Open File 1090

SUDBURY TIMMINS ALGOMA MINERAL PROGRAM

PROJECT 4A

MINERALIZATION IN THE ONAPING FORMATION, SUDBURY BASIN, ONTARIO

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$7.00

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SUDBURY, TIMMINS, ALGOMA MINERALS PROGRAM (STAMP)

The Sudbury, Timmins, Algoma Minerals Program was announced in Sudbury September 17, 1983, with the objective of stimulating mineral exploration and economic development in the region. It was initiated by the Department of Energy, Mines and Resources and supported by Employment and Immigration Canada. The program was designed and implemented by the Geological Survey of Canada in collaboration with Mineral Policy Sector. The individual projects were managed by the Department of Geology, Laurentian University, Sudbury, under the Chairman, Dr. A.E. Beswick. Field operations began in early October and continued into December. Following an eight-week extension, the Program terminated on May 25, 1984.

The Program comprised four projects with the following objectives:

Project 1 - Mineral Data Base (CANMINDEX)

- to collect, code and enter basic information on mineral occurrences in north-central Ontario into the Geological Survey of Canada data bank (CANMINDEX file); to provide information on these occurrences to the Ontario Geological Survey in their file format, and update information for the EMR (Mineral Policy Sector) National Mineral Inventory System; and to compile available rock geochemical data.

Project 2 - Swayze Belt Overburden Geochemistry

- to identify target areas for mineral exploration by geochemical sampling and analyses of overburden materials (eskers) in the Chapleau-Foyleyet-Gogama area.

Project 3 - Huronian Supergroup Geochemistry

- to define target areas with anomalous metal concentrations in Huronian sedimentary rocks in the Sault Ste. Marie-Sudbury region.

Project 4 - Rock Chemical Mineral Exploration Criteria

4A: to identify lithogeochemical criteria useful for mineral exploration in the Onaping Formation of the Sudbury Basin.

4B: to determine variations in rock geochemistry of major units of the Temagami Greenstone Belt and their relationships with mineralization.

The numbers and titles of the Geological Survey of Canda Open Files reporting results of these projects are listed on the back cover of this report. A description of the STAMP program, which includes overall co-ordination and administrative support, will be published in Current Research, Part A, GSC Paper 85-1A in January 1985.

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GEOLOGICAL SETTING

The Sudbury Basin is elliptical in plan view, 58 km long and 26 km wide, with the long axis trending 065° (Figure 1). Rocks of the Sudbury Igneous Complex outcrop in the form of an elliptical ring that outlines the basin perimeter. The outer segments of the basin are divided into three ranges: East, North and South. The basin straddles the lithologic contact between Early Proterozoic age rocks of the Southern Province and gneisses and migmatites of the Archean age.

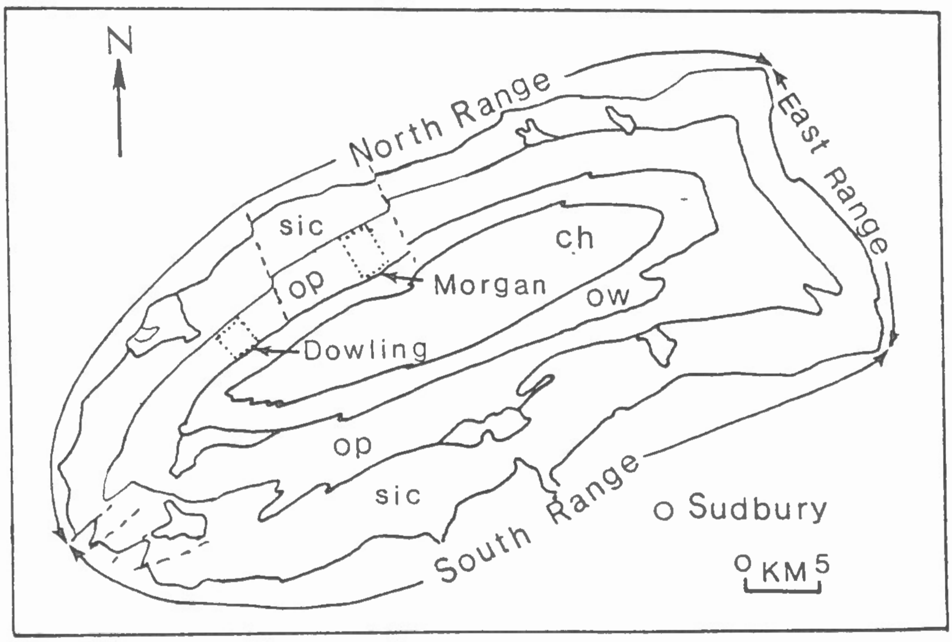


Figure 1. Map of Sudbury Basin showing the locations of the study areas. SIC - Sudbury Igneous Complex; OP - Onaping; OW - Onwatin; and CH - Chelmsford Formations.

Rocks of the Whitewater Group of Early Proterozoic Age comprise the fill of the basin and have no known equivalents outside the basin. The group consists of three formations which are, from oldest to youngest: the Onaping, Onwatin and Chelmsford Formations.

The Onaping Formation is divided into three members (Peredery, 1972a, 1972b; Muir 1982) plus an igneous-textured component termed melt rock (Peredery 1972) or Onaping Melt (Muir 1982). The basal member consists of various breccias that are composed mainly of fragments of Metaarkose and quartzite in the South Range (Stevenson, 1961) and metasedimentary, granite and gneissic fragments in the North Range.

The overlying grey member and the lower two-thirds of the uppermost black member contain a number of heterogeneous breccias which resemble pyroclastic rocks. Units in the upper one-third of the black member are locally bedded. Fragments in the grey and black member include a variety of devitrified glasses, quartzites, arkoses, siltstones, granites, gneisses and gabbros. The melt rocks underlie, penetrate and form irregular masses in all members of the Onaping Formation but tend to be concentrated in the lower half of the formation. Carbonaceous material, particularly abundant in the black member, imparts a dark colour to the rocks.

Sulphide minerals are disseminated throughout the entire Onaping Formation (Rousell 1982, 1983, in press). The sulphide content is variable;

it rarely exceeds 10 percent by volume and commonly is in the order of 1 percent by volume. Muir (1980) and Lafleur (1981) noted that in the North Range sulphide minerals are most abundant in the black member. The sulphide minerals occur mainly as discrete fragments that are 0.5 cm or less in diameter. There are also sulphide patches and grains within rock and glass fragments and in the melt rocks. Pyrrhotite is the most abundant sulphide mineral and it locally contains exsolution pentlandite. Chalcopyrite is common but comprises less than one percent of the total sulphides and is usually enclosed by pyrrhotite. Sphalerite, galena, marcasite and pyrite occur in minor amounts.

The only published chemical data on the metal content of the Onaping Formation consist of analyses of material from drill cores and outcrops by Sadler (1958) and Arengi (1977) and the analyses by Rousell (1982, 1983, in press) of a suite of 26 specimens collected from reported mineral occurrences scattered throughout the basin. These data indicate that there are a few localities in the South Range with moderately high values of Zn, Pb, Ba, As and Cr; elsewhere, metal values in the formation appear to be low to intermediate.

Rousell (in press) compared the average metal values in the Onaping Formation to the average metal values in rocks of intermediate composition (Krauskopf 1967) by a ratio of the two averages and to the average metal values in basalt (Krauskopf 1979) by a similar ratio. For intermediate rocks the range in ratios are: Cu, 0.4 to 4.7; Zn, 1.5 to 5.6; Ni, 1.4 to 3.4; Co, 2.4 to 7; Pb, 1.1 to 4; Cr, 2.1 to 12.4; As, 12.7; and Ag, 5 to 167. For basalt the range in ratios are: Cu, 0.1 to 1.5; Zn, 1 to 3.8; Ni, 0.3 to 0.8; Co, 0.4 to 1.3; Pb, 2.9 to 17; Ba, 1.8 to 2.6; Cr, 0.4 to 2.2; As, 14; Ag, 75 to 2,500;and Au < 60. Thus background metal values in the Onaping Formation are higher than values in intermediate rocks, particularly for Ag, As and Cr. Background metal values in the Onaping Formation tend to be higher than average values in basalt for Zn, Pb, Ba, As, Ag, and Au and lower for Cu, Ni, Co and Cr.

Whether the Sudbury Basin was formed by explosive volcanism or meteorite impact, sulphide-rich material must have been present prior to brecciation and incorporation into the Onaping Formation. The sulphide fragments may have been derived from sulphide-rich pods located at depth (Pattison 1979) and from rocks of the Huronian Supergroup which locally contain as much as 10 percent by volume of pyrrhotite, pyrite and chalcopyrite (Innes 1972). The Vermilion-Errington deposits (Zn-Pb-Cu) occur near the base of the Onwatin Formation. Rousell (1982, 1983) suggested that these may represent sedimentary exhalative deposits derived from metal-rich brines. These brines may have deposited some Zn, Pb and Cu during their passage through the Onaping Formation.

PURPOSE AND NATURE OF THE INVESTIGATION

Prior to this study, no systematic published investigation had ever been made on the economic significance of the mineralization in the Onaping Formation. Little was known of the metal content of the formation and the lateral and vertical distribution of metals. The objectives of the investigation were: to determine the Cu, Ni, Zn, Pb and Au content of the formation in two representative areas; to characterize the distribution pattern of the metals by computer-generated plots; to determine the minimum sampling density necessary to reproduce the pattern; to relate metal distribution to lithology; and to compare the Ni content of pyrrhotite in the Onaping Formation to that in the sublayer, the norite and the Huronian Supergroup.

Because of the large size of the outcrop belt and the complexity of the formation, the method of approach was to undertake a detailed geochemical study of two selected areas (Fig. 1). A 2 km x 3 km area in Morgan Township and a 2 km x 2 km area in Dowling Township were chosen for the following reasons: each area has been mapped in detail (Morgan - Muir and Taylor, 1981, Dowling - Peredery 1972a, 1972b); both areas are in the North Range where the rocks have not undergone ductile deformation; the rocks are well exposed and reasonably accessible; pits and drill holes indicate some exploration activity; and the two areas are sufficiently close so that comparisons can be made.

In order to facilitate sampling, a grid was established in each area (Morgan Township - Figure 2, Dowling Township - Figure 3). This involved the cutting and chaining of an accurate base line. Pace and compass lines were run from the base lines using aerial photographs for control. The grid lines are oriented normal and parallel to the strike of lithologic contacts. Samples were collected at 400 m intervals over the whole of each area. In addition, samples were collected at 100 m intervals in 9 subareas in Morgan Township and 7 subareas in Dowling Township; each subarea is 400 m square. Samples were also collected at 20 m intervals in two subareas in Morgan Township and two subareas in Dowling Township. Each subarea is 100 m square.

Map 1 and map 2 are simplified geological maps of Morgan Township and Dowling Township, respectively. They show the locations of the samples collected on the 400 m and 100 m scales. The locations of samples collected at the 20 m interval are shown on map 3 (in pocket). A total of 607 samples were collected - 332 from Morgan Township and 275 from Dowling Township. Field work was done in the fall of 1983 by a party of four.

All samples were chemically analyzed, by atomic absorption, for Cu, Ni, Zn and Pb. Samples from Morgan Township were analyzed for Au.

The Surface II software package, used to generate the contour and perspective diagrams, arrived at a late stage in the project. Consequently, only a certain number of these diagrams were produced.

There was insufficient time to do the microprobe analyses of pyrrhotite.

This report represents a revision, by the second author, of a report submitted by the senior author. The report was edited by the third author.

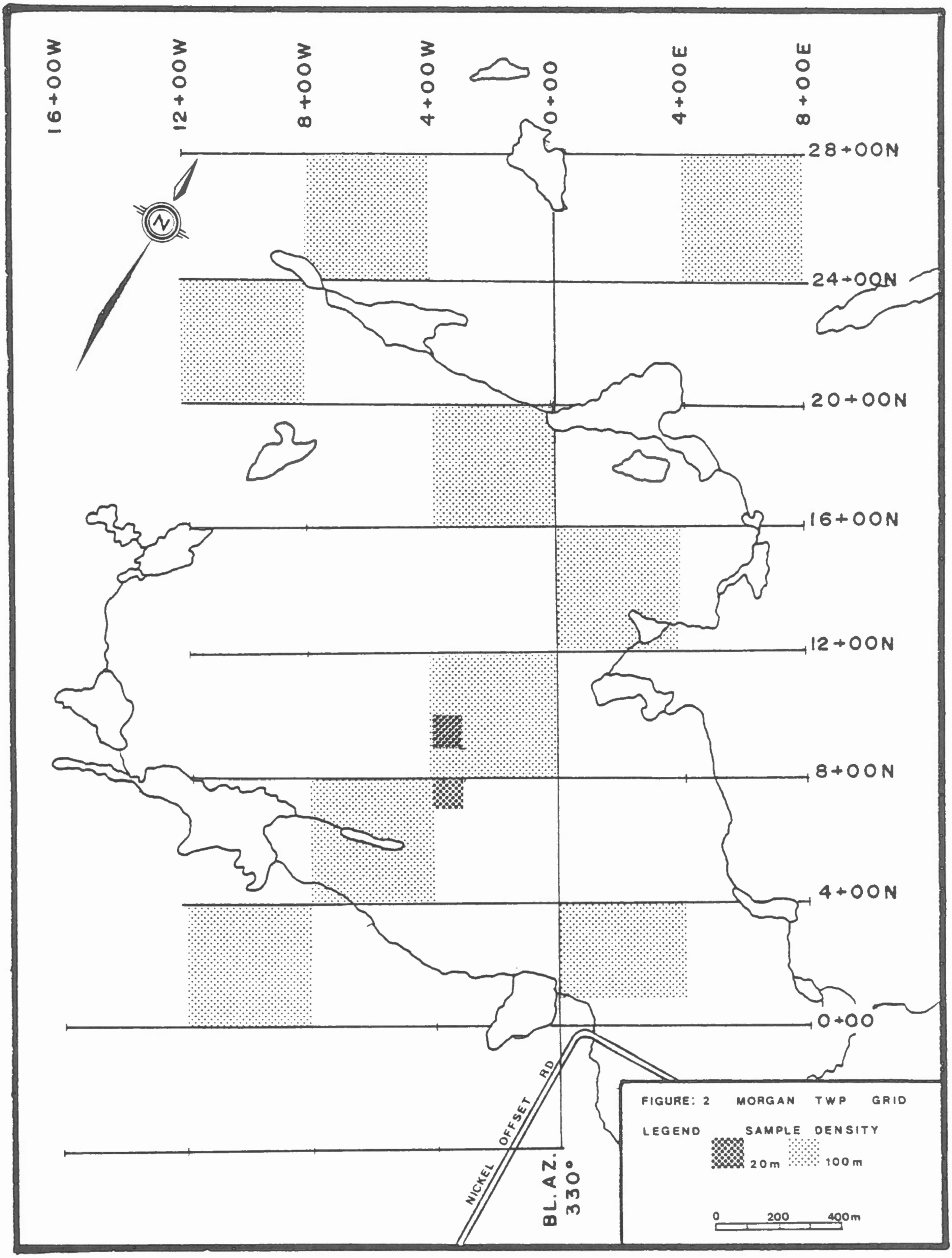


FIGURE: 2 MORGAN TWP GRID

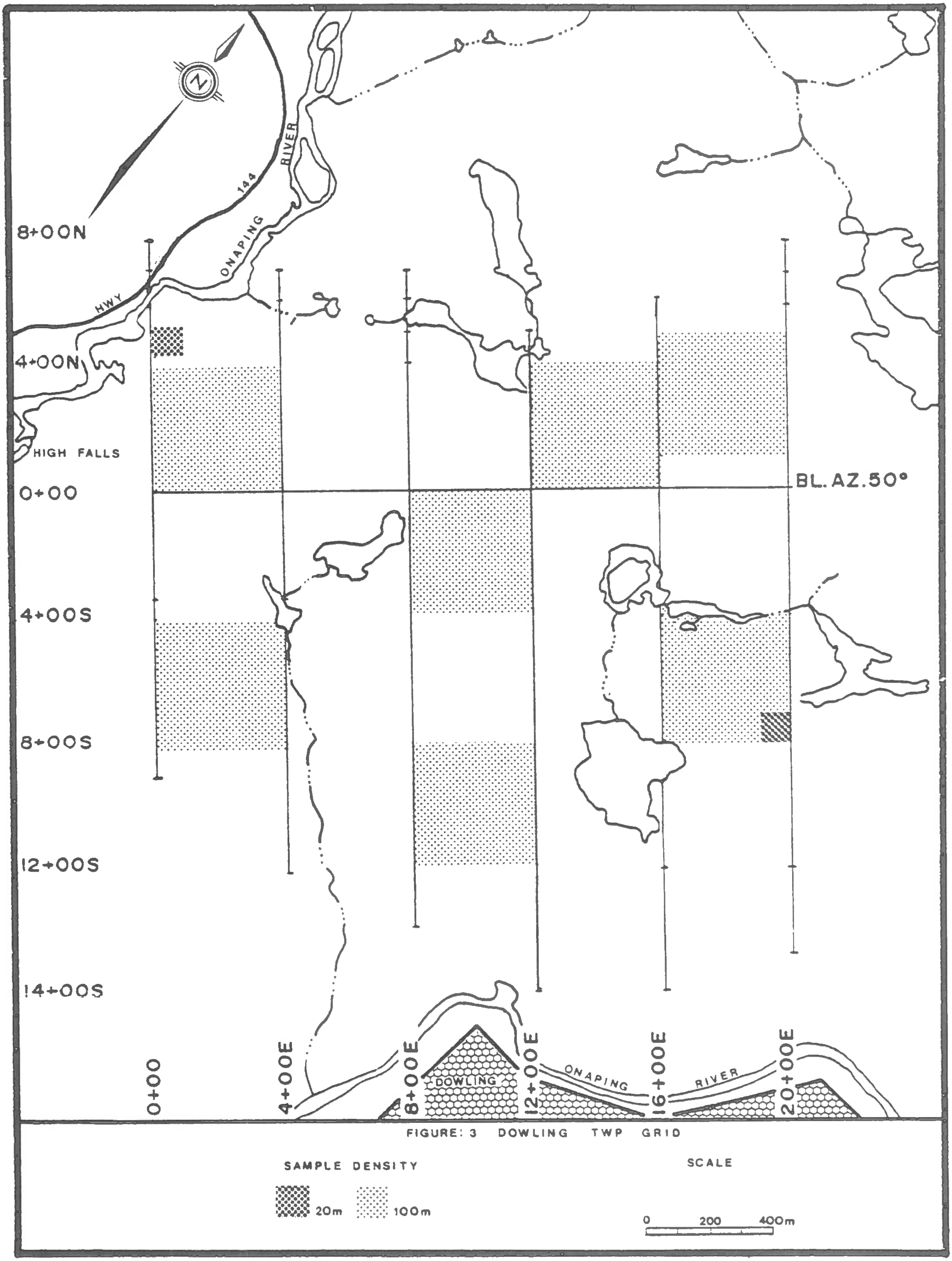


FIGURE: 3 DOWLING TWP GRID

ANALYSIS OF DATA

Introduction

Chemical analyses of samples from Morgan Township are given in Appendix A and analyses of samples from Dowling Township are given in Appendix B (UG/G = ppm).

Values of Pb were detected for only 33 of the samples from Morgan Township. The highest value, 500 ppm, is from a sample from the Black member. On the other hand, 193 of the samples from Dowling Township yielded Pb values and the highest, from the Grey member, is 4826 ppm. Most of the lead values, from both areas, are low and between 20 and 30 ppm.

Gold was detected in 200 of the samples from Morgan Township. The highest value was 20 ppb and most samples contained less than 10 ppb. The low Au values in the Morgan Township material suggested that it was not feasible to analyse the samples from Dowling for Au.

Because of their low values, the chemical data for Pb and Au are not considered further. The chemical data for Cu, Ni and Zn are presented and discussed in terms of statistical analyses, scatter diagrams and aerial distribution.

Statistical Analysis

Table 1 and Table 2 set out statistical summaries of Cu, Ni and Zn analyses from Morgan Township and Dowling Township, respectively. Frequency distribution histograms of analytical data from Morgan Township are given in Figures 4 to 6 inclusive, and from Dowling Township in Figures 7 to 10, inclusive. Note that high values are omitted from some of the histograms. The majority of values for a given metal fall in the lower end of the range; therefore, the mode and median are less than the mean. For simplicity, the data is discussed and compared in terms of the median and the maximum value. (Minimum values are uniformly low and the "maximum" minimum values for all sets of data is 40 ppm.) The frequency histograms give a general impression of the spread of the data and the value of the mode.

The median values of Cu, Ni and Zn, for all samples in Morgan Township (rounded off to the nearest whole number) are 40, 87 and 51 ppm, respectively; for Dowling Township the equivalent values are 43, 84, and 64 ppm. Thus, in general the two sets of data are similar and the median values are far below ore grade. The maximum values of Cu, Ni and Zn in Morgan Township are 1350, 1519 and 748 ppm respectively, while the same values in Dowling Township are 3025, 159 and 3860, respectively.

The median values of Cu, Ni and Zn for samples from the Grey member in Morgan Township are 33, 85 and 543 ppm respectively. For Dowling Township, the equivalent values are 38, 84 and 58 ppm respectively.

The two sets of data are quite similar. In Morgan Township, the maximum values for Cu, Ni and Zn are 1350, 120, and 1700 ppm, respectively, while in Dowling Township the same values are 202, 159 and 1700 ppm, respectively. Apart from Cu in Morgan Township and Zn in Dowling Township, the rest of the maximum values are quite low.

The median values of Cu, Ni and Zn for samples from the Black member in Morgan Township are 41, 88 and 64 ppm, respectively; for Dowling Township equivalent values are 46, 85 and 667 ppm, respectively. Median values of a given metal are remarkably similar in the two townships. The maximum values of Cu, Ni and Zn in Morgan Township are 199, 115 and 748 ppm, respectively; in Dowling Township equivalent values are 3025, 124 and 3860 ppm respectively. Thus, there are local moderately high values of Cu and Zn in Dowling Township.

The median values of Cu, Ni and Zn from melt rocks in Morgan Township are 56, 71 and 41 ppm, respectively; for Dowling Township equivalent values are 42, 73 and 78 ppm, respectively. Again, the median values for a given metal are similar in the two townships. The maximum values of Cu, Ni and Zn in Morgan Township are 679, 1519 and 77 ppm, respectively; in Dowling Township equivalent values are 250, 105 and 2640 ppm, respectively.

In summary, median values of a given metal are similar in the two townships. Moreover, there does not appear to be a significant difference in values among the three members. These data do not support the suggestion by Muir (1980) and Lafleur (1981) that metal values tend to be higher in the Black member than other members. Median values are all low and none exceeds 100 ppm. In general, median values tend to be highest for Ni, lowest for Cu and intermediate for Zn. Of the three metals, in Morgan Township, Ni has the highest maximum value and Zn the lowest maximum value, whereas in Dowling Township, Zn has the greatest maximum value and Ni the lowest maximum value. This suggests that maximum values are local in nature.

