.1	<.05	<10	30	96	<100		7
12B	200	710	75	56	170	92	190	60	2.8	<.05	27	20	53	120		8

Unit-area 13, New Quebec (NTS 33SW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
1	85	103	32	35	68	58	139	95	6.2	.25	25	25	<50	125	527	17
5	20	28	ND	<10	33	32	41	43	32	.085	<10	15	<50	<100	1267	8
6	120	190	<20	21	8.8	12	69	62	7.0	.20	14	16	<50	115	38	6
7	<20	26	ND	13	17	16	59	46	11.0	.075	11	<15	<50	130	6136	40
9	35	37	ND	15	23	22	61	54	16	.12	14	<15	<50	145	967	11
10	ND	<10	ND	<10	ND	6	<10	23	40	.11	<10	<15	<50	<100	13	2
AV (1,5,6,7,9,10)	19	33	-	13	23	21	61	49	14	.086	11	10	<50	120	8948	84
2B	ND	13	ND	<10	ND	9	12	ND	2.1	.14	<10	20	84	210		8
12B	66	74	39	47	62	43	230	34	2.0	.085	33	23	<50	130		5

Unit-area 14, New Quebec (NTS 33SE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
1	240	300	51	53	86	68	170	74	8.1	.27	31	23	<50	108	688	44
5	42	45	ND	13	51	25	50	55	21	.055	11	15	<50	118	12522	118
6	100	140	27	36	45	37	148	88	11	.11	27	22	60	120	545	24
7	36	52	ND	14	16	17	44	57	12	.050	10	16	<50	125	5955	70
8	50	71	<20	16	12	13	66	72	26	.14	14	19	50	125	58	1
9	ND	<10	ND	<10	16	15	18	35	26	.090	<10	15	<50	120	1988	21
10	ND	14	ND	<10	24	21	27	50	24	.050	<10	<15	<50	100	792	10
Av A(1,5,6,7,8,9,10)	43	52	-	14	38	23	51	55	19	.064	11	15	<50	119	22548	288
Av B(1,5,6,7,9,10)	43	52	-	14	38	23	51	55	18	.064	11	15	<50	119		
2B	ND	12	ND	<10	ND	11	13	ND	5.0	.10	<10	29	85	100		10
12A	1600	>1000	100	125	34	24	45	44	2.0	.14	15	17	<50	<100		2
12B	70	84	45	47	98	78	180	54	5.0	.090	76	23	<50	140		5

Unit-area 15, New Quebec (NTS 23SW)

Rock-type	Ni(1)	(Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
1	430	860	73	70	140	70	163	63	3.4	<.05	30	23	50	<100	136	21
5	59	93	ND	19	13	19	83	49	13	<.05	13	18	58	157	1168	13
6	120	178	<20	24	34	35	70	60	13	<.05	15	16	<50	123	417	11
7	<20	34	ND	12	18	21	49	39	13	<.05	11	17	<50	142	6998	96
8	<20	32	ND	13	24	24	66	48	13	<.05	12	15	51	143	5830	101
9	ND	14	ND	<10	9.6	13	28	56	46	.54	<10	19	75	245	4180	35
Av A(1,5,6,7,8,9)	16	42	-	12	19	21	53	47	20	.144	10	17	46	159	18279	277
Av B(1,5,6,7,9)	19	46	-	11	17	19	47	46	24	.194	10	18	45	165		
2B	ND	11	ND	<10	ND	9	19	ND	3.2	<.05	<10	24	60	130		25
2D	ND	21	ND	22	ND	14	33	ND	2.0	.090	14	56	195	120		6
5A	<20	19	ND	12	<8	14	78	83	16	<.05	14	20	60	320	349	10
7B	<20	28	ND	15	14	20	70	50	9.2	<.05	13	16	<50	135	1528	38
12A	440	800	42	66	120	89	118	58	3.5	.070	22	16	<50	<100		9
12B	130	175	38	51	73	64	180	70	4.0	.070	29	20	50	<100		7
12C	63	81	46	58	280	206	240	74	5.0	.096	34	26	66	130		21
12D	ND	14	<20	14	9.5	24	74	96	17	.090	24	26	66	300	134	7
Av 15′ Grenville															2011	55
Only (7b,5a,12d)	9	26	-	14	12	19	72	59	11	.029	14	17	34	178		

