# DISTRIBUTION OF SOME MINOR ELEMENTS IN THE NIPISSING DIABASE

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## ABSTRACT

Nine cross-sections of Nipissing diabase sheets in the Cobalt-Gowganda region were sampled and analyzed for nickel, cobalt, copper, chromium, silver, and in most cases, for barium, strontium, and boron. Nickel and chromium decrease, and cobalt increases with fractionation as expressed by the mafic index. Copper, silver, and arsenic generally increase with height above the bottom contacts of the intrusions; highest values are attained in varied-texture diabase and in the vicinity of the top contact. Although the total nickel content of the diabases is lowered with fractionation, leach tests indicate that the amount of nickel present in "sulphide" form does not necessarily decrease. Of the diabases examined in the present study, the New Lake basin at Cobalt is by far the most enriched in silver.

## INTRODUCTION AND PREVIOUS STUDIES

Cross-sections of the Nipissing diabase in the Cobalt-Gowganda region were sampled and analyzed for cobalt, nickel, copper, silver, and in most cases, a few additional elements. The sections traversed include three at Cobalt, three in Henwood township, and one each in South Lorrain, Elk Lake, and Gowganda.

The relevance of trace element data in understanding the origin of ore deposits is very commonly difficult to assess. However, it seemed worthwhile obtaining the factual data on the Nipissing diabase in order to supplement the limited studies that have been done in the past and to evaluate the published geochemical data which have been used to support various theories of genesis of the Cobalt ores. The earlier studies had focused primarily on the abundance of silver in diabase and granophyre.

The difficulties in the early attempts at determining silver in trace amounts in the diabase from the Cobalt area are summarized by Moore (1934). Subsequently, on the basis of 23 additional determinations, Moore (1956) concluded that granophyric diabase contains more silver than ordinary diabase. Spectrographic analyses of diabases from the Cobalt area are given in the theses by Hriskevich (1952) and Coldwell (1967). Although the theses do not include analyses for silver, Fairbairn *et al.* (1953) analyzed Nipissing diabases from several localities for several elements, including silver. Their range of 0.9 to 7.6 ppm Ag is markedly higher than the maximum of 0.24 ppm reported by Boyle (1968a) for 36 samples from the Stone-Eplett No. 3 drill hole in Henwood township. These differences emphasize the difficulties in obtaining accurate data for silver. The present study initially had the advantage that relatively large numbers of samples were to be processed in the same laboratories in a short time interval, and the problem of comparing inter-laboratory data and coping with changes in analytical procedures were therefore to be minimal. As will become evident later, this goal was only partly achieved. However, the second advantage was that most of the samples analyzed in the present study are from cross-section traverses of the diabase sheets, so that the trends of trace element variation in the differentiated intrusions are more meaningful than absolute abundances of the minor elements.

## SAMPLE PREPARATION AND ANALYSIS

All the diabase hand specimens were cut with a diamond saw to representative blocks approximately 1 × 2 × 4 cm. Larger specimens, particularly of coarse-grained or varied-texture diabase, were sawn into thin slabs

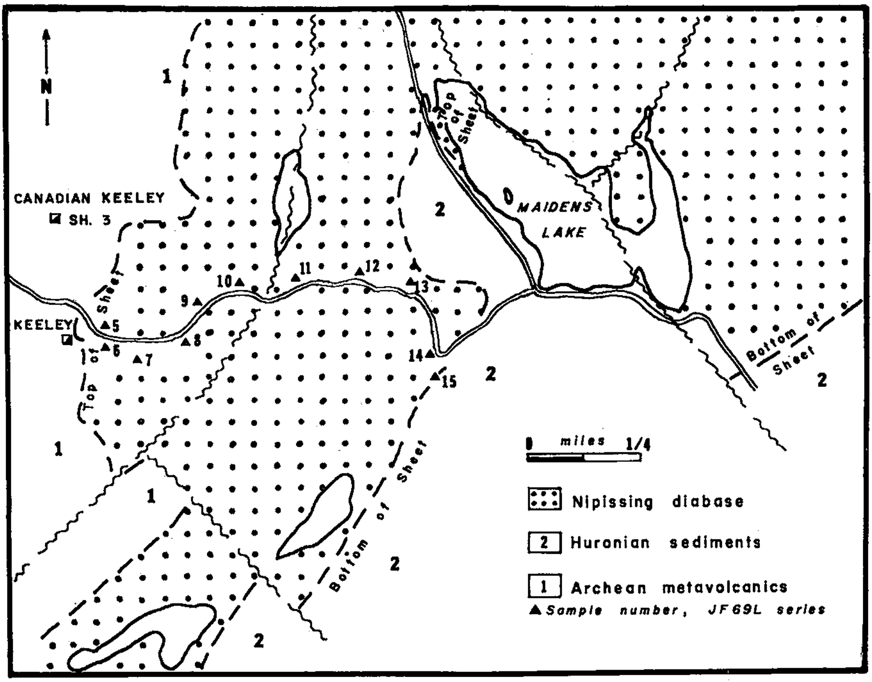

FIG. 201. Location of diabase samples in South Lorrain township.