Scatter Diagrams

Scatter diagrams for chemical data of samples from Morgan Township are shown in Figure 11 and those for Dowling Township are shown in Figure 12.

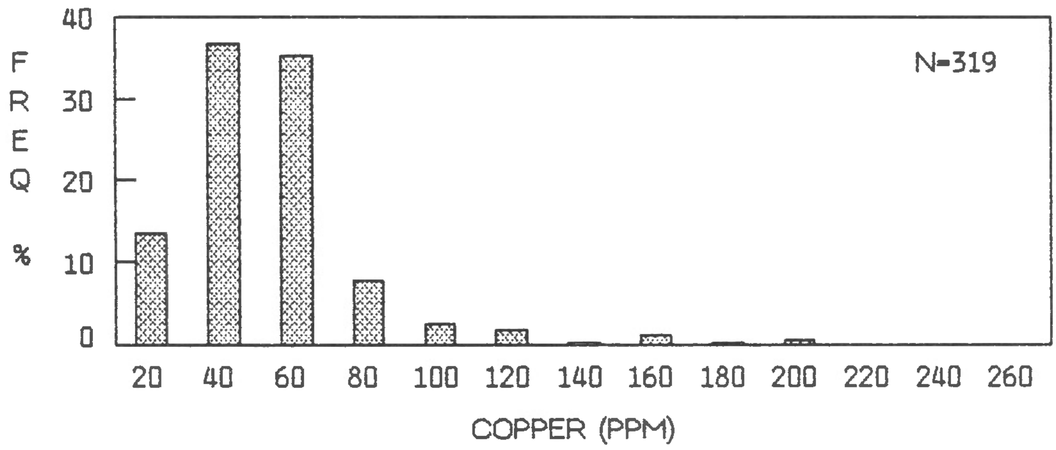
The plots of Cu vs. Ni (Figure 11a and Figure 12a) show a cluster of points and no obvious trends. The plot of Cu vs. Zn (Figure 11b and Figure 12b) indicate a tendency for Cu and Zn values to increase together. The plot of Ni vs. Zn (Figure 11c and Figure 12c) indicates a cluster of points with a tendency for Zn values to have a wider scattering than Ni values.

Table 1. Statistical data for Cu, Ni and Zn. Morgan Township.

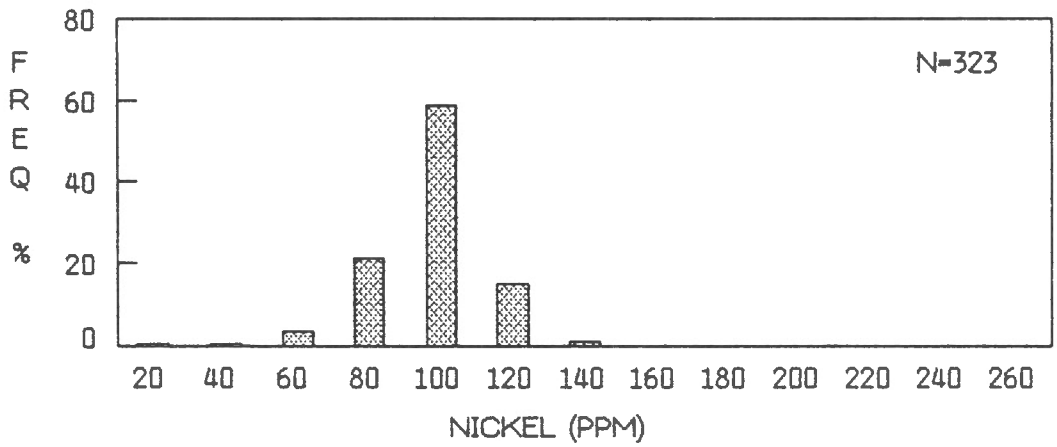
	Melt Member			Grey Member			Black Member			All Samples		
	Cu	Ni	Zn	Cu	Ni	Zn	Cu	Ni	Zn	Cu	Ni	Zn
No. of Samples	4	4	4	112	112	112	207	207	207	324	324	324
Mean	220.50	424.50	44.50	61.15	83.49	34.00	45.73	87.76	70.92	53.11	90.30	61.13
Std. Err.	154.98	364.92	12.12	13.90	1.43	23.31	1.66	0.92	4.58	5.30	4.50	3.11
Median	56.00	70.50	40.50	33.00	84.50	543.26	40.81	87.96	63.60	39.58	86.68	61.30
Mode	20.00	38.00	19.00	15.00	94.00	22.19	40.00	90.00	37.00	40.00	86.00	34.00
Std. Dev.	309.96	729.84	24.24	147.07	15.11	3.84	23.89	13.19	65.84	95.39	80.92	55.92
Variance	96072.33	532661.66	587.58	21629.64	228.45	193.00	570.85	173.89	4334.53	9099.78	6547.61	3127.09
Kurtosis	3.41	3.99	1.56	56.73	0.66	22.19	17.15	4.71	67.45	117.98	203.50	68.23
Skewness	1.84	2.00	0.87	7.06	-0.18	3.84	3.34	-1.29	7.40	9.91	17.14	8.17
Range	659.00	1481.00	58.00	1347.00	80.00	193.00	198.00	98.00	745.00	1349.00	1502.00	745.00
Minimum	20.00	38.00	19.00	3.00	40.00	14.00	1.00	17.00	3.00	1.00	17.00	3.00
Maximum	679.00	1519.00	77.00	1350.00	120.00	207.00	199.00	115.00	748.00	1350.00	1519.00	748.00
Sum	882.00	1698.00	177.00	6849.00	9351.00	4914.00	9467.00	18167.00	14681.00	17207.00	29257.00	19806.00

Table 2. Statistical data for Cu, Ni and Zn. Dowling Township.

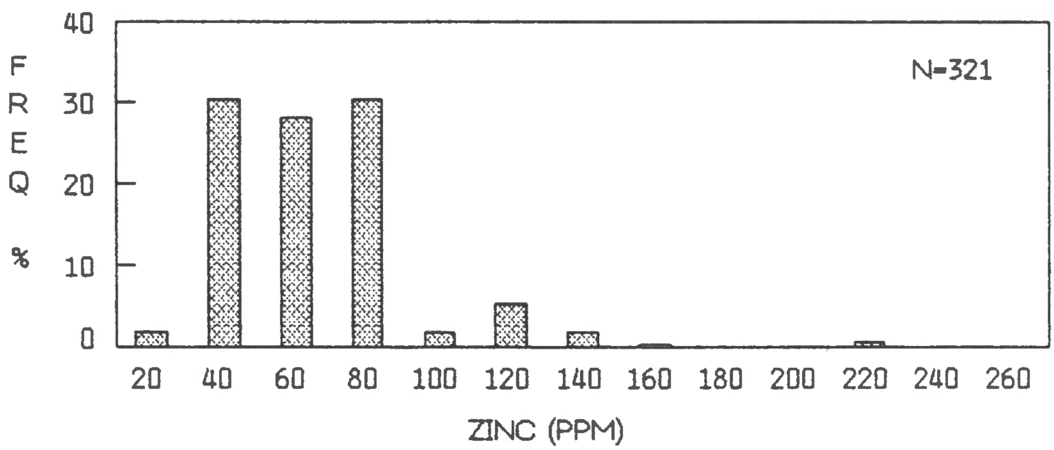
	Melt Member			Grey Member			Black Member			All Samples		
	Cu	Ni	Zn	Cu	Ni	Zn	Cu	Ni	Zn	Cu	Ni	Zn
No. of Samples	25	25	25	105	105	105	136	136	136	271	271	271
Mean	52.56	71.52	260.08	44.50	79.59	93.83	67.06	83.19	133.57	56.10	79.52	128.14
Std. Err.	9.80	4.43	107.74	3.75	2.26	16.49	22.03	1.18	31.36	11.19	1.25	19.77
Median	42.00	73.00	78.00	38.25	84.25	58.25	45.68	84.94	66.50	43.25	84.11	64.00
Mode	27.00	51.00	64.00	10.00	90.00	38.00	46.00	85.00	68.00	46.00	86.00	40.00
Std. Dev.	48.99	22.15	538.72	38.44	23.14	168.93	256.93	13.71	365.73	184.21	20.65	325.43
Variance	2400.42	490.76	290213.75	1477.37	535.32	28537.32	66015.15	187.98	133756.66	33972.71	426.33	105906.53
Kurtosis	10.97	1.61	17.12	2.95	1.51	80.39	5.00	6.45	82.80	252.50	2.72	80.02
Skewness	2.88	-0.89	3.96	1.49	-0.07	8.53	11.47	-1.25	8.57	15.63	-0.81	8.28
Range	245.00	99.00	2605.00	199.00	153.00	1686.00	3020.00	115.00	3839.00	3022.00	153.00	3850.00
Minimum	5.00	6.00	35.00	3.00	6.00	14.00	5.00	9.00	21.00	3.00	6.00	10.00
Maximum	250.00	105.00	2640.00	202.00	159.00	1700.00	3025.00	124.00	3860.00	3025.00	159.00	3860.00
Sum	1314.00	1788.00	6502.00	4672.00	8357.00	9852.00	9738.00	11566.00	-	-	-	-



(a)

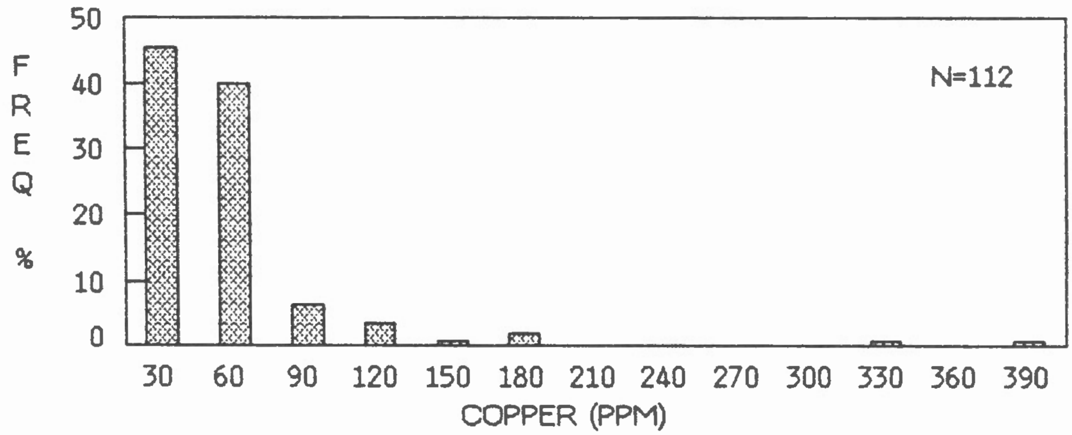


(b)

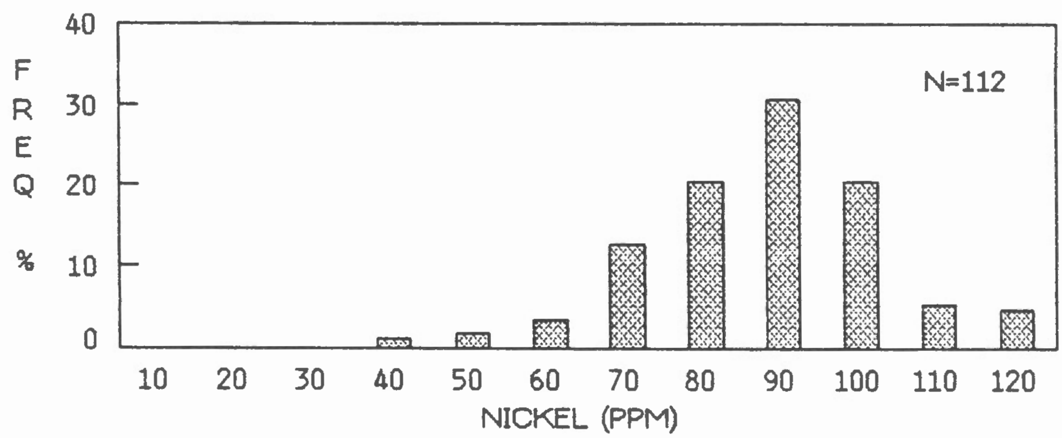


(c)

Figure 4. Frequency distribution of (a) Cu, (b) Ni, (c) Zn for all samples from Morgan Township. In figures 4 to 10, inclusive, the number under the individual histogram is the upper limit of the class interval; also, some high intervals are omitted for illustrative convenience.



(a)



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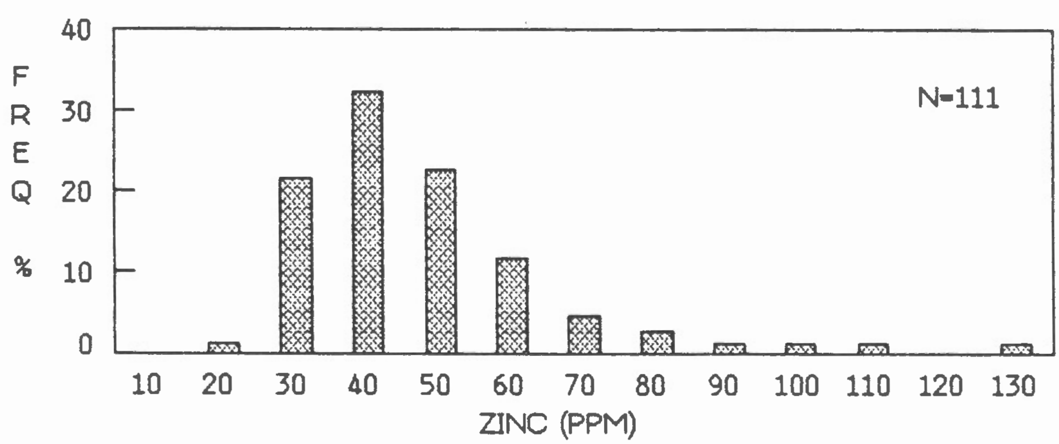


(c)

Figure 5. Frequency distribution histograms of (a) Cu, (b) Ni and (c) Zn for samples of the Grey member from Morgan Township.

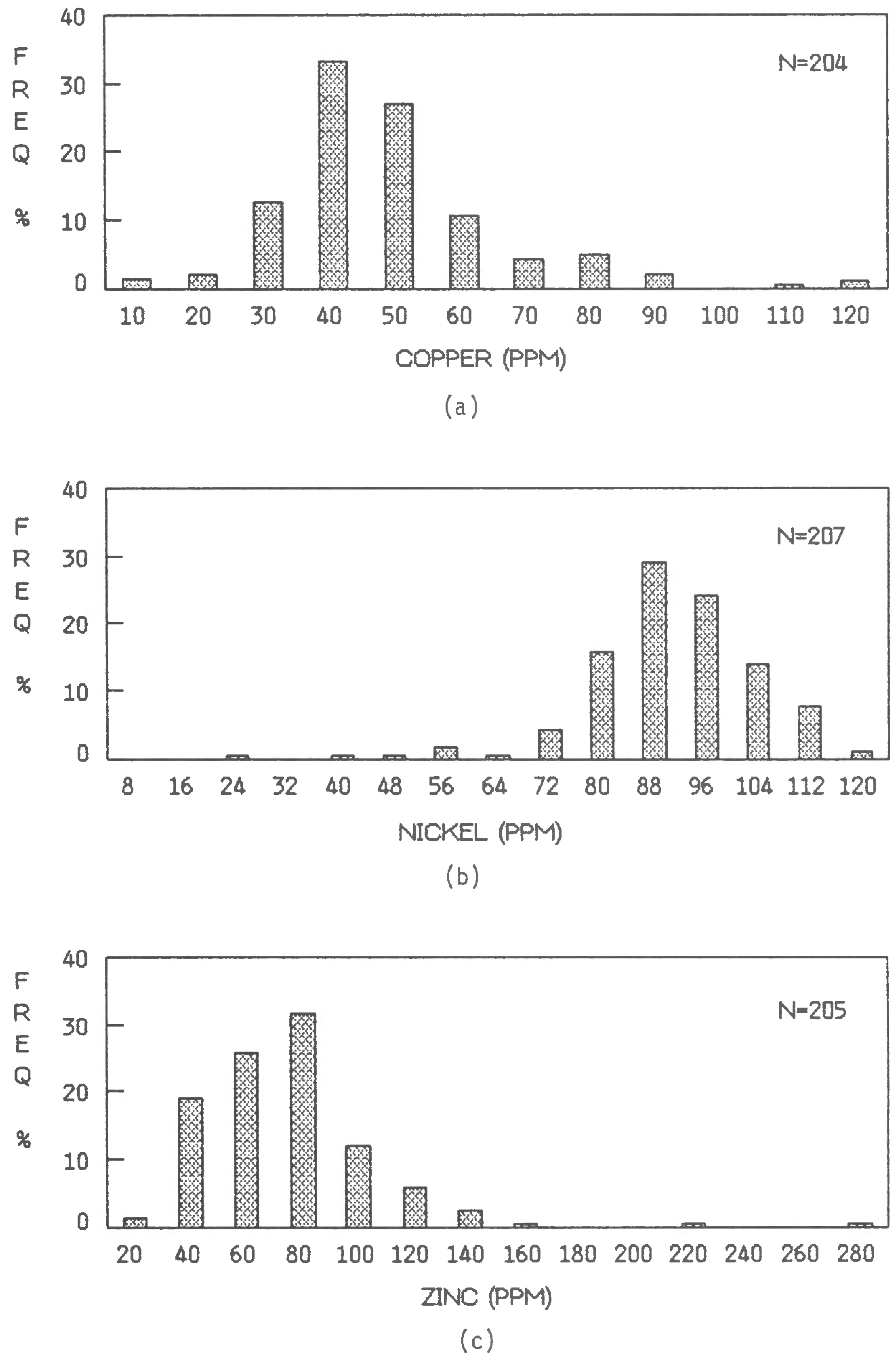
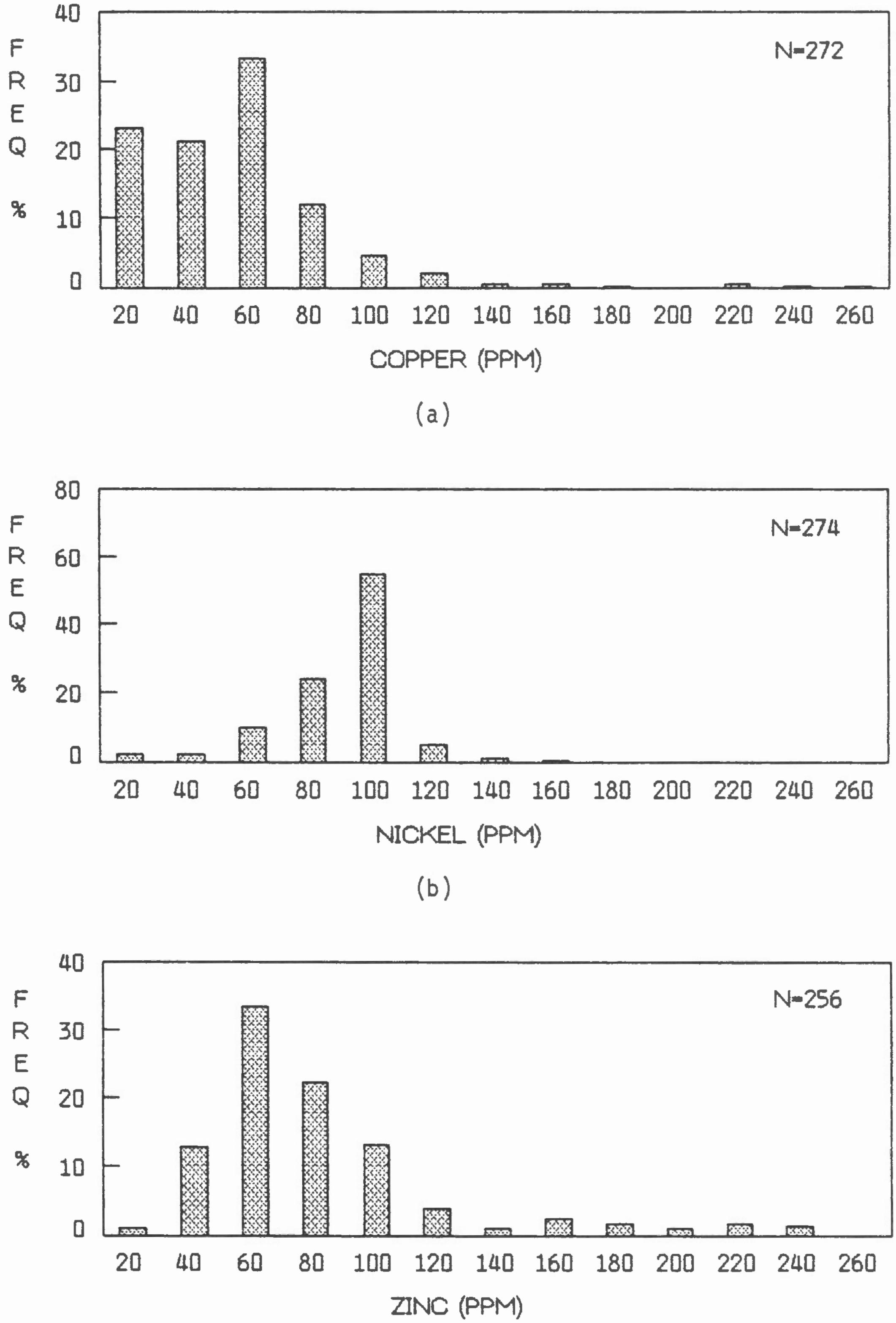


Figure 6. Frequency distribution histograms of (a) Cu, (b) Ni and (c) Zn for samples of the Black member from Morgan Township.



(a)

(b)

(c)

Figure 7. Frequency distribution histogram of (a) Cu, (b) Ni and (c) Zn for all samples from Dowling Township.