New Quebec - Averages - All of New Quebec

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr
Average Comp.														
All of N.Q. excluding Grenville	24	35	--	14	32	23	59	55	17	.091	11	17	49	149
All of N.Q. including Grenville	24	35	--	14	32	23	59	55	17	.091	11	17	49	150

Table 3. Analyses of Rock-Types and Average Compositions, Battle Harbour - Cartwright (NTS 13SE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
4	45	62	ND	21	24	23	71	55	8.2	<.05	16	22	68	158	70	18
5	<20	33	<20	20	37	36	107	67	19	.19	19	26	64	260	1148	108
7	ND	16	ND	12	45	33	59	90	35	.34	11	21	77	163	9004	204
9	ND	<10	ND	<10	ND	14	38	60	26	<.05	<10	26	113	655	6506	76
10	ND	16	17	11	29	16	58	170	22	.20	15	21	89	375	1194	69
11	ND	20	ND	13	20	19	37	62	6.5	<.05	16	21	<50	190	2444	52
12	140	230	35	50	56	61	145	61	3.1	<.05	29	19	<50	100	1389	79
Av A(ALL TYPES)	9	28	-	13	28	27	58	79	25	.174	12	23	79	326	21755	606
Av B(4,5,7,9)	-	13	-	10	27	26	54	77	30	.206	9	23	90	361		
Av C(10,11,12)	38	76	14	23	32	30	71	88	9	.067	19	20	40	210		

Table 4. Analyses of Rock-Types and Average Composition, by Unit-Areas, Northern District of Keewatin

Unit-Area 1, Northern District of Keewatin (NTS 57SW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
4	38	42	ND	23	42	39	108	48	8.0	<.05	17	21	43	157	425	18
5	52	48	ND	19	50	26	92	93	14	<.05	14	17	53	137	187	4
6	23	25	<20	14	51	10	67	45	7.0	<.05	15	21	<50	197	205	6
7	ND	16	ND	13	9.3	13	51	53	20	<.05	12	23	89	180	2452	48
9	ND	13	ND	<10	8.7	15	50	54	17	<.05	11	19	85	203	909	11
12	<20	122	39	115	96	145	1000	67	1.5	.07	59	34	85	100		2
12B	74	50	88	66	190	250	170	63	5.9	.18	44	97	260	390		1
Av A(4,5,6,7,9)	-	20	-	13	16	17	59	54	17	<.05	13	22	79	182	4178	87

Unit-Area 2, Northern District of Keewatin (NTS 57SE, W½)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
2B	ND	30	ND	20	ND	17	34	35	4.3	<.05	16	30	120	150	8	5
4	42	58	<20	32	200	210	130	59	5.9	.30	26	28	82	163	384	4
5	140	120	ND	29	41	19	127	79	13	<.05	22	32	145	190	691	12
6	190	80	ND	23	46	50	92	60	14	.07	18	23	82	155	745	21
7	ND	20	ND	13	21	18	55	55	31	.080	11	20	80	163	3456	29
9	31	43	ND	16	8.3	14	92	96	45	.28	14	16	65	165	230	2
12	60	78	43	63	46	51	700	82	5.8	.13	45	32	<50	110		1
12B	23	26	35	43	32	33	200	95	19	.065	31	35	140	290		2
Av A(2B,4,5,6,7,9)	47	44	-	18	39	35	76	61	25	.095	14	22	88	165	5514	73

Unit-Area 3, Northern District of Keewatin (NTS 66NE)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
2	ND	17	ND	<10	11	17	21	15	5.9	<.05	<10	20	55	155	148	8
4	ND	13	ND	13	ND	11	63	54	14	<.05	14	16	<50	133	307	6
6	ND	24	ND	18	19	20	105	45	11	<.05	16	22	73	188	3098	70
7	ND	17	ND	13	17	17	61	42	11	<.05	13	19	58	200	5752	106
9	ND	11	ND	11	<8	14	52	38	12	<.05	14	22	107	230	2189	38
12	46	49	40	54	110	95	325	48	4.0	<.05	27	28	78	198	26	7
Av A(2,4,6,7,9)	-	18	-	14	15	17	71	42	11	<.05	14	20	70	200		

