MINK NARROWS COPPER DEPOSIT
LAKE ATHAPAPUSKOW - MANITOBA

A Thesis

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ABSTRACT

The Mink Narrows copper deposit of Copper Reef Mines (1973) Ltd., is one of several massive sulphide deposits in the Flin Flon region, northern Manitoba. It outcrops on a small reef off the north shore of Lake Athapapuskow, 14 miles southeast of Flin Flon.

The vertical sheet-like deposit occurs in basic metavolcanic rocks of the Amisk Group and is approximately parallel to the contact of a nearby granodioritic intrusion.

The host rocks have been recrystallized and later affected by minor retrograde metamorphism. Adjacent to the intrusion, the metavolcanics have been fractured. An alteration zone of sericite, chlorite, carbonate and quartz is associated with the deposit.

Pyrite, pyrrhotite, chalcopyrite and sphalerite, are the major metallic minerals within the deposit and are present as both massive and disseminated sulphides. Consistent zonation of copper and zinc is not present within the deposit, however zoning occurs in several of the hole intersections.

Metamorphism of the sulphides is indicated by their recrystallization, replacement and cataclastic features.

Two main genetic possibilities exist for the deposit, either emplacement by hydrothermal fluids from the granodiorite intrusion, or by activities related to the volcanism.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

APPENDICES

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OBJECTIVES

The character of the Mink Narrows copper deposit is somewhat exceptional in the Flin Flon region of northern Manitoba. It is the only deposit that is located adjacent to a granitic intrusion and one of several located in basic metavolcanic rocks.

The primary objective of the thesis is to describe the geology of the rocks containing the deposit, the mineralization and the distribution of the metallic minerals within the deposit.

Having established a reasonably sound descriptive background of the deposit, the genetic possibilities of the mineralization are considered.

INTRODUCTION

The Mink Narrows copper deposit is one of several massive sulphide bodies in the Flin Flon region of Manitoba. It is located 14 miles southeast of Flin Flon and outcrops on a small, partially submerged reef amongst a group of islands near the north shore of Lake Athapapuskow (Figs. 1 & 2).

The sheet-like deposit occurs in basic metavolcanic rocks adjacent to a granodioritic intrusion. Several of the earlier drill holes show that the tabular deposit is approximately parallel to the contact of the intrusion, ranging from 10 feet to over 150 feet from the contact.

The mineralization of the deposit consists of chalcopyrite and sphalerite associated with pyrite and pyrrhotite.

Table 1 gives some characteristics of the neighbouring copper-zinc deposits in the region.

PREVIOUS WORK

Regional Geological Mapping

The region in which the deposit is located has been mapped several times by members of the Geological Survey of Canada. Bruce (1918), first mapped the Flin Flon area and established a system of stratigraphic nomenclature which has been only moderately altered to this day. Buckham (1944), has fairly accurately mapped the general area around the deposit.

Plate 1 View looking southeast showing the reef outcrop of the Mink Narrows copper deposit.

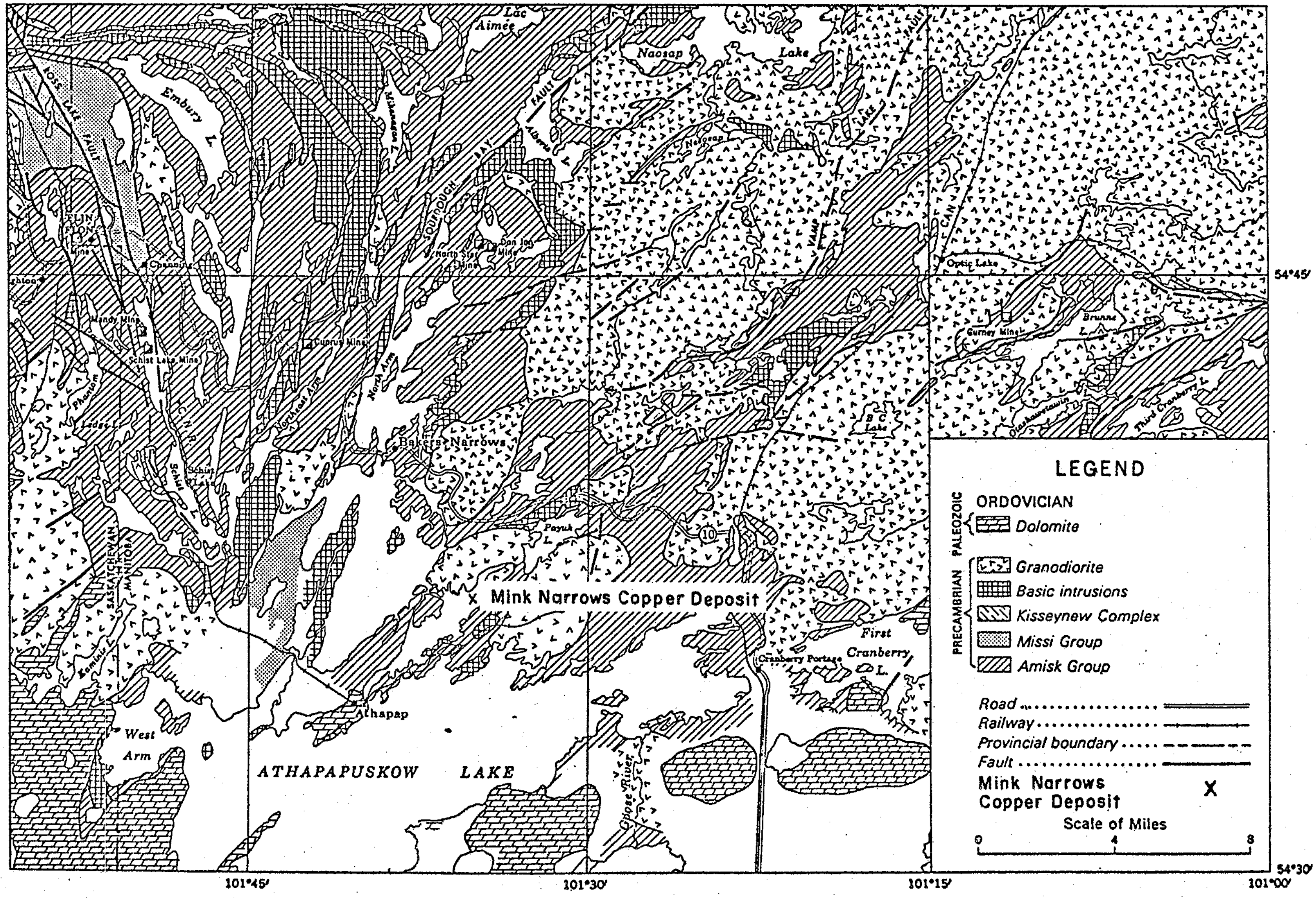

Fig. 1 Geology of Flin Flon Region (After Froese, 1968) and location of Mink Narrows copper deposit.

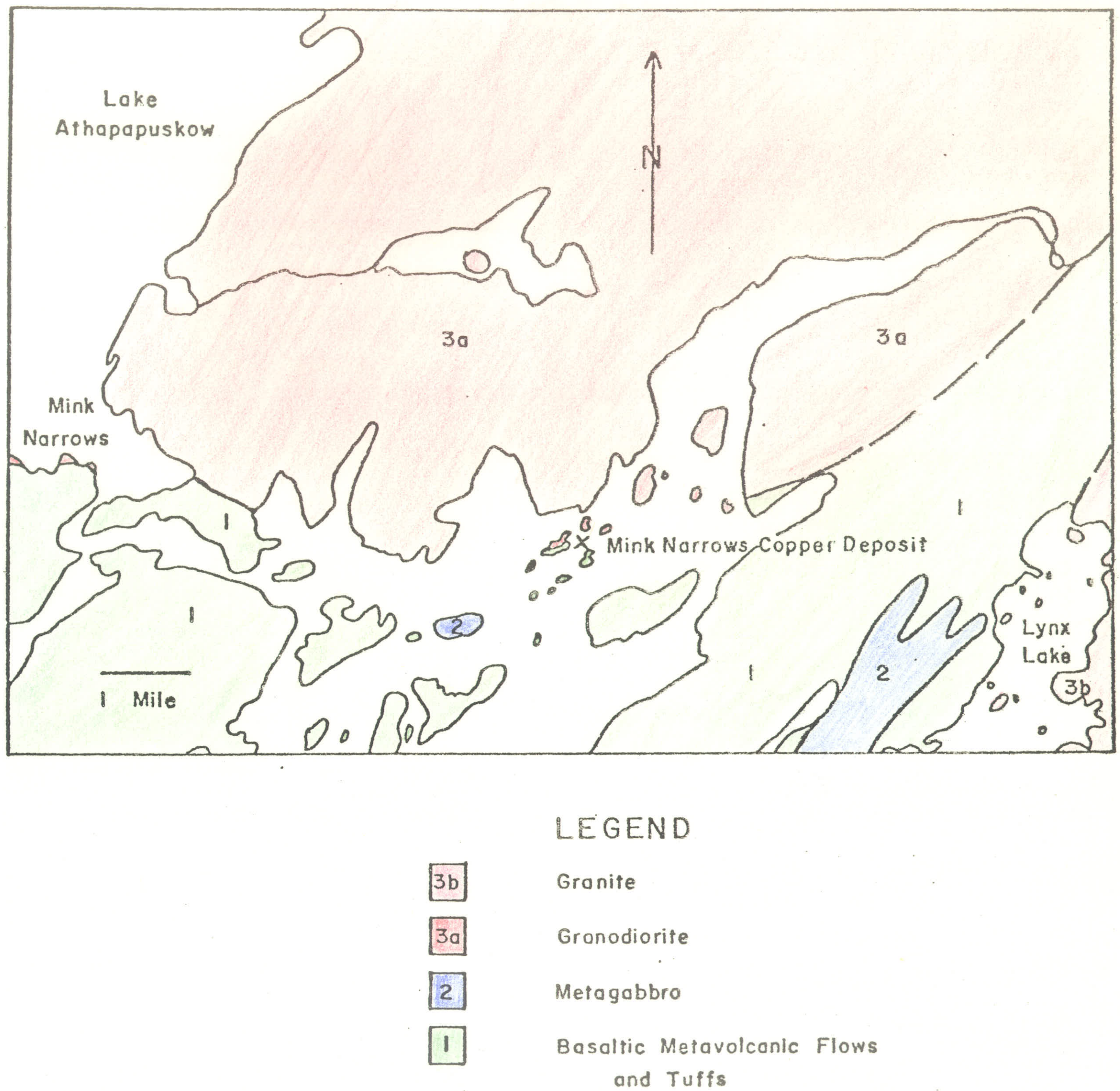

Fig. 2 Location of Mink Narrows copper deposit on Lake Athapapuskow

TABLE 1

COPPER AND ZINC DEPOSITS IN THE FLIN FLON REGION

Name	% Cu	% Zn	Total Tons (M.)	Host Rock	Stage
Flin Flon	2.3	4.6	64	Andesite & quartz porphyry	Producing
Schist Lake	4.5	4.6	.81	Andesite	Producing
Flexar	3.2	0.5	-	Intermediate lava flows	Producing
White Lake	1.9	4.4	-	Felsic tuff	Producing
Birch Lake	6.2	-	0.28	Intermediate lava flows	Mined Out
Mandy	7.5	9.4	0.14	Volcanic breccia	Mined Out
Cuprus	3.25	6.4	0.51	Andesite & tuff	Mined Out
North Star	6.1	-	0.26	Dacite & andesite	Mined Out
Don Jon	3.1	-	0.09	Dacite & quartz porphyry	Mined Out
Coronation	4.2	-	1.4	Basalt flows & tuff	Mined Out
Centennial	2.1	2.6	1.4		Developing
Pine Bay	1.3	-	1.5	Qtz. porphry & basalt lavas	Deposit
Mink Narrows	1.5	0.5	0.5	Basalt flows	Deposit

Data From:- Geology & Economic Minerals of Canada R.J.W. Douglas (Ed.) 1970

Geology & Mineral Resources of Manitoba, J.F. Davies et al 1962

Geology & Mineral Deposits of the Flin Flon Area, Sask. A.R. Byers et al 1965

Canadian Mines Handbook, 1973-1974

Mink Narrows Copper Deposit

The Mink Narrows copper deposit was discovered prior to 1943 and initially called the Copper Reef Deposit.

The first recorded work was that of trenching and sampling of the exposed sulphide mineralization.

During 1943, Thompson Drilling and Mining Development Co. Ltd., drilled nine short diamond drill holes (CR1-7) in the vicinity of the deposit.

Further work was not done on the deposit until 1952-53 when Hudson Bay Mining and Smelting Company under an option agreement, drilled 25 holes (1-11, 16, 17, 20-27, 35-40) that outlined a small, low grade copper-zinc deposit.

In 1968, Falconbridge Nickel Mines optioned the claims covering the deposit plus claims covering the adjacent area. During the following year, nine deep, controlled holes, were drilled into the deposit (MN5-MN14). Fig. 3 gives the position of all the drill holes.

A fairly steep dipping sulphide body had been outlined to a depth of 1,760 feet with an estimated tonnage of 503,000 tons, averaging 1.5% Cu. and 0.50% Zn.

GENERAL GEOLOGY

Regional Geology of Flin Flon Area

The Mink Narrows copper deposit is in the Flin Flon region which is part of the Churchill structural province of the Precambrian Shield (Fig. 1). The oldest rocks, known as the Amisk Group, have a whole rock Rb/Sr date of 1775 $\pm$ 89 m.y. (Mukherjee et al, 1971). The Amisk Group consists

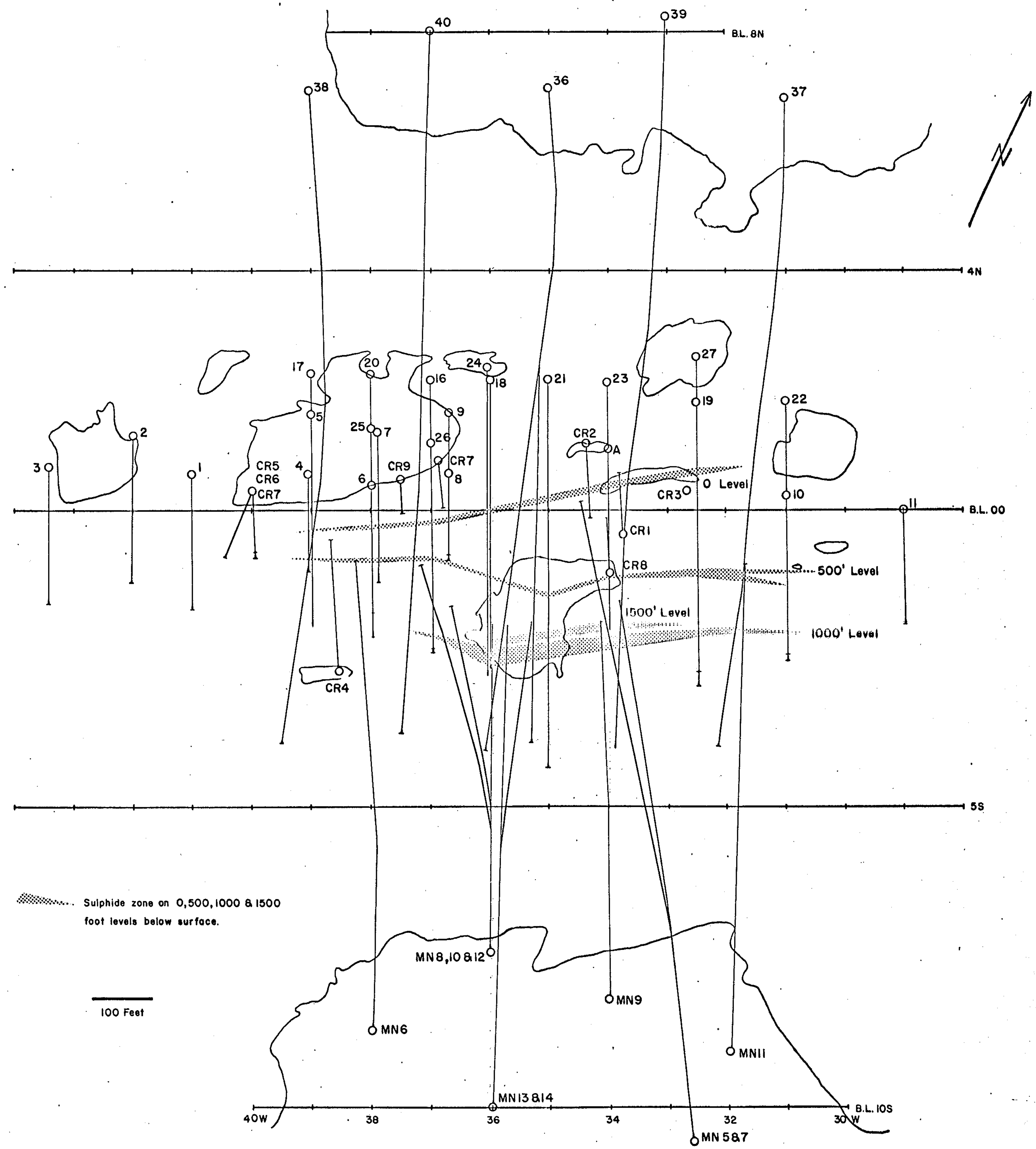

Figure 3 Diamond Drill Hole Locations

mainly of submarine volcanic flows (basalt, andesite, dacite, porphyritic andesite, quartz porphyry and flow breccia), with associated pyroclastic breccias and minor amounts of tuff. Conglomerate, greywacke and arkose, belonging to the Missi Group, were deposited on the eroded Amisk rocks and occur as small detached masses within the Amisk rocks.

East of Flin Flon, several pre-Missi granitic intrusions are believed to occur, indicating a pre-Missi orogeny. Porphyritic intrusive rocks, ranging in composition from diorite to granite form dikes, sills and small irregular bodies in Amisk volcanic rocks. They are thought to be closely related to the Amisk volcanic rocks and are commonly included within the Amisk Group. Basic intrusions of larger dimensions along with some ultrabasic rocks, are common in the volcanic rocks of the Amisk Group, and most of these intrusions are believed to be related to the same igneous activity.

All of the rocks from the above groups have been intruded by large masses of granite and granodiorite, subjected to regional metamorphism and deformation.

The Precambrian rocks are unconformably overlain by Upper Ordovician dolomitic limestone and dolomite in the southern part of the Flin Flon region.

A table of formations for the Flin Flon region is shown in Table 2.

Local Geology of the Deposit

The deposit is contained within basic metavolcanic rocks of the Amisk Group, consisting of pillow, flow, and

TABLE 2

TABLE OF FORMATIONS FOR FLIN FLON REGION
(After Bailes, 1971)

POST-MISSI INTRUSIVE GROUP

Intrusive rocks of variable composition related to the unit below.

Granodiorite and quartz diorite, generally gneissic. Large portions represent metasomatically granitized material.

INTRUSIVE CONTACT

MISSI GROUP

Arkose, greywacke, quartzite. Basal conglomerate common.

UNCONFORMITY

POST-AMISK INTRUSIVE GROUP

Gabbro and diorite with ultrabasic phases in places. Commonly differentiated. Includes rocks of several ages and diverse origins.

"Quartz-eye" granite.

INTRUSIVE CONTACT

AMISK GROUP

Argillite, greywacke, tuff. Turbidites common in eastern region.

Phyolite, dacite, quartz porphyry. Includes acidic crystal tuff and siliceous, carbonate-rich tuff.

Mafic to intermediate volcanic rocks: (a) pillowed varieties, and (b) fragmental varieties. Includes many small related intrusions.

amygdular lavas interlayered with thin beds of tuff. Within the metavolcanic rocks are large bodies of metagabboic rock that are believed to have been shallow intrusions at the time of volcanism. The general trend of the metavolcanic rocks is N60°E with a steep dip to the southeast. Tops of pillows face to the southeast.