so that representative blocks of material could be selected for the analysis. Classification of the material into diabase types was largely based on hand specimen identification, but about a third of the samples were also examined in thin sections. Because the various diabase varieties are gradational into each other, there was in some cases difficulty in precisely labeling individual hand specimens. The problem is, however, not a serious one if the gradational character of the diabase varieties is borne in mind.

Strontium analyses of the rocks were obtained by $x$-ray fluorescence techniques directly on the −150 mesh powders. Unless otherwise specified, all other elements were determined by optical spectrographic analysis by K.A. Church and staff of the Geological Survey. The elements Ba, Cr, Ni, Cu, and Co are considered by the Geological Survey's spectrographic laboratory to be accurate to within ± 15 per cent, and B and Ag to within ± 30 per cent. The results of the present study and the spectroscopic data compiled for rock standards by Flanagan (1969), indicate that these figures may be more realistically regarded in most cases only as an indication of the analytical precision.

TABLE 81. TRACE ELEMENT CONTENT (PPM) OF THE SOUTH LORRAIN DIABASE SHEET.

| JF69L- | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 1 | upper absolute chill | 94 | 31 | 97 | 100 | 300 | 190 | 6 | 0.29 |
| 2 | fine-grained quartz | 85 | 32 | 120 | 70 | 170 | 150 | 11 | 0.12 |
| 3 | diabase, progressively | 66 | 31 | 94 | 100 | 150 | 170 | 16 | 0.18 |
| 4 | coarser | 68 | 33 | 93 | 100 | 130 | 170 | 10 | 0.17 |
| 5 | varied-texture diabase | 48 | 50 | 220 | 70 | 140 | 20 | 13 | 0.28 |
| 6–1 | | 20 | 35 | 210 | 80 | 54 | NF | 6 | 0.22 |
| 6–2 | | 25 | 21 | 48 | 90 | 280 | NF | 17 | 0.15 |
| 7 | | 20 | 25 | 8 | 70 | 110 | NF | 13 | 0.52 |
| 8 | | NF | 34 | 34 | 100 | 240 | NF | 16 | 0.38 |
| 9 | | 40 | 34 | 100 | 100 | 160 | 20 | 9 | 0.14 |
| 10 | transitional to | NF | 37 | 50 | 110 | 180 | NF | 9 | 0.13 |
| 11 | hypersthene diabase | NF | 37 | 46 | 80 | 180 | NF | <5 | 0.14 |
| 12 | | 22 | 47 | 9 | 120 | 68 | NF | 12 | 0.16 |
| 13 | hypersthene | 50 | 28 | 84 | 110 | 130 | 20 | 8 | 0.17 |
| 14 | diabase | 200 | 32 | 55 | 110 | 97 | 170 | 8 | 0.58 |
| 15 | basal chill | 100 | 27 | 77 | 90 | 110 | 170 | 15 | 0.15 |

Analyses for this and succeeding tables are by K. A. Church and staff, spectrographic laboratories, GSC.

NF: not found; the detection limit for Ni, Co, and Cr in all tables is 10 ppm.

## DIABASE ANALYSES

### *South Lorrain*

The distribution of the Nipissing diabase in South Lorrain has been outlined in recent mapping by McIlwaine (1968). For the present study the diabase was sampled along a cross-section extending from the Keeley property to the southeast end of Maidens Lake (Fig. 201). The top of the sheet is known from mine workings to dip westward at about 45°. The diabase contact with overlying Archean volcanics is exposed near the shaft shown on the Keeley property. The bottom contact overlying Huronian sediments is exposed at sample position 15 (Fig. 201). The cross-section of the diabase is therefore equivalent to the elevated rim of an undulating sheet. However, the assumption made in the earlier days of the South Lorrain camp that the diabase formed a simple dome-shaped structure no longer appears to be valid. A more complex structure is indicated by the appearance of the top of a diabase sheet overlain by Huronian sediments at the northwestern end of Maidens Lake.