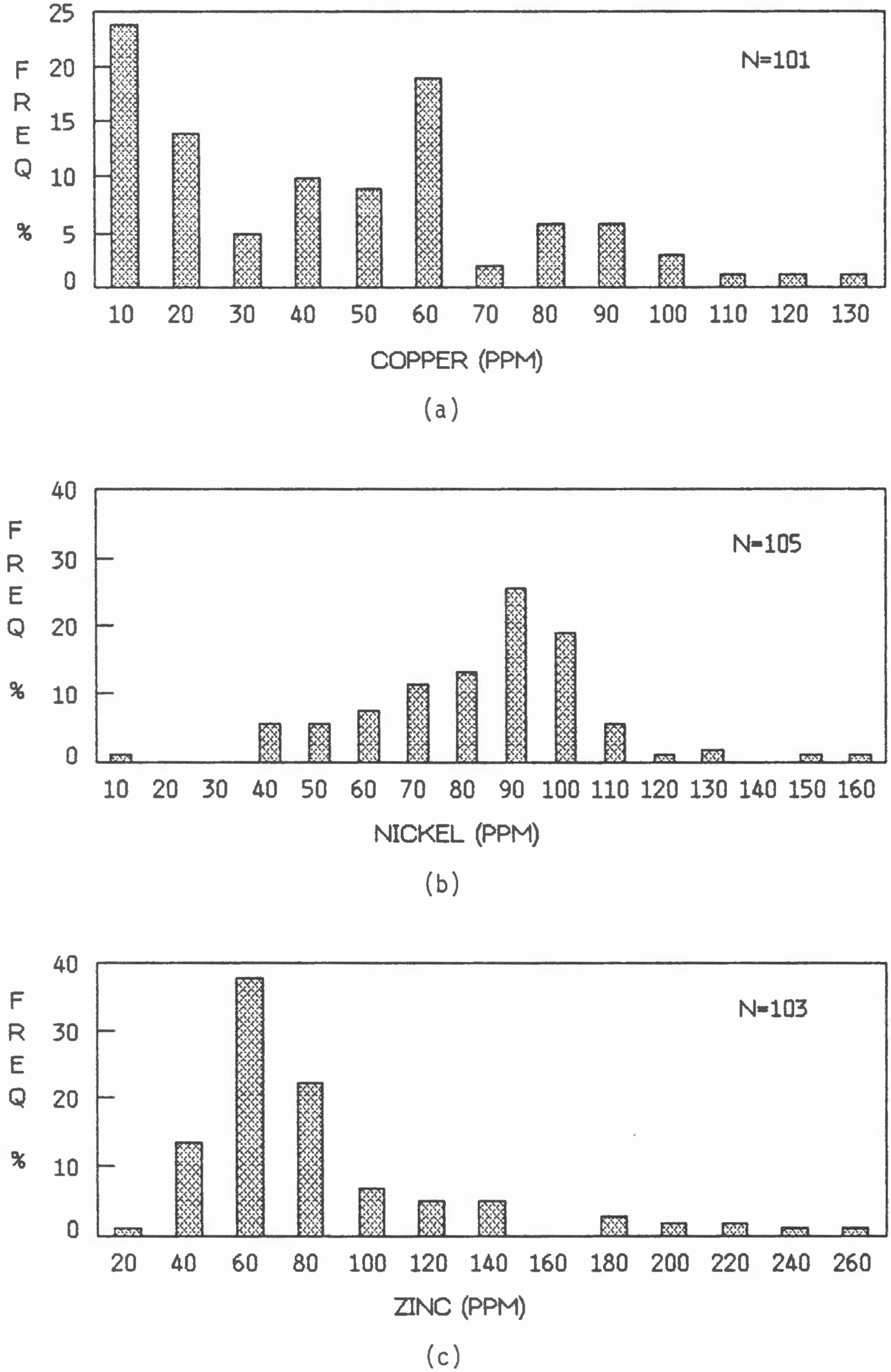
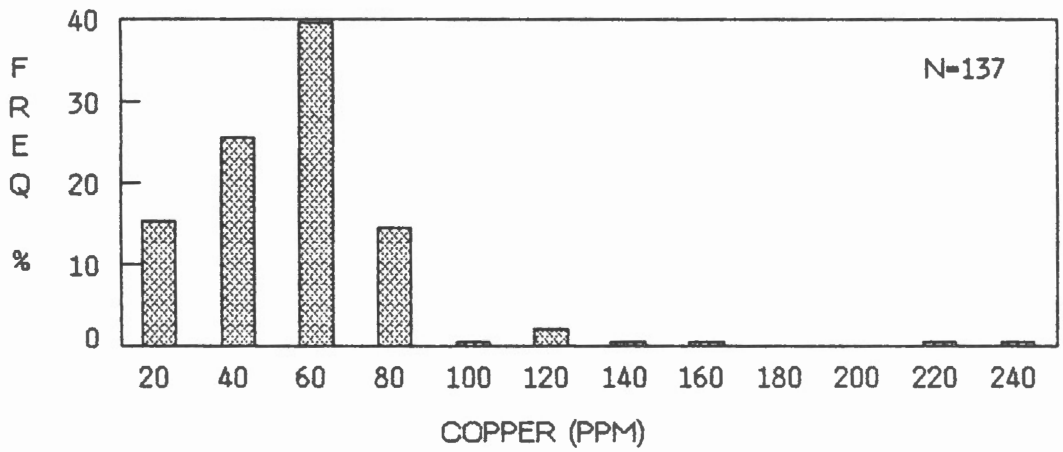
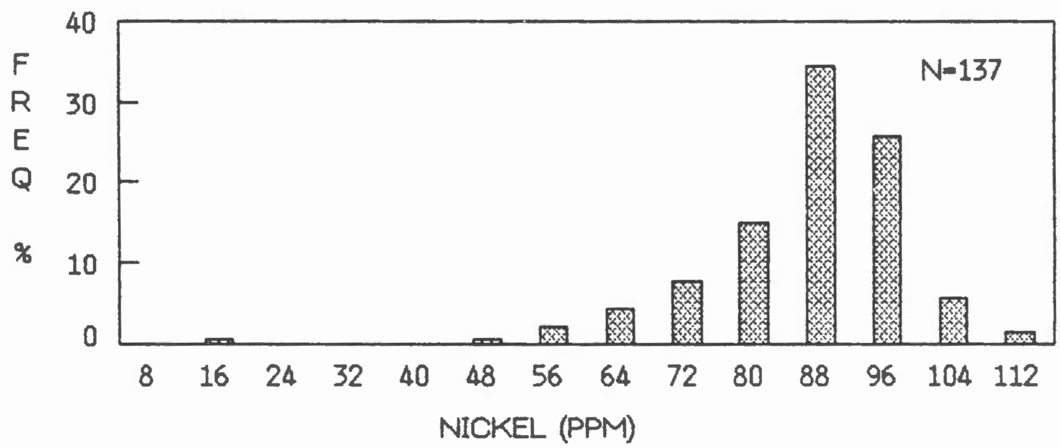


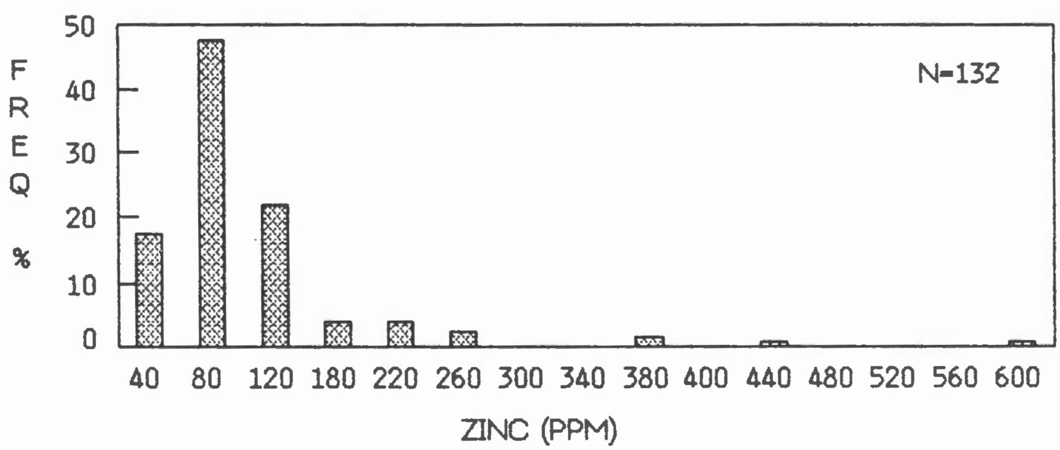
Figure 8. Frequency distribution histograms of (a) Cu, (b) Ni and (c) Zn for samples of the Grey member from Dowling Township.



(a)



(b)



(c)

Figure 9. Frequency distribution histograms of (a) Cu, (b) Ni and (c) Zn for samples of the Black member from Dowling Township.

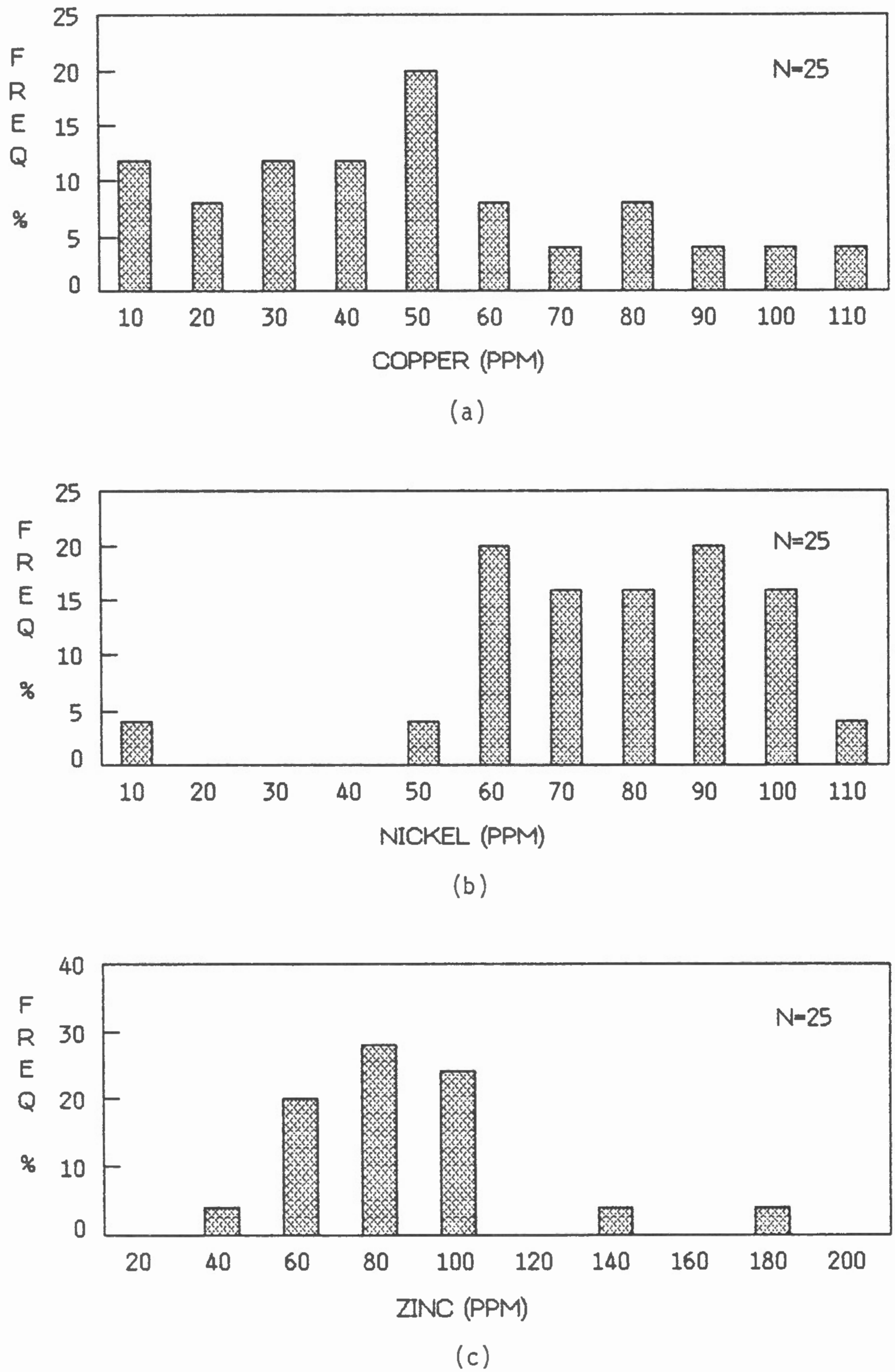


Figure 10. Frequency distribution histograms of (a) Cu, (b) Ni and (c) Zn for samples of the Onaping melt from Dowling Township.

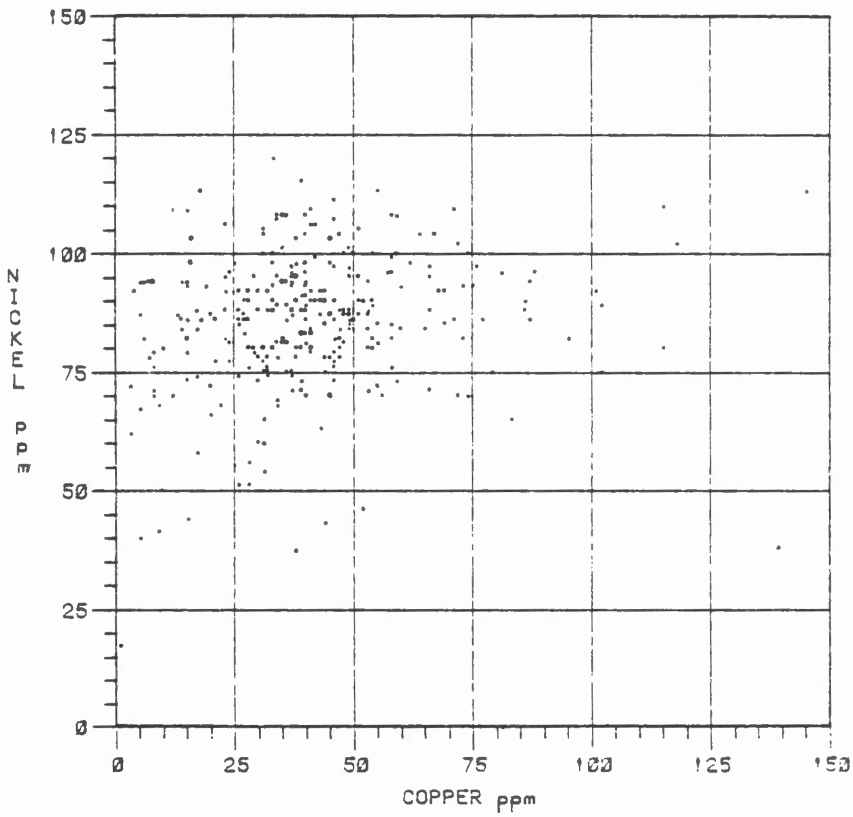


Figure 11a

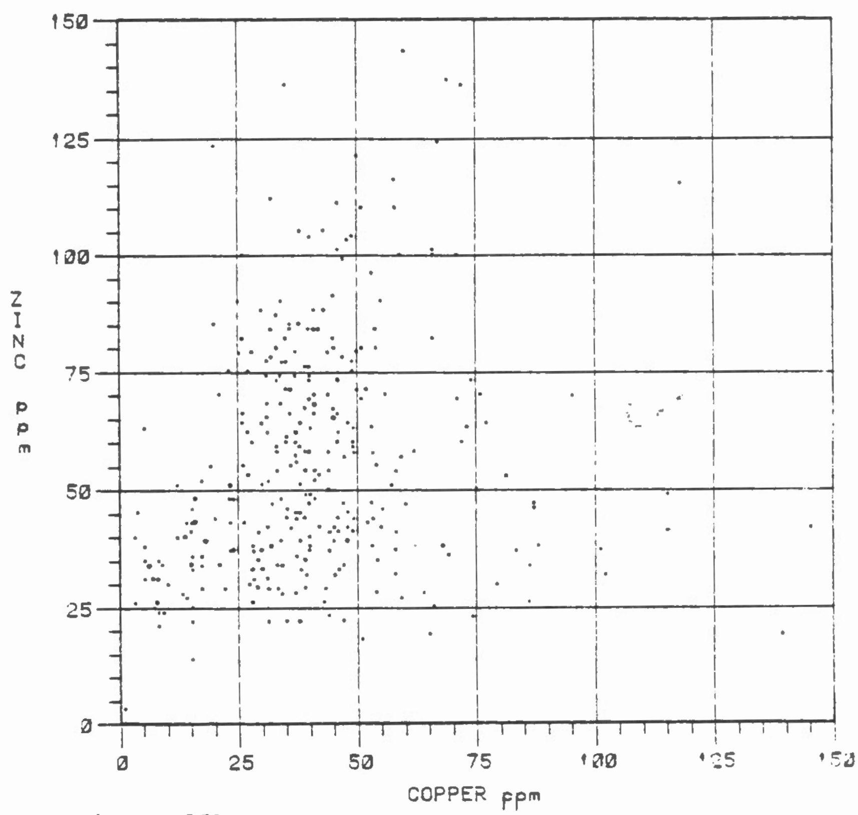


Figure 11b

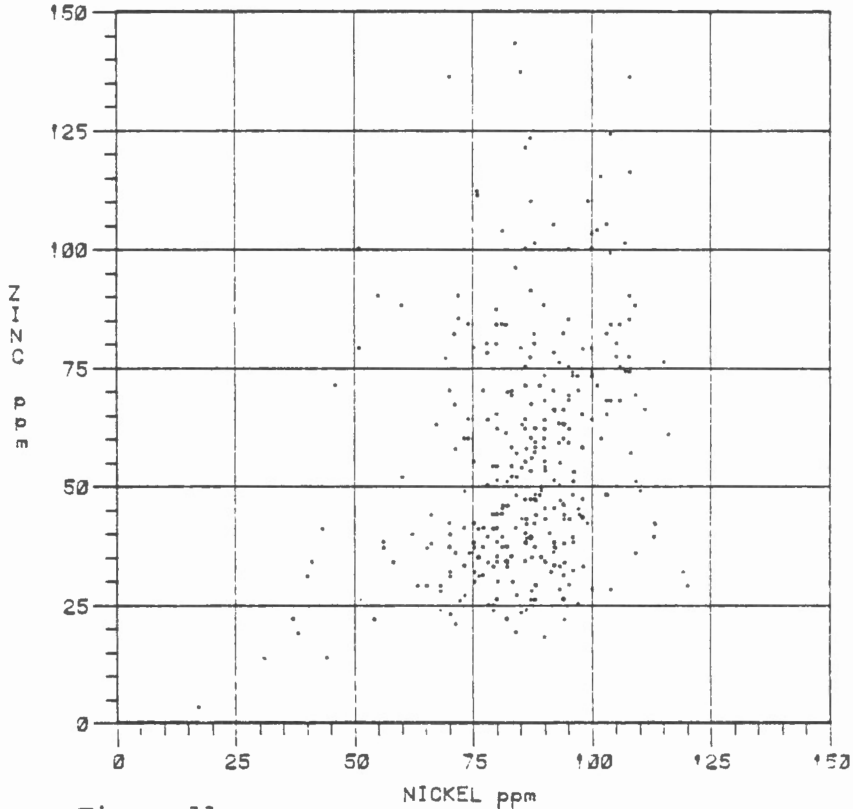


Figure 11c

Figure 11. Scatter diagram of chemical from Morgan Township.
(a) Cu vs. Ni, (b) Cu vs. Zn, (c) Ni vs. Zn

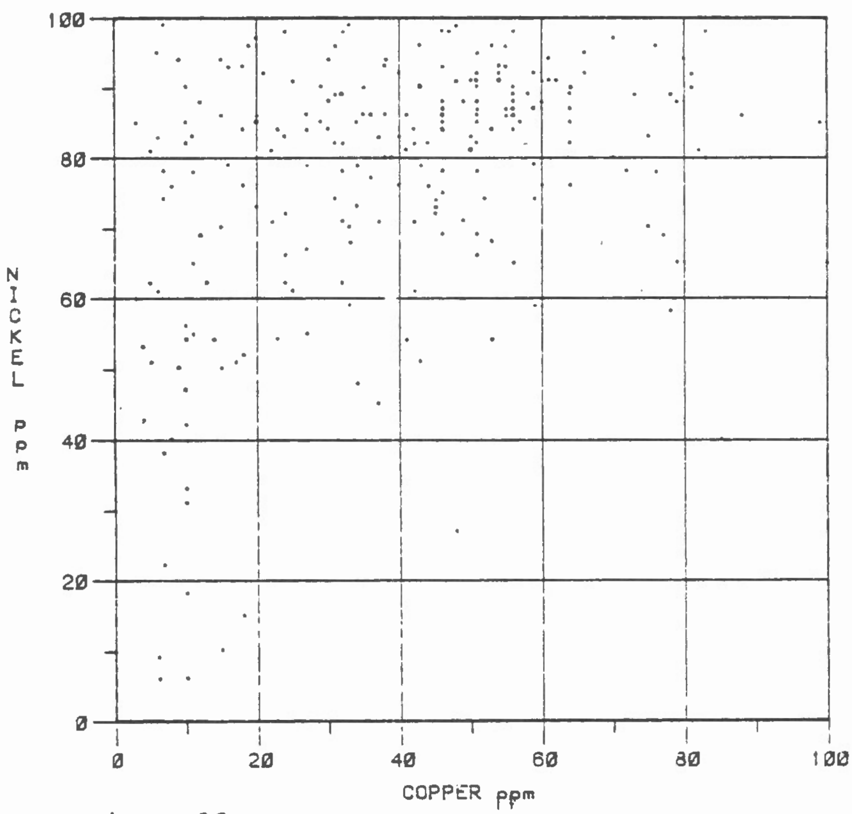


Figure 12a

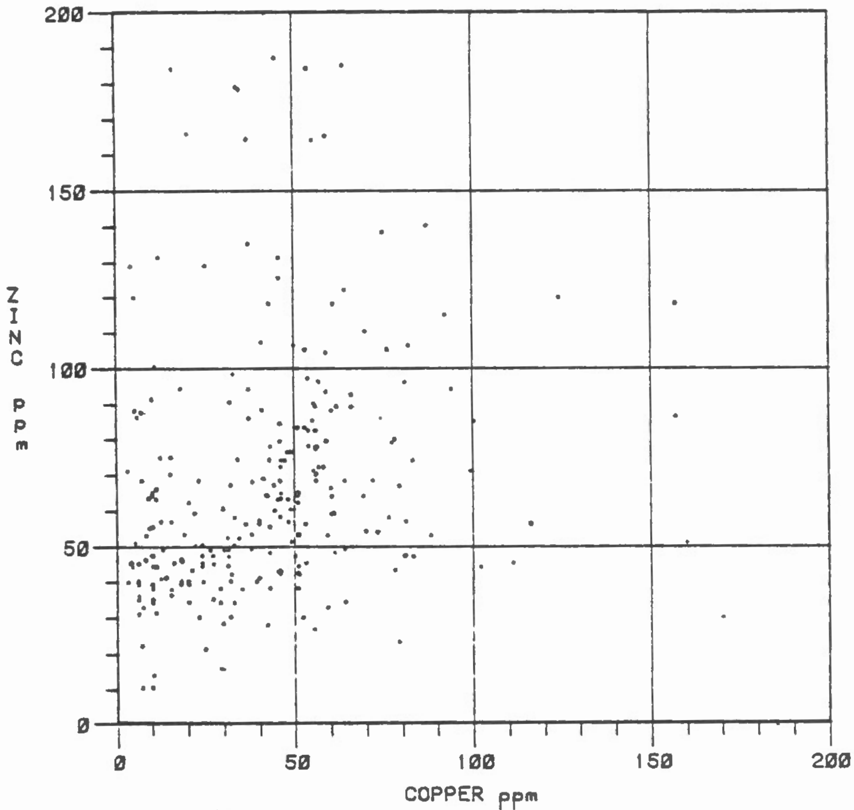


Figure 12b

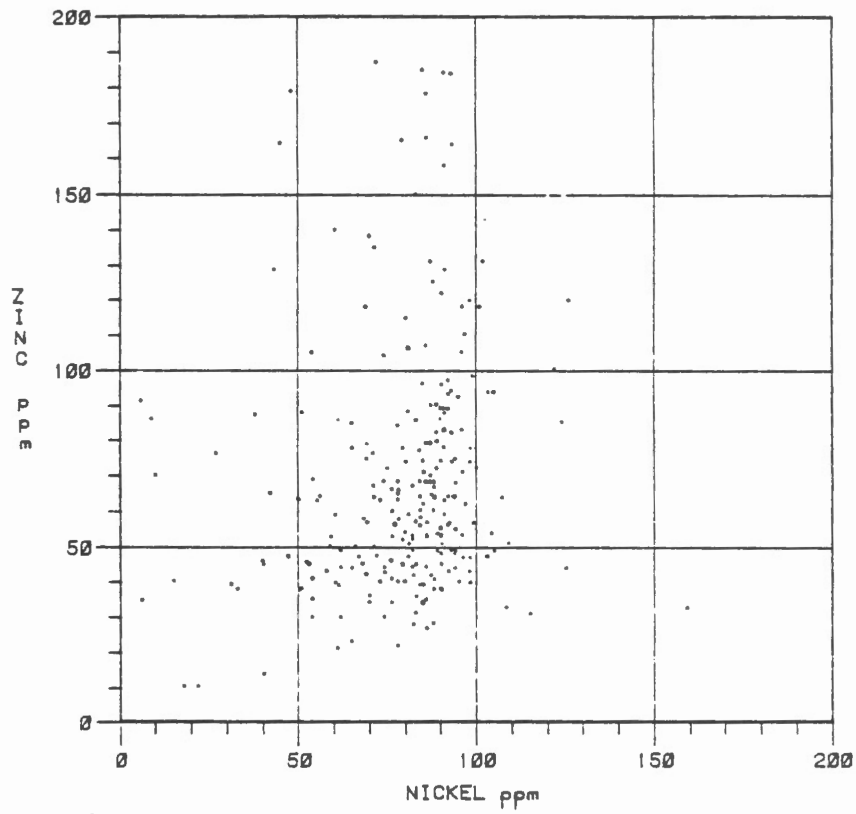


Figure 12c

Figure 12. Scatter diagram of chemical data from Dowling Township.