Several large granodioritic bodies have intruded the metavolcanic rocks in the area. The deposit lies approximately parallel to the contact of one of these intrusive bodies. The intrusion is lithologically distinctive from the other intrusions in that it has numerous phenocrysts of strongly zoned euhedral crystals of oligoclase (Buckham 1944). In the vicinity of the deposit, however, the granodiorite is an equigranular and medium grained rock lacking phenocrysts, and has a quartz-diorite composition. The rock's major components are 10-15% quartz, 5-10% biotite, 5-10% hornblende and 70% iron-stained plagioclase with minor potassium feldspar and magnetite. Epidote is present in minor quantities, especially along fracture zones. Random unorientated quartzose-feldspathic veins of variable grain-size occur within the intrusion.

The contact between the granodiorite and the metavolcanic rocks is sharp, although several granodioritic dikes intrude the metavolcanic rocks. Several of these dikes are located southwest of the deposit and are also intersected by several of the drill holes.

SELECTION OF SAMPLES

The selection of samples for study was restricted to the cores from the diamond drill holes drilled by Falconbridge Nickel Mines Ltd. because the deposit occurs under water. The selection was further restricted since Falconbridge had skeletonized all their drill core except for the mineralized sections, and only short representative pieces for every ten feet of core were saved.

Two holes, MN5 and MN10, were chosen as representative drill holes through the deposit (Fig. 3). Samples were taken at a 20 foot interval from 100 feet southeast of the mineralization to 100 feet northwest of the mineralization or the end of the hole. The sample interval was reduced to 10 feet near the mineralization.

Petrographic slides and polished sections, where feasible, were made for observation. Whole rock chemical analyses were done on the samples.

Several random samples from other holes were taken for petrographic and ore microscopic examinations.

Drill logs and assay records of the holes drilled by Falconbridge and Hudson Bay were also available.

The location of the drill hole samples are listed in Appendix I.

MINK NARROWS COPPER DEPOSIT

GEOMETRICAL AND STRUCTURAL FEATURES OF THE DEPOSIT

The deposit is a steeply dipping body that lies approximately parallel to the granodiorite contact as shown in sections 32W, 34W, and 36W (Fig. 4, 5, & 6). The deposit is closest to the intrusion near the surface but appears to diverge from it at depth.

The deposit has a strike length of 700 feet and extends from the surface to a depth of 1,700 feet. The strike of the deposit is approximately N65°E and dips 70° to the southeast, down to a depth of 1,100 feet. Below this level, the dip changes to 75° to the northwest. Unfortunately, below this depth, drill holes do not intersect the metavolcanic-granodiorite contact, thus the position of this contact is unknown. However, the contact also must have changed dip, as indicated in section 34W, where holes MN5 and MN7 do not intersect the granodiorite.

The true thickness of the deposit increases from a range of 0.5 to 5.8 feet on surface to a maximum of 62 feet at a depth of 1,200 feet, close to the location where the deposit changes dip. Below this depth, the thickness gradually decreases. Figure 7 is a contoured plot of the true thickness of intersections projected to a vertical plane.

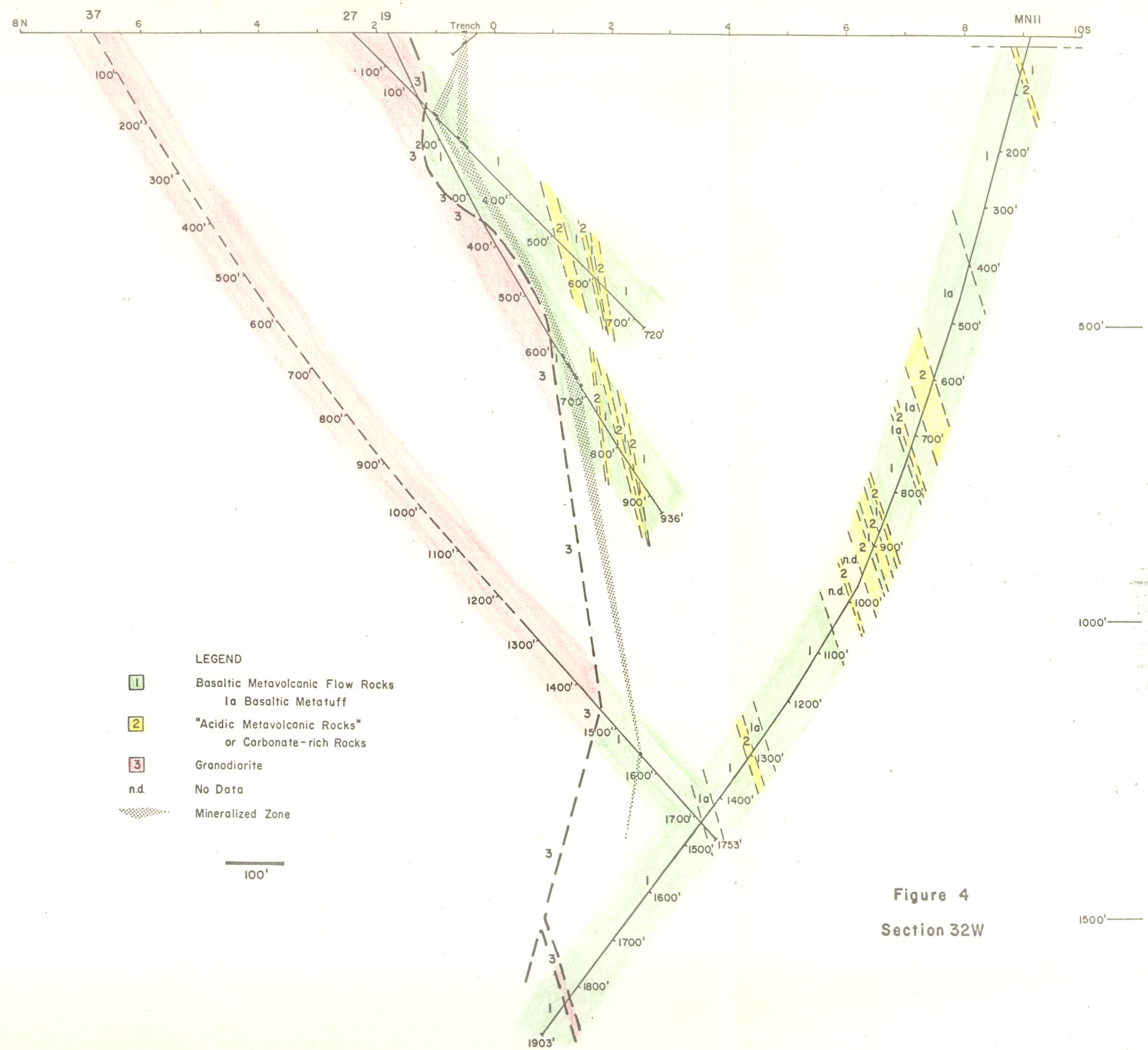

Figure 4

Section 32W

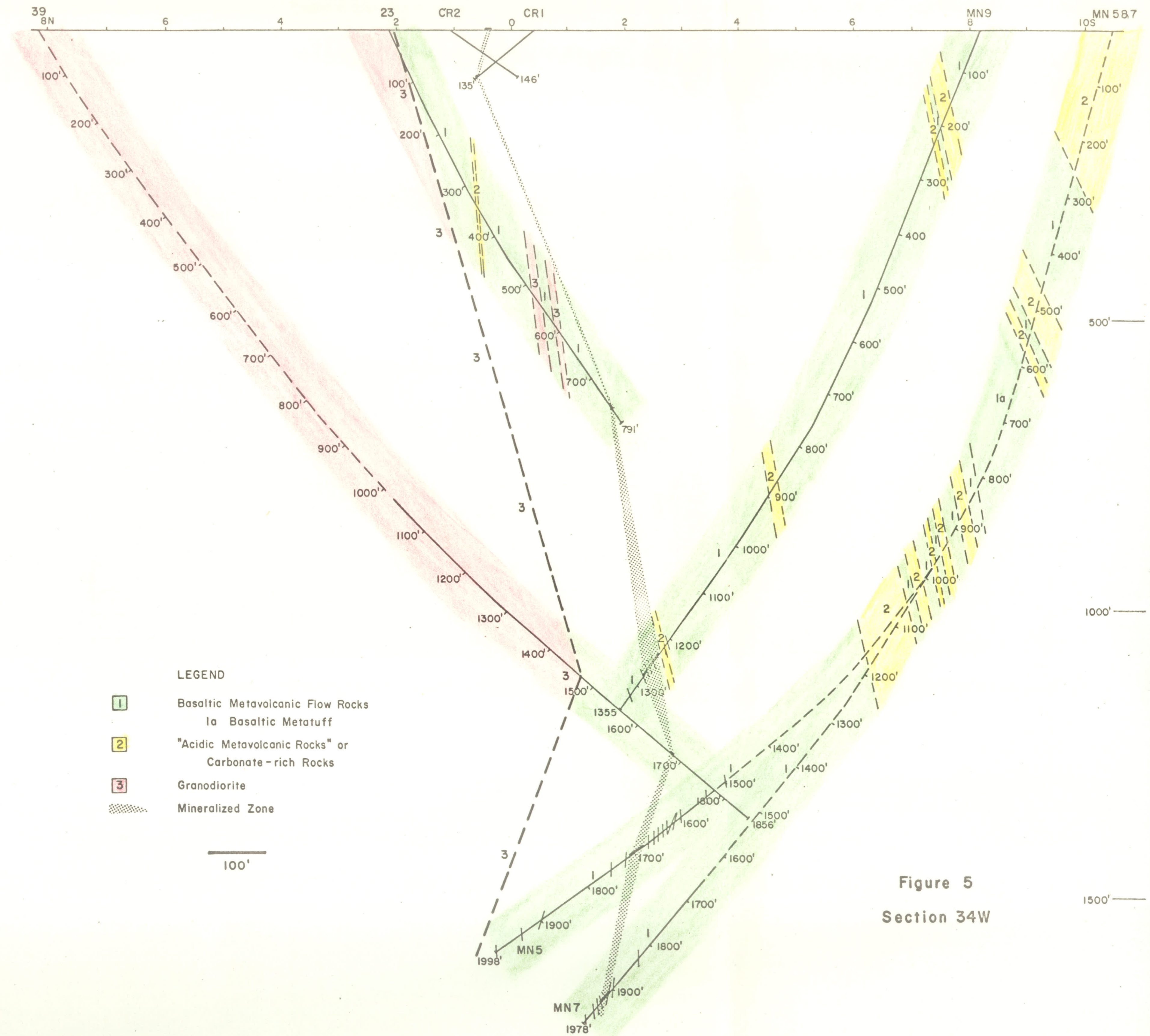

Figure 5
Section 34W

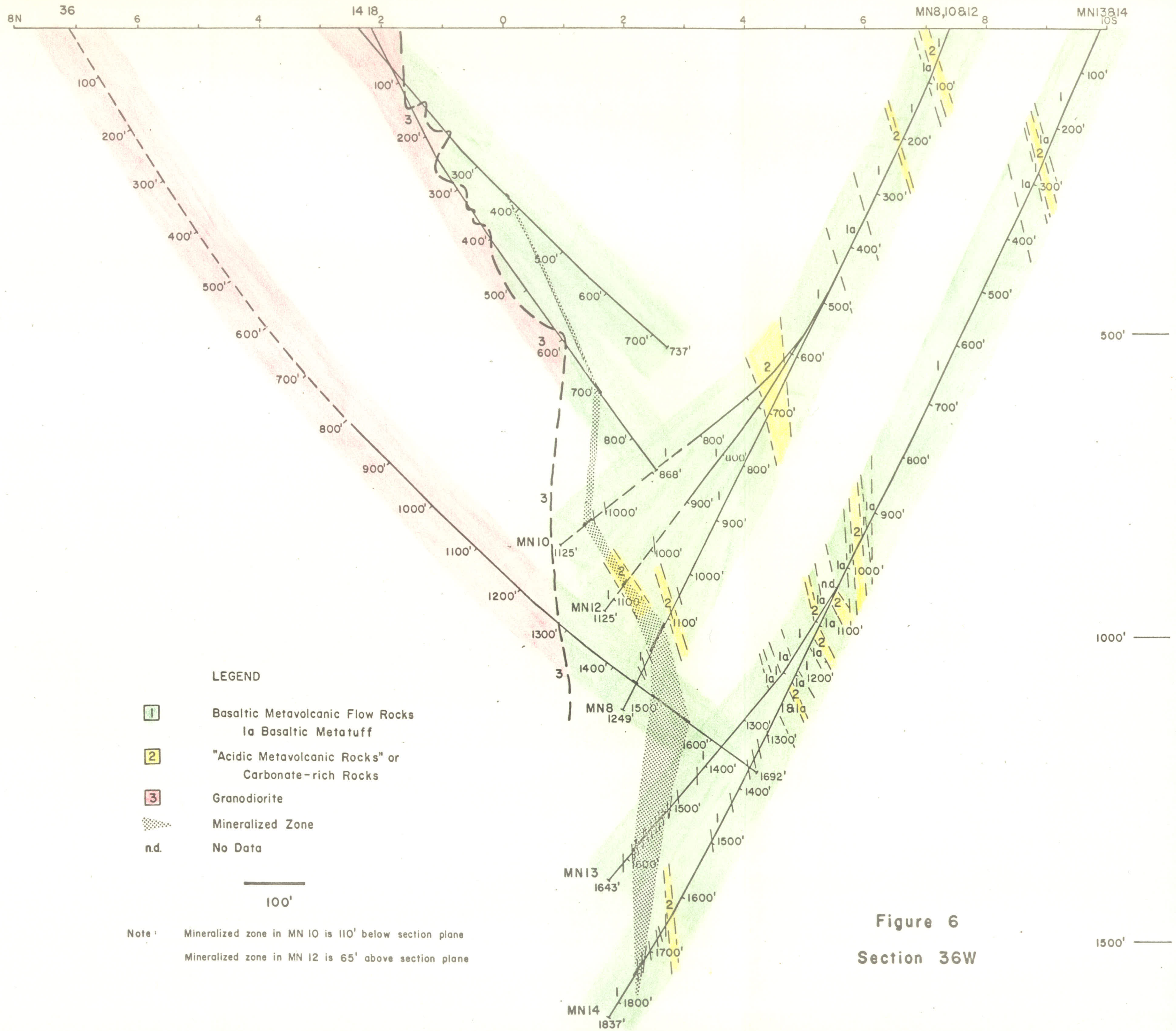

Figure 6

Section 36W

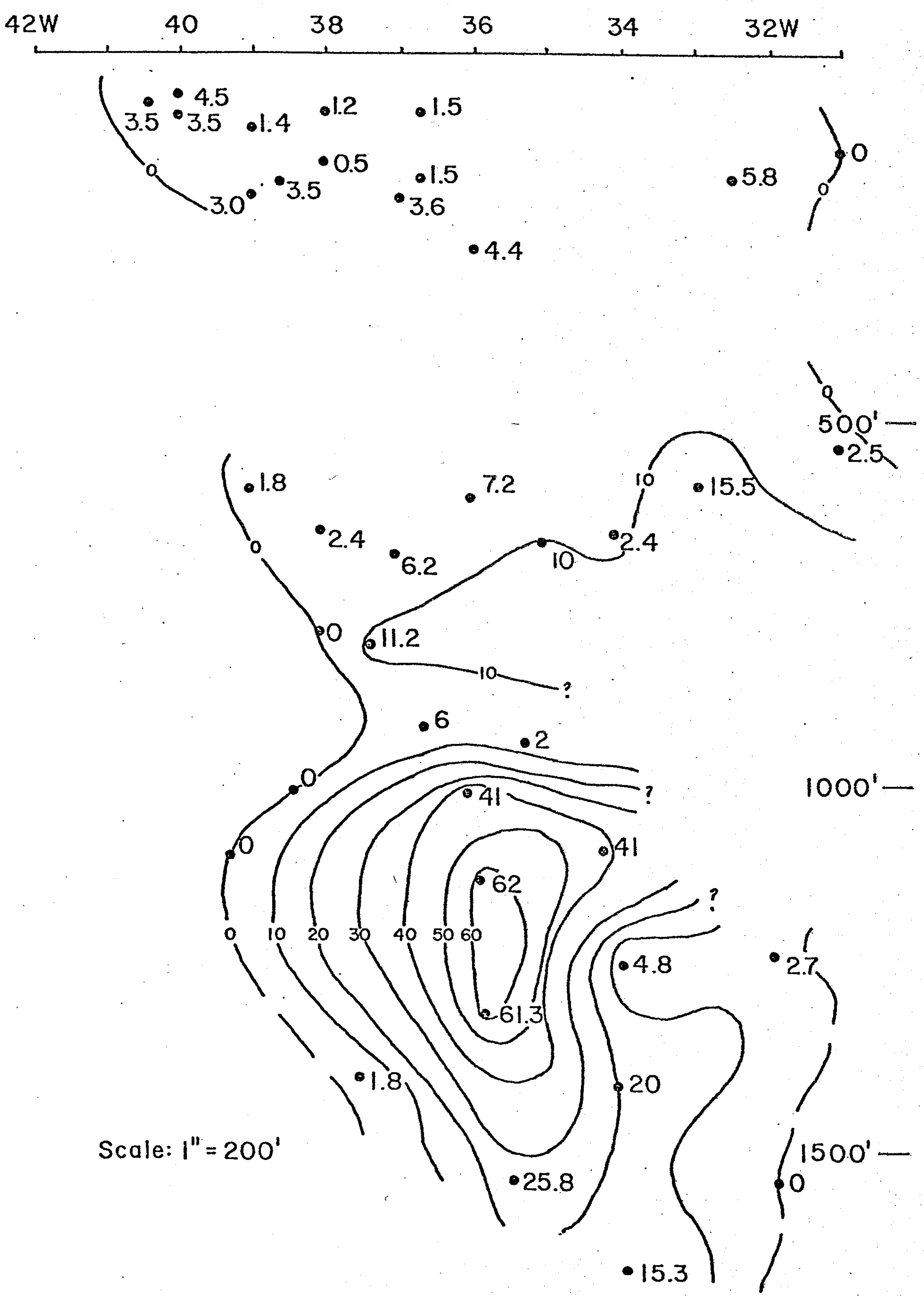

Fig. 7 Contour plot of true thickness (ft.)

The schistosity in the metavolcanic rocks is usually parallel to both the contact and the deposit, as is the schistosity in several of the disseminated mineralization zones.

Stratigraphic layering is not observable in the metavolcanic rocks and therefore it is not possible to determine whether or not the deposit is strata-bound.

GEOLOGY OF THE HOST METAVOLCANIC ROCKS

The host rocks of the deposit consist mainly of basaltic metavolcanic flow rocks that are believed to be submarine in nature due to the presence of pillow lavas in the region.

Thin beds of basaltic pyroclastic material are present, but it is not possible to use them to correlate between drill holes. Drill hole sections that have been formerly logged as acidic metavolcanic are carbonate-rich zones within the basaltic metavolcanic rocks as shown by the chemical analyses of two samples, C12 and C13, from one zone in hole MN12 (Appendix II). This particular carbonate-rich zone contains the mineralized zone.

The metavolcanic rocks have been recrystallized to a medium to fine-grained texture, comprised of anhedral to euhedral grains. The dominant mineral assemblage of the recrystallized metavolcanic is green hornblende, plagioclase and quartz (Plate 2). Near the granodiorite intrusion, large porphyroblastic grains of green hornblende are present in a fine-grained groundmass of the dominant minerals (Plate 3).