Unit-Area 4, Northern District of Keewatin (NTS 56NW)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
2	ND	12	ND	<10	23	6	12	ND	2.1	.13	<10	21	68	198	1	1
2B	ND	17	ND	11	10	50	28	52	13	.10	<10	48	88	150	8	6
3	<20	27	ND	20	12	21	69	59	19	.085	17	41	110	220	371	58
4	88	108	ND	22	27	25	81	88	14	.10	16	22	55	135	2094	83
7	<20	21	ND	15	16	60	51	72	24	.090	14	27	101	185	9876	172
9	<20	24	ND	11	<8	12	40	62	22	.050	11	19	<50	110	1633	35
12A	75	>1000	45	76	32	49	77	130	2.0	.080	26	95	220	230		22
12B	ND	47	ND	47	150	138	225	80	6.2	.050	27	41	97	230		2
Av A(2,2B,3,4,7,9)	22	35	-	16	16	48	55	73	22	.087	14	26	85	170		

Unit-Area 5, Northern District of Keewatin (NTS 56NE, W½)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
2B	ND	77	ND	20	<8	22	70	36	16	.12	14	20	56	160	16	6
4	45	14	ND	12	19	14	14	65	13	<.05	<10	26	78	143	2104	93
7	ND	17	ND	11	11	13	43	59	21	<.05	<10	18	87	165	4291	75
9	ND	10	ND	11	14	14	27	56	28	<.05	<10	23	115	395	525	16
12A	880	>1000	66	106	41	43	108	93	2.0	.080	26	47	105	125		18
12B	280	650	49	63	150	150	180	95	7.1	.075	33	47	110	250		6
Av A(2B,4,7,9)	14	16	-	11	14	13	33	61	19	.025	5	21	86	176	6936	190

Average Compositions, all of Northern District of Keewatin

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr
Average, All rocks	16	27	-	14	17	29	59	59	19	.055	12	23	81	179

Table 5. Analyses of Rock-types and Average Composition, Fort Enterprise (NTS 86A)

Rock-type	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag	Sq. Miles	No. Specs.
1	200	50	46	74	6.3	.080	104	12
2A	62	26	70	110	7.5	.090	21	1
5	55	ND	42	79	15	.060	209	12
7	95	ND	130	71	12	.080	1926	57
10	74	ND	45	64	13	<.05	1750	34
Av A (ALL TYPES)	86	—	86	69	12	.055	4010	116

Table 6. Analyses of Rock-types and Average Composition, Snowbird Lake (NTS 65D)

Rock-type	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag	Sq. Miles	No. Specs.
1	87	50	57	52	3.0	< .05	256	19
1A	ND	ND	18	27	4.7	< .05	3	2
2	50	32	62	70	9.4	.060	424	14
2A	< 20	< 20	60	80	25	< .05	4	1
2B	34	44	25	34	1.2	< .05	106	23
3	68	< 20	56	43	2.8	< .05	139	7
4	180	37	90	65	2.9	< .05	29	22
5	ND	ND	36	50	12	< .05	1026	27
7	ND	ND	32	50	11	< .05	1074	27
9	ND	ND	< 8	35	16	< .05	734	18
12	56	37	260	48	6.9	< .05	47	13
Av A (ALL TYPES)	17	8	37	49	11	.025	3842	173
Av B (1,2,3,4,5, 7,9,12)	17	8	37	49	11	.025	3729	147

Table 7. Analyses of Rock-types and Average Composition, Kasmere Lake (NTS 64N)

Rock-type	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag	Sq. Miles	No. Specs.
2B	ND	ND	18	38	13	< .05	234	35
2C	24	ND	31	43	6.5	< .05	195	29
2D	ND	ND	39	23	2.5	< .05	16	10
5	< 20	ND	46	55	12	< .05	114	83
7	ND	ND	22	47	15	< .05	809	193
9	ND	ND	21	54	16	< .05	933	114
10	ND	ND	ND	43	23	< .05	912	78
Av A (ALL TYPES)	--	--	17	47	17	.025	3213	542