(a) Cu vs. Ni, Cu vs. Zn, (c) Ni vs. Zn

Aerial Distribution

The aerial distribution of Cu, Ni and Zn values are illustrated by means of a series of computer-generated contour diagrams and perspective diagrams derived from the contour diagram. There are three pairs of diagrams for a particular metal per Township: one pair for the whole area and sampled at 400 m intervals, a pair representing an area sampled at the 200 m interval, and a pair representing an area sampled at the 20 m interval. Thus, there are a total of 18 pairs of diagrams.

The distributions of Cu, Ni and Zn in Morgan Township, sampled at the 400 m interval, are shown in Figures 13a, 13b and 13c respectively. The two highs on Figure 13a are entirely the result of high copper values in two samples; the high at the top of the diagram is due to a sample of melt rock (6007) with values of 679 ppm and the other is due to a sample in the Black member (6106) with a Cu value of 199 ppm. Elsewhere, values are low. Figure 13b indicates Ni values are very low except for a single high (1519 ppm) and due to a sample (6007) that also has a high Cu value. The diagrams for Zn (Figure 13c) show no peaks but a moderately high background value; this is due to a number of samples with Zn values of 100-150 ppm.

The distributions of Cu, Ni and Zn, in a local area in Morgan Township and samples at 100 m intervals, are shown in Figure 13d, 13e and 13f respectively. Figure 13d shows a single sharp peak for Cu and due to a value of 702 ppm in a single sample (6128) from the Grey member. Elsewhere, Cu values are very low in this local area. Note that an airborne electromagnetic conductor is near sample 6128 (see Map 1). The local high of Figure 13d is actually located on a low of Figure 13a. Figure 13e shows no peaks for Ni but instead moderate background values of approximately 100 ppm and rather similar to Figure 13b. Figure 13f shows three peaks for Zn; the two peaks on the left are for two specimens in the Black member - 6122 with 748 ppm and 6126 with 599 ppm. The low peak to the right-hand side is caused by a specimen from the Grey member (6128) with 207 ppm Zn. There is no indication of these high values in Figure 13c.

The distributions of Cu, Ni and Zn, in a 100 m square area in Morgan Township and sampled at a 20 m interval, are shown in Figure 13g, 13h, and 13i, respectively. In Figure 13g, the two peaks correspond to Cu values of 115 and 118 ppm. This small area straddles the 45 m contour of Figure 13a. Figure 13h for Ni shows no peaks but with broad areas having values around 100 ppm, similar to Figure 13b. Figure 13i displays three modest peaks corresponding to four specimens with Zn values ranging from 102 to 137 ppm. Figure 13i can be compatibly imposed on Figure 13c.

The distributions of Cu, Ni and Zn in Dowling Township, sampled at the 400 m interval, are shown in Figures 14a, 14b and 14c, respectively. In Figure 14a there are two peaks due to a sample of melt rock (6403) with Cu values of 250 ppm and a sample of the Grey member (6503) with Cu values of 160 ppm. Figure 14b indicates moderate Ni values without local highs; there are a number of samples with values circa 80 ppm. Figure 14c has a very high peak due largely to a specimen (6403) of melt rock containing

2640 ppm Zn. A specimen of the Black member (6504) with 178 ppm Zn produces the other peak.

The distribution of Cu, Ni and Zn, in a local area in Dowling Township, sampled at 100 m intervals, are shown in Figures 14d, 14e and 14f, respectively. Figure 14d shows no peaks and with all values of Cu less than 100 ppm. This small area occurs between two peaks in Figure 14d. Figure 14e shows a typical pattern for Ni - no peaks with fairly uniform values circa 80 ppm. Figure 14b shows a similar pattern. Figure 14f shows very low Cu values. A specimen from the Black member (6504) has a value of 178 ppm and is responsible for the single peak.

All samples, from the small area in Dowling Township sampled at 20 m intervals, are from the Black member. Figure 14g shows two peaks from samples of Cu yielding 138 ppm (6599) and 112 ppm (6607); elsewhere Cu values are low. Figure 14h again is typical for Ni - no peaks and with many values between 80 and 90 ppm. Figure 14i shows numerous peaks for Zn and this is due to several high values including: 820 ppm (6588), 131 ppm (6586), 419 ppm (6587), 110 ppm (6589), 184 ppm (6594), 225 ppm (6599) and 3860 ppm (6602). This small area occurs within an area sampled on the 100 m scale. Neither the 400 m sampling grid nor the 100 m sampling grid revealed the presence of this local area of high Zn values.

Figure 13a-i. Contour diagrams and perspective plots of Cu, Ni and Zn values from Morgan Township. Contour interval 3 or 5 ppm. Angle of view of the perspective plots is 30° above the horizontal. Co-ordinates correspond with those of Fig. 2 except that west co-ordinates are represented by negative values on the contour plots. The lower right-hand edge of the perspective plate corresponds to the right-hand edge of the contour diagrams (330°) except from Fig. 13d where the lower right-hand edge of the perspective corresponds to the lower edge of the contour diagram.

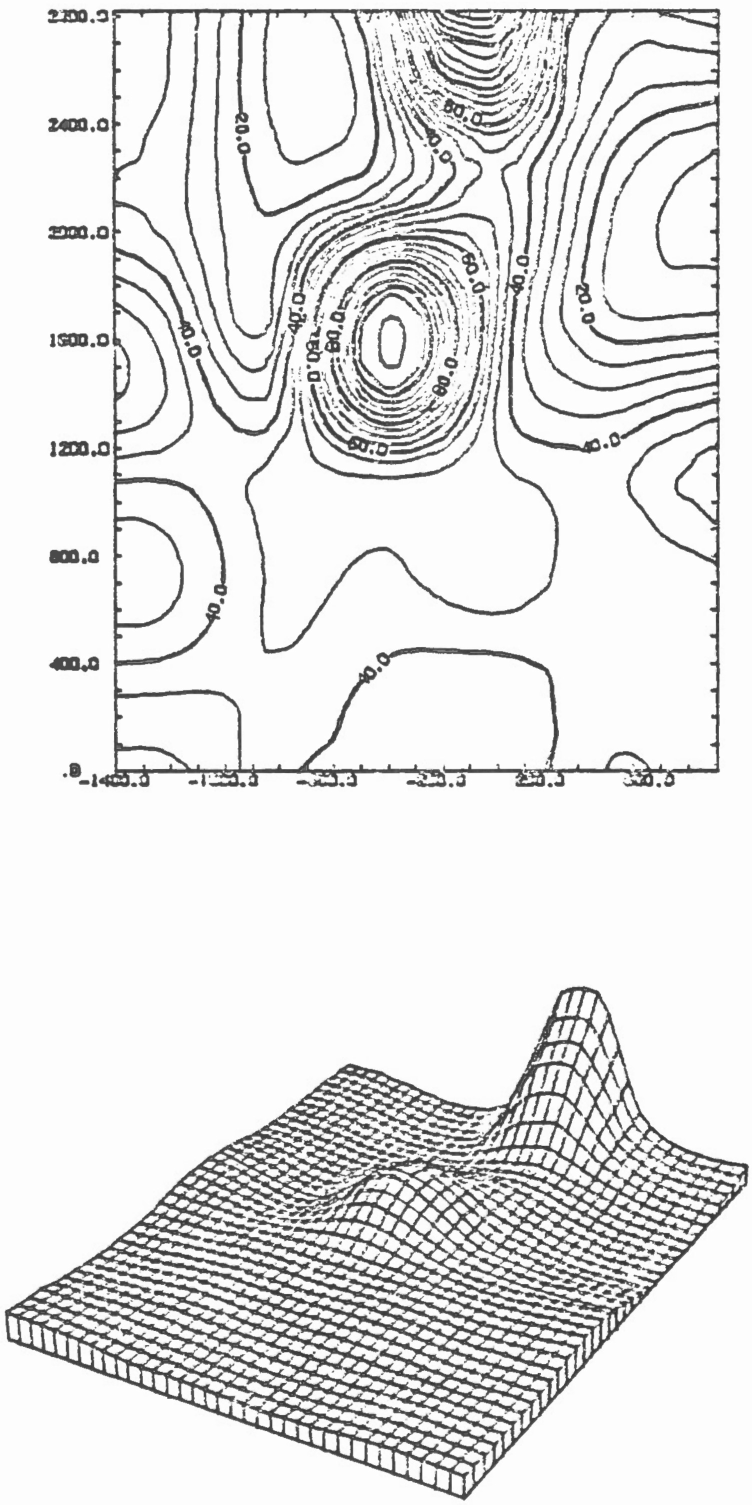
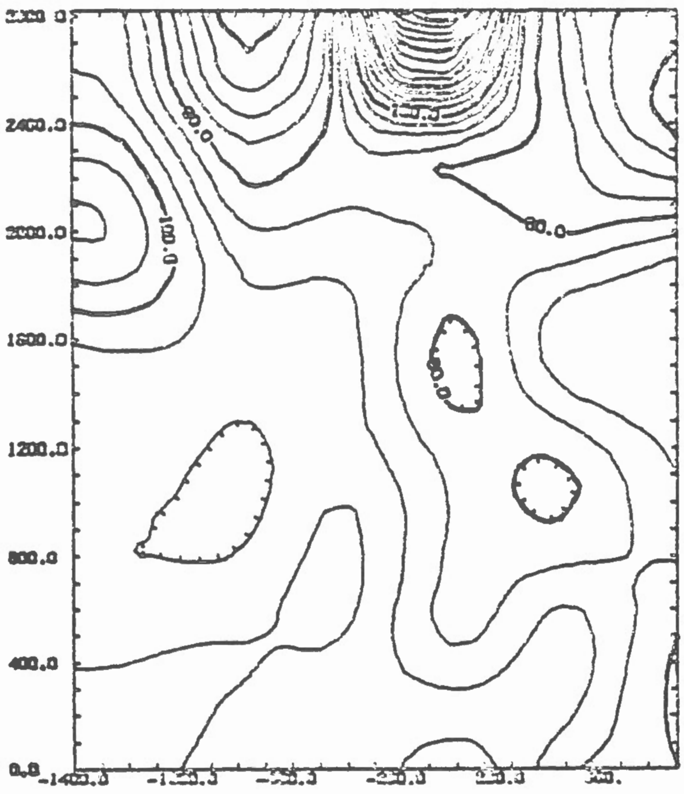


Figure 13a. Cu - 400 m sampling density.



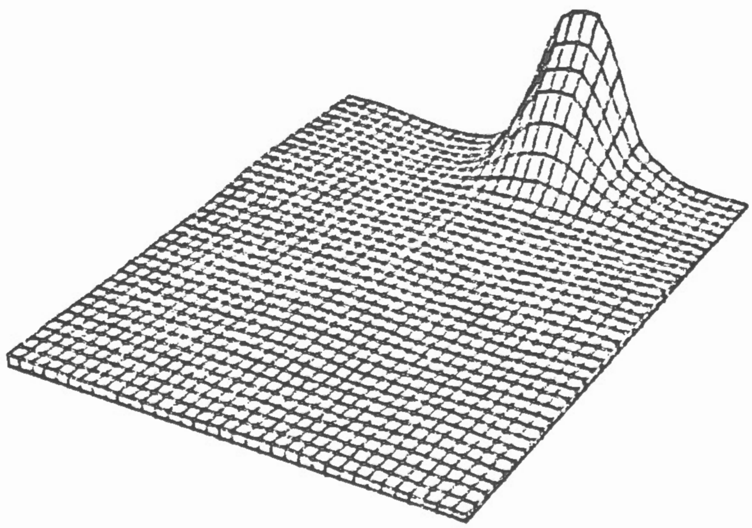


Figure 13b. Ni - 400 m sampling density.

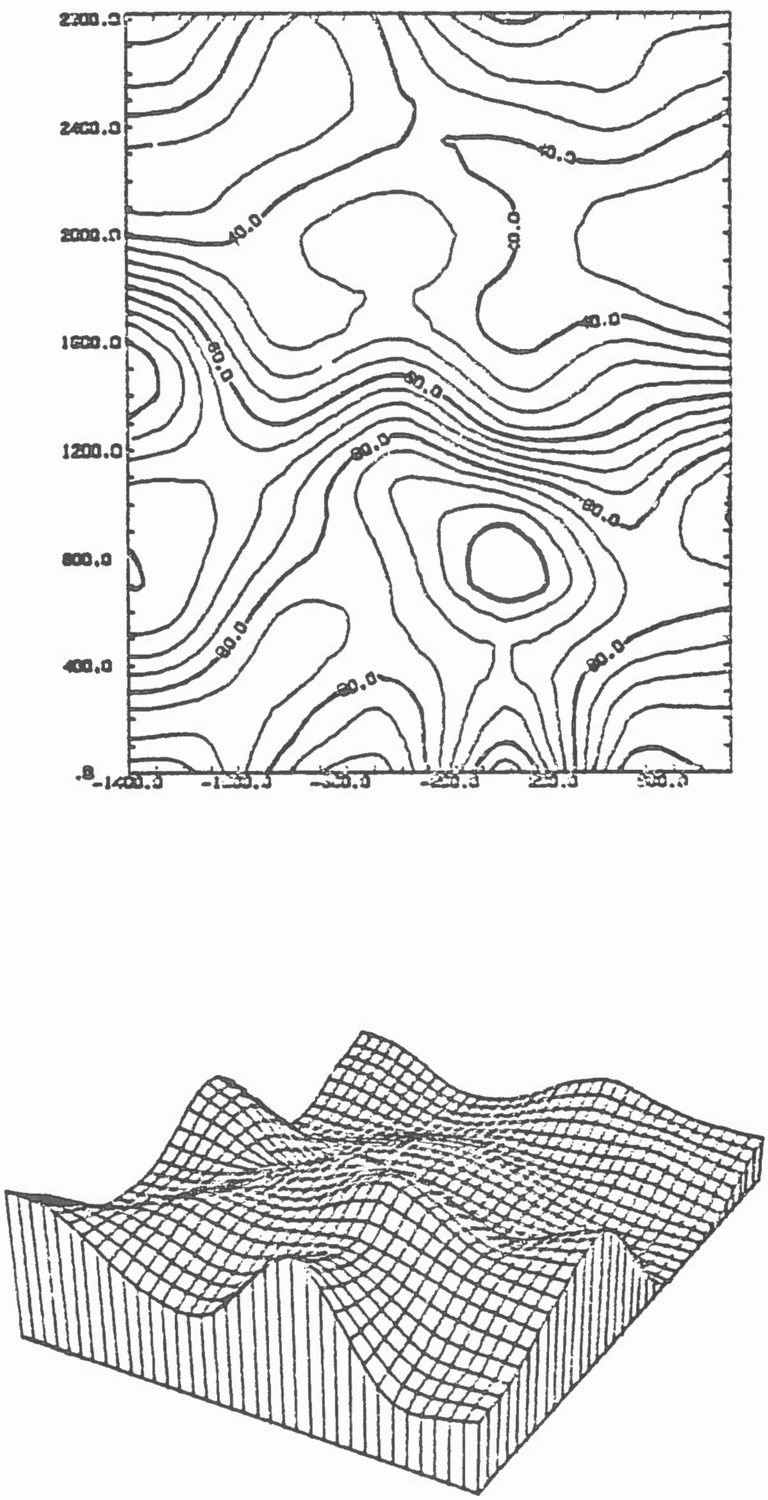


Figure 13c. Zn - 400 m sampling density.

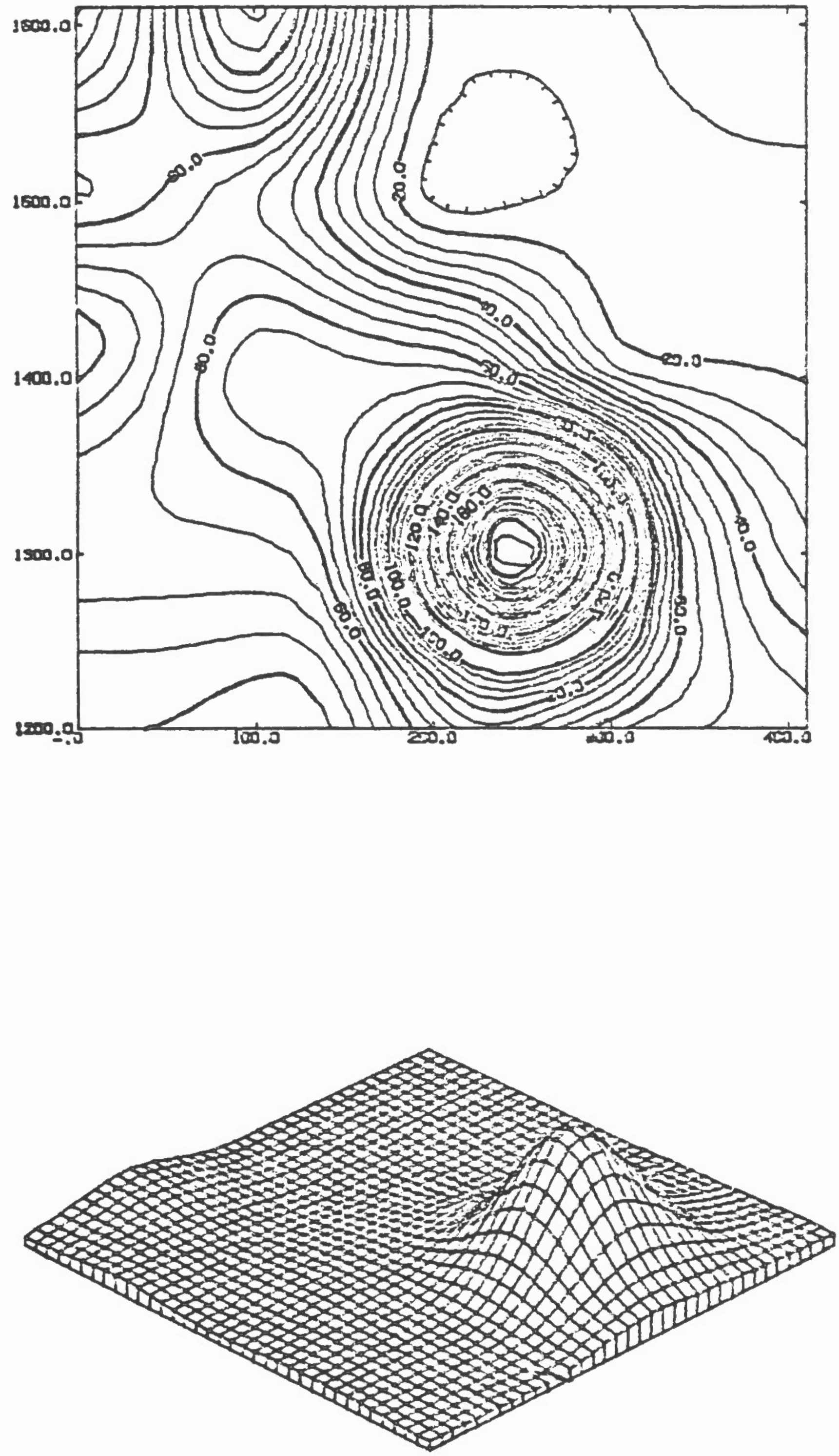
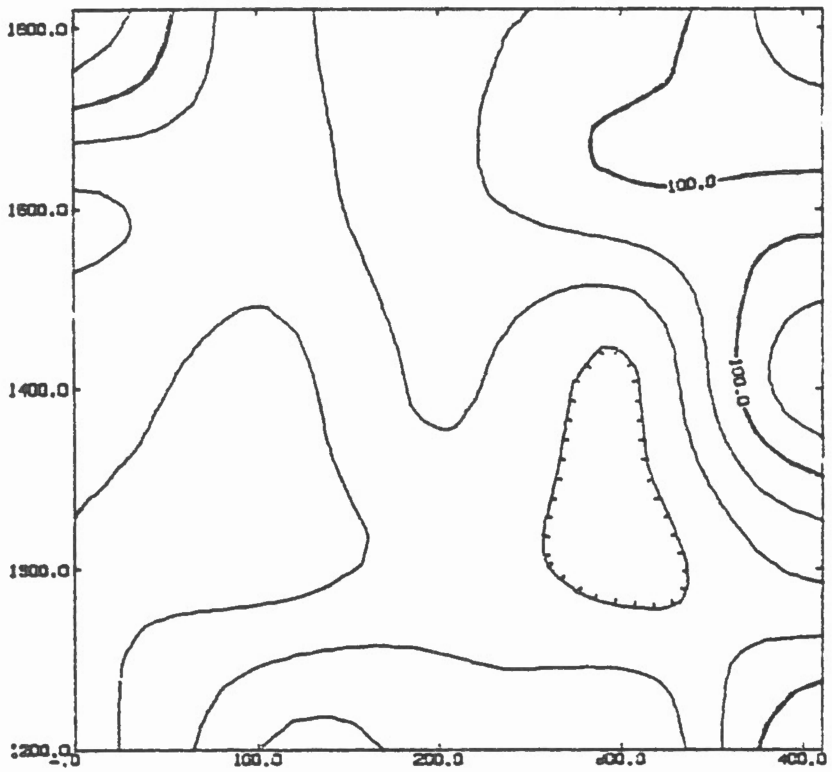


Figure 13d. Cu - 100 m sampling density.