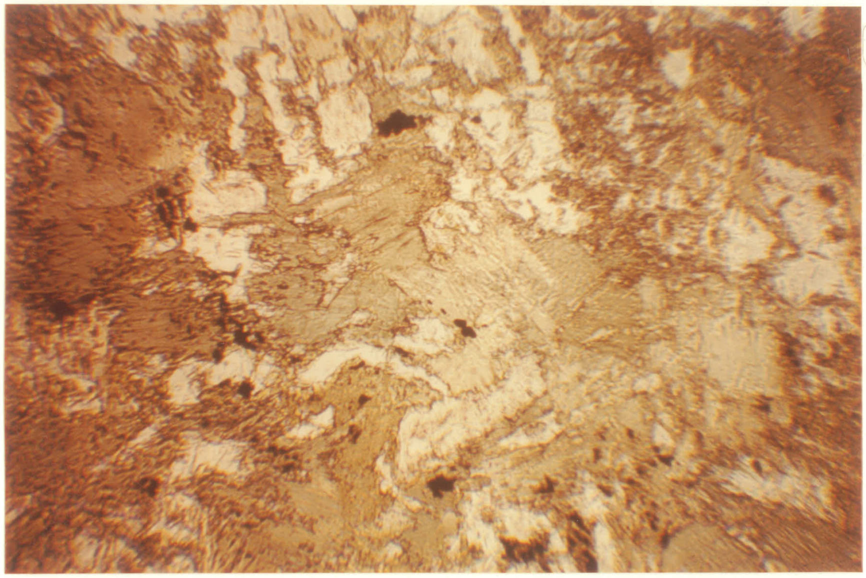

Plate 2 Recrystallized metavolcanic rock C62 80X

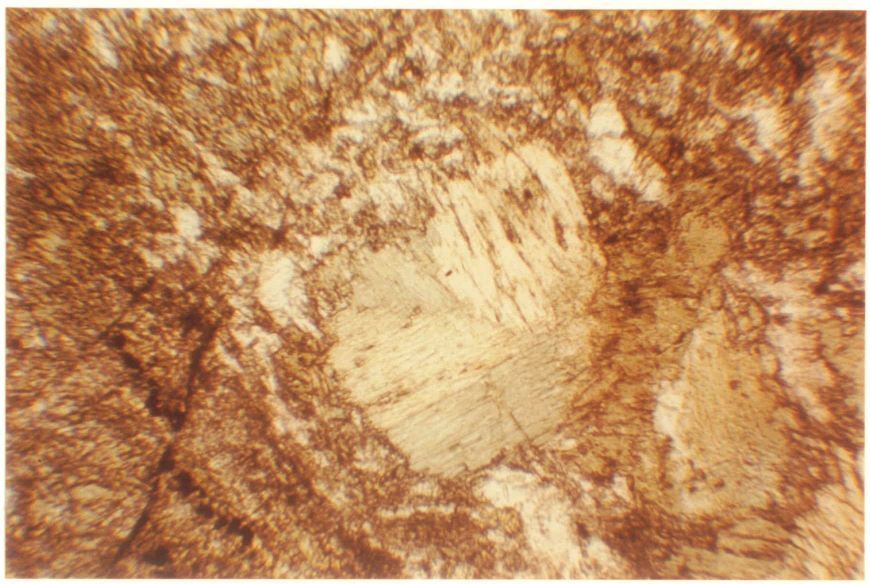

Plate 3 Hornblende porphyroblast C56 80X

Carbonate veinlets cut these rocks (Plate 4). A greater concentration of these veinlets is present just northwest of the deposit.

The metavolcanic rocks adjacent to the granodiorite, especially those in hole MN10, have been fractured with some displacement evident (Plate 5). The fracturing is more intense near the granodiorite and decreases toward the deposit. Carbonate veins within this region show evidence of considerable shearing (Plate 6).

Retrograde metamorphism has further altered the host rocks, especially in the zone between the deposit and the granodiorite. Chlorite has grown in the fractures previously described (Plate 7), and plagioclase and hornblende have been altered to sericite and epidote respectively (Plate 8).

Adjacent to the granodiorite, the metavolcanic rocks contain mainly biotite, sericite, epidote, chlorite and quartz, with minor hornblende and plagioclase (Plate 9).

Two of the samples, C64 and C66, taken in hole MN5 southeast of the deposit, were mineralogically distinct from the majority of the others. Sample C64 was comprised of mainly biotite with minor quartz. Sample C66 was comprised of subhedral grains of garnet, epidote and sulphides, concentrated together and surrounded by a fine-grained assemblage of green hornblende, plagioclase and quartz. The mineralogy of these two samples is believed to be due to local alterations within the metavolcanic rocks.

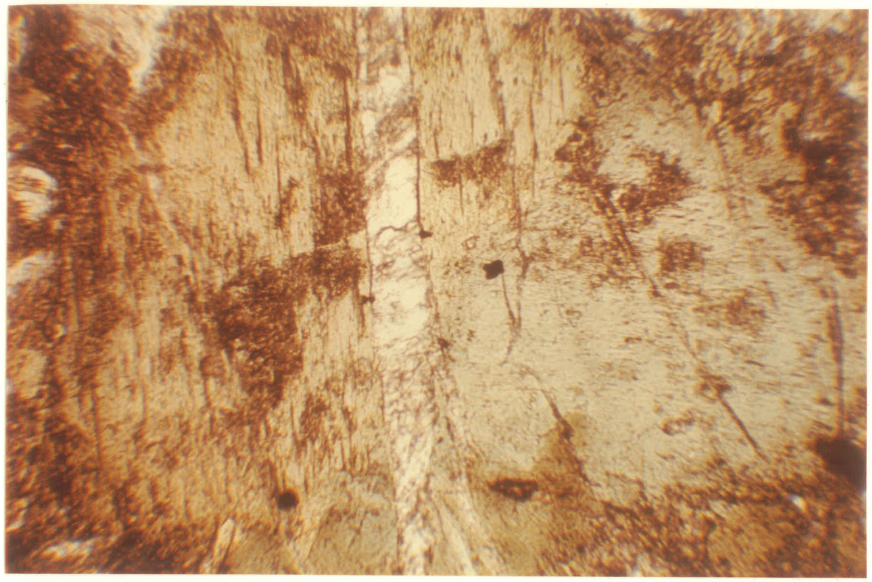

Plate 4 Carbonate vein cutting hornblende porphyroblast C55 110X

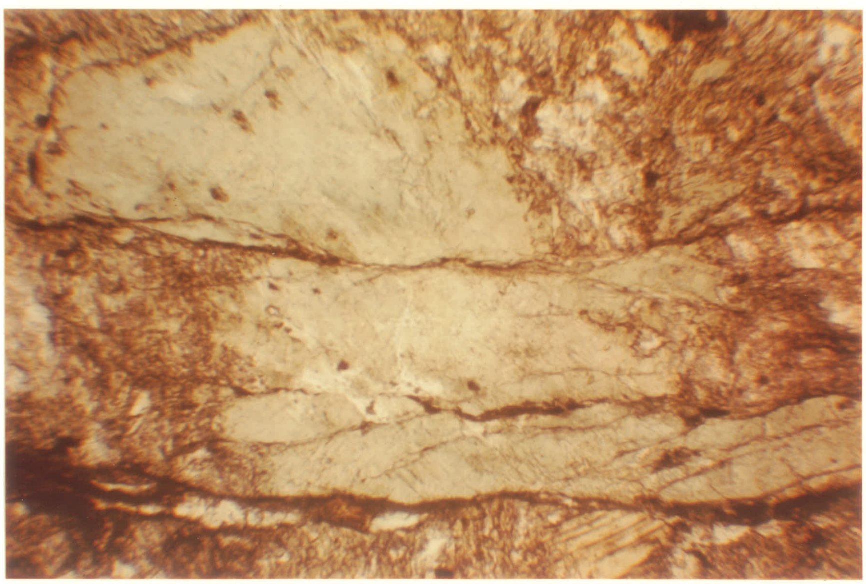

Plate 5 Fractured and displaced hornblende porphyroblast C56 110X

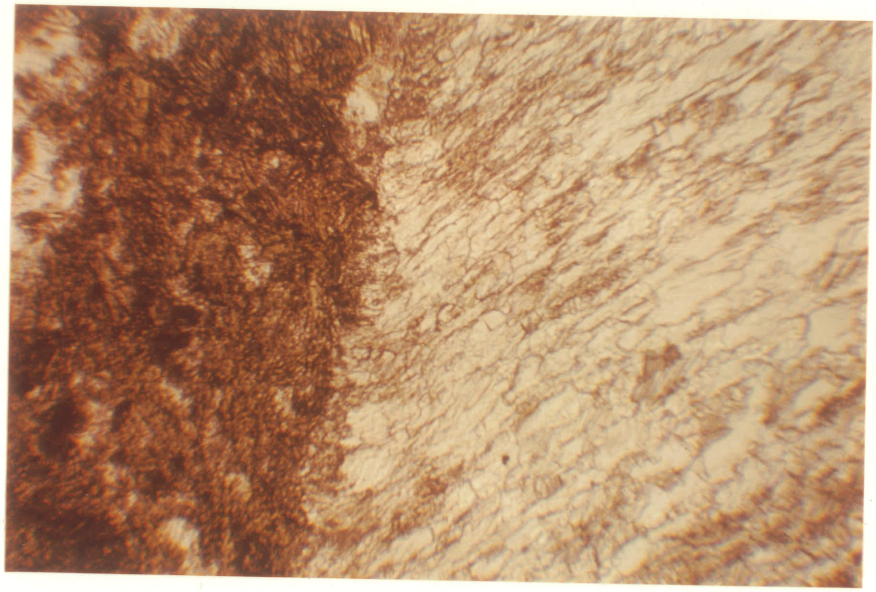

Plate 6 Sheared carbonate vein C56 110X

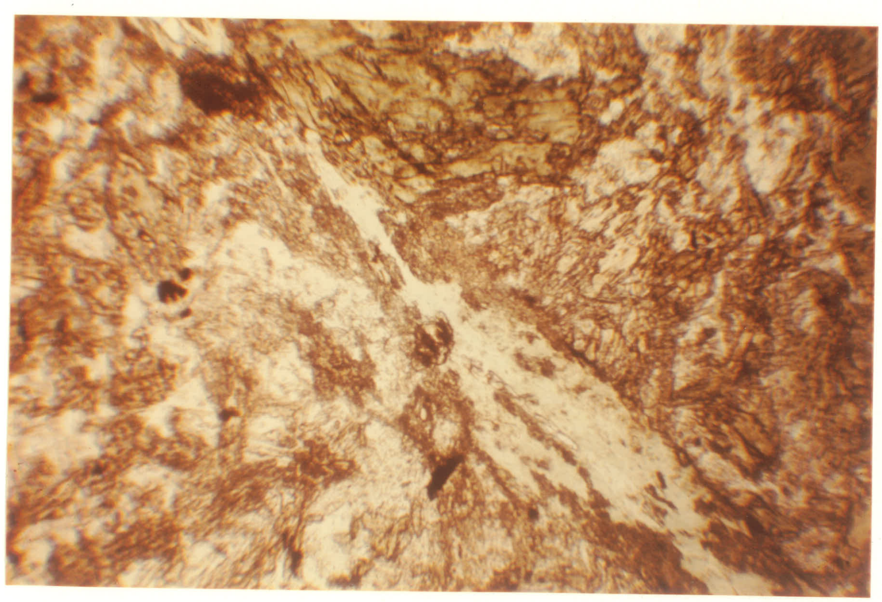

Plate 7 Chlorite-filled fracture within meta-volcanic rock C70

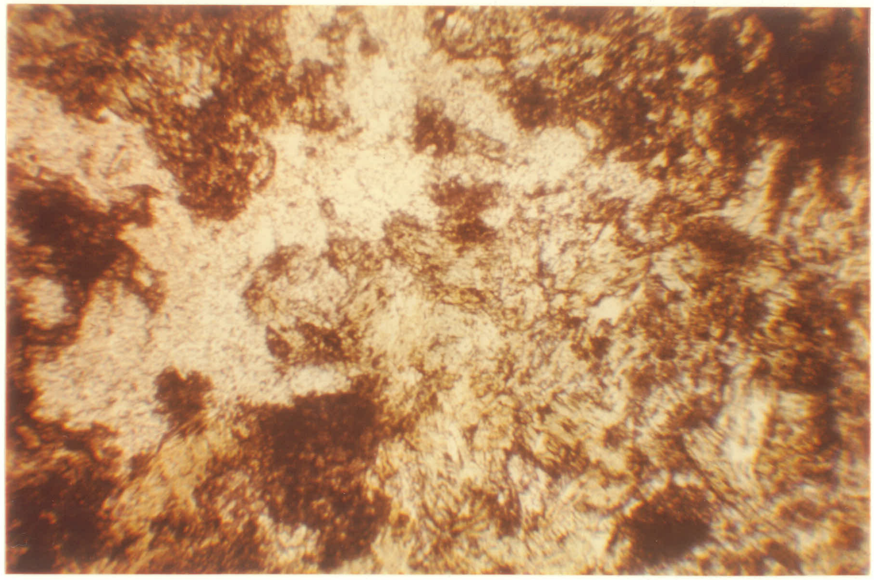

Plate 8 Hornblende and plagioclase highly altered to epidote and sericite C76 80X

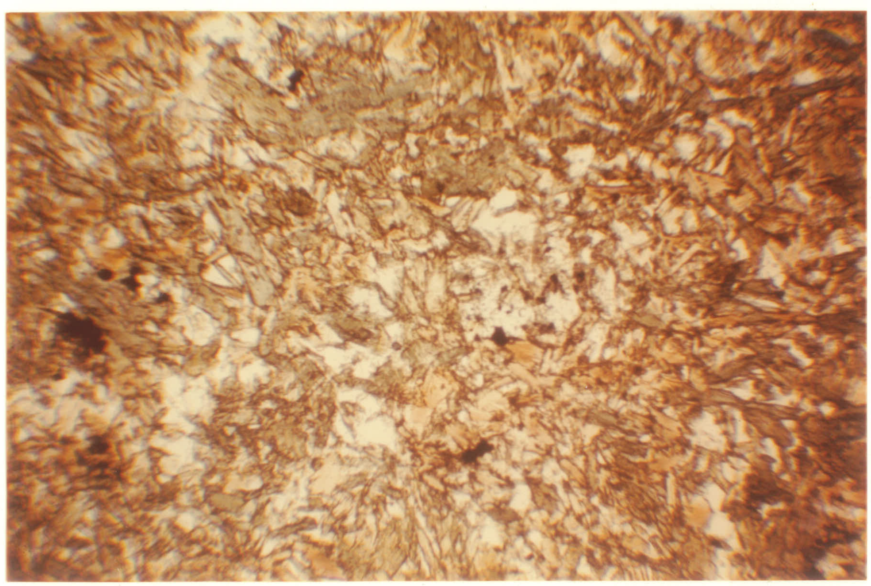

Plate 9 Biotite-rich rock near intrusion C84 80X

THE MINERALOGICAL ALTERATION ADJACENT TO THE DEPOSIT

Holes MN5 and MN10 do not have completely similar alteration zones adjacent to the deposit. In hole MN10, along the southeast edge of the mineralized zone, sample C51, the rocks are comprised of anhedral magnetite grains in a groundmass of chlorite and sericite. Chlorite appears to replace several of the magnetite grains. On the northwest edge of the deposit, sample C54, the rocks are mainly comprised of a schistose aggregation of carbonate, sericite and quartz. In hole MN5, along the southeast edge of the deposit, sample C71, the rocks are slightly schistose and fine-grained, composed of green hornblende, plagioclase, quartz with minor sericite, epidote and chlorite. Along the northwest edge of the deposit, sample C73, the rocks are similar to those in sample C51 and comprised of anhedral grains of pyrite, chalcopyrite and magnetite grains with several euhedral biotite grains in a groundmass of sericite and chlorite. The chlorite in places also appears to replace the magneite grains (Plate 10).

In hole MN10, the alteration zone southeast of the deposit is similar to that northwest of the deposit in hole MN5 except for the presence of sulphides in hole MN5. An alteration zone is not present southeast of the deposit in hole MN5. In MN10, northwest of the deposit, a different type of alteration zone is present. Thus, there does not

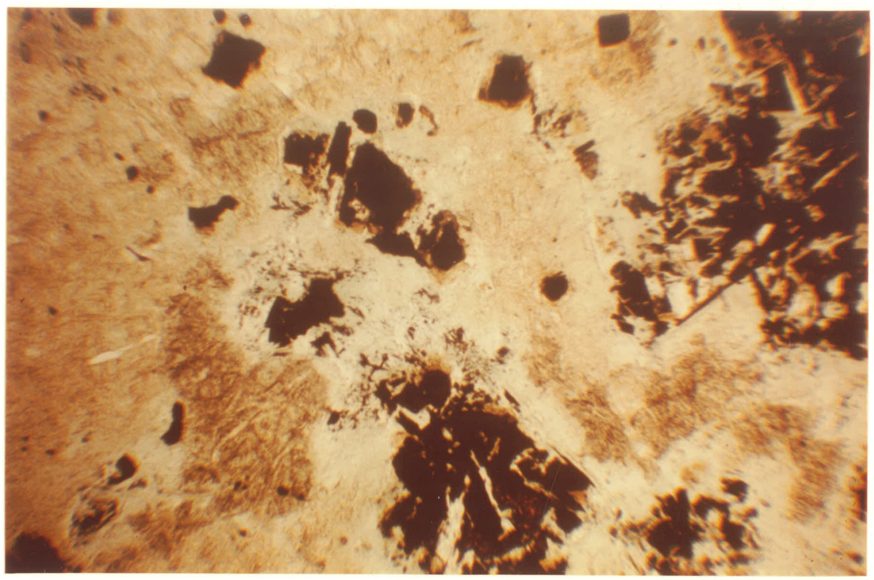

Plate 10 Chlorite replacing magnetite in alteration zone. C73 80X

appear to be any distinct pattern of mineralogical alteration associated with the deposit.

CHEMICAL COMPOSITION

Whole rock chemical analyses were done on the samples from holes MN5 and MN10 to determine whether any chemical variations occurred within the metavolcanic rocks (Appendix III & IV).

The average chemical composition of three representative samples of recrystallized metavolcanic rocks, C47, C49 and C50, were compared with the average composition of five samples of basaltic lava flows from the Coronation Mine region and the average composition of Canadian Archean basaltic lava flows (Table 3). The chemical values are similar except that in the analyses from the metavolcanic rocks near the deposit, MgO is relatively lower in value and Na_2O and K_2O are relatively higher in value.

Upon examination of plots of the chemical analyses of samples from holes MN5 and MN10 (Fig. 8 & 9), several variations in chemical analyses are noticeable, especially near the mineralized zone. In the two similar alteration zones, as in samples C51 and C73, several similar chemical variations are present. The values of H_2O, FeO, Fe_2O_3 and K_2O are relatively higher than the average composition of the metavolcanic rock, whereas Na_2O is relatively lower.

In the alteration zone adjacent to the northwest edge of the depost as in sample C54, the values of CaO, CO_2 and

TABLE 3

COMPARISON OF COMPOSITION OF BASALTIC LAVA FLOWS

Sample No.	1	2	3
SiO_2	49.80	50.20	49.83
Al_2O_3	13.80	14.12	14.64
Fe_2O_3	2.94	2.96	3.03
FeO	9.63	8.57	8.77
MgO	6.81	8.46	7.36
CaO	9.41	9.58	10.46
Na_2O	3.50	1.96	2.02
K_2O	0.51	0.32	0.23
H_2O	1.72	2.13	1.81
CO_2	0.37	0.24	0.33
TiO_2	0.46	0.79	0.94
MnO	0.12	0.11	0.21
P_2O_5	0.23	0.18	0.19
S	-	0.15	-
TOTAL	99.30	99.77	99.82

1). Average composition of samples C47, C49, and C50.

2). Average composition of 5 samples of basaltic lava flows from the Coronation Mine region (Froese, 1969).

3). Average composition of Canadian Archean basaltic lava flows (Wilson et al, 1965).