Table 8. Analyses of Rock-types and Average Composition, Hardisty Lake (NTS 86C, W½)

Rock-type	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag	Sq. Miles	No. Specs.
1B	ND	ND	82	56	24	.080	157	14
6	77	ND	51	83	17	.05	2	2
9	ND	ND	37	49	17	< .05	1111	72
10	ND	ND	18	40	26	< .05	344	20
Av A (1B,6,9,10)	--	--	37	48	20	.030	1614	108
2	ND	ND	16	ND	5.8	< .05		

Table 9. Analyses of Rock-Types and Average Composition, Baie Comeau (NTS 22F, part)

Rock-type	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr	Sq. Miles	No. Specs.
5	ND	16	ND	11	11	23	57	55	12	<.05	10	23	73	245	273	19
7	ND	16	ND	<10	23	13	45	72	16	<.05	10	29	85	340	966	67
8	ND	<10	29	32	14	17	150	150	6.3	.07	19	47	124	180	48	1
9	ND	10	ND	<10	10	12	39	60	17	<.05	10	25	57	355	199	9
10	ND	<10	ND	<10	ND	6	<10	62	30	<.05	<10	79	260	295	35	1
11	110	128	29	34	110	105	95	54	6.3	<.05	18	16	<50	<100	65	4
12	180	310	58	70	32	31	87	57	1.2	<.05	25	22	50	<100	15	2
Av A (ALL TYPES)	6	22	3	9	22	18	51	69	15	.026	11	29	82	305	1601	103
Av B (5,7,9,10)	-	15	-	6	18	15	46	67	16	.025	10	29	83	323		
Av C (11,12)	123	161	34	41	96	91	94	55	5	.025	19	17	30	50		

Table 10. Summary of Average Compositions, Tables 2 to 9

Sample Area	Unit-Area	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr
New Quebec'	1	47	37	33	15	33	26	66	42	8.9	<.05	12	16	52	175
	2	24	27	--	15	43	23	48	38	4.5	<.05	12	18	66	158
	3	32	36	<20	17	27	27	66	44	5.1	.045	12	17	<50	106
	4	70	39	<20	18	49	27	78	37	7.6	<.05	15	17	53	138
	5	28	27	--	14	--	21	63	70	16	.099	13	20	65	158
	6	16	35	<20	16	36	21	61	60	13	.030	13	19	59	187
	7	28	19	--	13	39	19	60	38	10	<.05	15	17	78	166
	8	<20	19	<20	13	32	21	62	58	16	.046	11	17	74	153
	9	9	24	--	11	15	21	54	63	17	.084	8	17	59	150
	10	24	39	7.5	12	17	18	58	63	25	.17	9	16	36	156
	11	4	25	--	14	43	28	63	67	26	.162	11	16	37	161
	12	30	49	--	13	24	29	55	46	15	.115	10	16	54	146
	13	19	33	--	13	23	21	61	49	14	.086	11	10	<50	120
	14	43	52	--	14	38	23	51	55	19	.064	11	15	<50	119
	15	16	42	--	12	19	21	53	47	20	.144	10	17	46	159
New Quebec excluding Grenville		24	35	--	14	32	23	59	55	17	.091	11	17	49	149
Grenville 15'		9	26	--	14	12	19	72	59	11	.029	14	17	34	178
New Quebec including Grenville		24	35	--	14	32	23	59	55	17	.091	11	17	49	150

Table 10. Summary of Average Compositions, Tables 2 to 9 (cont.)

Sample Area	Unit-Area	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Zn	Pb	Ag	Sc	Y	La	Zr
Northern District of Keewatin	1	--	20	--	13	16	17	59	54	17	<.05	13	22	79	182
	2	47	44	--	18	39	35	76	61	25	.095	14	22	88	165
	3	--	18	--	14	15	17	71	42	11	<.05	14	20	70	200
	4	22	35	--	16	16	48	55	73	22	.087	14	26	85	170
	5	14	16	--	11	14	13	33	61	19	.025	5	21	86	176
Northern District of Keewatin Average		16	27	--	14	17	29	59	59	19	.055	12	23	81	179
Hardisty Lake		--		--		37			48	20	.030				
Fort Enterprise		86		--		86			69	12	.055				
Snowbird Lake		17		8		37			49	11	.025				
Kasmere Lake		2		--		17			47	17	.025				
Baie Comeau		6	22	3	9	22	18	51	69	15	.026	11	29	82	305
Battle Harbour-Cartwright		9	28	--	13	28	27	58	79	25	.174	12	23	79	326
Red Lake-Lansdowne House (Reilly and Shaw, 1967 *Holman, 1963)						17			31*			<8	<30		58