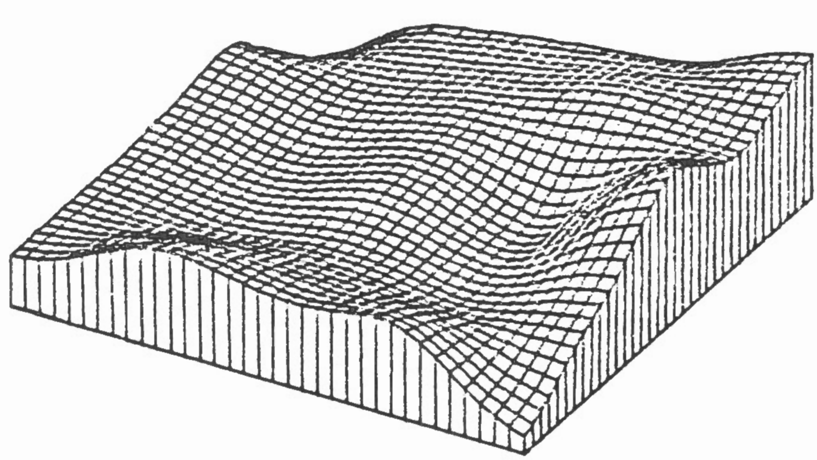
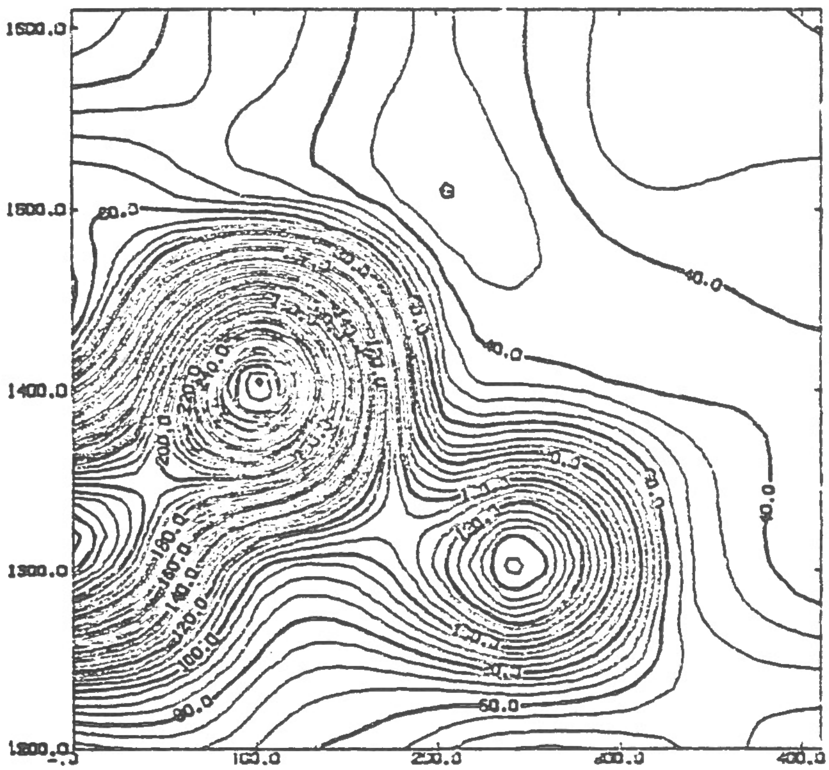


Figure 13e. Ni - 100 m sampling density.



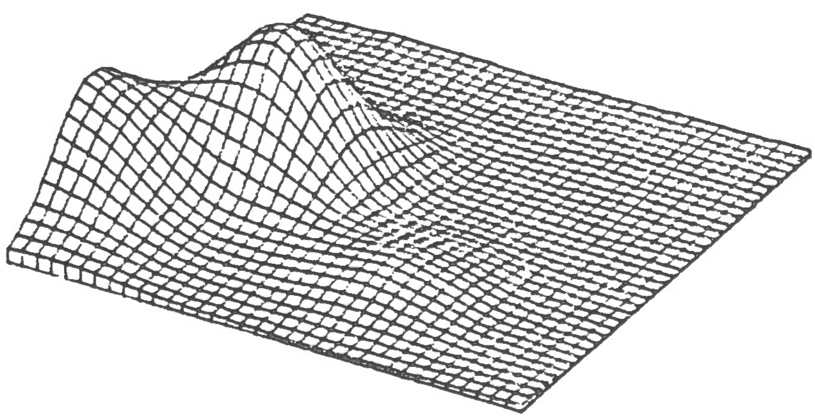


Figure 13f. Zn - 100 m sampling density.

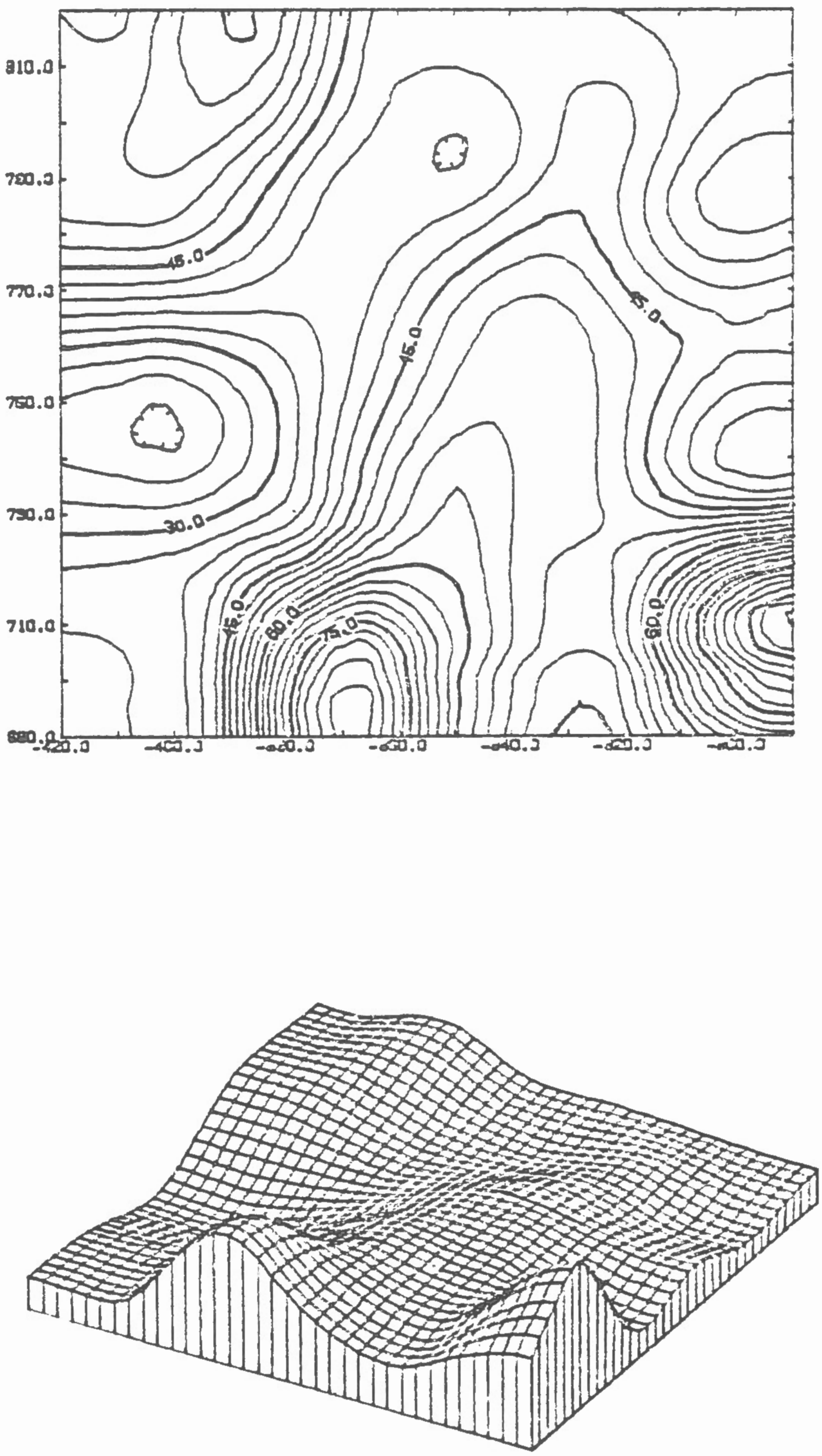


Figure 13g. Cu - 20 m sampling density.

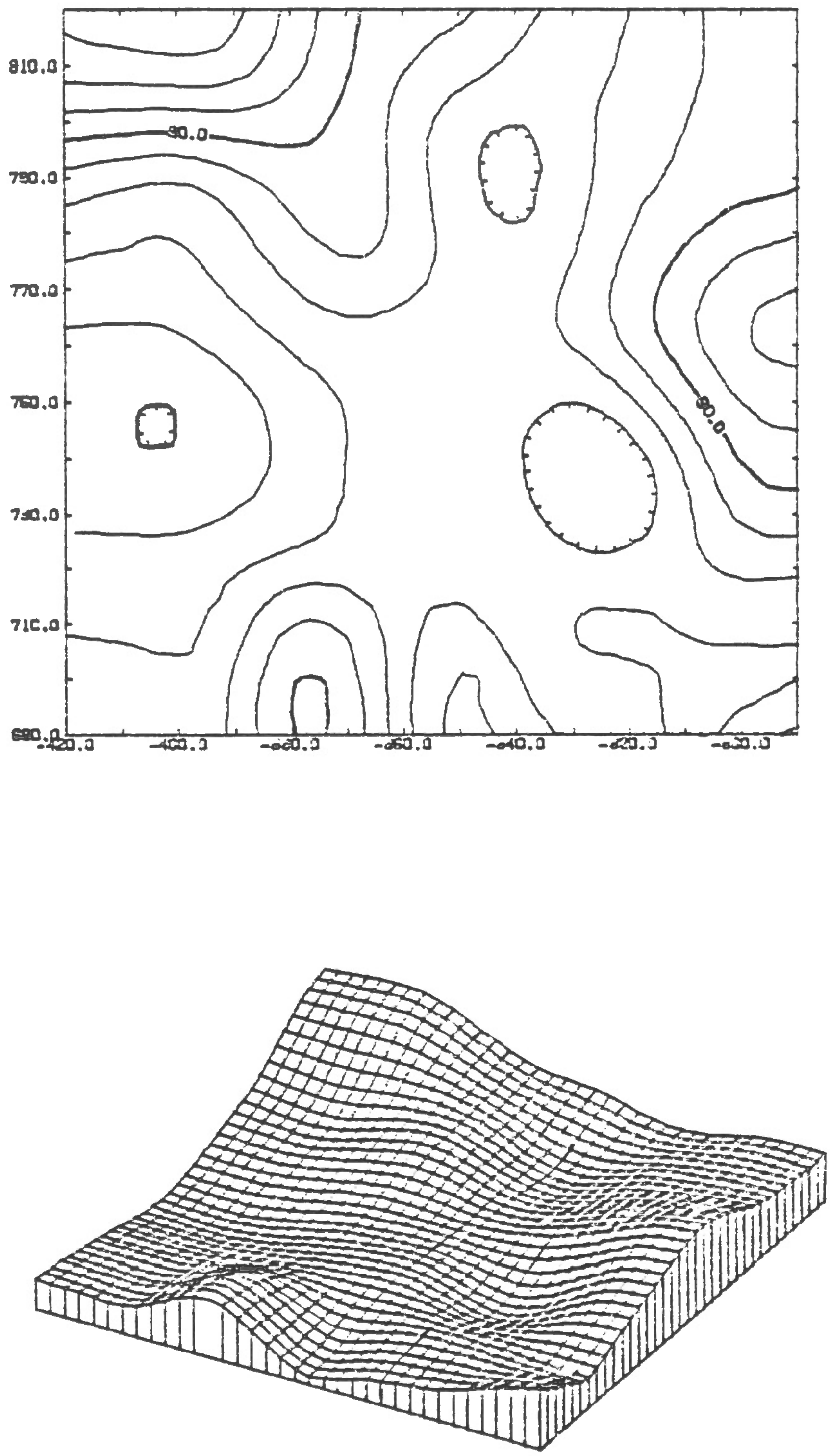


Figure 13h. Ni - 20 m sampling density.

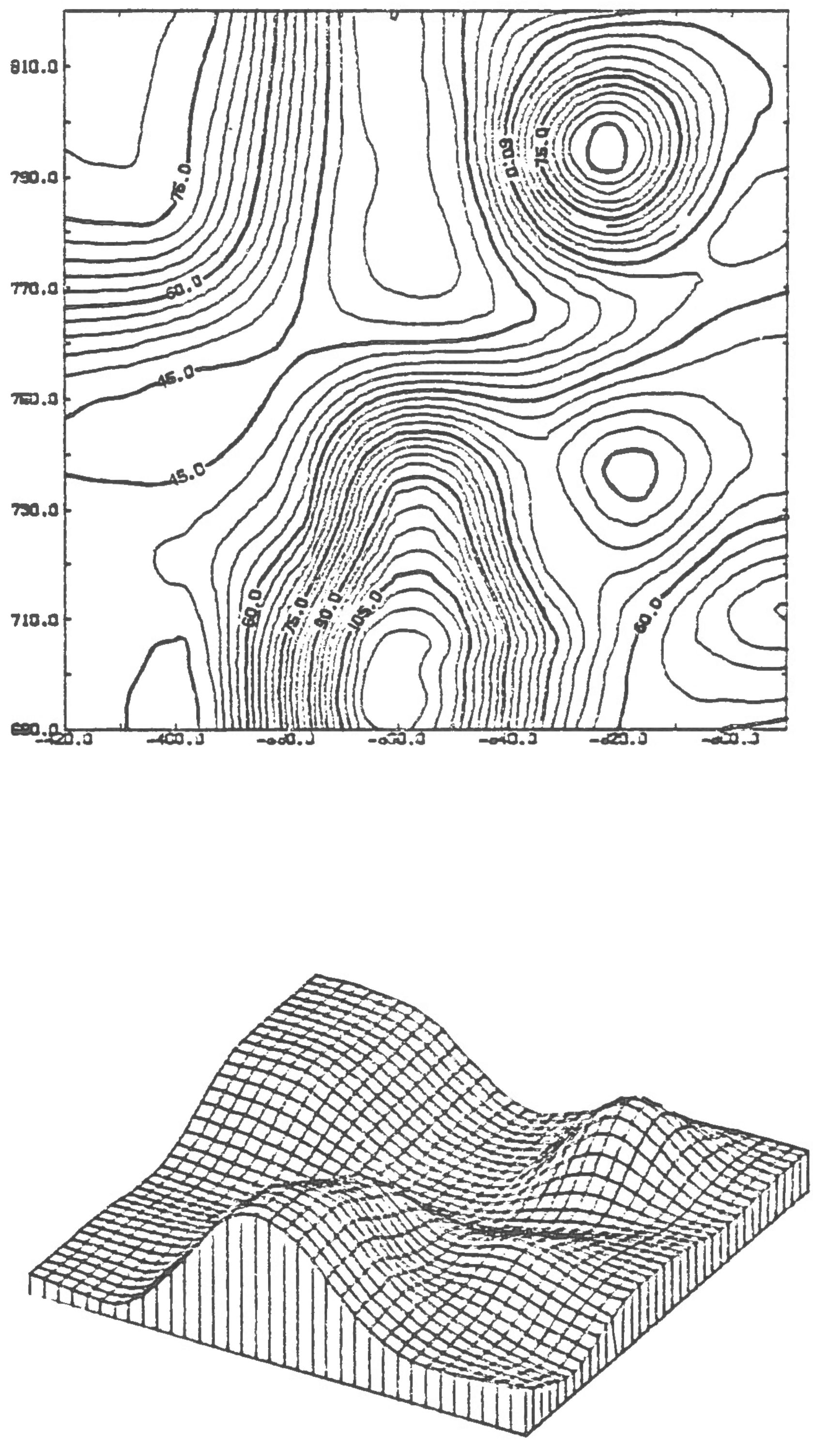


Figure 13i. Zn - 20 m sampling density.

Figure 14a-i. Contour diagrams and perspective plots of Cu, Ni and Zn values from Dowling Township. Contour interval 3, 5 and 10 ppm. Angle of view of the perspective plots is 30° above the horizontal. Co-ordinate correspond to those of Fig. 3 except that the south co-ordinates are represented by negative numbers on the perspective plots. The lower right-hand edge of the perspective plots corresponds to the right-hand edge of the contour diagram.

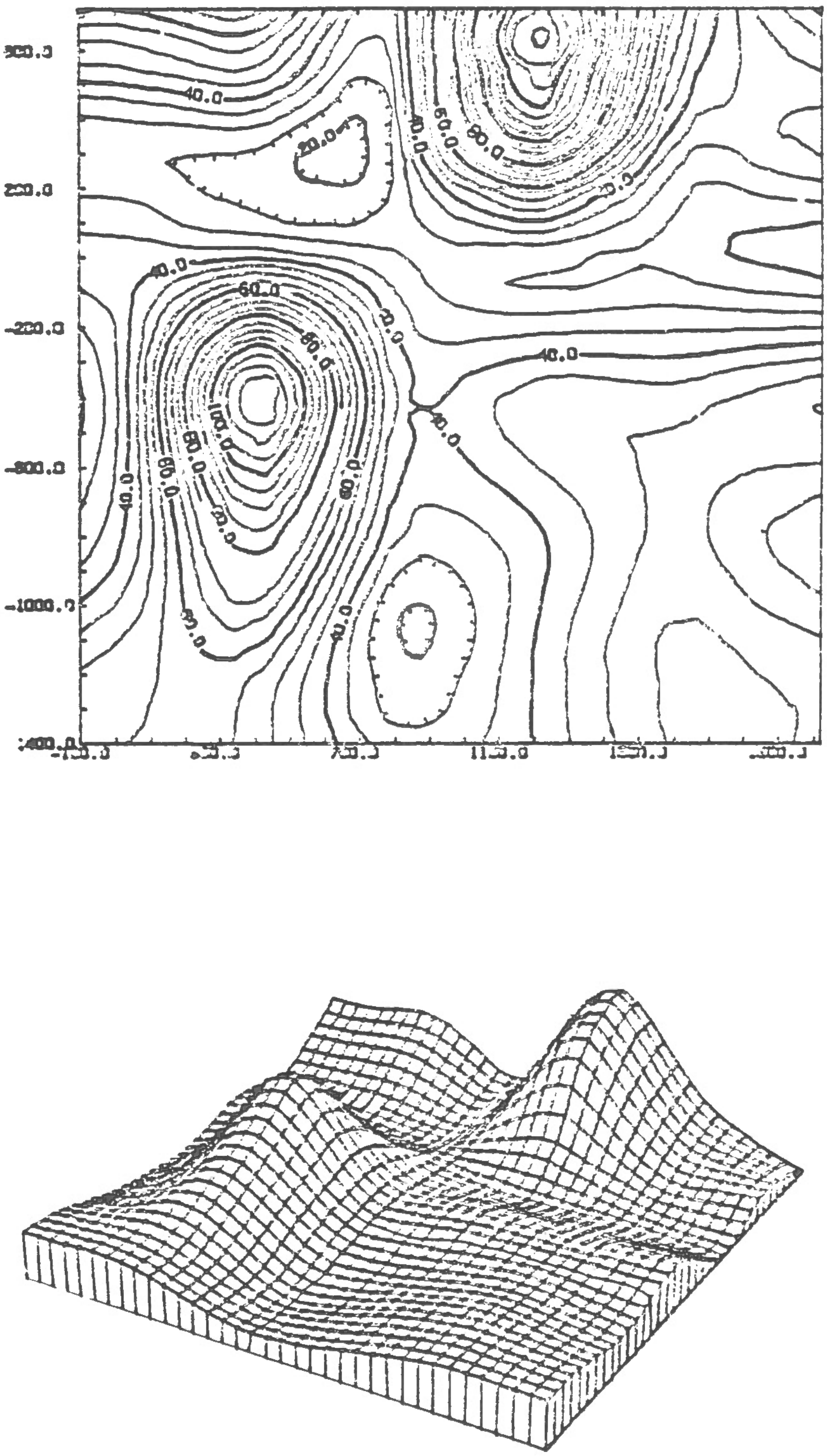
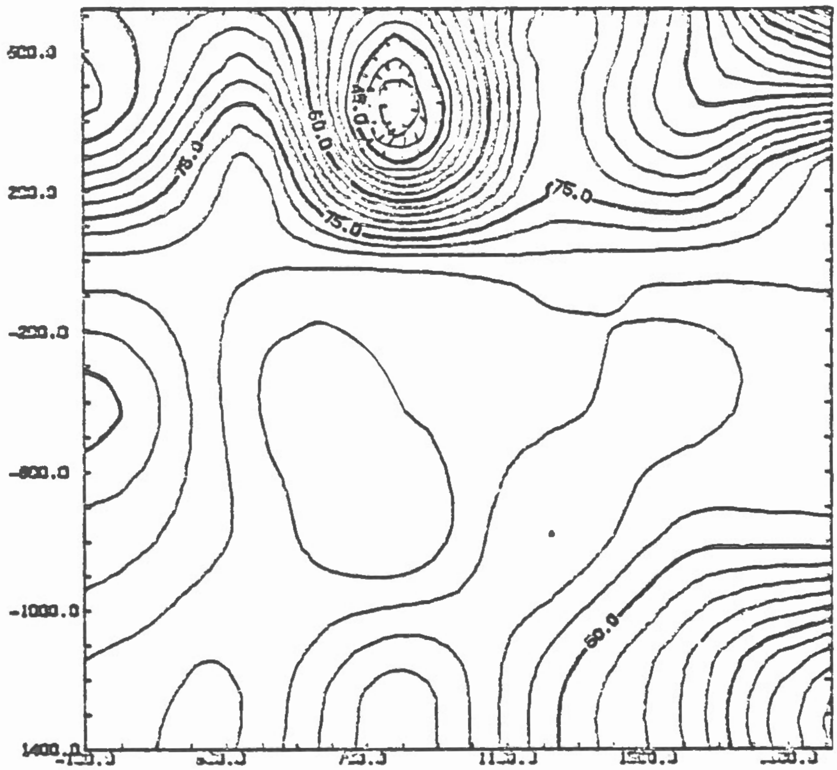


Figure 14a. Cu - 400 m sampling density.