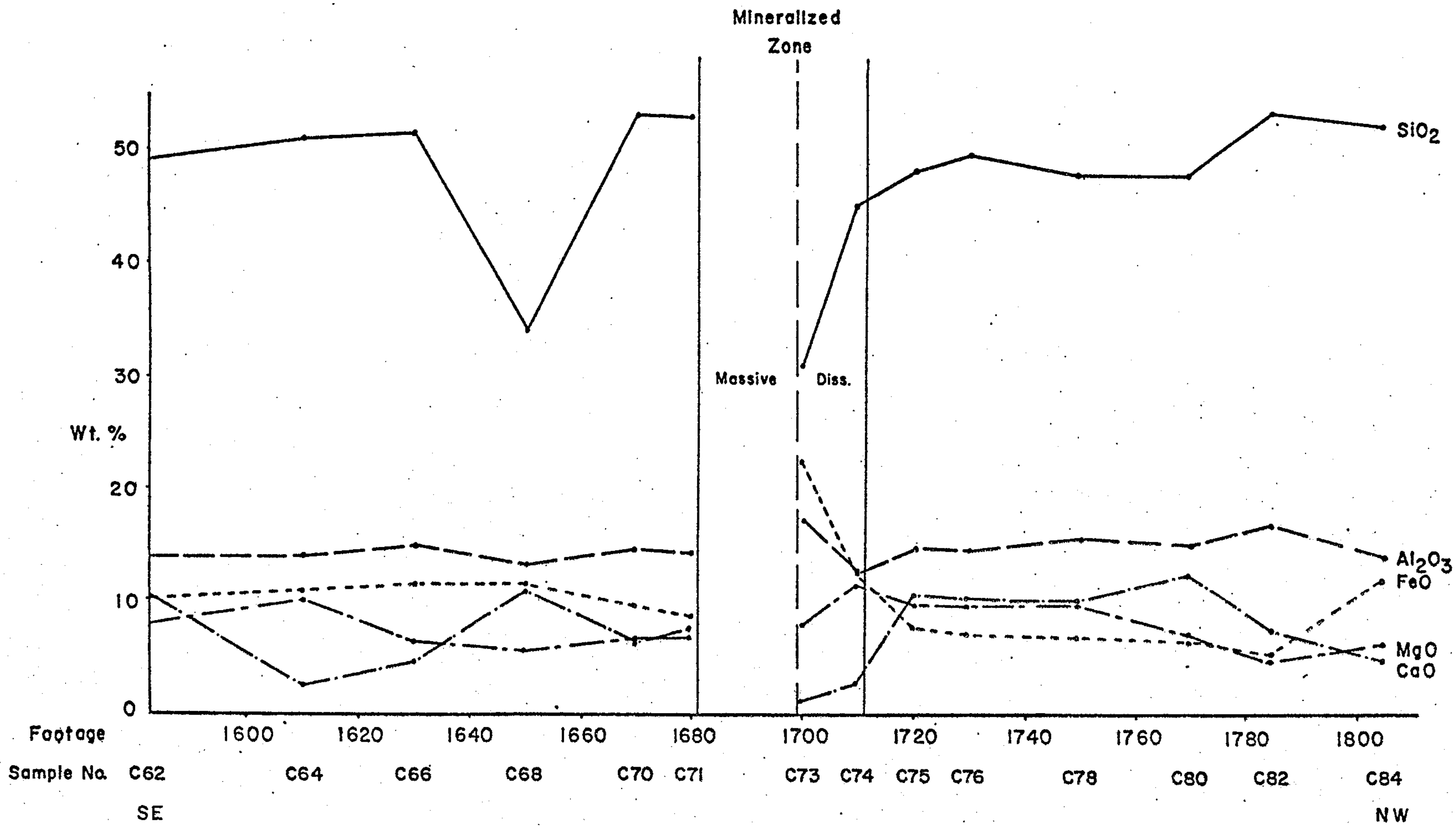

Fig. 8a . Plot of chemical analyses in drill hole MN5

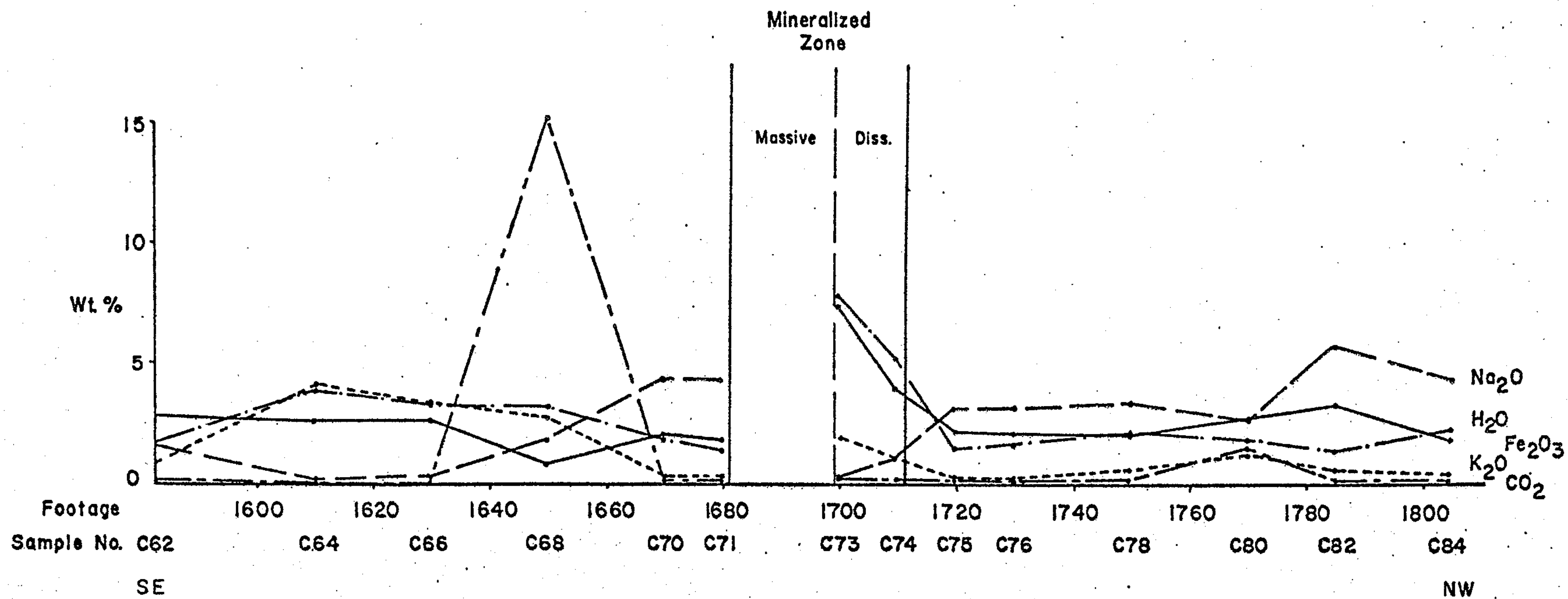

Fig. 8b Plot of chemical analyses in drill hole MN5

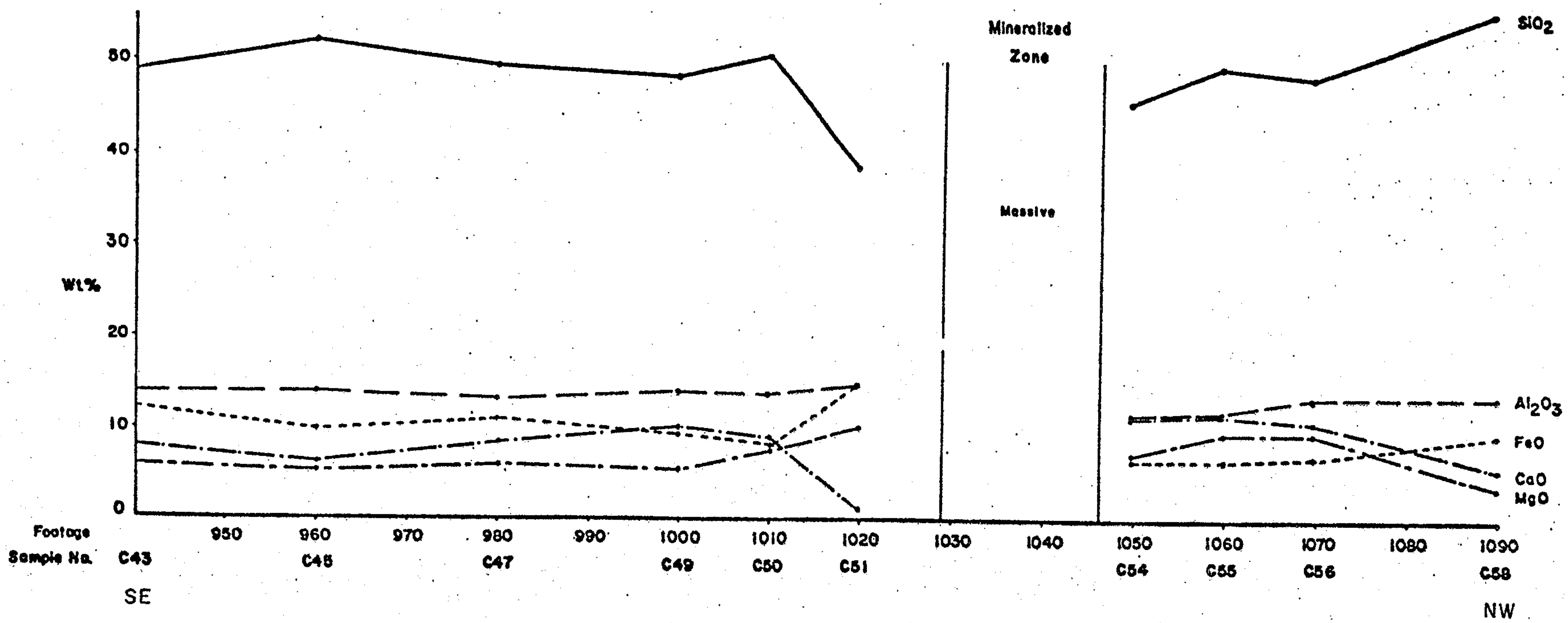

Fig. 9a Plot of chemical analyses in drill hole MN10

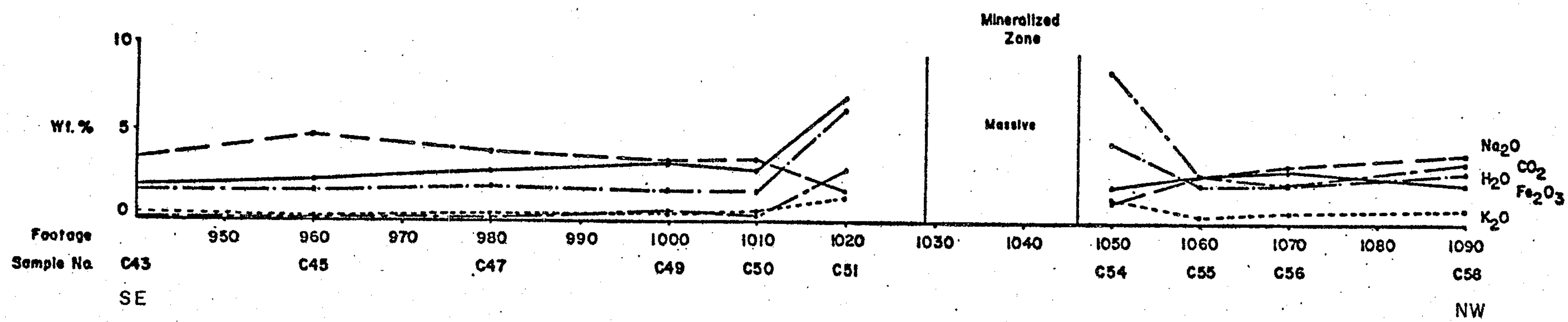

Fig. 9b Plot of chemical analyses in drill hole MN10

H_2O are relatively higher than in the average composition. Further northwest of the deposit, especially in hole MN10, the values of CaO, MgO and CO_2 are slightly higher than in the average composition. This increase may be explained by the presence of carbonate veins.

Several other distinct variations are indicated by the analyses. The high K_2O values southeast of the deposit in hole MN5, as in samples C64 and C66, are due to local peculiarities in mineralogy as previously described. On Figure 8a & b, the plot for the chemical analyses of samples from hole MN5, the first trough in the SiO_2 plot and rise in the CaO and CO_2 plot are due to a carbonate vein within the sample.

The plots of the chemical analyses of samples from both holes do not vary greatly adjacent to the granodiorite intrusion. The only distinct common variation is a slight decrease in the CaO content.

DESCRIPTION OF THE MINERALIZATION

The deposit consists of both massive and disseminated sulphides. Down to a depth of 1,000 feet, the sulphides occur as thin massive zones ranging from 0.5 feet to more than 10 feet in thickness. Below that level, they occur as both disseminated and massive sulphides with zones up to 62 feet thick. At the greatest depths, the sulphides occur as wide, disseminated zones.

Massive sulphides, where present with disseminated sulphides, occur usually on the southeast side with the basic metavolcanic rocks and the disseminated sulphides.

The principal metallic minerals in the deposit are pyrite, pyrrhotite, chalcopyrite and sphalerite respectively, with minor tetrahedrite, arsenopyrite and magnetite.

Massive Sulphides

The massive sulphides occur in three mineralogical assemblages: pyrite, pyrrhotite, pyrite and pyrrhotite. Chalcopyrite and sphalerite are associated with all three assemblages. In the thicker massive sulphide zones such as in hole MN8, the assemblages occur as bands or layers ranging in composition and in thickness from several inches to more than 10 feet and do not have any stratigraphic zoning. In hole MN8, their total distribution may be broken down as follows: 42% pyrite, 34% pyrite and pyrrhotite, and 24% pyrrhotite. Assemblages are commonly foliated and in places banded. The contacts between them are sharp in most places, however, some are sheared.

The concentrations of massive pyrite mineralization vary in composition and texture. Pyrite occurs in places concentrated into equigranular and subhedral grains. Several of these grains are sheared, with the sheared-off pieces of pyrite emplaced in a matrix of gangue (Plate 11). The pyrite has been replaced along the grain boundaries by chalcopyrite (Plate 12). Minor tetrahedrite is associated with the chalcopyrite. The pyrite has been recrystallized and in places has an annealed texture (Plate 13). Two different phases of pyrite mineralization occur in several of the massive zones.

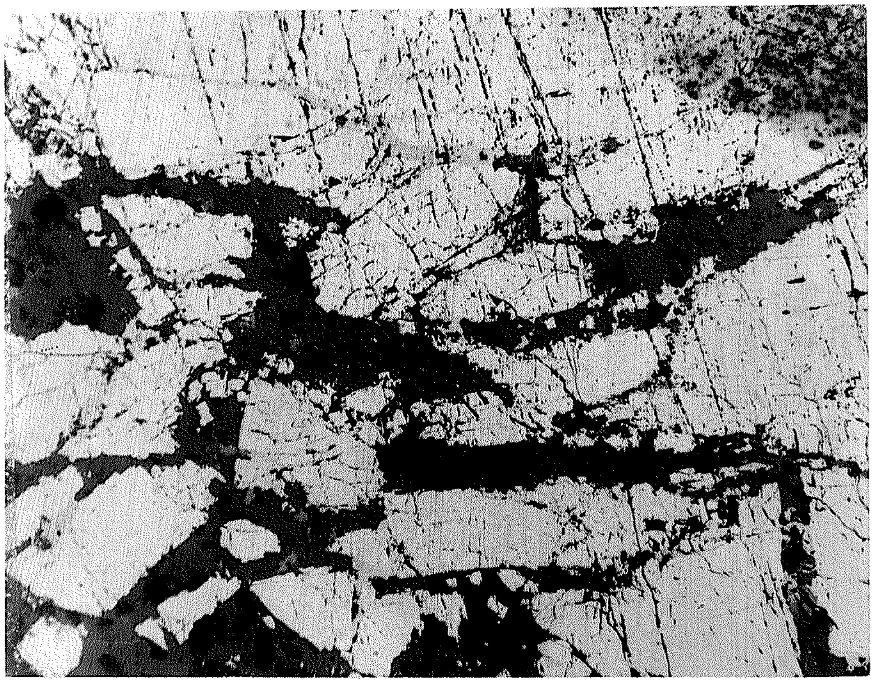

Plate 11   Sheared pyrite   C53   31X

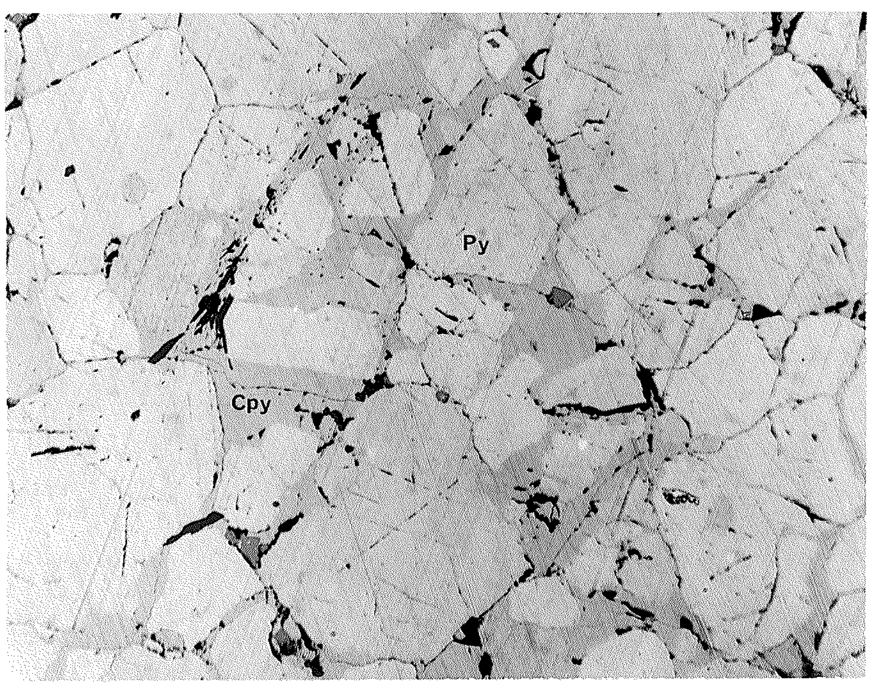

Plate 12   Chalcopyrite replacing pyrite   C30   31X

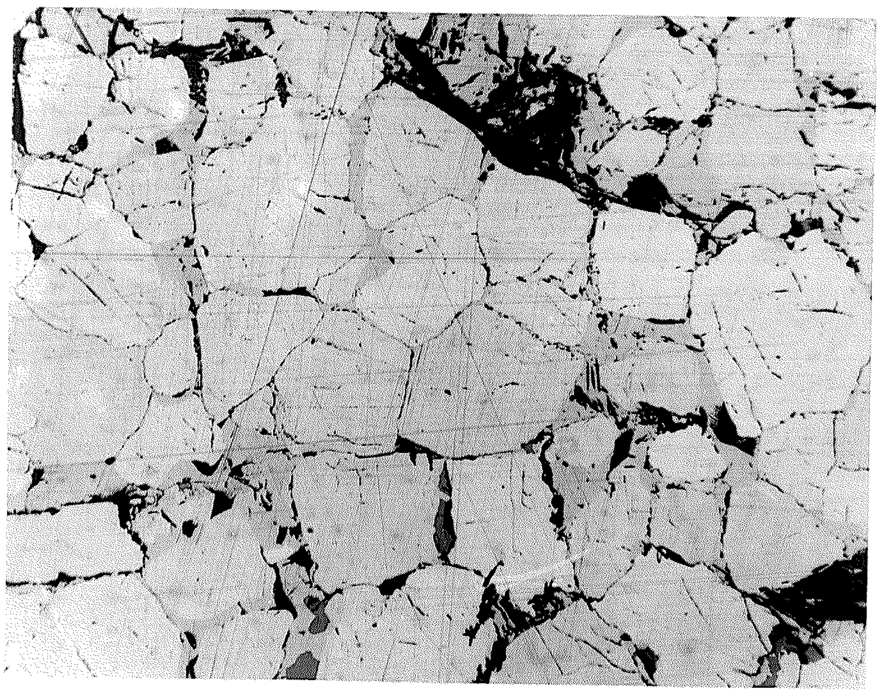

Plate 13 Pyrite with annealed texture C30 31X

Large subhedral to euhedral grains of massive, homogeneous pyrite appear to have grown in a matrix of finer grained, anhedral pyrite, whose interstices are filled with sphalerite and gangue (Plate 14). The pyrite:sphalerite ratio in the matrix is 2:1 with the sphalerite replacing the pyrite in places (Plate 15). Chalcopyrite replaces some of the anhedral pyrite matrix along fractures and is replaced along with all the other minerals by the euhedral pyrite (Plate 16).