Table 11. Average Abundances of Elements in Crystalline Rocks of the Canadian Shield

Unit	Ni(1)		Co(1)		Cu(1)		Zn		Pb		Ag
Average weighted as to size of eight sample areas	22		--		30		58		18		.089
Average all eight areas weighted equally	20		--		34		59		17		.060
Unit	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Sc	Y	La	Zr
Average weighted as to size of four sample areas (New Quebec, Battle Harbour-Cartwright, Baie Comeau, Northern District of Keewatin)	22	33	--	14	29	24	59	11	18	57	170
Average all four areas weighted equally	14	28	--	12	25	24	57	11	23	73	240
Unit	Ni		Co		Cu		V			Zr	
Average, Shaw et al., (1967)	23		21		14		53			400	

Table 12. Average Abundance of Elements in Crystalline Rocks of the Canadian Shield, by Structural Provinces, and Overall Average Abundance, Weighted According to Size of Structural Province

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Bear Province (Hardisty Lake)	--	--	37	48	20	.030
Slave Province (Fort Enterprise)	86	--	86	69	12	.055
Churchill Province (Snowbird Lake Kasmere Lake, Northern Keewatin)	15	--	19	57	18	.051
Superior Province (New Quebec, part)	24	--	32	55	17	.091
Grenville Province (Battle Harbour-Cartwright, Baie-Comeau, New Quebec, part)	9	3	26	76	24	.153
Average, Canadian Shield, weighted according to size of structural province	19	2	26	60	18	.076
Abundance in continental crust (Taylor, 1964)	75	25	55	70	12.5	.07
Abundance in continental crust (Tan and Chi-Lung, 1970)	61	18	50	81	13	.065
Canadian Shield, estimate (Shaw et al., 1967)	23	21	14			

Table 12. Average Abundance of Elements in Crystalline Rocks of the Canadian Shield, by Structural Provinces, and Overall Average Abundance, Weighted According to Size of Structural Province (continued)

	Ni(1)	Ni(2)	Co(1)	Co(2)	Cu(1)	Cu(2)	V	Sc	Y	La	Zr
Churchill Province (Northern Keewatin)	16	27	--	14	17	29	59	12	23	81	179
Superior Province (New Quebec, part)	29	35	--	14	32	23	59	12	17	58	150
Grenville Province (Battle Harbour-Cartwright, Baie-Comeau, New Quebec, part)	9	27	3	13	26	26	59	12	23	77	313
Average (weighted according to size of structural province)	18	29	2	14	23	27	59	12	21	71	190
Abundance in continental crust (Taylor, 1964)	75		25		55		135	22	33	30	165
Abundance in continental crust (Tan and Chi-Lung, 1970)	61		18		50		120	17	27	39	140
Canadian Shield estimate (Shaw et al., 1967)	23		21		14		53				200

Table 13. Average Composition of Archean and Proterozoic Rocks

	PROTEROZOIC		MIXED PROTEROZOIC AND ARCHEAN				ARCHEAN		Proterozoic Average (Weighted average of 1,2,3,4,5,6)	Archean Average (Weighted average of 7,8)
	(1) Hardisty Lake	(2) Baie Comeau	(3) Kasmere Lake	(4)* Battle Harbour-Cartwright	(5) Northern District Keewatin	(6) Snowbird Lake	(7) Fort Enterprise	(8) New Quebec		
Ni(1)	--	6	2	1	16	17	86	24	11	26
Co(1)	--	--	--	--	--	8	--	--	--	--
Cu(1)	37	22	17	27	17	37	86	32	20	33
Zn	48	69	47	77	59	49	69	55	63	55
Pb	20	15	17	30	19	11	12	17	21	17
Ag	.030	.026	.025	.206	.055	.025	.055	.091	.095	.091

*Does not include anorthosite and related rocks.