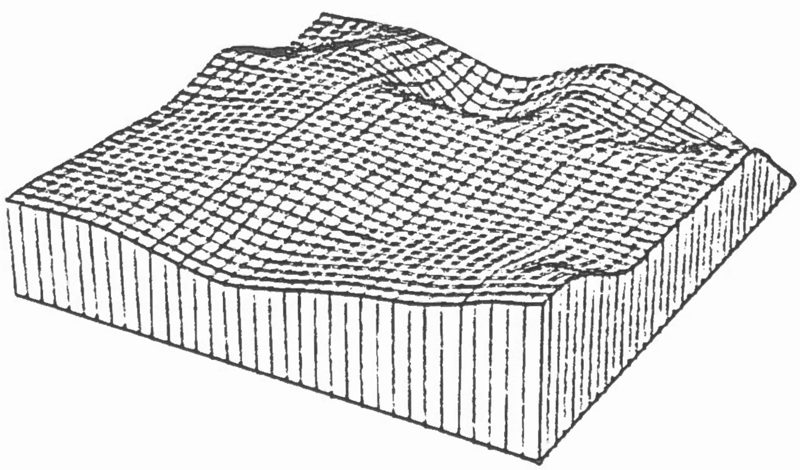


Figure 14b. Ni - 400 m sampling density.

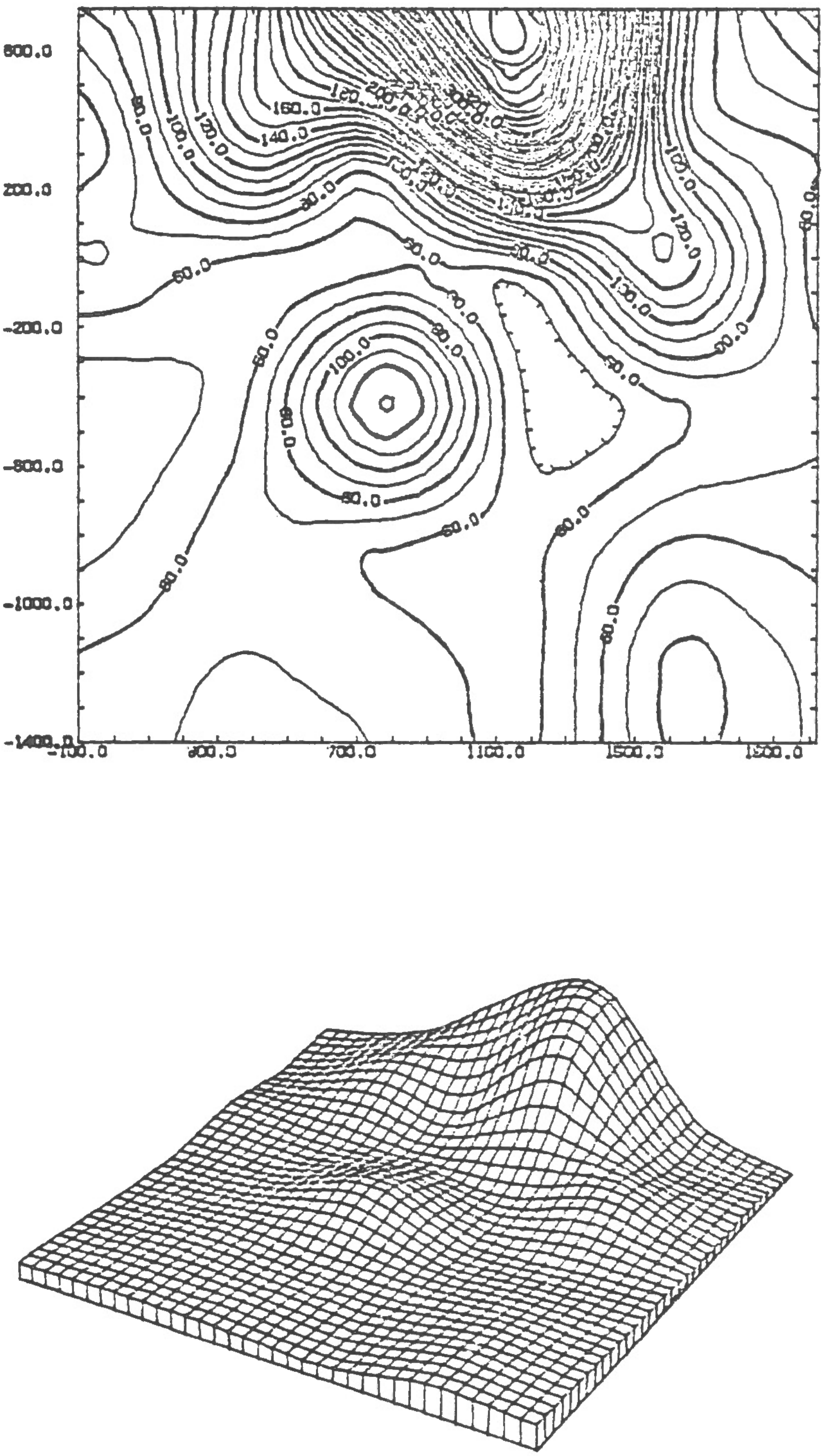


Figure 14c. Zn - 400 m sampling density.

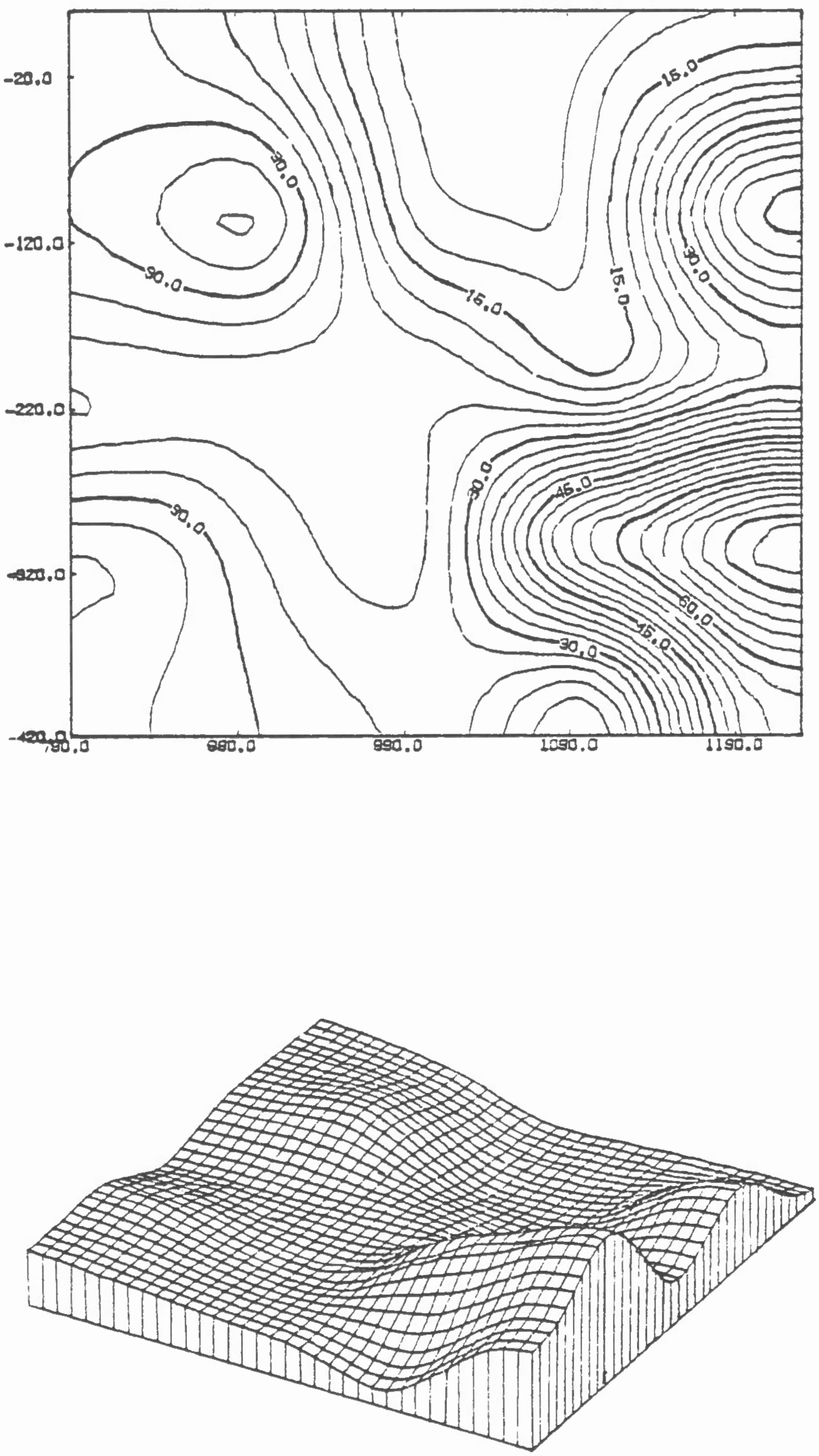


Figure 14d. Cu - 100 m sampling density.

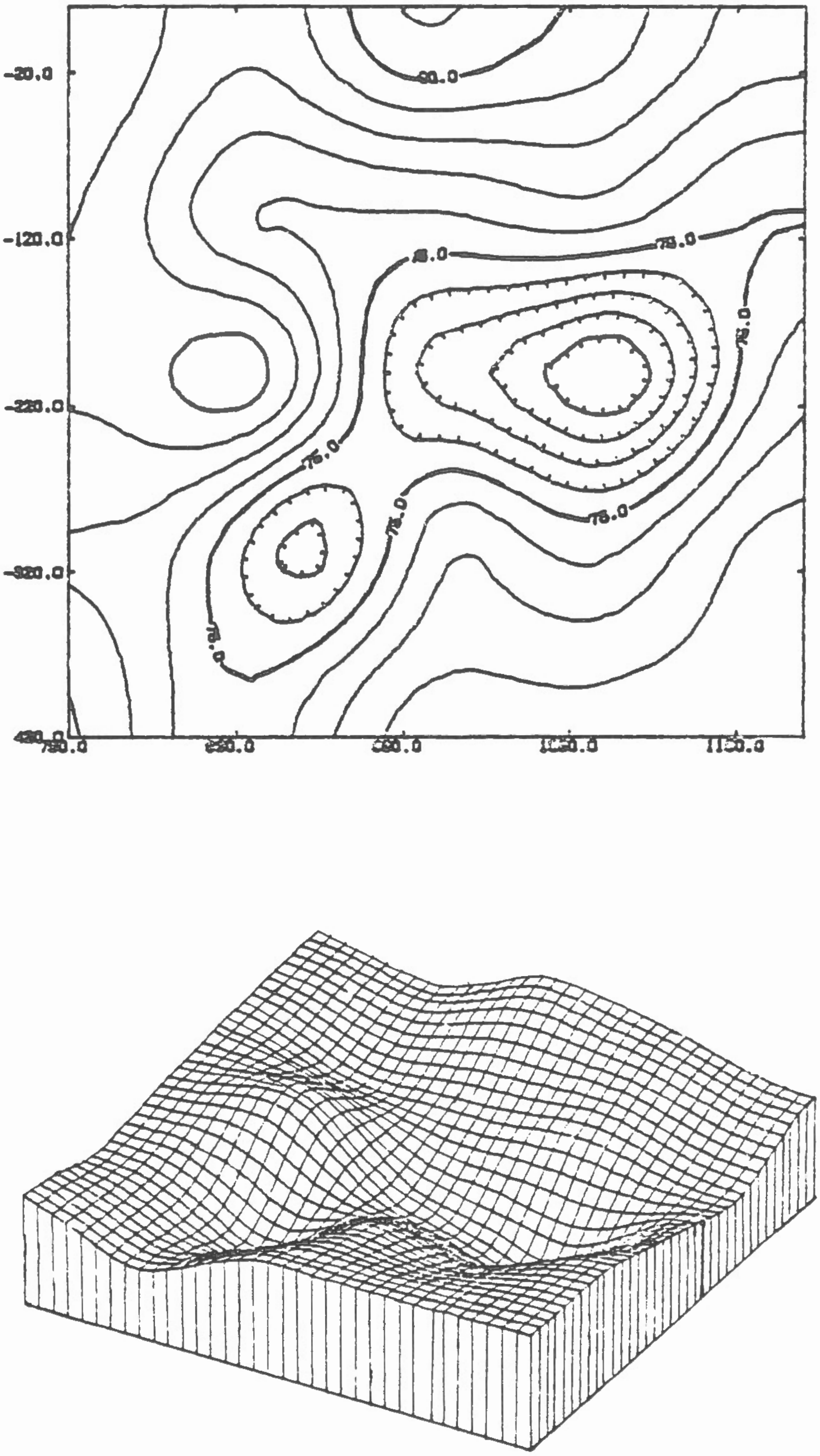
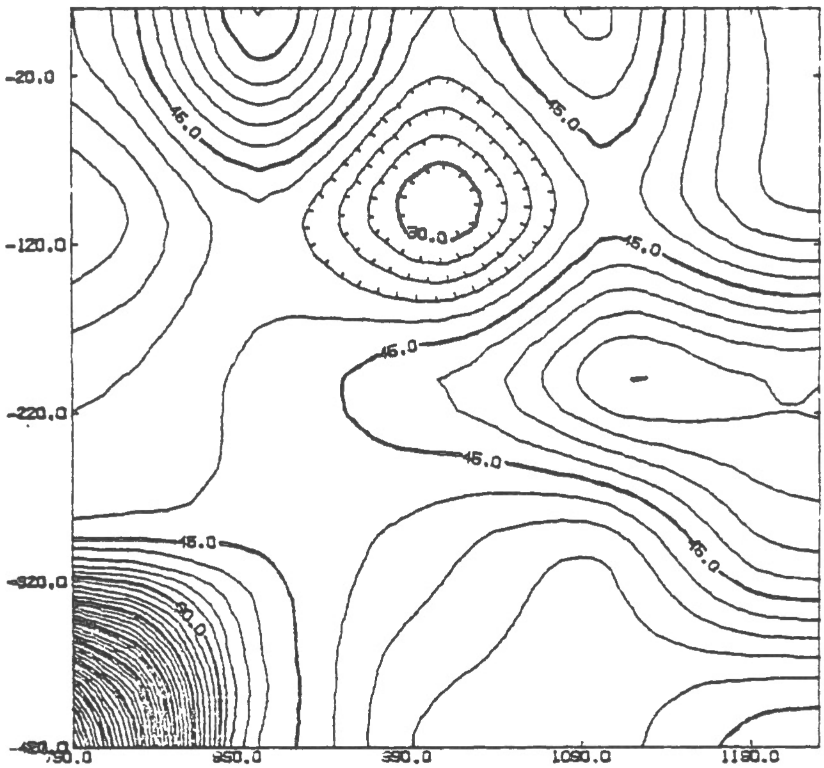


Figure 14e. Ni - 100 m sampling density.



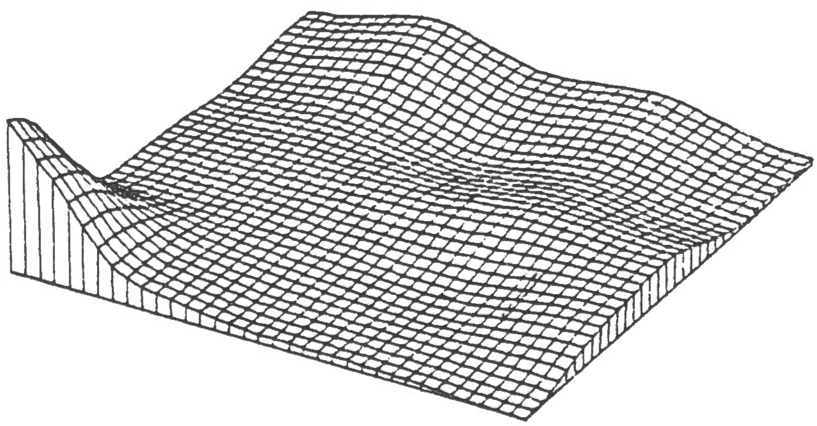


Figure 14f. Zn - 100 m sampling density.

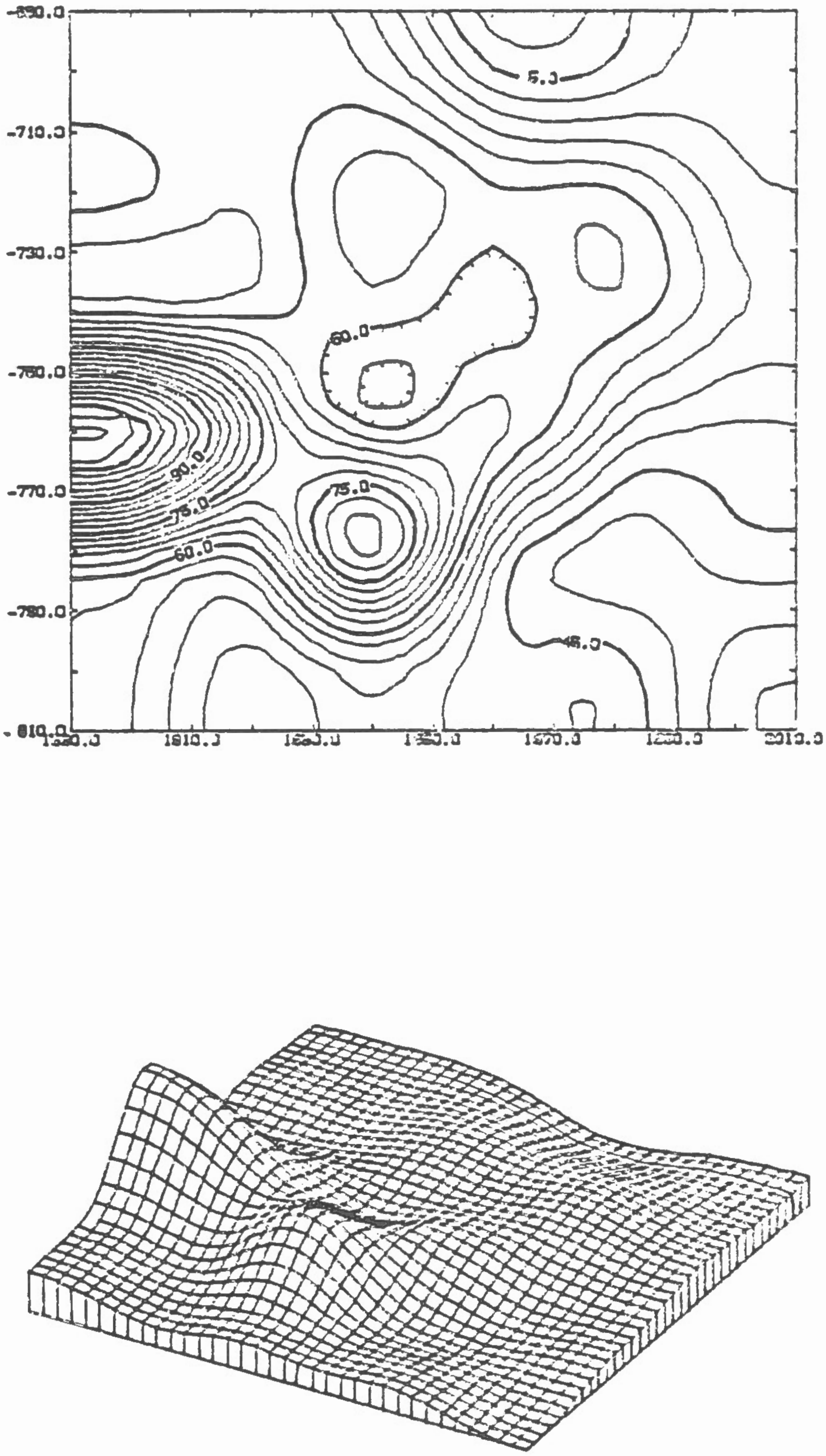


Figure 14g. Cu - 20 m sampling density.

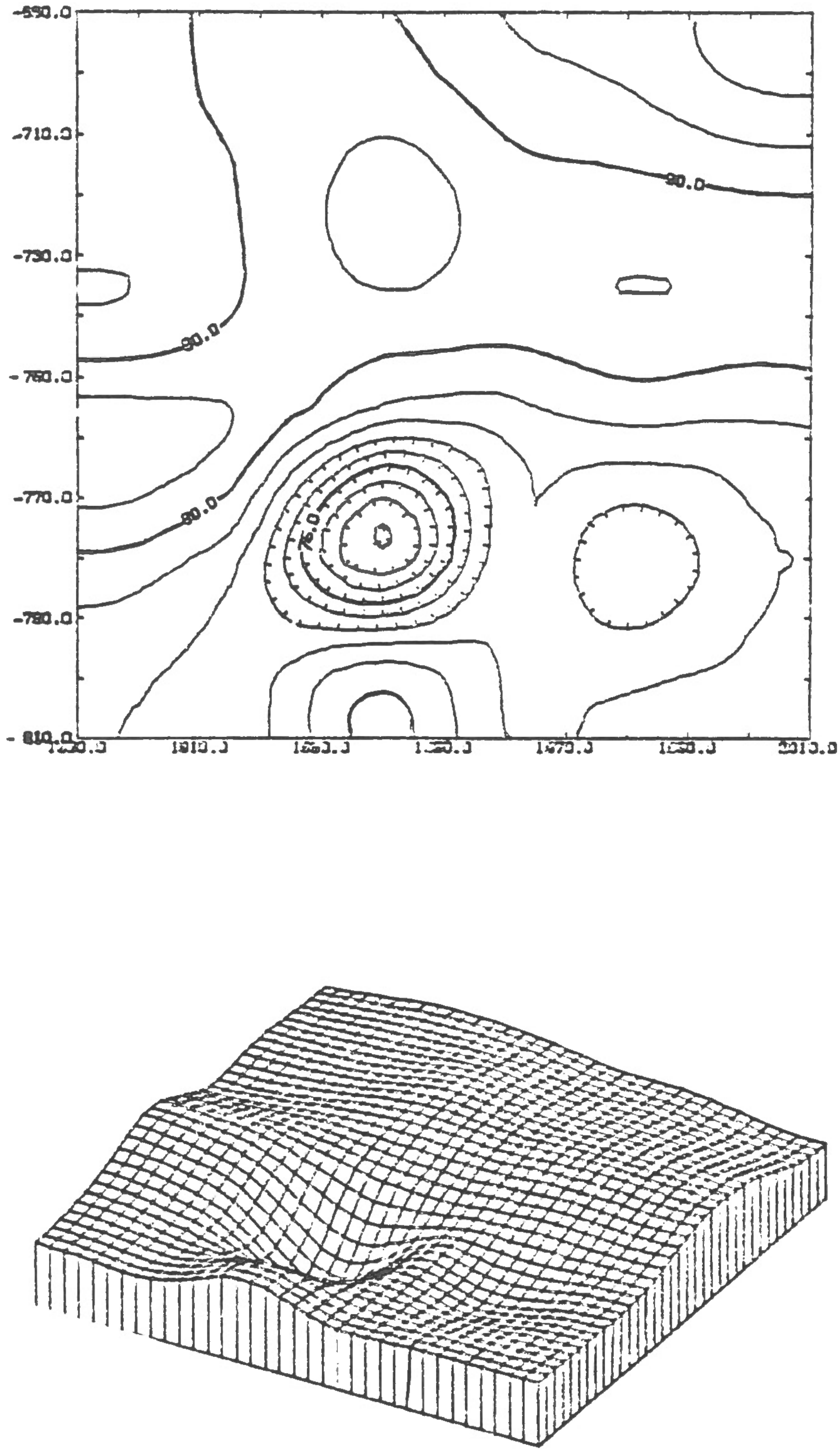


Figure 14h. Ni - 20 m sampling density.