The pyrrhotite concentrations within the massive sulphides are comprised of large, fractured, anhedral to euhedral, equigranular grains. The pyrrhotite has been recrystallized and has an annealed texture in places (Plate 17). Metablasts of euhedral pyrite grains are present within the massive pyrrhotite zones (Plate 18). The interstices of the pyrrhotite grains are filled with both chalcopyrite and sphalerite which commonly replace the pyrrhotite (Plate 19).

In one example where massive pyrite is in contact with massive pyrrhotite, the contact is sheared. The contact zone is comprised of subhedral to euhedral pyrite, anhedral pyrrhotite, occurrances of massive pyrrhotite, several euhedral pyrite metablasts are present. The pyrite metablasts have been fractured with some displacement evident (Plate 21). Later, quartz veins cut across all of the above features.

Where pyrite and pyrrhotite occur together, the pyrrhotite is equigranular and subhedral with the pyrite being subhedral to euhedral in a varying size range (Plate 22).

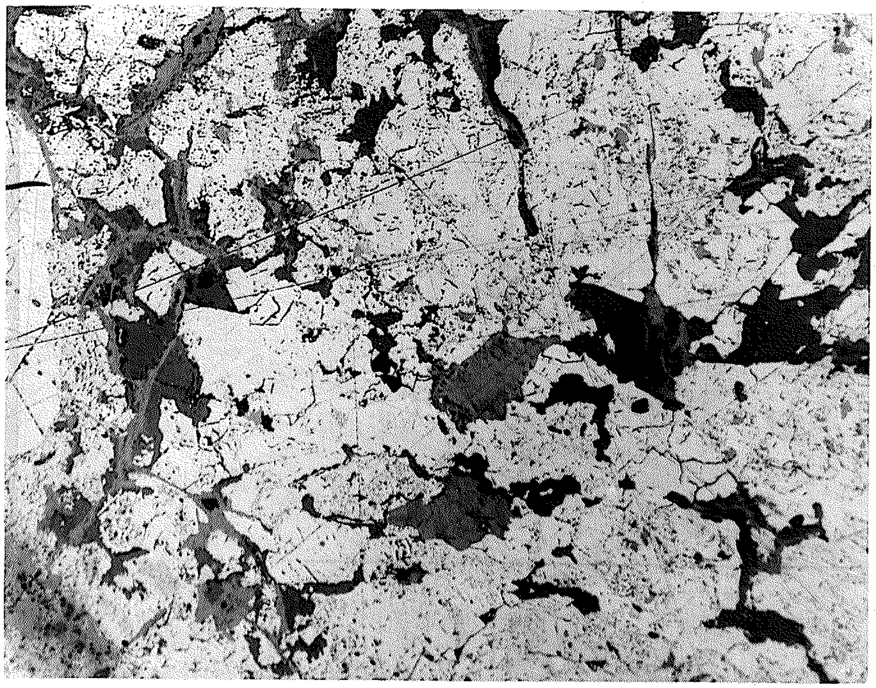

Plate 14 Anhedral pyrite with sphalerite C52 31X

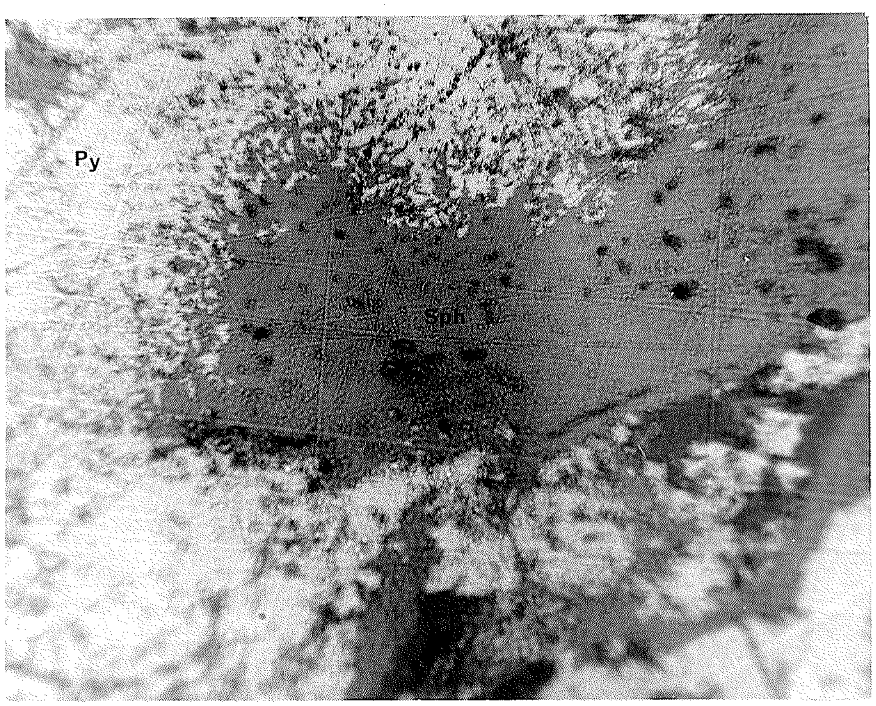

Plate 15 Sphalerite replacing pyrite C52 162.5X

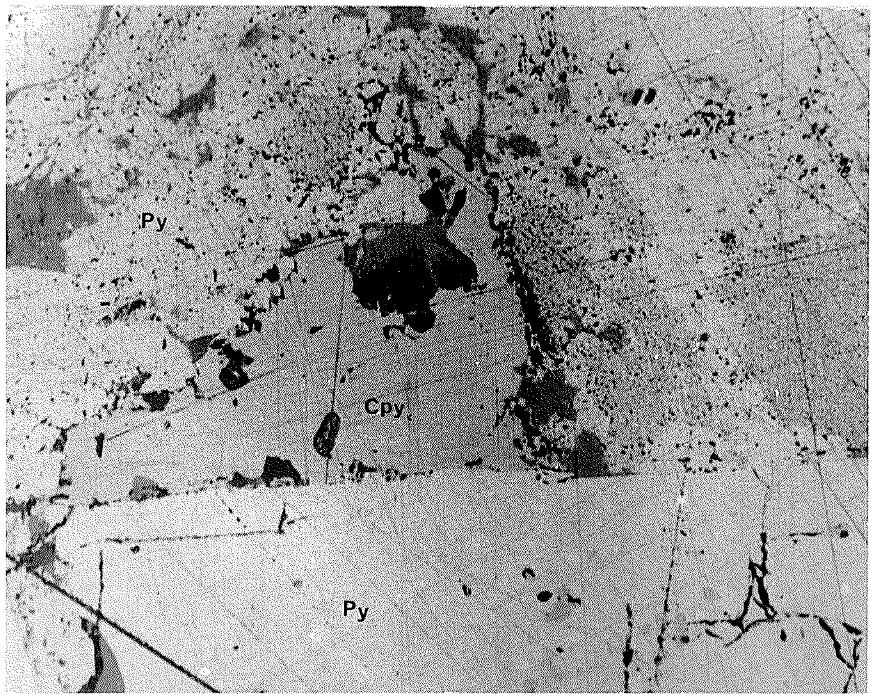

Plate 16 Euhedral pyrite replacing chalcopyrite and anhedral pyrite. C52 44X

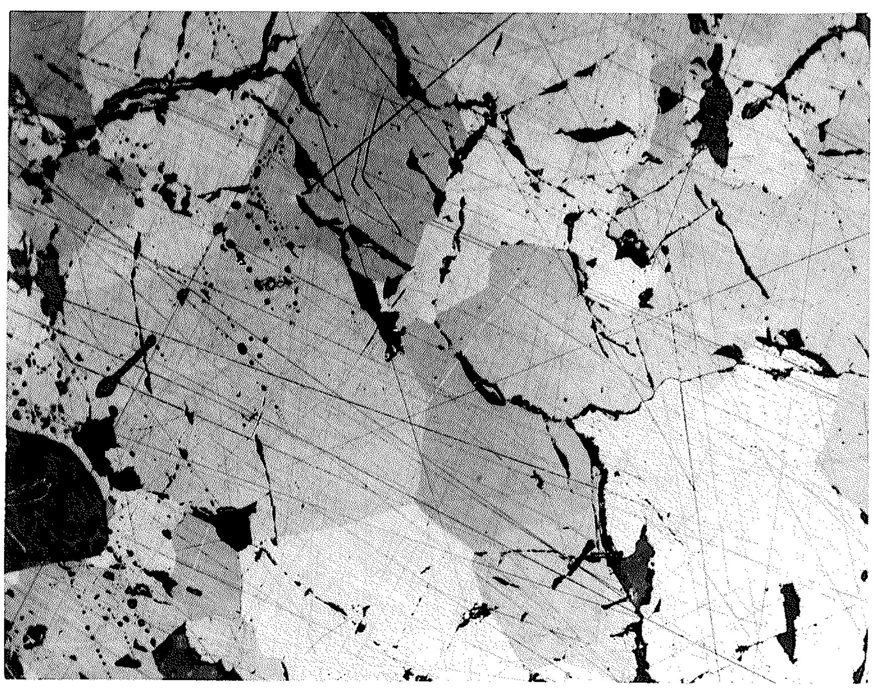

Plate 17 Pyrrhotite with annealed texture. Partial X-nicols C28 36X

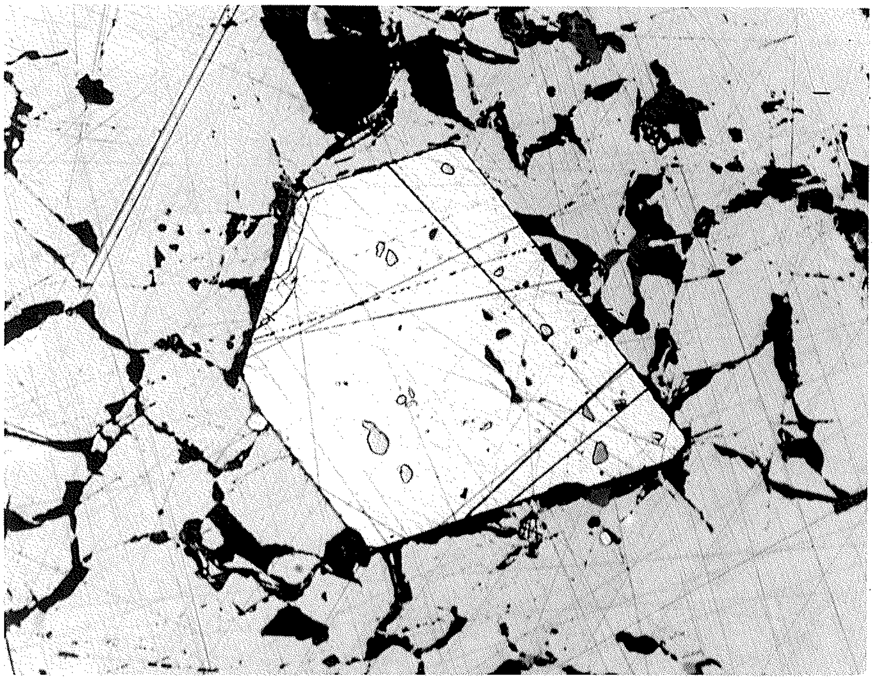

Plate 18 Pyrite metablast in pyrrhotite C28 47X

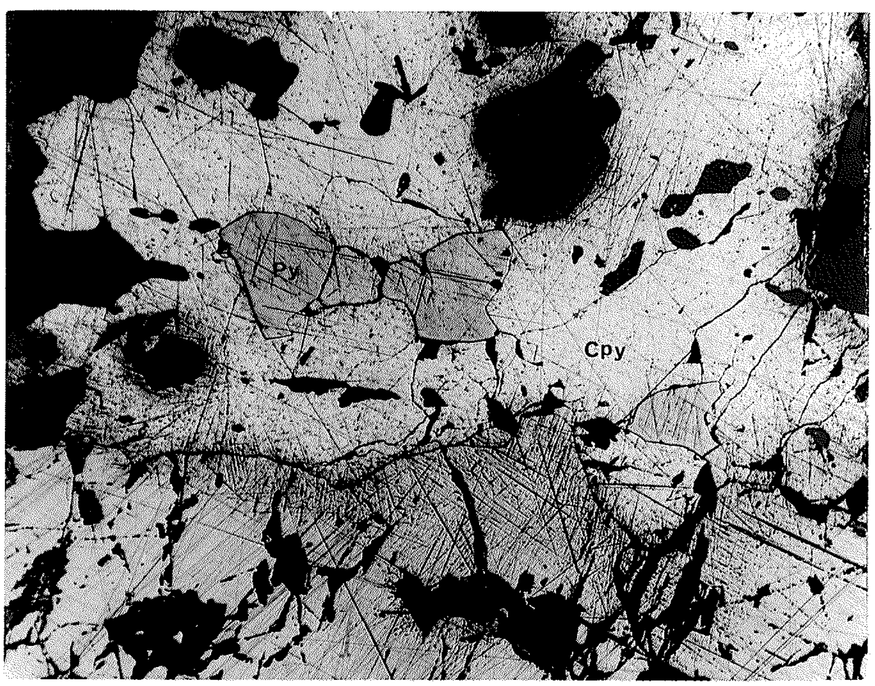

Plate 19 Chalcopyrite replacing pyrrhotite C72 31X

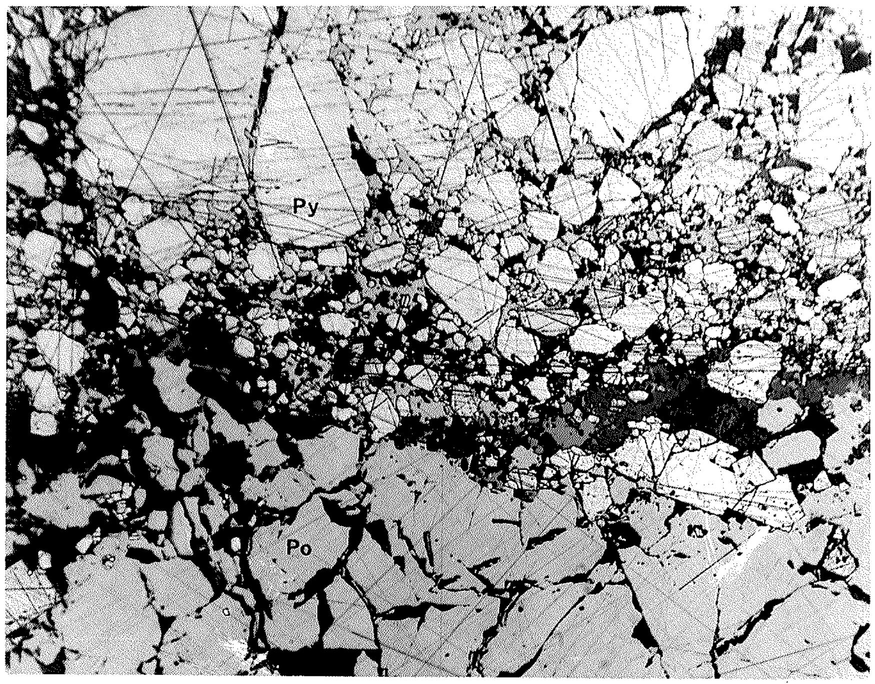

Plate 20 Sheared contact between pyrite and pyrrhotite C28 31X

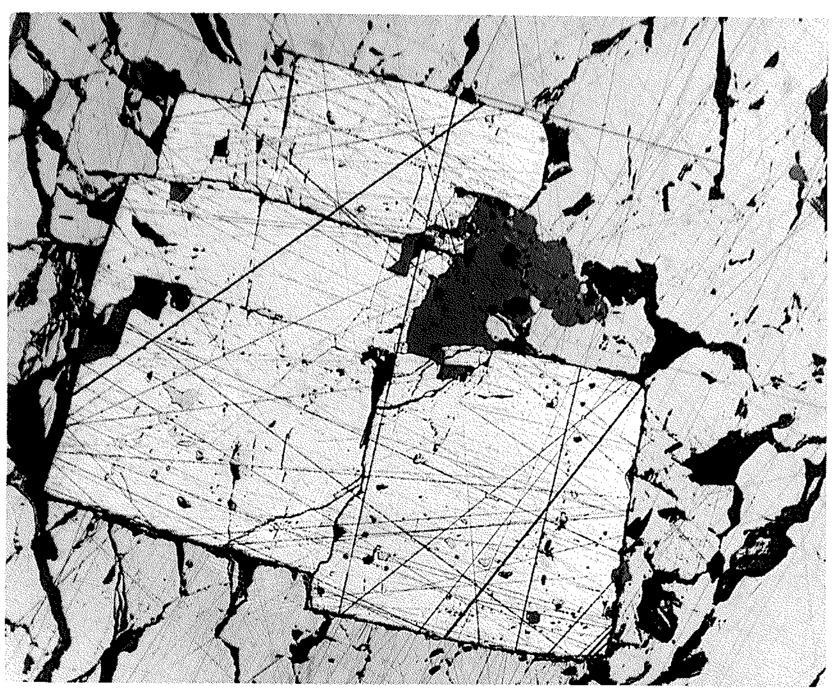

Plate 21 Fractured and displaced pyrite metablast in pyrrhotite C28 40X

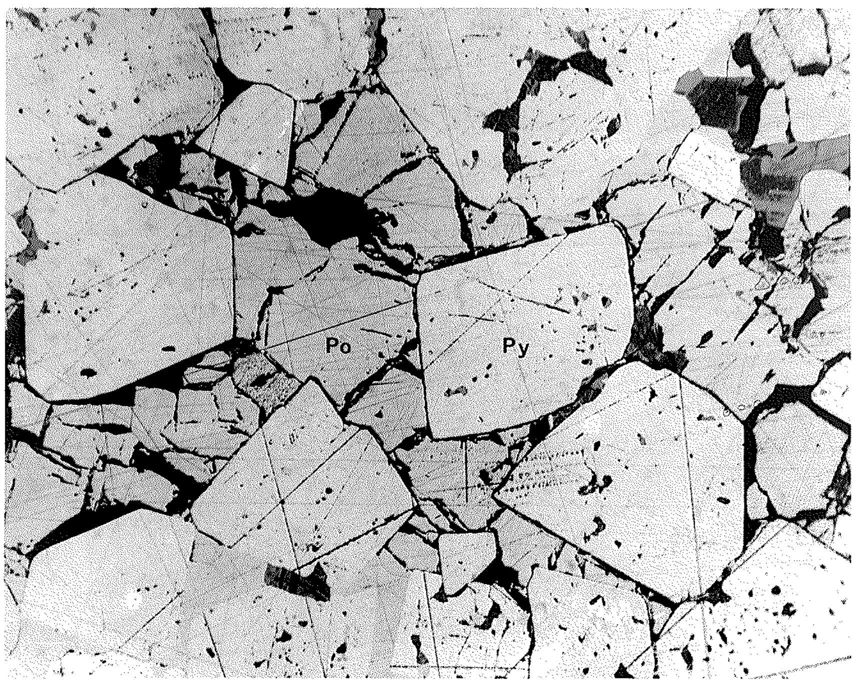

Plate 22 Pyrite and pyrrhotite occurring together
C29 31X

Chalcopyrite and/or sphalerite occur along the grain boundaries of the pyrite and pyrrhotite and replace both minerals (Plate 23). Sphalerite appears to replace, in places, pyrite, pyrrhotite and chalcopyrite (Plate 24).