Table 14. Composition of Amphibolite Facies (a) and Granulite Facies (g) Rocks, by Unit-areas (1 to 15) New Quebec

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
Ni(1)	a	45	25	32	60	21	24	28	<20	8	13	4	37	19	43	19	23
	g	66	<20		110	30	ND	<20	36	<20	140		<20		50	<20	29
Ni(2)	a	37	28	36	42	20	33	19	17	22	23	25	57	33	52	46	34
	g	35	21		30	29	37	26	30	35	200		28		71	32	38
Co(1)	a	33	--	<20	<20	--	<20	--	--	--	6	--	--	--	--	--	--
	g	40	<20		ND	ND	ND	<20	<20	ND	20		ND		<20	ND	--
Co(2)	a	14	15	17	18	10	15	12	12	10	11	14	13	13	14	11	13
	g	26	15		17	17	17	21	17	15	23		12		16	13	15
Cu(1)	a	33	44	27	47	45	18	35	32	15	15	43	21	23	38	17	31
	g	40	23		54	27	68	250	29	19	28		35		12	24	35
Cu(2)	a	26	22	27	25	15	20	18	20	20	17	28	27	21	23	19	22
	g	23	30		33	27	23	26	24	28	27		36		13	24	28
V	a	61	47	66	75	45	58	59	58	51	57	63	55	61	51	47	56
	g	125	62		86	78	66	79	79	78	60		54		66	66	69
Zn	a	42	38	44	35	55	60	38	61	63	61	67	46	49	55	46	54
	g	42	43		44	65	61	43	43	65	86		48		72	48	53
Pb	a	8.7	4.5	5.1	7.7	14	13	10	18	18	25	26	14	14	18	24	17
	g	4.2	4.1		7.5	11	11	4.7	8	12	19		19		26	13	13
Ag	a	<.05	<.05	.045	<.05	.084	.033	<.05	.051	.083	.16	.162	.065	.086	.064	.194	.089
	g	<.05	<.05		<.05	.062	<.05	<.05	<.05	.10	.20		.25		.14	<.05	.088
Sc	a	12	13	12	15	9	12	15	11	8	9	11	10	12	11	10	11
	g	18	10		15	15	14	17	13	10	14		10		14	12	13
Y	a	16	18	17	17	15	19	17	17	17	16	16	16	10	15	18	16
	g	19	17		18	20	20	20	18	18	16		15		19	15	17
La	a	48	65	<50	48	49	59	77	77	60	37	37	53	<50	<50	45	46
	g	71	82		69	65	58	<50	60	56	<50		57		50	51	58
Zr	a	178	160	106	135	122	180	167	144	150	158	161	155	120	119	165	145
	g	138	133		150	148	200	110	191	154	138		120		125	143	153
Zn/Pb	a	4.8	8.4	8.6	4.5	3.9	4.6	3.8	3.4	3.5	2.4	2.6	3.3	3.5	3.1	1.9	3.2
	g	10	10.5		5.9	5.9	5.5	9.1	5.4	5.4	4.5		2.5		2.8	3.7	4.1

Table 15. Average Composition of Rocks of Rock-type 1

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Average, Type 1, New Quebec	211	46	83	81	8	.233
Type 1, Fort Enterprise	200	50	46	74	63	.080
Type 1, Snowbird Lake	87	50	57	52	3.0	<.05
Average, All Rock-type 1	192	46	77	77	7	.194
	Ni	Co	Cu	Zn	Pb	Ag
Amphibolite facies greenstone Yellowknife Belt; (Boyle, 1961)	50-100	5-10	20-100	10-80	10-20	0.6-1.4
Epidote-amphibolite facies greenstone, Yellowknife Belt; op. cit.	50-100	5-10	20-120	10-100	5-15	0.3-1.2
Metavolcanic rocks, Red Lake-Lansdowne House; (Reilly and Shaw, 1967; *Holman, 1963)	91	47	48	35*		