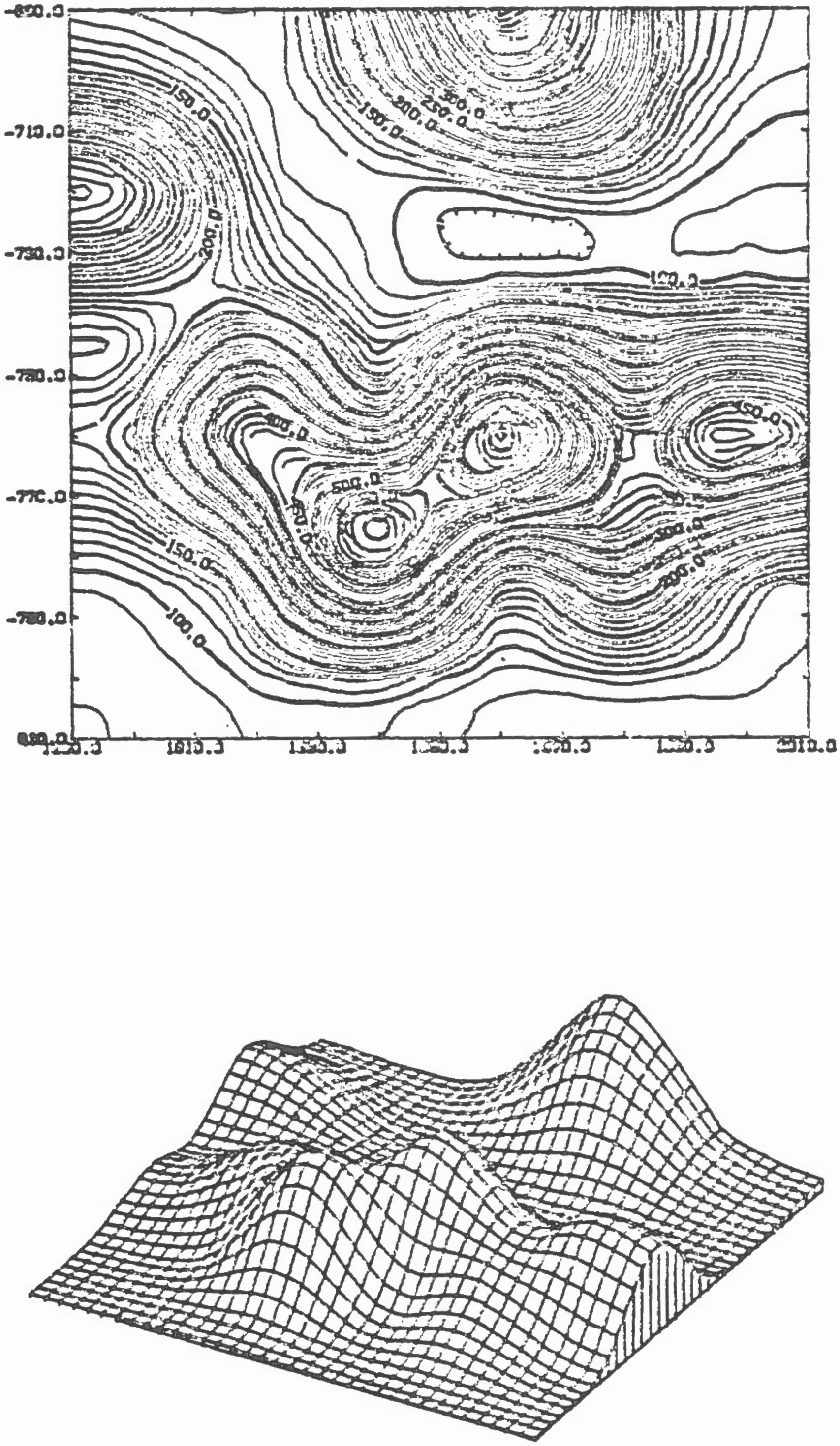


Figure 14i. Zn - 20·m sampling density.

SUMMARY AND CONCLUSIONS

Overall concentrations of Pb and Au in the Onaping Formation of the two areas is very low.

The median value of Cu (all samples) in the Onaping Formation in the Morgan Township area is similar to the median value of Cu (all samples) of the formation in the Dowling Township area; Ni and Zn show a similar relationship. Similarly, the median value of a given metal in one of the members is similar in both townships. Moreover, the three members have a similar metal content. Accordingly, the data does not support the suggestion (Muir 1980, Lafleur 1981) that the Black member has a higher metal content than other members.

In general, Ni has the highest median value, Zn is intermediate and Cu least. All median values are below 100 ppm. The highest values recorded are Cu - 3025 ppm, Ni - 1519 ppm and Zn - 3860 ppm. All are well below ore grade.

The scatter diagrams show no obvious trends except perhaps for a weak correlation between Cu and Zn.

The distribution pattern of a metal, from sampling on the 20 m grid, is seldom reproduced by larger scale sampling. This is well illustrated by the high Zn values in a 20 m sample area in Dowling Township; there is no evidence of the high in the contour diagram based on 100 m sampling. Consequently, diagrams produced by sampling a large interval cannot, in general, predict local high metal values.

The computer-generated contour and perspective plots, contained in this report, are not entirely suitable for displaying these kinds of data. The analytical data are highly skewed with the maximum as much as 60 times the median. Contour lines become very closely spaced and unreadable in diagrams that have local high values. Also, the contour lines are evenly spaced around peaks but in actual fact the peaks are usually due to a single sample.

A logarithm scale should be used in the contour and perspective plots. An effective type of perspective plot would be one in which each analysis is represented by a line, parallel to the z-axis, whose length is proportioned to the log of the analytical value. It would also be useful to plot the analytical values on the sample-location map.

In conclusion, the metal content of the Onaping Formation in the two areas is low and uneconomic. The distribution of metals is erratic and not stratigraphically controlled. Sampling on a widely-spaced grid cannot predict the presence of small localities with relatively high metal values. This erratic pattern supports the fact that the bulk of the sulphide minerals in the Onaping Formation are fragmental in nature.

REFERENCES

Arengi, J.T. 1977. Sedimentary evolution of the Sudbury Basin. M.Sc. thesis, University of Toronto, 141p.

Innes, D.G. 1972. Proterozoic Volcanism and associated sulphide-bearing metasediments in the Sudbury area, Ontario. B.Sc. thesis, Laurentian University, 87p.

Krauskopf, K.B. 1967. Source rocks for metal-bearing fluids. IN: Geochemistry of hydrothermal ore deposits, H.L. Barnes, editor. Holt, Rinehart and Winston, p. 1-33.

_____ 1979. Introduction to Geochemistry. McGraw-Hill, 617p.

Lafleur, J. 1981. Cascaden, Dowling and Trill Townships, District of Sudbury. IN: Summary of Field Work, 1981, by the Ontario Geological Survey, J. Wood, O.L. White, R.B. Barlow and A.C. Colvine, editors. Onatario Geological Survey Miscellaneous Paper 100, p. 80-83.

Muir, T.L. 1980. Morgan Lake - Nelson Lake area. IN: Summary of Field Work, 1980, by the Ontario Geological Survey, V.G. Milne, O.L. White, R.B. Barlow, J.A. Robertson and A.C. Colvine, editors. Ontario Geological Survey Miscellaneous Paper 96, p. 79-82.

Muir, T.L. 1982. Geology and origin of the Onaping Formation. IN: Summary of Field Work, 1982, by the Ontario Geological Survey, J. Wood, O.L. White, R.B. Barlow and A.C. Colvine, editors. Ontario Geological Survey Miscellaneous Paper 106, p. 76-79.

Muir, T.L. and Taylor, A.B. 1981. Precambrian geology of the Morgan Lake - Nelson Lake area, Sudbury District; Ontario Geological Survey Preliminary Map P.2419, Geological Series, Scale: 1:15840.

Pattison, E.F. 1979. The Sudbury sublayer. Canadian Mineralogist, Volume 17, p. 257-274.

Peredery, W.V. 1972a. Chemistry of fluidal glasses and melt border in the Onaping Formation. IN: New Developments in Sudbury Geology, J.V. Guy-Bray, editor. Geological Association of Canada Special Paper 10, p. 49-59.

Peredery, W.V. 1972b. The origin of rocks at the base of the Onaping Formation, Sudbury, Ontario. Ph.D. thesis, University of Toronto, 366p.

Rousell, D.H. 1982. Mineralization in the Whitewater Group, Sudbury Basin. IN: Geoscience Research Grant Program, Summary of Research 1981-82, E.G. Pye, editor. Ontario Geological Survey Miscellaneous Paper 103, p. 171-184.

Rousell, D.H. 1983. Nature and origin of mineralization inside the Sudbury Basin. Ontario Geological Survey Open File Report 5443, 53p.

_____ in press. Nature and origin of mineral occurrences inside the Sudbury Basin. Canadian Institute of Mining and Metallurgy Bulletin.

Sadler, J.F. 1958. A detailed study of the Onwatin Formation. M.Sc. thesis, Queen's University, 184p.

Stevenson, J.S. 1961. Recognition of the quartzite breccia in the Whitewater Series, Sudbury Basin. Transactions of the Royal Society of Canada, 3rd Series, Volume 55, p. 57-66.

APPENDIX A

ONAPING PROJECT ATOMIC ABSORPTION TRACE ELEMENT ANALYSES (TOTAL DIGESTION)

Morgan Township

SAMPLE # ROCK TYPE		Cu (ppm)	Ni (ppm)	Zn (ppm)	Pb (ppm)	Au (ppb)
6000	3	31	65	29	ND	1
6001	3	40	94	63	ND	1
6002	5	9	41	34	ND	ND
6003	3	52	90	43	ND	ND
6004	3	57	96	51	ND	2
6005	3	29	79	41	ND	2
6006	2	20	66	44	ND	13
6007	2	679	1519	77	163	2
6008	3	5	67	63	55	2
6009	3	31	60	52	ND	6
6010	3	36	86	42	ND	5
6011	3	81	96	53	60	2
6012	3	28	56	37	ND	2
6013	3	53	71	58	ND	2
6014	3	74	70	23	ND	2
6015	2	44	75	37	ND	2
6016	2	139	38	19	59	ND
6017	3	37	94	44	ND	1
6018	3	17	58	34	ND	6
6019	3	58	76	41	20	5
6020	3	44	43	41	ND	ND
6021	3	34	69	77	10	6
6022	3	40	89	49	ND	2
6023	3	31	54	22	ND	1
6024	3	49	85	63	ND	13
6026	3	3	62	40	ND	-
6028	3	58	85	54	ND	2
6029	3	1350	116	61	ND	2
6030	3	35	82	46	ND	1
6031	3	37	71	36	ND	1
6032	3	55	81	46	ND	ND
6033	3	40	81	104	79	ND
6035	3	153	79	33	ND	ND
6036	3	5	94	38	ND	2
6037	3	39	73	49	55	3
6038	3	10	80	30	ND	2
6039	3	3	72	26	ND	1
6040	3	45	70	32	ND	1
6041	3	370	66	38	ND	ND

MORGAN TOWNSHIP con't

	Cu	Ni	Zn	Pb	Au
6042 3	46	82	33	ND	2
6043 3	327	119	32	ND	ND
6044 3	23	95	43	ND	2
6045 3	8	70	31	ND	2
6046 3	38	98	33	ND	-
6047 3	8	79	24	ND	2
6048 3	102	75	32	ND	1
6049 3	17	88	29	ND	1
6050 3	9	68	24	ND	1
6051 3	86	90	34	ND	2
6052 3	22	68	29	ND	1
6053 3	47	84	57	ND	2
6054 3	6	82	34	ND	1
6055 3	43	63	29	ND	3
6056 3	23	82	51	ND	1
6057 3	12	70	40	ND	1
6058 3	14	94	43	ND	3
6059 3	54	89	35	ND	ND
6060 3	5	40	31	ND	2
6061 3	14	84	27	ND	2
6062 3	7	78	25	ND	1
6063 3	171	86	24	ND	ND
6064 3	15	44	14	ND	1
6065 3	79	75	30	ND	ND
6066 3	59	73	27	ND	ND
6067 3	15	109	36	ND	3
6068 3	8	76	35	ND	ND
6069 3	25	98	79	ND	1
6070 3	145	113	42	ND	1
6071 3	17	74	36	0	ND
6072 3	19	93	55	ND	3
6073 3	59	108	57	65	ND
6074 3	115	110	49	ND	3
6075 3	15	86	43	ND	1
6076 4	38	37	22	ND	10
6077 3	33	120	29	ND	2
6078 3	32	88	47	ND	ND
6079 3	95	82	70	122	ND
6080 3	26	85	43	ND	ND
6081 3	17	84	52	ND	2
6082 3	37	87	56	ND	ND
6083 3	18	86	39	ND	ND
6084 3	49	97	44	ND	1
6085 3	34	78	34	10	2
6086 3	60	93	47	ND	ND
6087 3	8	71	21	ND	10
6088 3	6	94	34	ND	7
6089 3	15	79	25	ND	ND
6090 3	27	83	30	ND	ND
6091 3	23	92	37	ND	ND
6092 3	39	91	32	ND	ND
6093 3	5	87	35	ND	ND
6094 4	39	83	35	ND	ND
6095 4	21	86	34	ND	ND

MORGAN TOWNSHIP con't

	Cu	Ni	Zn	Pb	Au
6096 3	53	88	44	ND	ND
6097 3	83	65	37	ND	2
6098 3	28	76	31	ND	2
6099 4	87	86	47	ND	3
6100 4	40	70	37	ND	2
6101 4	40	98	47	ND	ND
6102 3	49	86	58	ND	1
6103 3	13	87	28	ND	1
6104 4	66	88	101	ND	ND
6105 4	7	94	31	ND	ND
6106 4	199	96	39	ND	ND
6107 4	14	86	40	ND	4
6108 4	87	94	46	ND	ND
6109 4	30	73	33	10	2
6110 3	34	68	28	ND	2
6111 3	102	89	50	30	2
6112 3	15	93	33	ND	1
6113 3	15	94	46	ND	2
6114 3	12	109	51	ND	ND
6115 3	15	94	22	ND	ND
6116 4	73	93	63	ND	ND
6117 3	48	87	39	ND	4
6118 3	8	94	26	ND	ND
6119 3	16	103	48	ND	2
6120 3	16	98	43	ND	ND
6121 4	30	88	37	ND	4
6122 4	73	82	748	244	ND
6123 3	68	92	38	ND	ND
6124 3	15	82	34	ND	ND
6125 3	18	113	39	ND	8
6126 4	55	85	549	500	ND
6127 4	54	82	84	ND	1
6128 3	702	86	207	74	2
6129 3	28	80	26	ND	1
6130 3	28	92	33	ND	1
6131 4	45	98	65	ND	ND
6132 4	50	86	71	ND	ND
6133 4	43	92	105	ND	2
6134 4	66	71	82	10	ND
6135 4	27	87	53	ND	ND
6136 4	24	81	37	ND	1
6137 4	39	83	54	ND	ND
6138 4	33	98	58	ND	ND
6139 4	69	92	36	ND	15
6140 4	42	99	42	ND	ND
6141 4	46	73	60	0	ND
6142 4	66	95	100	ND	ND
6143 4	38	90	64	ND	2
6144 3	41	80	84	ND	2
6145 4	54	90	55	ND	ND
6146 4	37	97	45	ND	ND

MORGAN TOWNSHIP con'T

		Cu	Ni	Zn	Pb	Au
6147	4	41	83	52	ND	2
6148	3	44	78	50	ND	4
6149	3	32	75	38	ND	2
6150	3	59	100	100	ND	ND
6151	3	67	104	124	ND	2
6152	4	35	82	61	66	2
6153	4	45	87	67	ND	1
6154	4	28	86	38	ND	2
6155	4	49	87	60	ND	ND
6156	4	41	83	70	ND	2
6157	4	47	78	78	ND	2
6158	4	26	86	55	ND	3
6159	4	49	87	77	ND	2
6160	4	71	86	100	ND	2
6161	4	36	89	71	ND	2
6162	4	35	94	60	ND	ND
6163	4	45	103	82	ND	1
6164	4	37	88	57	ND	ND
6165	4	42	90	53	ND	ND
6166	4	46	90	73	ND	ND
6167	4	60	84	143	ND	1
6168	4	36	81	84	ND	ND
6169	4	45	87	91	ND	ND
6170	4	40	91	40	ND	ND
6171	4	46	79	44	ND	ND
6172	4	44	92	70	ND	1
6173	4	43	90	88	ND	ND
6174	4	38	95	59	ND	ND
6175	4	40	96	73	ND	1
6176	4	46	76	111	ND	ND
6177	4	28	90	60	ND	ND
6178	4	35	94	82	ND	ND
6179	4	31	80	65	ND	ND
6180	4	72	102	60	ND	2
6181	4	46	107	101	ND	ND
6182	4	26	88	82	ND	ND
6183	4	51	87	110	ND	3
6184	4	51	105	80	ND	1
6185	4	45	78	80	10	2
6186	4	27	86	75	ND	2
6187	4	40	104	84	ND	ND
6188	4	45	103	65	ND	2
6189	4	32	74	84	62	ND
6190	4	37	95	62	ND	ND
6191	4	27	90	62	ND	5
6192	4	40	93	76	ND	1
6193	4	48	100	103	ND	ND
6194	4	24	96	48	ND	2
6195	4	33	80	87	ND	ND

MORGAN TOWNSHIP con't

		Cu	Ni	Zn	Pb	Au
6196	4	32	78	215	86	3
6197	4	36	94	66	ND	1
6198	4	32	92	78	ND	ND
6199	4	38	95	85	ND	1
6200	4	30	78	64	ND	ND
6201	4	34	95	68	ND	ND
6202	4	38	103	105	ND	ND
6203	4	41	106	68	ND	ND
6204	4	42	106	84	ND	1
6205	4	39	71	67	20	10
6206	4	41	92	66	ND	ND
6207	4	33	100	73	ND	3
6208	4	47	104	99	ND	2
6209	4	31	104	68	ND	7
6210	4	23	106	75	ND	2
6211	4	40	83	69	ND	4
6212	4	50	100	79	ND	1
6213	4	158	103	68	ND	2
6214	4	51	95	69	ND	3
6215	4	40	108	74	ND	1
6216	4	41	109	88	ND	ND
6217	4	35	101	71	ND	1
6218	4	52	46	71	50	ND
6219	4	49	95	75	54	ND
6220	4	196	56	38	ND	10
6221	4	32	76	112	174	5
6222	4	36	108	85	ND	ND
6223	4	46	111	66	ND	ND
6224	4	31	105	77	ND	3
6225	4	58	108	116	ND	2
6226	4	39	115	76	ND	3
6227	4	31	100	74	ND	2
6228	4	34	107	74	ND	2
6229	4	35	108	77	ND	ND
6230	4	34	108	90	ND	2
6231	4	35	108	136	106	2
6232	4	58	99	110	ND	2
6233	4	41	90	68	ND	ND
6234	4	49	101	104	55	2
6235	4	31	80	62	ND	2
6236	4	37	88	62	ND	2
6237	4	40	88	58	ND	2
6238	4	1	17	3	ND	ND
6239	-	-	-	-	-	2
6243	3	33	88	80	ND	-
6245	4	23	88	48	ND	12
6246	4	48	100	64	ND	8
6247	4	26	92	66	ND	17
6248	4	115	80	41	ND	ND
6249	4	46	97	73	ND	2

MORGAN TOWNSHIP con't

		Cu	Ni	Zn	Pb	Au
6250	4	38	78	39	ND	2
6251	4	50	86	121	ND	2
6252	4	53	87	47	ND	4
6253	4	55	72	90	ND	ND
6254	4	46	86	62	ND	20
6255	4	36	75	55	ND	2
6256	4	24	77	37	ND	4
6257	4	53	84	96	ND	15
6258	4	49	84	41	ND	8
6259	4	53	80	38	ND	4
6260	4	31	75	42	ND	5
6261	4	44	90	54	ND	5
6262	4	26	74	64	ND	1
6263	4	72	70	136	20	2
6264	4	69	85	137	ND	4
6265	4	33	90	34	ND	4
6266	4	40	86	38	ND	8
6267	4	39	88	29	ND	4
6268	4	74	100	73	ND	11
6269	4	38	90	45	ND	17
6270	4	35	81	44	ND	2
6271	4	33	80	54	ND	6
6272	4	118	102	115	ND	10
6273	4	46	77	41	ND	1
6274	4	54	80	80	ND	15
6275	4	15	73	41	ND	ND
6276	4	38	80	51	ND	11
6277	4	29	80	35	ND	3
6278	4	34	89	48	ND	5
6279	4	54	100	28	ND	5
6280	4	75	93	50	ND	10
6281	4	88	96	38	ND	16
6282	4	4	92	45	ND	5
6283	4	65	84	19	ND	2
6284	4	30	92	51	ND	ND
6285	4	33	93	59	ND	3
6286	4	49	88	59	ND	5
6287	4	39	83	58	ND	4
6288	4	37	96	74	ND	9
6289	4	76	97	70	ND	14
6290	4	43	87	26	ND	2
6291	4	58	82	37	ND	ND
6292	4	35	82	22	ND	4
6293	4	66	97	25	ND	8
6294	4	86	88	26	ND	2
6295	4	55	113	42	ND	5
6296	4	44	85	23	ND	2
6297	4	77	86	64	ND	-
6298	4	47	80	34	ND	6
6299	4	47	82	22	ND	9

MORGAN TOWNSHIP con't

		Cu	Ni	Zn	Pb	Au
6300	4	29	95	29	ND	ND
6301	4	39	80	44	ND	2
6302	4	101	92	37	ND	3
6303	4	53	94	63	ND	12
6304	4	37	93	28	ND	1
6305	4	51	90	18	ND	2
6306	4	64	104	28	ND	ND
6307	4	58	96	32	ND	5
6308	4	45	70	42	ND	ND
6309	4	45	87	39	ND	8
6310	4	44	90	58	ND	ND
6311	4	71	109	69	ND	ND
6312	4	45	70	280	ND	3
6313	4	41	84	48	ND	ND
6314	4	48	81	45	ND	ND
6315	4	41	79	54	ND	ND
6316	4	62	98	58	ND	9
6317	4	47	88	47	ND	5
6318	4	20	87	123	ND	ND
6319	4	21	77	70	ND	6
6320	4	37	74	60	ND	ND
6321	4	48	88	42	ND	1
6322	4	31	77	31	ND	ND
6323	4	34	81	39	ND	18
6324	4	56	70	70	ND	1
6325	4	44	85	79	ND	ND
6326	4	28	51	79	42	3
6327	4	26	51	100	30	ND
6328	4	25	55	90	38	ND
6329	4	37	75	79	52	1
6330	4	30	60	88	53	14
6331	4	20	72	85	52	2

ND: not detected
- : not analysed

Rock Types:
1 Basal Breccia
2 Melt Member
3 Grey Member
4 Black Member
5 Granophyre or inclusions