The recrystallization, replacement and cataclastic features that are present within the massive sulphide zones are typical features of metamorphosed sulphides (Vokes, 1969).

Disseminated Sulphides

The disseminated sulphides occur mainly in a quartz and sericite-rich groundmass and consist of, in order of abundance, pyrite, pyrrhotite, chalcopyrite and sphalerite. Magnetite is associated with the sulphides especially in the alteration zones near the deposit as in C73.

Pyrite is present in many forms and grain sizes. It occurs in separate anhedral to euhedral grains (Plate 25) and in clusters of anhedral to euhedral grains (Plate 26). Gangue minerals such as quartz, carbonate or sericite are commonly found as inclusions with the larger pyrite grains.

Pyrrhotite is present in minor quantities as anhedral grains within the gangue.

Chalcopyrite occurs mainly as tiny blebs within the gangue minerals and occasionally associated with pyrite.

Sphalerite rims some pyrite grains and is present as blebs within the gangue.

Veinlets of sulphides, comprised mainly of euhedral pyrite grains, chalcopyrite and sphalerite occur within the disseminated zones (Plate 27).

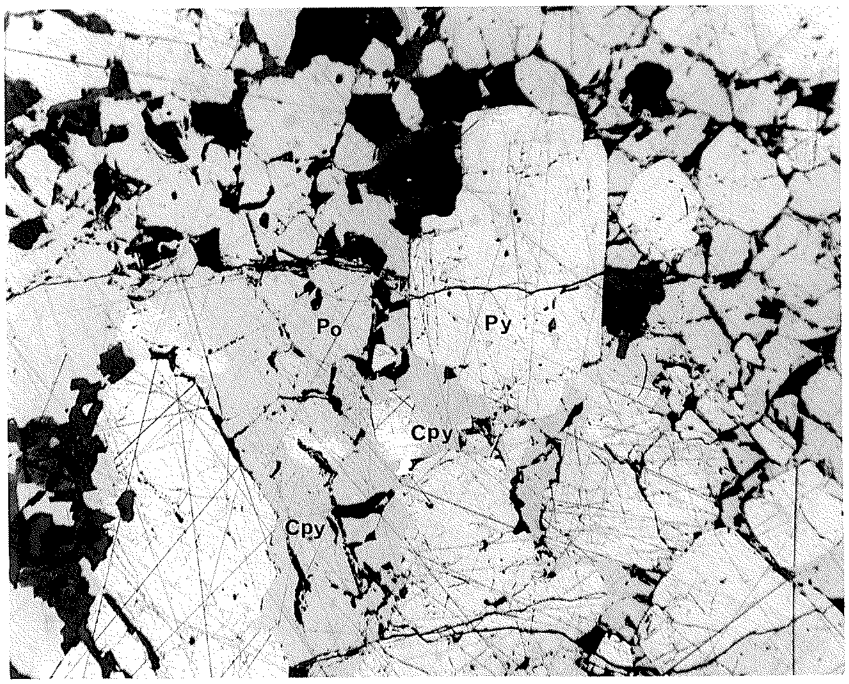

Plate 23 Chalcopyrite replacing pyrrhotite and pyrite C29 31X

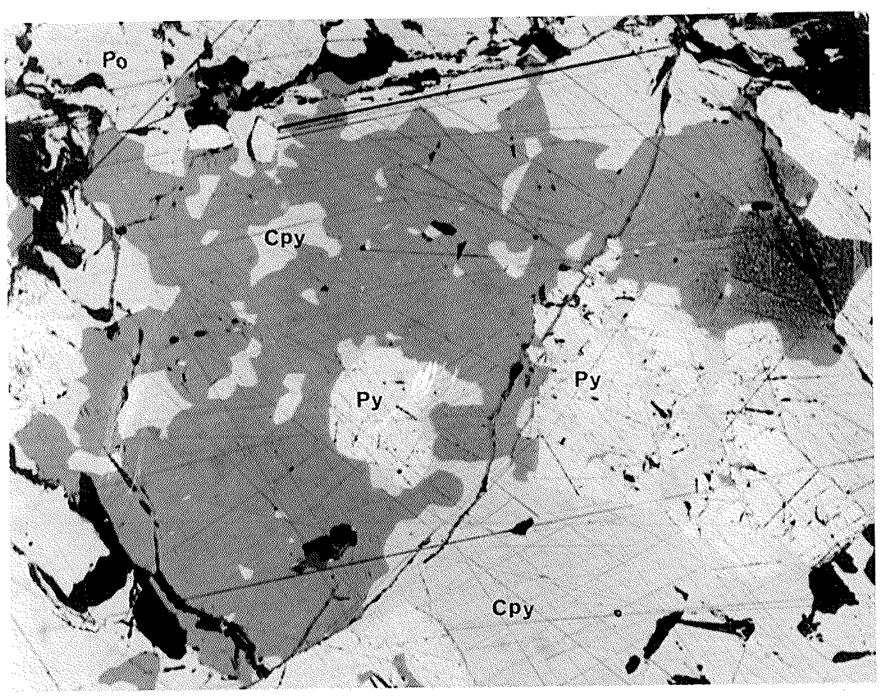

Plate 24 Sphalerite replacing chalcopyrite and pyrite C29 47X

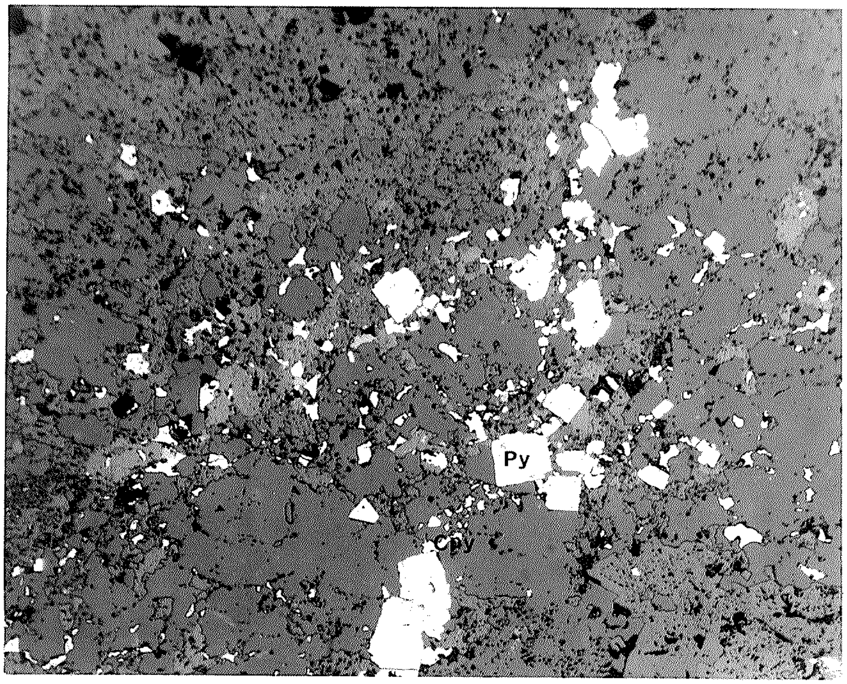

Plate 25 Separate pyrite crystals with chalcopyrite as found in disseminated sulphides C26 31X

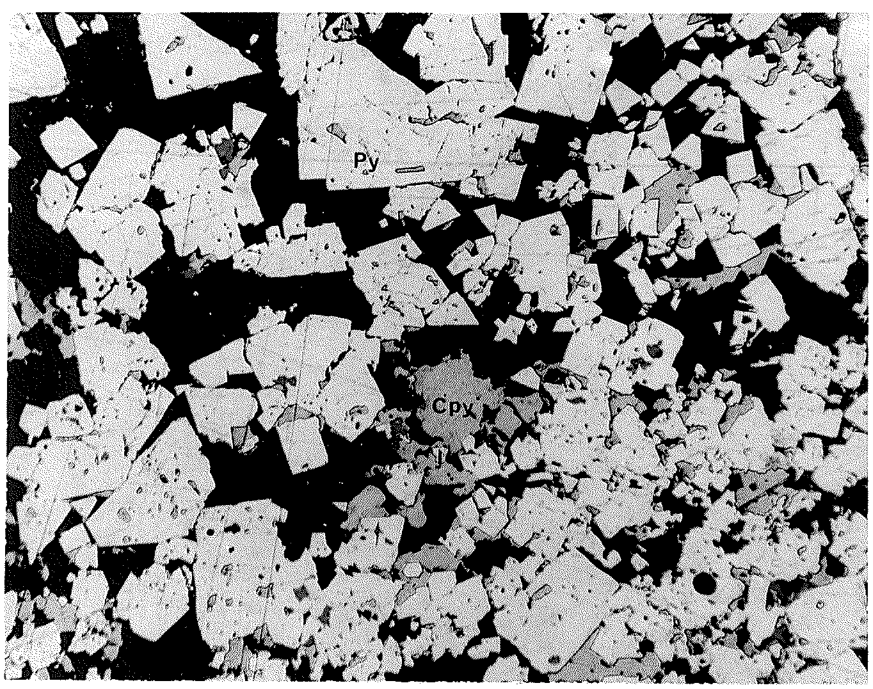

Plate 26 Clusters of pyrite crystals and chalcopyrite as found in disseminated sulphides C26 31X

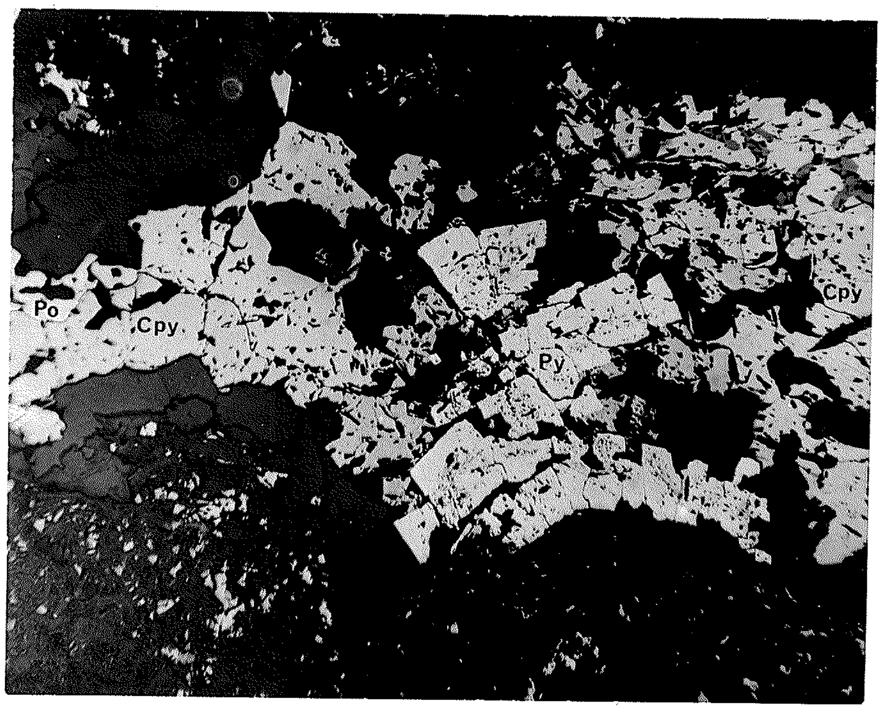

Plate 27 Pyrite, pyrrhotite and chalcopyrite in a sulphide vein within the disseminated sulphides C73 31X

COPPER AND ZINC DISTRIBUTION

The assay results of the deeper mineralized drill hole intersections were analyzed for their copper and zinc content. Separate plots of the copper content, zinc content, and the Cu/Cu + Zn ratio were made for these intersections (Fig. 10a-g).

The general pattern for the copper and zinc distribution is that the copper content is always greater than the zinc content. Along the southeast side of the deposit, the copper content is always greater than the zinc content. Along the northwest side, there is no distinct distribution pattern for copper and zinc, however, in half of the intersections, in both the massive and the disseminated sulphides, the zinc content is greater, such as in drill intersections of holes MN8 and MN7. In two of the thicker intersections of disseminated sulphides, holes MN13 and MN9, the zinc content is greater in the middle of the intersection. Thus, there does not appear to be any distinct overall zoning of copper and zinc across the deposit.

The distribution of copper and zinc within the deposit differs from the typical volcanogenic deposits such as the Flin Flon deposit. In the Flin Flon deposit, the zinc is on top stratigraphically with the massive ore containing chalcopyrite, sphalerite and pyrite and the disseminated ore containing mainly chalcopyrite and little sphalerite and pyrite.