Table 16. Average Composition of Rocks of Rock-type 5

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Average, Type 5, New Quebec	42	—	46	53	21	.055
Type 5, Battle Harbour-Cartwright	<20	<20	37	67	19	.19
Average, Type 5, Keewatin	121	—	43	82	13	.025
Type 5, Fort Enterprise	55	—	42	79	15	.060
Type 5, Snowbird Lake	—	—	36	50	12	<.05
Type 5, Kasmere Lake	<20	—	46	55	12	<.05
Type 5, Baie Comeau	—	—	11	55	12	<.05
Average, All Rock-type 5	41	—	44	56	20	.060
	Ni	Co	Cu	Zn		
Average metasedimentary rocks, Red Lake - Lansdowne House; (Reilly and Shaw, 1967; *Holman, 1963)	38	16	22	33*		

Table 17. Average Composition of Rocks of Rock-type 6

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Average, Type 6, New Quebec	84	10	43	64	12	.080
Average, Type 6, Northern Keewatin	36	--	26	48	11	.033
Type 6, Hardisty Lake	77	--	51	83	17	.05
Average, All Rock-type 6	53	--	32	53	11	.049

Table 18. Average Composition of Rocks of Rock-type 7.

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Average, Type 7, New Quebec	29	4	28	54	14	.073
Type 7, Battle Harbour-Cartwright	--	-	45	90	35	.340
Average, Type 7, Keewatin	4	-	15	59	21	.057
Type 7, Fort Enterprise	95	-	130	71	12	.080
Type 7, Snowbird Lake	--	-	32	50	11	<.05
Type 7, Kasmere Lake	--	-	22	47	15	<.05
Type 7, Baie Comeau	--	-	23	72	16	<.05
Average, All Rock-type 7	22	-	28	58	17	.087
	Ni	Co	Cu	Zn		
Paragneiss, lit-par-lit gneiss, migmatite, mixed rock, hybrid granitic rocks with amphibolitic inclusions, Red Lake - Lansdowne House; (Reilly and Shaw, 1967; *Holman, 1963)	14	9.4	22	30*		

Table 19. Average Composition of Rocks of Rock-type 9

	Ni(1)	Co(1)	Cu(1)	Zn	Pb	Ag
Average, Type 9, New Quebec	3	-	28	59	24	.148
Type 9, Battle Harbour-Cartwright	-	-	—	60	26	<.05
Average, Type 9, Keewatin	4	-	6	52	19	.043
Type 9, Snowbird Lake	-	-	<8	35	16	<.05
Type 9, Kasmere Lake	-	-	21	54	16	<.05
Type 9, Hardisty Lake	-	-	37	49	17	<.05
Type 9, Baie Comeau	-	-	10	60	17	<.05
Average, All Rock-type 9	3	-	23	58	23	.120
	Ni	Co	Cu	Zn		
Foliated granodiorite, Red Lake - Lansdowne House; (Reilly and Shaw, 1967; *Holman, 1963)	8.7	5.2	13	25-27*		
Massive to slightly foliated granite, includes undivided granite rocks, Red Lake - Lansdowne House; op. cit.	3.5	4.2	8.5	29*		

Table 20. Average Composition of Rocks of Rock-type 10

	Ni(1)	Co(2)	Cu(1)	Zn	Pb	Ag
Average, Type 10, New Quebec	--	--	24	50	24	.051
Type 10, Battle Harbour-Cartwright	--	17	29	170	22	.20
Type 10, Fort Enterprise	74	--	45	64	13	<.05
Type 10, Kasmere Lake	--	--	--	43	23	<.05
Type 10, Hardisty Lake	--	--	18	40	26	<.05
Type 10, Baie Comeau	--	--	--	62	30	<.05
Average, All Rock-type 10	26	4	27	81	20	.071
	Ni	Co	Cu	Zn	Pb	Ag
Leucocratic pink and white massive granite, Red Lake - Lansdowne House; (Reilly and Shaw, 1967; *Holman, 1963)	3.3	<1	4.0	27*		
Massive porphyritic granite (phenocrysts of potash feld-spar) Red Lake - Lansdowne House; op. cit.	5.0	5.3	10	32*		
Prosperous Lake Granite, Yellowknife District (Boyle, 1961)	5-10	<10	10-40	10-40	10-30	0.3-1.4