APPENDIX A con't

ONAPING PROJECT ATOMIC ABSORPTION TRACE ELEMENT ANALYSES
(TOTAL DIGESTION)

Dowling Township

SAMPLE # ROCK TYPE		Cu (ppm)	Ni (ppm)	Zn (ppm)	Pb (ppm)
6400	2	74	61	86	23
6401	2	87	60	140	20
6402	2	17	51	375	ND
6403	2	250	96	2640	152
6404	3	5	81	51	ND
6405	3	78	89	80	27
6406	3	12	69	57	22
6407	3	83	80	74	ND
6408	5	18	15	40	ND
6409	3	10	40	14	21
6410	3	5	126	120	ND
6411	3	26	105	49	ND
6412	3	6	115	31	47
6413	5	15	10	70	10
6414	3	12	69	75	22
6415	3	12	88	41	ND
6416	3	48	91	63	27
6417	3	8	76	53	ND
6418	5	10	18	10	30
6419	2	41	54	69	ND
6420	2	42	71	64	21
6421	2	48	99	57	ND
6422	3	46	84	250	27
6423	2	56	86	922	21
6424	3	15	50	38	36
6425	3	45	74	43	22
6426	3	59	59	53	ND
6427	3	92	80	115	ND
6428	3	16	93	184	ND
6429	2	6	6	35	10
6430	3	42	61	200	62
6431	2	34	48	179	57
6432	2	45	73	63	ND
6433	3	60	60	59	30
6434	2	18	52	46	21
6435	3	51	95	206	29
6436	3	15	94	75	ND
6437	3	64	90	122	36
6438	3	55	96	71	20
6439	4	78	58	43	20

DOWLING TOWNSHIP con't

		Cu	Ni	Zn	Pb
6440	4	70	80	54	ND
6441	3	55	93	164	ND
6442	3	37	71	135	ND
6443	4	5	62	237	ND
6444	3	47	98	74	10
6445	3	6	40	45	20
6446	3	4	43	129	20
6447	3	6	61	39	20
6448	3	20	97	62	ND
6449	4	59	79	165	33
6450	2	60	88	64	ND
6451	3	22	71	50	ND
6452	2	44	76	60	21
6453	4	32	89	90	21
6454	3	4	125	44	21
6455	3	3	60	40	ND
6456	3	96	141	1700	4826
6457	3	7	159	33	ND
6458	2	5	51	88	10
6459	4	72	78	68	ND
6460	4	46	88	125	ND
6461	4	46	86	68	ND
6462	4	64	85	185	34
6463	4	49	109	51	ND
6464	3	37	103	94	ND
6465	3	25	91	129	35
6466	3	11	65	44	ND
6467	3	73	104	54	ND
6468	3	46	93	74	56
6469	4	20	73	40	ND
6470	4	46	98	43	ND
6471	4	16	79	45	ND
6472	4	20	85	34	ND
6473	4	24	83	45	ND
6474	4	29	90	38	ND
6475	4	23	84	68	ND
6476	4	6	95	40	ND
6477	4	10	90	55	ND
6478	4	11	83	31	ND
6479	2	34	79	52	ND
6480	2	9	94	55	ND
6481	2	24	98	40	ND
6482	3	20	86	166	ND
6483	3	6	83	36	ND
6484	4	30	88	28	ND
6485	4	40	76	41	24
6486	4	7	78	22	21
6487	4	10	82	44	ND
6488	4	52	74	30	ND
6489	4	18	84	39	ND
6490	4	21	92	43	ND
6491	4	24	66	50	20
6492	4	10	56	64	21
6493	4	22	81	59	20
6494	4	39	80	40	28

DOWLING TOWNSHIP con't

		Cu	Ni	Zn	Pb
6495	4	24	62	44	24
6496	4	20	85	39	20
6497	4	64	76	34	20
6498	3	88	86	53	20
6499	4	15	70	36	20
6500	2	56	65	78	26
6501	4	32	71	67	22
6502	4	27	67	47	22
6503	3	160	90	51	ND
6504	4	35	86	178	54
6505	4	31	74	44	34
6506	4	27	86	35	27
6507	4	10	85	34	20
6508	3	55	86	27	22
6509	4	50	81	47	24
6510	4	64	82	49	24
6511	4	82	81	106	30
6512	4	56	87	70	35
6513	4	64	87	68	27
6514	4	24	72	47	23
6515	4	40	92	56	20
6516	4	32	78	40	ND
6517	4	51	69	42	21
6518	3	42	82	28	20
6519	4	54	91	78	21
6520	4	46	78	63	20
6521	4	56	88	68	22
6522	4	46	78	84	20
6523	4	46	69	42	29
6524	4	40	83	57	29
6525	4	23	54	30	29
6526	4	51	86	44	26
6527	4	30	84	60	29
6528	3	31	89	49	25
6529	3	60	91	88	28
6530	3	33	68	58	31
6531	3	43	79	78	23
6532	4	6	9	86	32
6533	4	51	82	53	22
6534	3	56	98	78	ND
6535	3	124	98	120	20
6536	3	69	107	64	27
6537	3	38	94	68	32
6538	3	31	96	47	ND
6539	4	49	71	76	10
6540	4	51	91	83	25
6541	4	57	100	72	25
6542	4	57	85	96	35
6543	4	50	81	106	20
6544	3	27	79	45	ND
6545	4	33	70	34	20
6546	4	32	62	30	ND
6547	4	38	86	53	27
6548	3	99	85	71	27

DOWLING TOWNSHIP con t

	Cu	Ni	Zn	Pb
6549 3	30	94	49	21
6550 3	32	82	42	22
6551 3	59	108	33	21
6552 3	15	86	57	29
6553 4	36	77	56	32
6554 4	54	89	83	32
6555 4	60	76	66	52
6556 4	59	74	104	51
6557 4	56	84	77	33
6558 4	34	85	74	54
6559 4	61	94	48	43
6560 4	25	61	21	29
6561 4	230	81	357	34
6562 4	29	85	34	36
6563 4	38	93	49	34
6564 4	31	82	52	31
6565 4	45	72	187	90
6566 4	111	90	45	27
6567 4	33	59	50	16
6568 4	43	90	74	25
6569 4	43	51	38	30
6570 4	67	108	202	36
6571 4	18	93	94	34
6572 4	3025	91	158	108
6573 4	51	92	64	33
6574 4	58	89	72	29
6575 4	43	96	118	33
6576 4	7	74	68	28
6577 4	12	102	131	32
6578 4	11	122	100	36
6579 4	33	99	98	33
6580 4	43	90	48	32
6581 4	61	101	118	30
6582 4	55	124	85	35
6583 4	59	92	93	29
6585 4	36	86	820	454
6586 4	46	87	131	80
6587 4	64	89	419	307
6588 4	56	90	89	41
6589 4	70	97	110	37
6590 4	61	91	59	37
6591 4	66	92	89	32
6592 4	50	91	83	32
6593 4	42	84	64	63
6594 4	54	91	184	64
6595 4	62	91	89	29
6596 4	54	92	97	29
6597 4	66	95	92	30
6598 4	54	93	82	24
6599 4	138	99	225	68
6600 4	80	94	600	405
6601 4	41	86	107	64
6602 4	75	83	3860	238
6603 4	49	88	60	28
6604 4	46	85	72	35

DOWLING TOWNSHIP con't

	Cu	Ni	Zn	Pb
6605 4	56	89	82	33
6606 4	50	83	150	76
6607 4	112	46	1640	69
6608 4	43	90	55	31
6609 4	34	73	359	174
6610 4	46	84	58	37
6611 4	41	81	88	32
6612 4	53	96	83	44
6613 4	44	82	67	37
6614 4	51	85	62	39
6615 3	35	90	38	22
6616 3	46	87	65	27
6617 3	11	55	63	26
6618 3	55	87	90	30
6619 3	11	78	66	30
6620 3	73	89	54	27
6621 3	77	69	79	22
6622 3	102	94	44	23
6623 3	51	87	42	24
6624 3	81	90	96	ND
6625 3	81	92	57	24
6626 3	76	78	58	26
6627 3	83	98	47	ND
6628 3	157	90	86	ND
6629 3	116	77	56	25
6630 3	51	90	53	ND
6631 3	202	94	64	25
6632 3	81	103	47	26
6633 3	18	76	46	ND
6634 3	4	53	45	ND
6635 3	10	47	47	ND
6636 3	9	50	63	ND
6637 3	14	54	41	ND
6638 3	59	87	79	ND
6639 3	13	62	49	ND
6640 3	157	69	118	ND
6641 3	53	54	105	ND
6642 3	10	54	35	ND
6643 3	8	40	46	ND
6644 3	53	84	56	ND
6645 3	10	31	39	ND
6646 3	75	70	138	80
6647 3	51	66	224	ND
6648 4	20	97	62	ND
6649 4	79	65	23	ND
6650 3	51	88	38	ND
6651 4	46	86	79	25
6652 4	76	96	105	20
6653 4	19	96	53	20
6654 4	46	75	72	22
6655 2	100	65	85	88
6656 2	94	105	94	ND
6657 3	10	33	38	ND
6658 3	53	68	45	22
6659 3	37	45	164	61

DOWLING TOWNSHIP con't

		Cu	Ni	Zn	Pb
6660	4	205	78	4940	33
6661	4	107	87	1160	481
6662	4	306	88	6700	25
6663	2	37	83	86	33
6664	2	79	88	67	26
6665	2	27	55	497	192
6666	2	27	84	560	228
6667	3	51	78	65	39
6668	3	10	42	65	28
6669	3	7	38	87	28
6670	3	7	99	220	50
6671	3	10	6	91	33
6672	5	48	27	76	56
6673	5	7	22	10	23
6674	3	38	80	452	132

ND: not detected
- : not analysed

Rock Types:
1 Basal Breccia
2 Melt Member
3 Grey Member
4 Black Member
5 Granophyre or inclusions

APPENDIX B

STAMP ANALYTICAL METHODS REPORT

Sample Preparation:

A total of 3,910 samples were analyzed for various elements. All of these were catalogued and stored once a subsample was taken for analysis. Project 3 and Project 4 subsamples were crushed using a Bico Jaw crusher then ground to ~ 200 mesh in a tungsten carbide dish on a shatterbox grinder. The resulting powders were stored in polystyrene vials. Project 2 esker samples were dried and sieved to < 2 um and stored in plastic sample bags. The coarser fraction of these was also stored for future reference. The following analyses were done at Laurentian University.

Gold Analysis:

Project 2 esker powders were analyzed for gold following a partial acid digestion. A 2 gm weight was transferred to a 50 ml capacity test tube and digested with 15 ml of aqua regia for 1 hr. at low heat. Rock powders from the other projects were totally digested prior to gold analysis. A 2 gm weight was digested in a teflon beaker with a 30 ml HF/15 ml $HClO_4$ mixture to dryness. The residue was then dissolved in 25 ml aqua regia. Gold was then extracted from the aqua regia solutions into a 3 ml aliquot of methyl iso-butyl ketone (MIBK). Project 2 samples required centrifugation at this stage. Once the layers had separated a 0.5 ml aliquot of the gold bearing MIBK was removed for analysis. Gold determinations were done using a Model 703 Perkin-Elmer Atomic Absorption spectrophotometer with graphite furnace and HGA 500 programmer. The analysis program for gold is outlined in Table 1. The instrument was calibrated using standards prepared from the appropriate dilution of a stock solution of 'Fisher purified' gold metal, which was then extracted into MIBK as for the samples.

All analyses were done with a deuterium lamp background corrector to minimize any matrix enhancement effects. Highly anomalous samples were reanalyzed as often as four times. Due to the inherent nature of gold it is very difficult to obtain a homogeneous sample distribution. Ideally a larger sample size would have been preferable however not economical in view of the large number of samples. The large majority of samples analyzed were near the detection limits (ie. 2 ppb).

APPENDIX B con't

Table 1
Gold Analysis Program

Step 1 (drying)	150°c Temperature 70 sec. Ramp 15 sec. Hold Baseline
Step 2 (charring)	800°c Temperature 55 sec. Ramp 15 sec. Hold 40 sec. Recorder
Step 3 (atomization)	2700°c Temperature 3 sec. Ramp 7 sec. Hold 5 sec. Read Recorder 40 Internal Flow
Step 4	2750°c Temperature 1 sec. Ramp 3 sec. Hold Recorder
Step 5	30°c Temperature 10 sec. Ramp 5 sec. Hold 10 sec. Read

Note: 20 ul sample volume

Traces by Atomic Absorption Spectrophotometry:

All project 3 and project 4 samples were analyzed for Cu, Ni, Zn and Pb following a total digestion (ie.$HF/HClO_4$). The digestion residue from a 0.5 gm sample was then dissolved in 5% HCl and analyzed by flame atomic absorption spectrophotometry using a Perkin-Elmer Model 5000 with an AS50 autosampler in conjunction with a Model 3600 Data Station. Project 3 samples were also analyzed for Fe and Mn by this method. All flame atomic absorption spectrophotometry standard solutions were prepared by the appropriate dilution of Fisher 'Certified A.A. Standard' 1000 ppm stock solution with 5% HCl. Single element electrodeless discharge lamps were used for Pb and Zn while all other analyses were done with single element hollow cathode lamps. All anlyses were done with flow spoiler option.

Detection limits for each element are shown in Table 2. Precision was determined by repeated analysis of random samples as shown in Table 3.

Project 2 esker samples were analyzed for a number of traces by atomic absorption spectrophotometry at Queen's University following an aqua regia digestion.

Table 2
A.A. Detection Limits

Element	D.L. (ppm)
Cu	.16
Ni	.06
Zn	.03
Pb	.68
Fe	.03
Mn	.09

Table 3
Results of Repeated Analyses

Sample	Content (ppm ± S.D.[A])					
	Cu	Ni	Zn	Pb	Mn	Fe
6067	4 ± 1	16 ± 12	2.5 ± .6	ND	-	9431 ± 952
6099	172 ± 12	117 ± 38	117 ± 13	ND	1945 ± 147	119,525 ± 3,521
6176	58 ± 6	36 ± 11	13 ± 1	ND	92 ± 32	12,786 ± 2,949
6181	7 ± 3	60 ± 15	57 ± 7	ND	306 ± 46	231,425 ± 21,885

A) standard deviation based on 4 separate analyses.

Traces by X-ray Fluorescence Spectrometry:

A Philips Model 1220 Semi-Automatic Spectrometer was used to determine Y, Rb, Sr, Zr and As levels. Samples were analyzed as 4 gm loose powders in spectro cups on mylar film. The instrument conditions are shown in Table 4.

The XRF data were processed on a PDP11/03 (Digital Equip. Co.). Matrix correction for these elements was based on the total mass absorption coefficient as determined by comparing their Mo - K compton peak intensity to that of several standards of known absorption coefficients. Duplicate sample powders were also prepared and analyzed, one in every 20 samples. Accuracy and precision were determined by analyzing international rock standards with each sample batch. Table 5 shows these results along with the published values for these standards.

APPENDIX B con't

Table 4
Operating Conditions for X-ray Fluroescence

Element	Tube	Excitation		Crystal	Counter
Si	Cr	50kv	40 mA	PE	Flow
Ti	Cr	50kv	35 mA	LiF200	Flow
Al	Cr	50kv	40 mA	PE	Flow
Fe	W	35kv	10 mA	LiF200	Flow
Mn	W	50kv	40 mA	LiF200	Flow
Mg	Cr	50kv	40 mA	TLAP	Flow
Ca	Cr	40kv	30 mA	LiF200	Flow
K	Cr	50kv	40 mA	PE	Flow
P	Cr	50kv	40 mA	PE	Flow
Na	Cr	50kv	40 mA	TLAP	Flow
Y[A]	Mo	95kv	20 mA	LiF200	Scintillation
Rb	Mo	95kv	20 mA	LiF200	Scintillation
Zr[B]	Mo	95kv	20 mA	LiF200	Scintillation
Sr	Mo	95kv	20 mA	LiF200	Scintillation
As	Mo	60kv	40 mA	LiF200	Scintillation

A) Y and Rb were determined simultaneously in order to correct for the enhancement of Y by Rb directly.

B) Zr and Sr were determined simultaneously in order to correct for Sr enhancement of Zr.

Table 5
Comparison of Published Values to Experimental Values for International Standards.[A]

Element	W-1 Published Value(Abbey)	L.U. Value	GSP-1 Published Value	L.U. Value	BCR1 Pub. Value	L.U. Value
Sr	190	190 ± 4			330	328 ± 6
Zr	105	90 ± 11			185	177 ± 7
Y	25	28 ± 2	29	34 ± 2		
Rb	21	21 ± 1	250	260 ± 8		

A) based on at least 6 analyses.

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Whole Rock Analysis by X-ray Fluorescence Spectrometry

The ten major oxides were determined on sample beads by a Philips PW 1220 semi-automatic X-ray spectrometer. The sample beads were prepared by adding 4.2 gm of lithium tetraborate and 1 gm of ammonium nitrate to 1.4 gm of roasted sample powder. Loss on ignition was determined from the roasting data. This dry mixture was then mechanically mixed and transferred to a non-wetting platinum crucible of the Claisse Automatic Fluxer. The sample was fused and cast in a platinum mould to form the bead.

Matrix correction for the major elements was based on mass absorption comparisons between samples and international standards. Approximately one in every twenty samples was a duplicate bead. The accuracy of these results is shown in Table 6. Table 7 shows the results of our analyses of the international standards and their published values. Also shown are the results of a basalt rock powder (BAS) run as an internal check with each sample batch, a total of 17 separate analyses. The instrument conditions for these analyses are listed in Table 4.

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Table 6
Results for Duplicate Beads

Major Oxides (%)

CODE	NA	MG	AL	SI	P	K	CA	TI	MN	FE
0063A)	4.42	1.43	16.74	67.64	0.06	2.44	3.04	0.43	0.07	3.75
B)	4.38	1.37	16.67	67.87	0.06	2.45	3.02	0.43	0.06	3.69
2003A)	3.38	6.15	12.58	51.52	0.01	0.60	10.60	0.96	0.17	14.03
B)	3.62	6.15	12.76	51.23	0.01	0.60	10.59	0.95	0.16	13.9
4015A)	3.86	7.22	17.32	49.34	0.08	0.12	1.85	1.57	0.20	18.44
B)	3.92	7.25	17.45	49.34	0.07	0.12	1.89	1.60	0.21	18.14
4101A)	2.87	2.96	20.19	63.17	0.12	1.57	1.70	0.86	0.07	6.49
B)	3.01	2.97	20.17	62.97	0.12	1.57	1.70	0.85	0.07	6.56
4165A)	2.84	1.22	15.41	73.12	0.12	2.54	2.37	0.39	0.03	1.97
B)	2.31	1.16	15.49	73.56	0.11	2.53	2.43	0.40	0.03	1.99
C)	2.69	1.21	14.91	73.47	0.12	2.92	2.41	0.39	0.03	1.85
4284A)	0.05	3.09	13.81	63.75	0.12	3.37	7.91	0.75	0.17	6.98
B)	0.07	3.04	13.84	63.77	0.14	3.39	7.94	0.73	0.18	6.90
4070A)	3.19	8.09	15.03	49.03	0.08	0.25	9.87	1.06	0.21	13.20
B)	3.14	8.09	15.09	49.20	0.08	0.26	9.78	1.04	0.21	13.10
4096A)	5.14	4.75	15.20	62.28	0.13	1.13	5.43	0.55	0.09	5.30
B)	4.88	4.91	15.51	62.24	0.14	1.11	5.38	0.53	0.08	5.22
0205A)	2.22	3.65	13.25	56.46	0.16	1.84	5.28	1.99	0.26	14.89
B)	2.88	3.62	13.18	56.02	0.16	1.86	5.26	1.98	0.27	14.76
0236A)	0.11	6.27	16.08	54.46	0.21	1.86	7.95	1.18	0.15	11.71
B)	0.09	6.34	16.13	54.41	0.22	1.86	7.83	1.17	0.15	11.79
0144A)	2.86	0.34	14.63	73.88	0.02	4.18	1.56	0.24	0.02	2.27
B)	2.70	0.22	14.55	73.94	0.02	4.28	1.65	0.25	0.02	2.36
0194A)	1.17	16.54	21.24	30.42	0.64	1.55	15.24	1.07	0.35	11.78
B)	1.85	16.51	21.16	30.19	0.65	1.56	15.08	1.07	0.35	11.58
0244A)	5.24	4.28	15.46	60.31	0.10	0.83	6.30	0.50	0.12	6.86
B)	5.40	4.19	15.47	60.20	0.09	0.84	6.28	0.49	0.13	6.89
2100A)	0.33	1.57	17.04	65.65	0.26	4.38	2.11	0.68	0.06	7.92
B)	0.36	1.51	17.04	65.78	0.26	4.36	2.08	0.68	0.06	7.87
4101A)	2.87	2.96	20.19	63.17	0.12	1.57	1.70	0.86	0.07	6.49
B)	3.01	2.97	20.17	62.97	0.12	1.57	1.70	0.85	0.07	6.56
4165A)	2.84	1.22	15.41	73.12	0.12	2.54	2.37	0.39	0.03	1.97
B)	2.31	1.16	15.49	73.56	0.11	2.53	2.43	0.40	0.03	1.99
4284A)	0.05	3.09	13.81	63.75	0.12	3.37	7.91	0.75	0.17	6.98
B)	0.07	3.04	13.84	63.77	0.14	3.39	7.94	0.73	0.18	6.90
4070A)	3.19	8.09	15.03	49.03	0.08	0.25	9.87	1.06	0.21	13.20
B)	3.14	8.09	15.09	49.20	0.08	0.26	9.78	1.04	0.21	13.10

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Table 7

Results for International Standards Compared to Their Published Values

Oxide Content (%)

Standard	Na_2O	MgO
GSP1[A]	2.76 ± .25	0.96 ± .03
published	2.82	0.97
BCR1[A]	3.48 ± .28	3.49 ± .09
published	3.28	3.48
BAS	4.71 ± .32	4.93 ± .13

Standard	AL_2O_3	SiO_2
GSP1[A]	15.10 ± .53	68.12 ± 1.5
published	15.32	67.91
BCR1[A]	13.40 ± .19	54.58 ± .38
published	13.65	54.72
BAS	15.92 ± .46	49.8 ± .8

Standard	P_2O_5	K_2O
GSP1[A]	0.21 ± .01	5.06 ± .34
published	0.28	5.58
BCR1[A]	0.34 ± .005	1.56 ± .08
published	0.33	1.68
BAS	0.5 ± .03	1.11 ± .06

Standard	CaO	TiO_2
GSP1[A]	1.98 ± .09	0.66 ± .02
published	2.04	0.66
BCR1[A]	6.97 ± .04	2.30 ± .33
published	6.96	2.21
BAS	5.80 ± .09	3.09 ± .25

Standard	MnO	Fe_2O_3
GSP1[A]	0.04 ± .003	4.34 ± .05
published	0.04	4.37
BCR1[A]	0.18 ± .006	13.70 ± .27
published	0.19	13.70
BAS	.20 ± .008	14.01 ± .38

A) based on 10 analyses

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