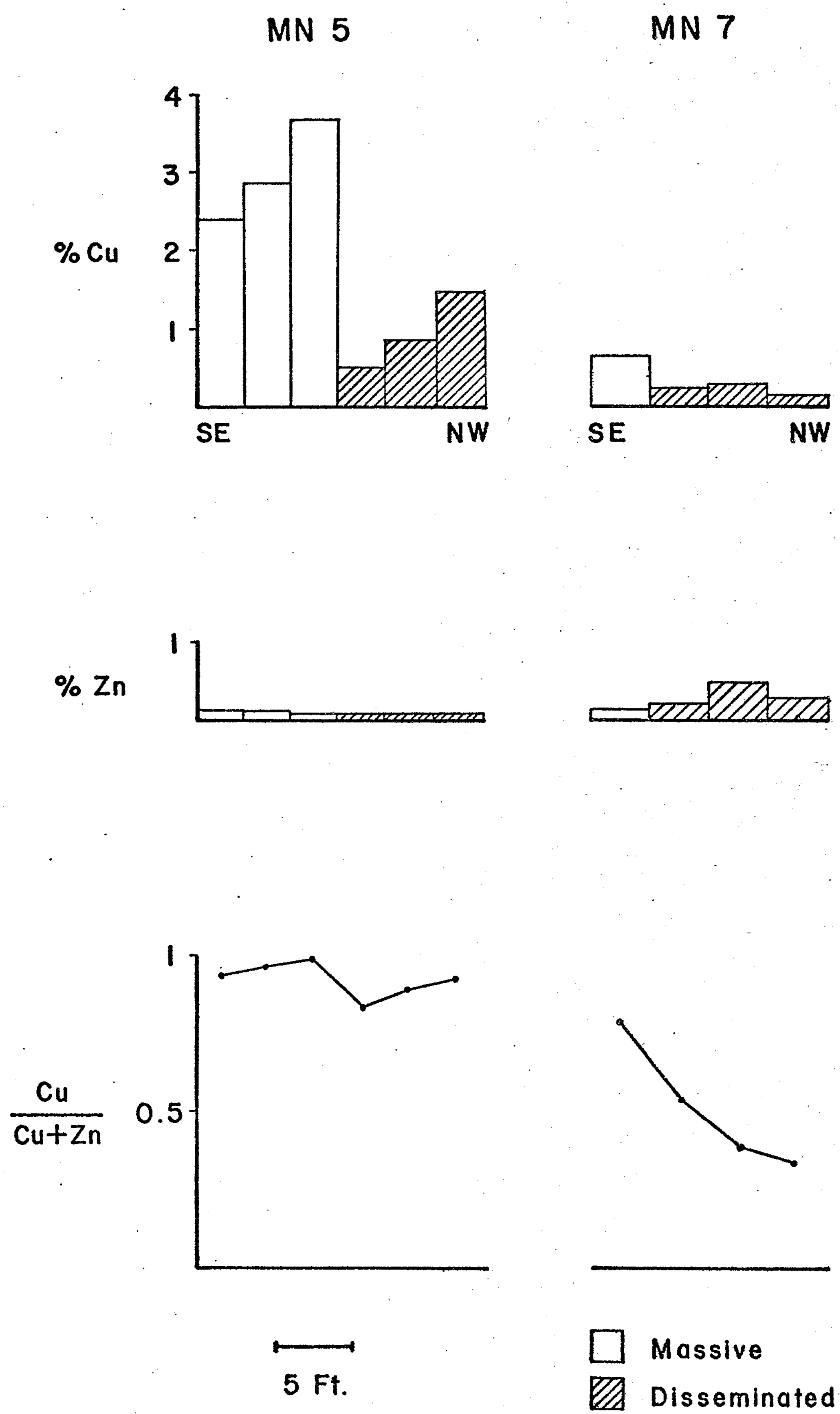

Fig. 10a Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill holes MN5 & MN7

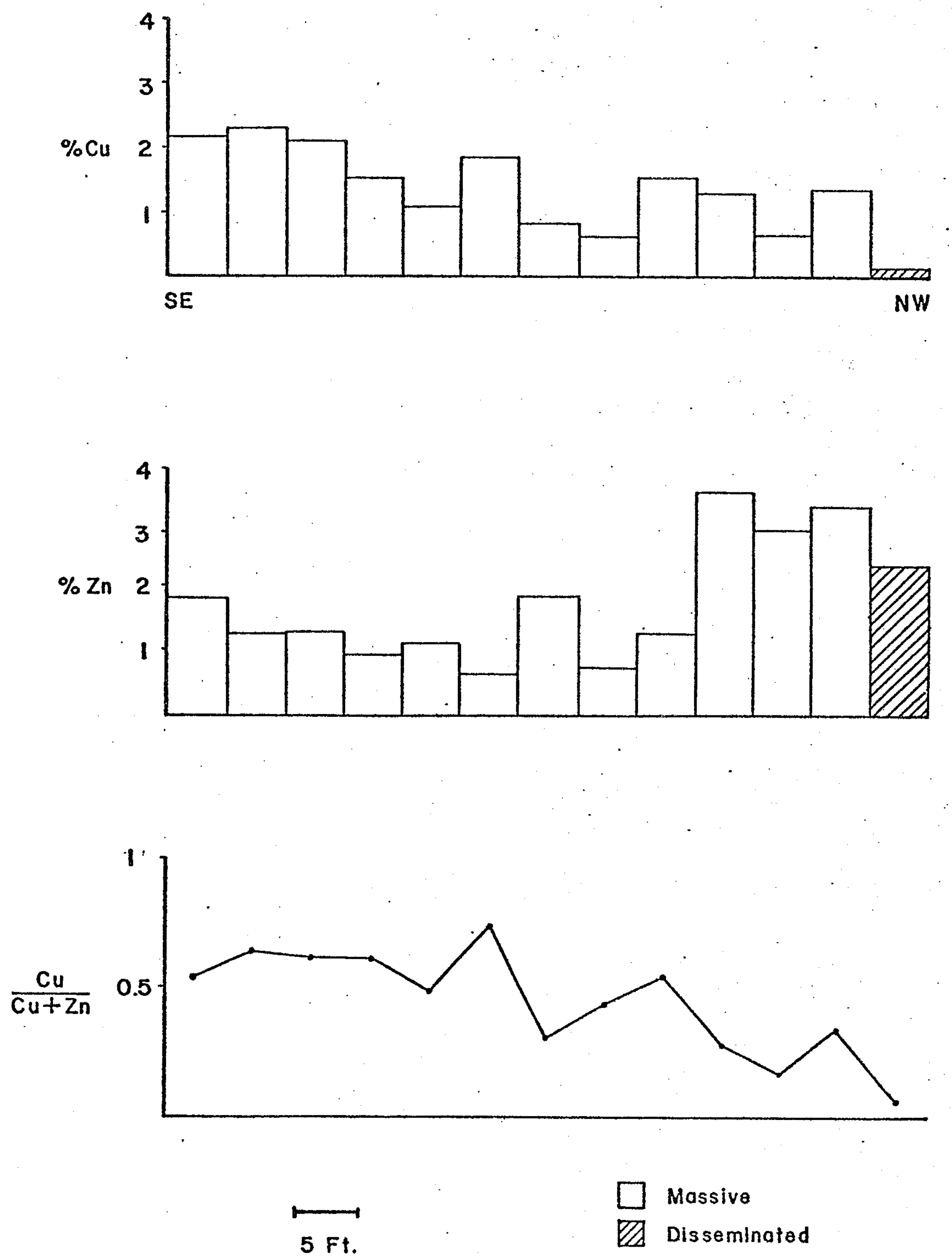

Fig. 10b Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill hole MN8

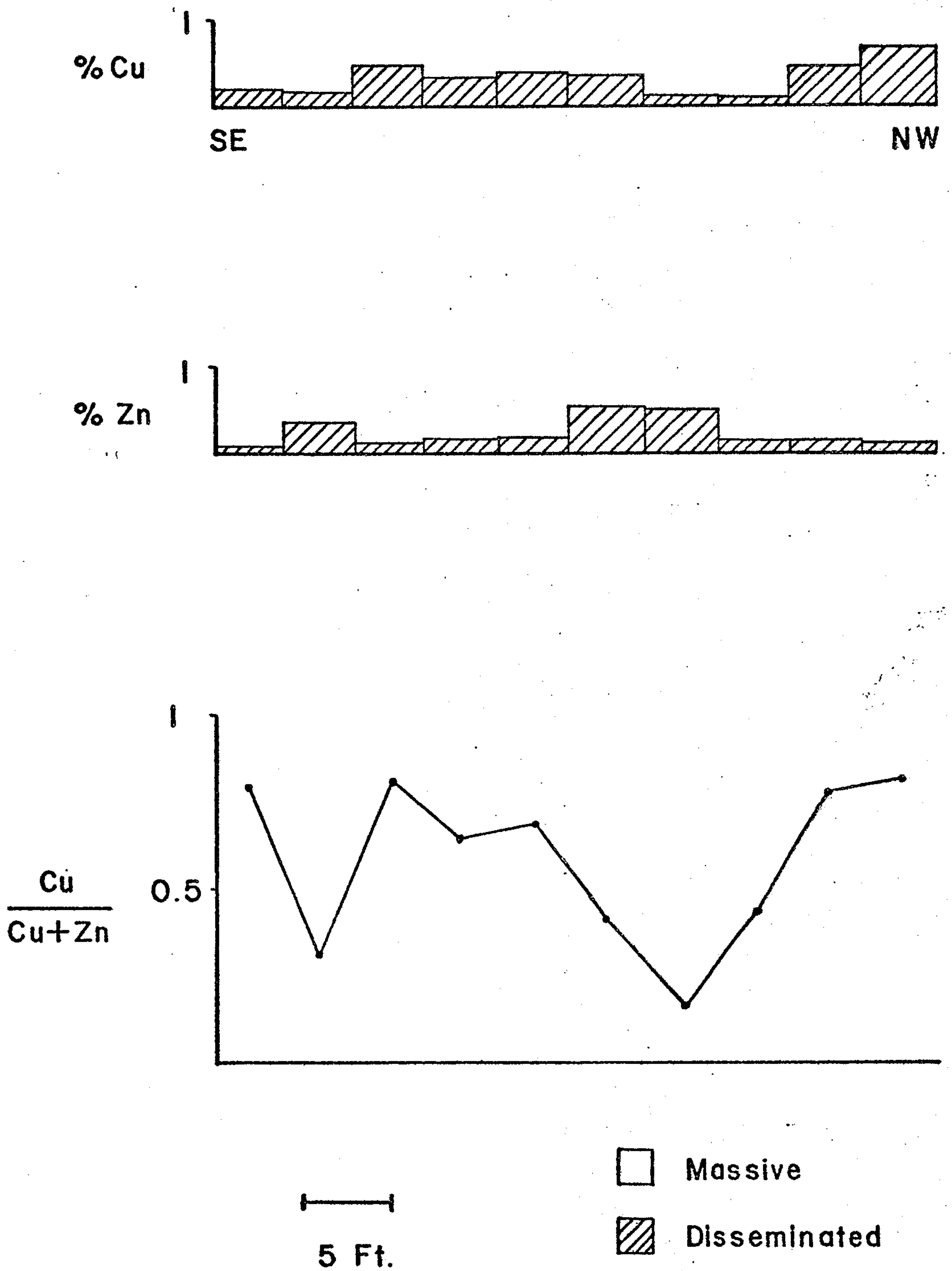

Fig. 10c Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill hole MN9

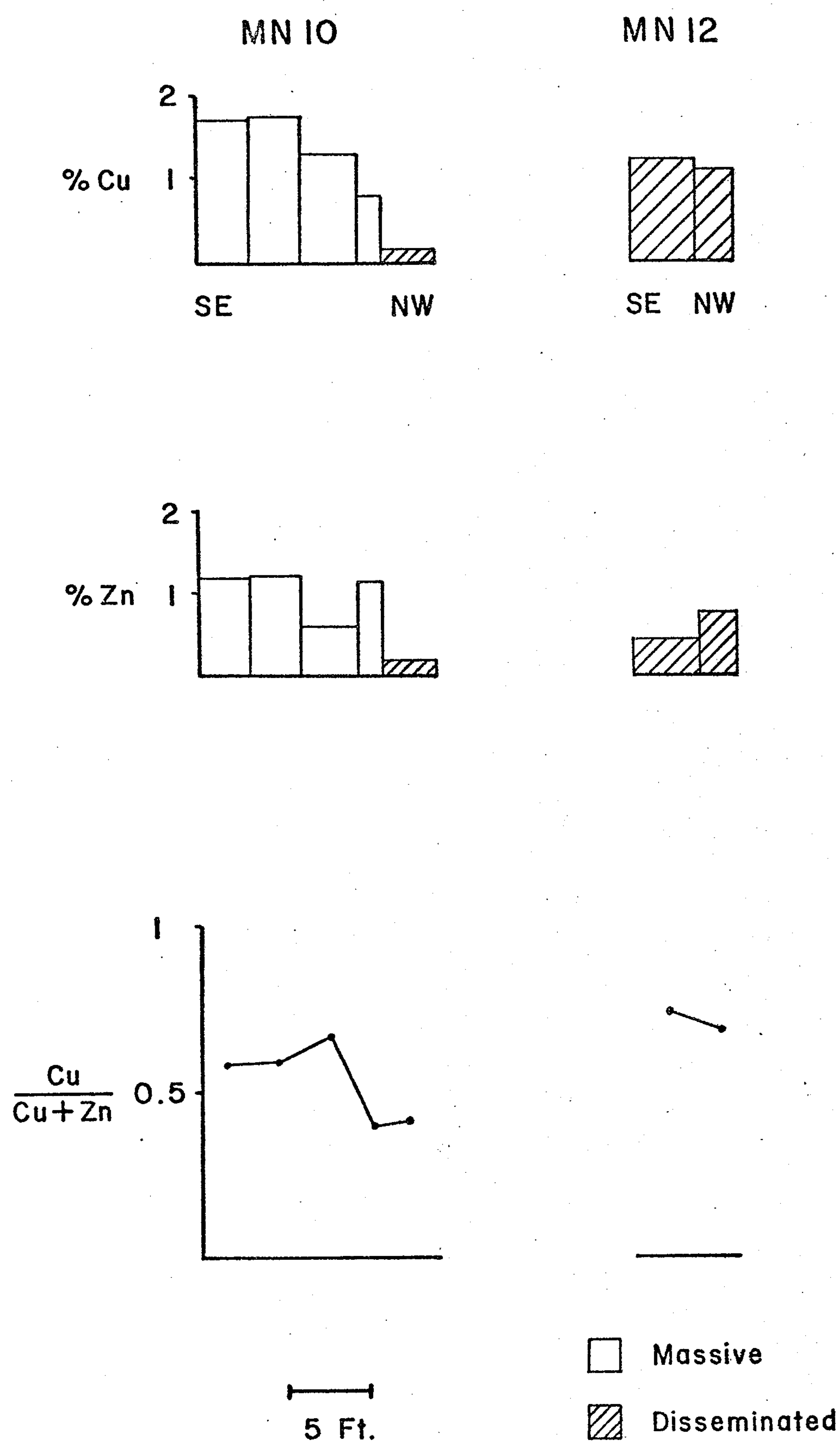

Fig. 10d Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill holes MN10 & MN12

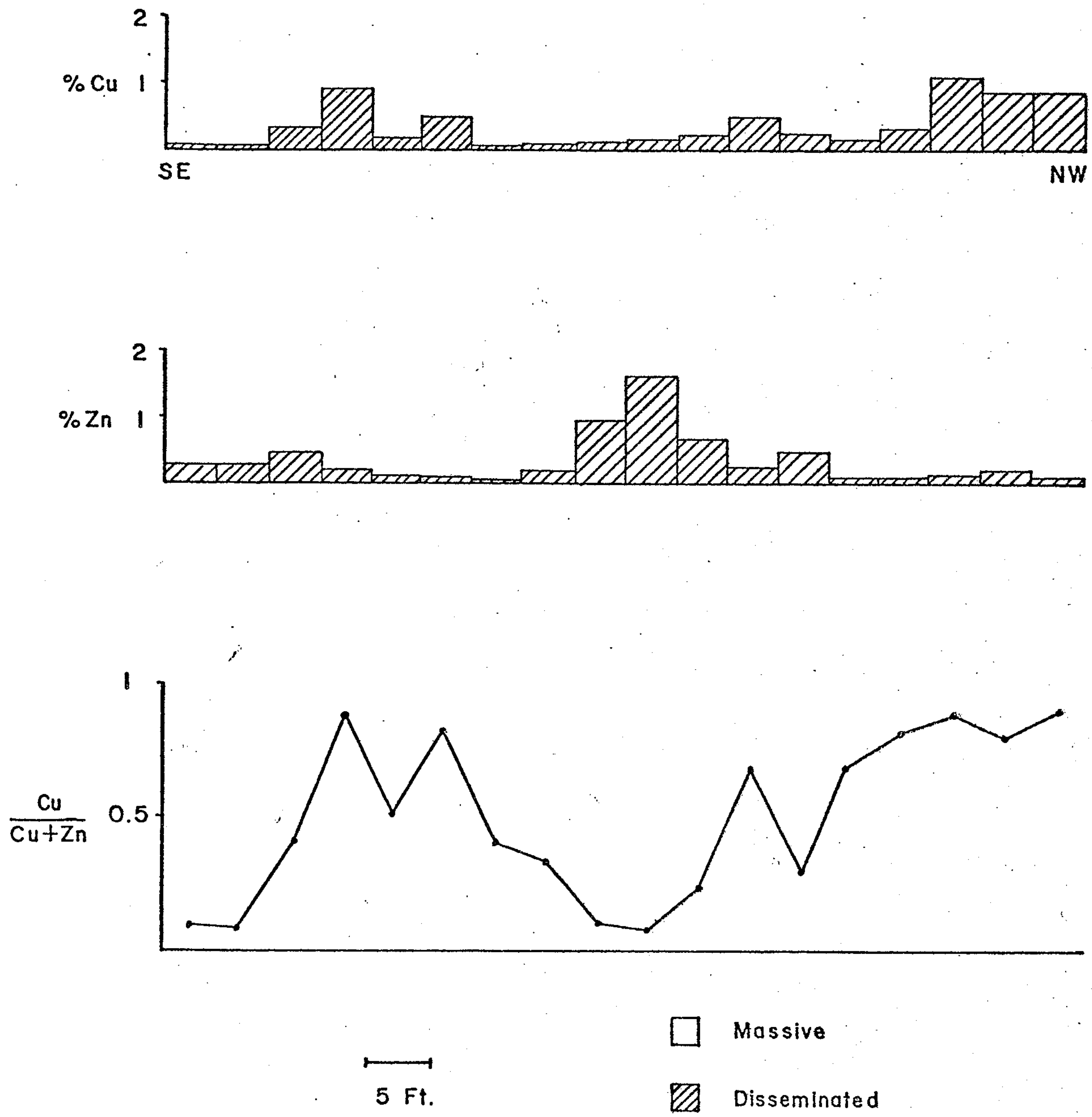

Fig. 10e Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill hole MN13

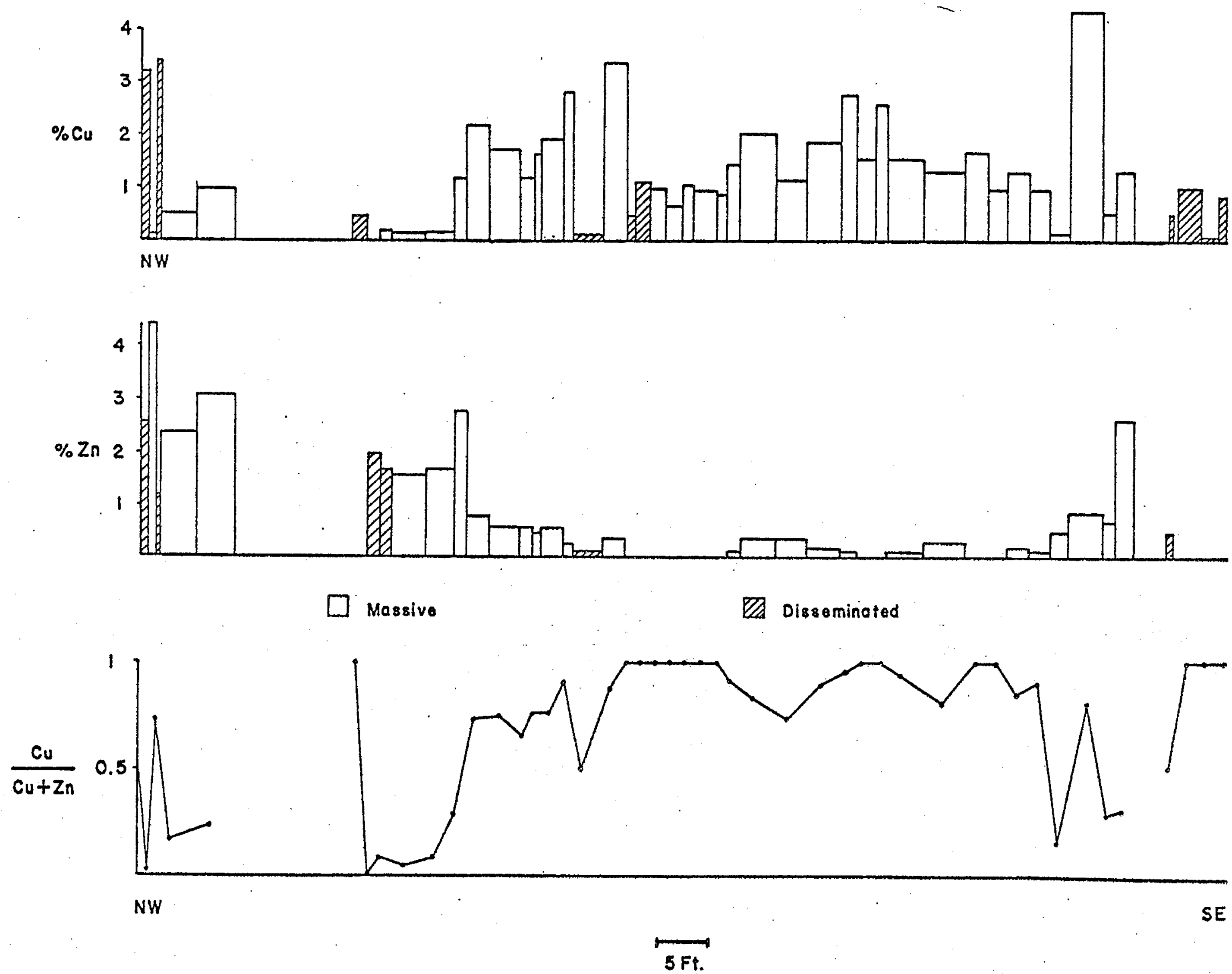

Fig. 10f Plot of copper & zinc distribution and Cu/Cu + Zn ratios for drill hole 36

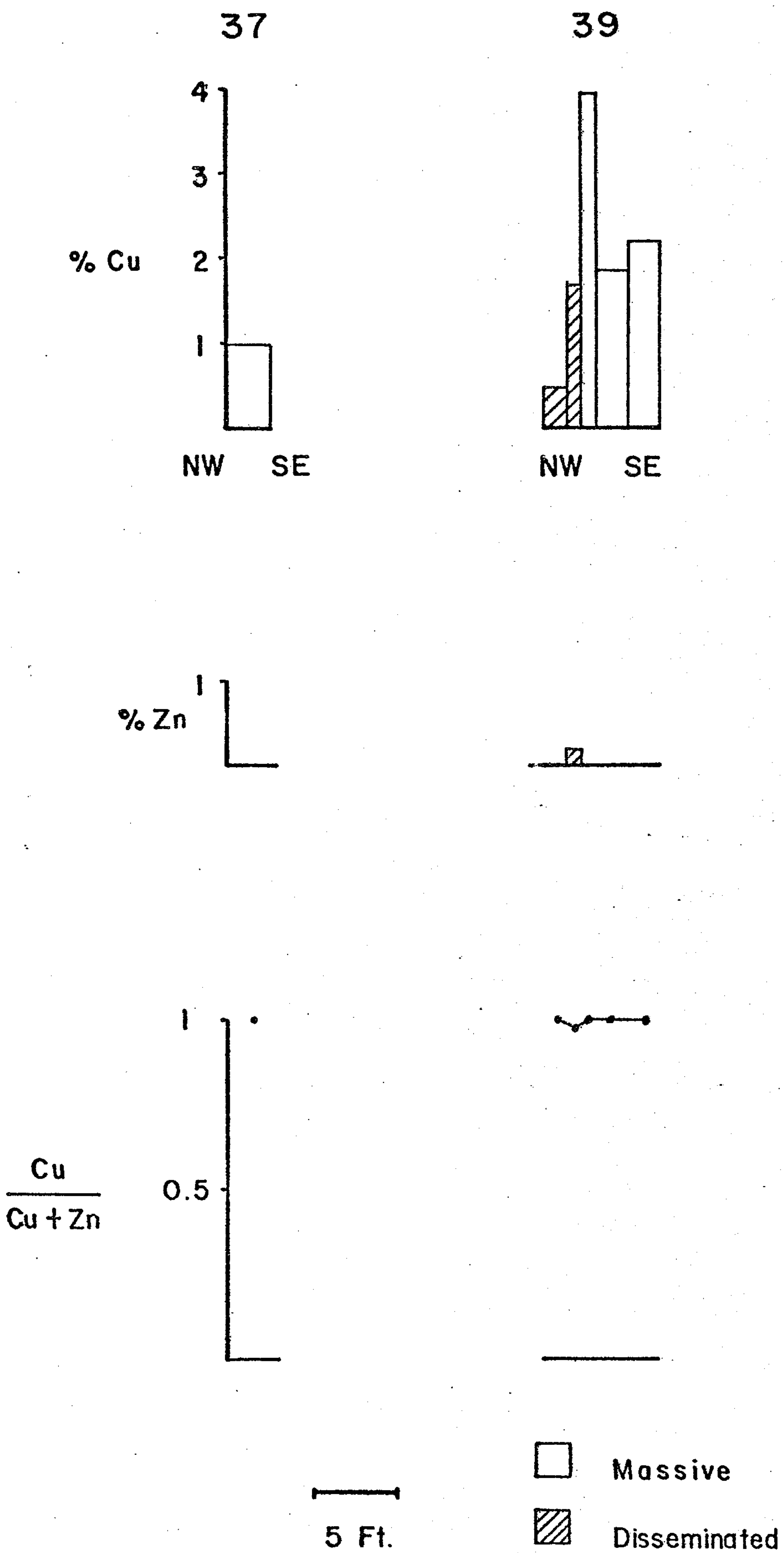

Fig. 10g Plot of copper and zinc distribution and Cu/Cu + Zn ratios for drill holes 37 & 39

The plots of the Cu/Cu + Zn ratios also do not show any distinct overall pattern and do not show any great variation between the massive and disseminated sulphides. The massive sulphides generally have greater copper and zinc content than the disseminated sulphides. Several assayed samples of disseminated sulphides, however, have quite a large copper and/or zinc content such as in holes MN5 and 36.