The trace element abundances for 16 samples of the diabase are given in Table 81. Both the top and bottom chilled contacts are extensively altered, with the feldspars being saussuritized and the pyroxenes replaced

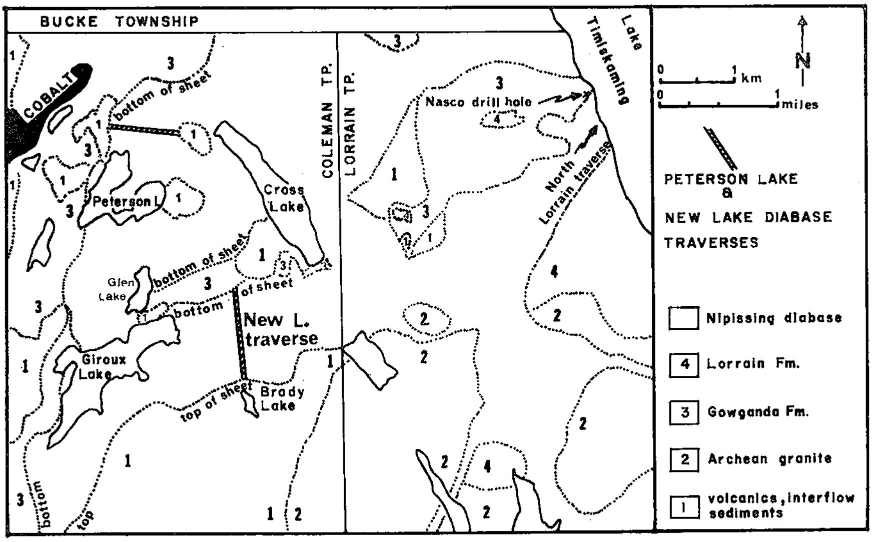

FIG. 202. General locations of the North Lorrain, New Lake, and Peterson Lake diabase samples. The position of the Nasco drill hole studied by Colwell (1967) is also shown.

by amphibole and chlorite. The two samples from position 6 are pinkish granophyric diabase from the varied-texture zone.

### *Cobalt area*

*North Lorrain basin* — The southeastern portion of the North Lorrain diabase basin was traversed along the shore of Lake Timiskaming (Fig. 202), where the sheet intrudes Huronian sediments. Insufficient information is available to permit drawing a cross-section of the diabase in this area, but the sheet as a whole is known to be roughly basin-shaped. The principal ambiguities are the unknown thickness and dip of the diabase along the southern portion of the basin. If the basin shape prevails, then the southernmost rim of the sheet is the bottom contact. Sampling of the intrusion was begun at the bottom of the sheet (Table 82). Although the

TABLE 82. TRACE ELEMENT CONTENT (PPM) OF THE NORTH LORRAIN DIABASE (SOUTHERN PART) ALONG LAKE TIMISKAMING.

| JF69T– | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 23 | Top of sheet transitional to quartz diabase | 68 | 33 | 110 | | 140 | 160 | 9 | 0.25 |
| 22 | varied-texture (22–18) | 56 | 34 | 74 | | 120 | 96 | 10 | 0.11 |
| 21 | | 60 | 30 | 130 | 70 | 140 | 170 | 17 | 0.21 |
| 20 | | 90 | 36 | 110 | 90 | 140 | 59 | 9 | 0.14 |
| 19 | | <20 | 37 | 150 | 70 | 230 | NF | 11 | 0.19 |
| 18 | | <20 | 41 | 86 | 60 | 170 | NF | | |
| 17 | quartz diabase | NF | 17 | 21 | 110 | 42 | NF | 11 | 0.40 |
| 16 | granophyre | NF | 31 | 11 | 60 | 140 | NF | <5 | 0.19 |
| 15 | varied-texture, transitional to quartz diabase with visible micropegmatite (15–4) | <20 | 42 | 120 | 70 | 150 | NF | 5 | 0.12 |
| 14 | | 23 | 36 | 140 | 100 | 160 | NF | 9 | 0.19 |
| 13 | | 29 | 31 | 75 | 90 | 180 | NF | 7 | 0.34 |
| 12 | | 29 | 34 | 180 | 100 | 160 | NF | 15 | 0.15 |
| 10 | | 26 | 31 | 79 | 110 | 200 | <20 | 8 | 0.36 |
| 9 | | 28 | 34 | 84 | | 240 | <20 | 13 | 0.16 |
| 7 | | 54 | 30 | 130 | 120 | 160 | <20 | 10 | 0.16 |
| 6 | | 39 | 26 | 76 | 120 | 300 | <20 | 13 | 0.13 |
| 4 | 7 m from contact | 84 | 28 | 87 | | 35 | 120 | 13 | 0.15 |
| 2 | 5 m from contact | 83 | | 110 | | 150 | 210 | 6 | 0.24 |
| 1 | chill (<2 m from contact) | 99 | 52 | 170 | | 110 | 240 | 13 | 0.06 |