The Cu/Cu + Zn ratios based on the average copper and zinc values of the deposits in the Flin Flon region were calculated (Table 4). The ratio for the Mink Narrows deposit is relatively high, 0.75, compared to the other deposits. The average Cu/Cu + Zn ratio for all the deposits is 0.68. The deposits within the mafic metavolcanic rocks have a greater copper content.

Plots of percentage copper times true thickness and percentage zinc times true thickness of all the mineralized intersections projected to a vertical plane, give some indication of the vertical distribution of the metals (Fig. 11 & 12). In the copper plot, the maximum value is at a depth of 1,100 feet in hole 36, with a second high value at a depth of 1,400 feet in hole MN5. In the plot of zinc, the maximum value is at a depth of 1,000 feet in hole MN8, with several high values close to the surface at a depth of 100-200 feet in holes 4 and 26. These plots demonstrate that the bulk of both copper and zinc content is below the 1,000 foot level, where the deposit thickens out to its maximum thickness. The several high values of zinc close to the surface are due to narrow intersections such as that in hole 26,

TABLE 4

CU/CU + ZN RATIOS OF THE COPPER AND ZINC DEPOSITS IN THE FLIN FLON REGION

Name	% Cu	% Zn	Cu/Cu + Zn
Flin Flon	2.3	4.6	0.33
Schist Lake	4.5	4.6	0.49
Flexar	3.2	0.5	0.86
White Lake	1.9	4.4	0.30
Birch Lake	6.2	-	1.00
Mandy	7.5	9.4	0.44
Cuprus	3.25	6.4	0.33
North Star	6.1	-	1.00
Don Jon	3.1	-	1.00
Coronation	4.2	-	1.00
Centennial	2.1	2.6	0.44
Pine Bay	1.3	-	1.00
Mink Narrows	1.5	0.5	0.75

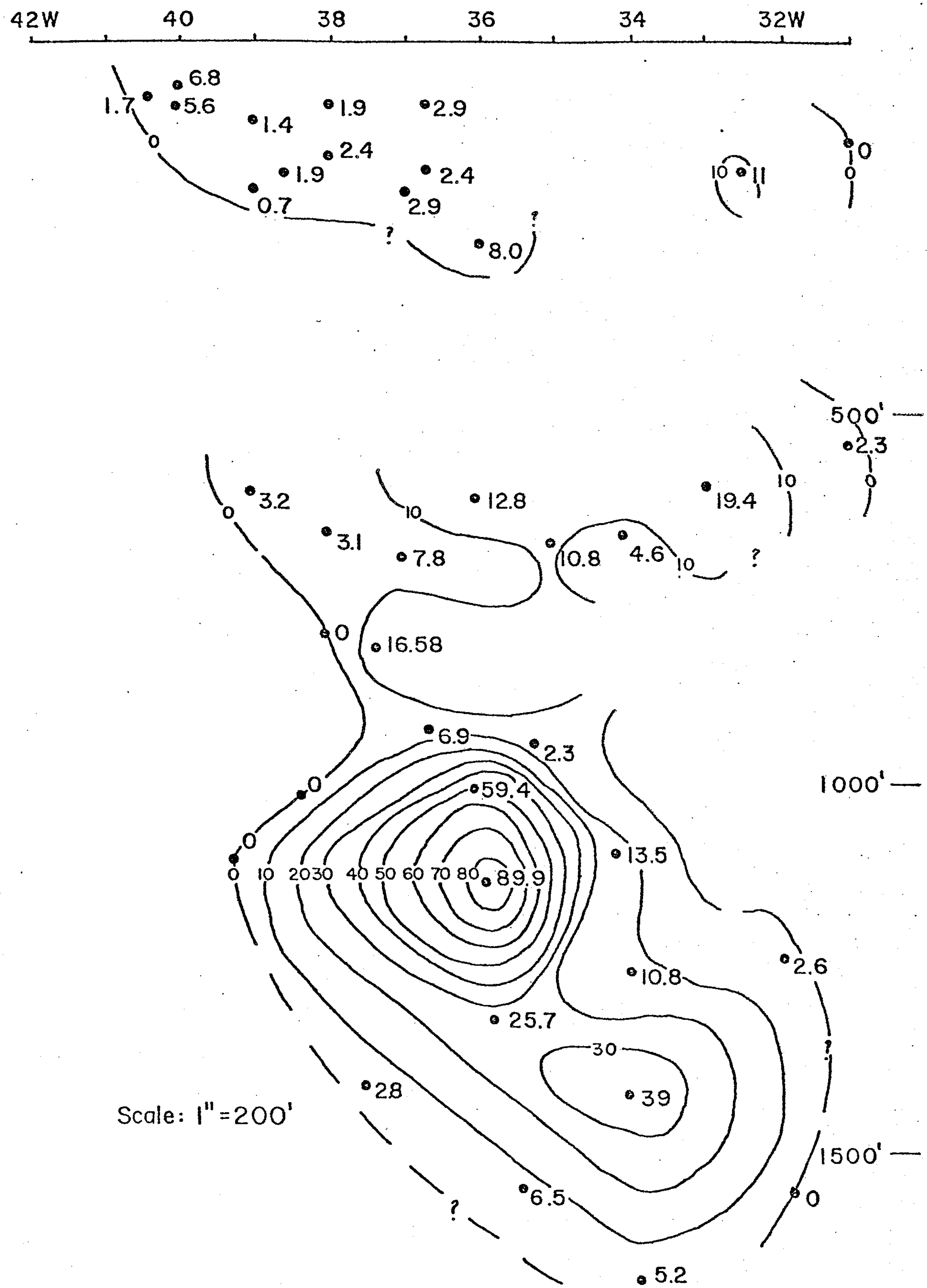

Fig. 11 Contoured plot of percentage copper times true thickness (ft.)

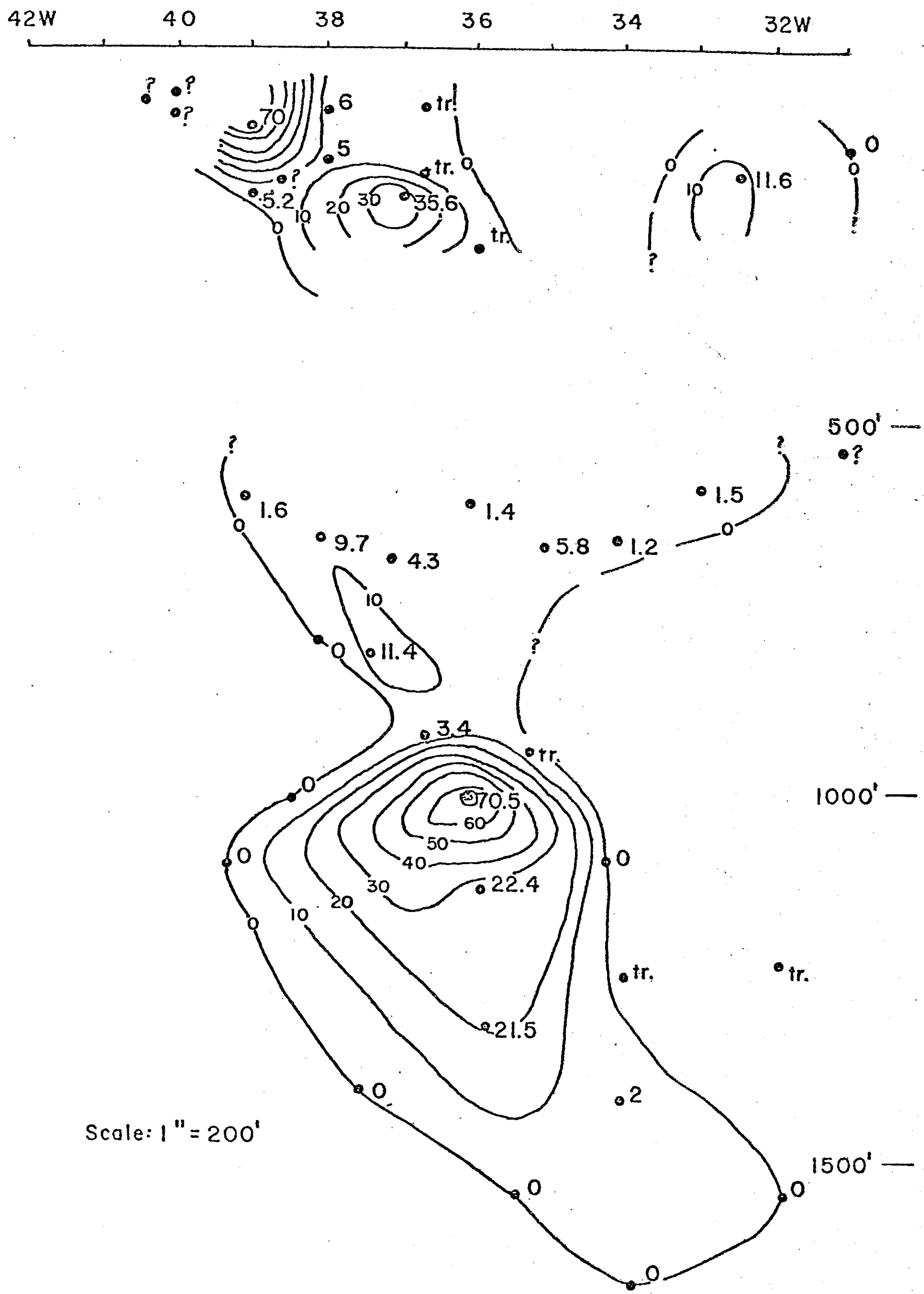

Fig. 12 Contoured plot of percentage zinc times true thickness (ft.)

which had 9.9% Zn. The narrow intersections close to the surface are mainly massive sulphides having a wide variation in grade of copper and zinc.

GOLD AND SILVER DISTRIBUTION

Upon examination of the assay results of the drill holes where gold and silver were analyzed, gold values were low with an average content of around 0.01 oz./ton. Silver values, however, had a greater range, with the maximum being 0.94 oz./ton. The higher silver values, 0.4 oz./ton or greater, were generally associated with sampled intervals that had a copper assay value greater than 1% copper. Sampled intervals with high zinc values and low copper values generally had little or no silver present.

ORE GENESIS

Upon examination of the geological data available, two main genetic possibilities of the deposit exist. The deposit may have been emplaced by hydrothermal fluids from the granodioritic intrusion or deposited during the period of volcanism, i.e. a volcanogenic deposit.

Several factors favouring the former genetic possibility are present. The deposit is parallel to the contact between the granodiorite and basaltic metavolcanic. The basaltic metavolcanics are fractured in the zone between the deposit and the intrusion. The fractured rock provides a network along which hydrothermal fluids may have migrated. Stratigraphic layering is not observable within the metavolcanics, thus, it is not known whether the deposit is strata-bound. A distinct zonation of copper and zinc is not present within the deposit as in many volcanogenic deposits (Sangster, 1972). These are several of the factors favouring an emplacement of the deposit by hydrothermal fluids from the granodioritic intrusion.

Factors favouring a volcanogenic origin are also present. The massive sulphides within the deposit have been metamorphosed. The metamorphism may be due to the intrusion of the granodiorite. A mineralogical zoning occurs within the sulphides and may be metamorphic layering. The mineralogical composition of the metavolcanic is fairly uniform on either side of the deposit. An influx of K_2O and Na_2O does not exist in the rocks between the granodiorite and the deposit to suggest the passage of hydrothermal fluids from the granodiorite. The fractures in the metavolcanic rocks are not mineralized. If mineralizing solutions had passed through, some remnant mineralization would be expected. These are several factors that support a volcanogenic origin of the deposit.

Two types of volcanogenic origin for the deposit are possible. The deposit may be formed by syngenetic processes, i.e. the sulphides were emplaced as exhalative precipitates during volcanism or by epigenetic processes, i.e. emplaced by hydrothermal fluids related to the volcanism.

At the present time without more conclusive evidence for either one, the origin of the deposit is undetermined.

SUMMARY

The Mink Narrows copper deposit is a metamorphosed sulphide deposit in basaltic metavolcanic rocks lying parallel to a nearby granodioritic intrusion. The basaltic metavolcanic rocks have been recrystallized, fractured and retrogradely metamorphosed. The massive sulphides consisting mainly of pyrite, pyrrhotite, chalcopyrite and sphalerite, have undergone metamorphism in the form of recrystallization, fracturing and replacement. The deposit has an alteration zone comprised of sericite, chlorite, quartz and carbonate. This zone is found on the northwest side of the deposit and in some places, on the southeast side.

Although distinct overall copper and zinc distribution patterns are not present, some zoning is noticeable in several of the holes. The bulk of the copper and zinc content is restricted to the regions where the deposit is thickest, at the 1,000 foot depth.

CONCLUSION

The Mink Narrows copper deposit is distinct from the other massive sulphide deposits in the Flin Flon region. It is one of several that occur in basaltic metavolcanic rocks, however, it is the only one that also occurs adjacent to a granitic intrusion.

Two main genetic possibilities exist for the deposit, either emplacement by hydrothermal fluids from the granodiorite intrusion or by activities related to the volcanism.

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APPENDICES

APPENDIX I

SAMPLE LOCATIONS

Sample No.	Hole No.	Footage	Sample No.	Hole No.	Footage
C1	MN8	1200	C34	MN13	1576
C2	MN9	210	C35	MN9	1247
C3	MN10	710	C36	MN12	1069
C4	MN14	1050	C37	MN13	1535
C5	MN7	1100	C38	MN7	1716
C6	MN10	910	C39	MN9	1270
C7	MN13	290	C43	MN10	940
C8	MN12	900	C45	MN10	960
C9	MN7	1450	C47	MN10	980
C10	MN9	850	C49	MN10	1000
C11	MN12	1020	C50	MN10	1010
C12	MN12	1065	C51	MN10	1020
C13	MN12	1080	C52	MN10	1030
C14	MN12	1085	C53	MN10	1040
C15	MN9	1287	C54	MN10	1050
C16	Mn7	1727	C55	MN10	1060
C17	MN8	1158	C56	MN10	1070
C18	MN13	1503	C58	MN10	1090
C19	MN13	1597	C62	MN5	1582
C20	MN7	1907	C64	MN5	1610
C21	MN9	1301	C66	MN5	1630
C22	MN10	1047	C68	MN5	1650
C23	MN7	1943	C70	MN5	1670
C24	MN9	1232	C71	MN5	1680
C25	MN13	1599	C72	MN5	1690
C26	MN5	1960	C73	MN5	1700
C27	MN14	1760	C74	MN5	1710
C28	MN8	1084	C75	MN5	1720
C29	MN8	1086	C76	MN5	1730
C30	MN8	1010	C78	MN5	1750
C31	MN8	1043	C80	MN5	1770
C32	MN7	1912	C82	MN5	1790
C33	MN10	1031	C84	MN5	1805

APPENDIX II

CHEMICAL ANALYSES OF TWO SAMPLES FROM DRILL HOLE MN12

Sample Number	C12	C13
SiO	39.95	44.50
Al_2O_3	12.10	12.61
Fe_2O_3	1.55	1.90
FeO	11.88	10.84
MgO	6.30	8.50
CaO	8.08	6.18
Na_2O	2.32	2.06
K_2O	1.15	0.48
H_2O	3.22	5.12
CO_2	12.41	7.05
TiO_2	0.75	0.36
P_2O_5	0.14	0.13
MNO	0.24	0.15
S	-	-
TOTAL	100.09	99.88

APPENDIX III

CHEMICAL ANALYSES OF SAMPLES FROM DRILL HOLE MN5

Sample Number	C62	C64	C66	C68	C70	C71	C73
SiO_2	49.40	51.25	51.95	34.05	53.40	54.05	31.20
Al_2O_3	13.98	13.91	13.98	13.22	14.72	14.32	17.63
Fe_2O_3	2.89	2.75	2.71	0.89	2.08	1.85	7.45
FeO	9.92	10.65	11.17	11.21	9.20	8.48	22.68
MgO	7.73	7.95	6.13	5.33	6.78	6.85	7.80
CaO	10.51	2.50	4.63	10.85	6.36	7.56	1.05
Na_2O	1.63	0.22	0.39	1.81	4.40	4.28	0.47
K_2O	0.80	4.13	3.45	2.75	0.38	0.38	1.95
H_2O	1.74	3.94	3.27	3.16	1.82	1.43	7.78
CO_2	0.19	0.02	0.02	15.17	0.08	0.10	0.38
TiO_2	0.52	1.04	1.01	0.71	0.41	0.31	0.41
P_2O_5	0.22	0.26	0.26	0.20	0.13	0.17	0.32
MnO	0.19	0.24	0.34	0.32	0.24	0.21	0.18
S	0.03	1.05	1.25	0.41	-	-	1.34
TOTAL WT.%	99.75	99.36	99.93	99.88	100.00	99.99	99.97

APPENDIX III (Cont'd)

CHEMICAL ANALYSES OF SAMPLES FROM DRILL HOLE MN5

Sample Number	C74	C75	C76	C78	C80	C82	C84
SiO_2	45.55	48.40	49.90	48.15	47.10	53.65	52.50
Al_2O_3	12.52	14.93	14.70	15.59	15.06	16.82	13.92
Fe_2O_3	3.98	2.11	2.06	2.01	2.71	3.38	1.41
FeO	12.56	7.68	7.08	6.92	6.68	5.28	11.96
MgO	11.40	9.53	9.53	9.68	7.82	4.70	6.03
CaO	2.75	10.57	10.18	9.96	12.32	7.23	4.93
Na_2O	1.05	3.13	3.14	3.40	3.58	5.70	4.32
K_2O	1.09	0.29	0.28	0.59	1.26	0.61	0.49
H_2O	5.08	1.41	1.60	2.10	1.95	1.48	2.22
CO_2	-	0.20	0.19	0.18	2.00	0.20	0.31
TiO_2	0.35	0.98	0.55	0.58	0.54	0.56	0.69
P_2O_5	0.24	0.19	0.17	0.15	0.15	0.20	0.15
MnO	0.29	0.18	0.18	0.19	0.18	0.19	0.18
S	4.40	0.20	0.19	0.07	0.25	0.03	0.72
TOTAL WT.%	99.06	99.60	99.65	99.61	99.84	100.01	99.47

APPENDIX IV

CHEMICAL ANALYSES OF SAMPLES FROM DRILL HOLE MN10

Sample Number	C43	C45	C47	C49	C50	C51	C54	C55	C56	C58
SiO_2	49.30	52.90	49.90	48.60	50.90	38.50	45.75	49.35	48.40	55.20
Al_2O_3	14.16	14.23	13.34	14.12	13.96	14.91	11.68	11.89	13.26	13.26
Fe_2O_3	1.96	2.27	2.68	3.21	2.93	6.86	1.89	2.53	2.81	2.12
FeO	12.20	9.92	11.13	9.48	8.28	15.00	6.52	6.52	6.88	9.10
MgO	6.90	5.35	6.05	6.63	7.75	10.50	7.28	9.60	9.35	3.45
CaO	8.06	6.50	8.50	10.62	9.13	1.07	11.38	11.56	10.68	5.18
Na_2O	3.46	4.71	3.75	3.30	3.47	1.68	1.16	3.05	3.20	3.71
K_2O	0.42	0.37	0.47	0.48	0.59	1.31	1.36	0.43	0.61	0.83
H_2O	1.65	1.65	1.93	1.59	1.64	6.07	4.35	2.01	2.07	2.98
CO_2	0.14	0.21	0.21	0.53	0.39	2.95	8.24	2.56	2.06	3.17
TiO_2	0.79	0.46	0.81	0.33	0.26	0.55	0.26	0.23	0.26	0.63
P_2O_5	0.15	0.12	0.18	0.09	0.09	0.15	0.08	0.09	0.12	0.13
MnO	0.26	0.18	0.26	0.23	0.21	0.36	0.14	0.21	0.17	0.15
S	0.08	0.01	-	-	-	-	-	-	-	-
TOTAL WT.%	99.53	98.88	99.21	99.21	99.60	99.91	100.09	100.03	99.87	99.81