NF: not found; blanks: not determined

absolute chill was not found, the diabase contact with Lorrain arkose was traceable to within less than 2 meters. The diabase in this vicinity contains irregular, steeply-dipping aplite stringers up to 15 cm wide. Northward toward the top of the sheet, there is a fairly rapid progression toward medium-grained diabase containing visible micropegmatite. The succession is then to well-defined varied-texture diabase and granophyre without any intervening section of hypersthene diabase. Without delving into alternative explanations, the present writer's interpretation is that the bottom contact may be relatively flat along most of the basin, but at the southeastern rim the sheet turns upward along a steep to vertical contact. The zone of hypersthene diabase accumulation would therefore intersect the contact at a greater depth and at a relatively obtuse angle rather than the acute one which should prevail if the basal contact had a continuous shallow dip.

The results of the trace element analyses of the traversed section are given in Table 82. With the exception of 1, 2, 17, and 23, all samples are varied-texture or contain visible micropegmatite. Sample 2 is a normal quartz diabase, and 23 is transitional from varied-texture to quartz diabase near the roof contact. The appearance of quartz diabase slightly past the mid-point of the traverse (no. 17) is worthy of mention because the rock is recognizably distinct in the field and was also identified by Colwell (1967) in the core of a deep drill hole on the Nasco property (Fig. 202). The unit as logged by Colwell is approximately 200 feet ( ~ 60 m) thick, with the upper transition to varied-texture diabase occurring approximately 180 feet (55 m) vertically below the top contact. Extrapolation from the drill hole to the approximate position of the quartz diabase in the traverse area gives the unit an apparent dip of roughly 15 degrees north. Although it has not been studied in detail, the material appears to be a conformable unit within the sheet. Almost all the rocks, including the central quartz diabase, have undergone intense deuteric alteration.

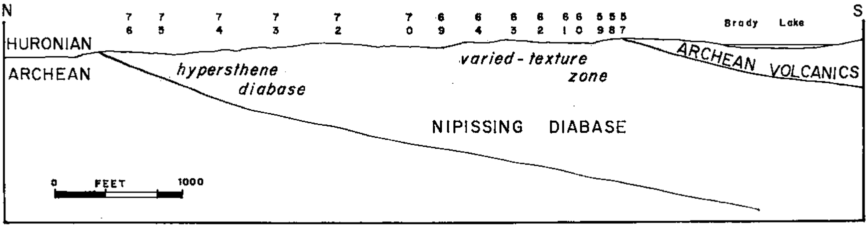

FIG. 203. Cross-section and sample positions of the New Lake diabase traverse shown in Figure 202. Horizontal and vertical scales are identical .

*New Lake basin* — The north end of the New Lake diabase basin was sampled along a cross-section extending from Brady Lake to the Kerr Lake arch (Fig. 202). The configuration of the diabase sheet and the approximate position of the analyzed samples are shown in Figure 203. Results for the trace element analyses are given in Table 83. Numerous silver properties occur within the basin, the production being surpassed only by deposits associated with the Peterson Lake basin to the northeast.

*Peterson Lake basin* — The Peterson Lake diabase was traversed northeastward from the upper contact at the Colonial mine to the lower contact near the north end of Peterson Lake (Fig. 202). The upper and lower absolute chills were not obtained, but both contacts are traceable to within a meter or two.

Hriskevich (1952) has studied the petrological variation of the diabase in the vicinity of the Colonial mine shaft, and Colwell (1967) has spectrographically analyzed samples representing a section through the diabase at the Rix Athabasca property, the latter being about 1000 feet (305 m) east of the Colonial shaft. A cross-section through these points

TABLE 83. TRACE ELEMENT CONTENT (PPM) OF THE NIPISSING DIABASE SHEET, NEW LAKE BASIN, COBALT.

| JF69C– | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 57 | roof quartz diabase | 90 | 46 | 160 | 100 | 140 | 160 | 12 | 0.36 |
| 58 | varied-texture diabase | 64 | 32 | 100 | 100 | 210 | 98 | 15 | 0.49 |
| 59 | | 78 | 44 | 160 | 110 | 160 | 150 | 11 | 0.93 |
| 60 | | 35 | 21 | 80 | 110 | 180 | <20 | 10 | 1.2 |
| 61 | | 36 | 27 | 79 | 110 | 180 | <20 | 12 | 0.44 |
| 62 | | 73 | 45 | 150 | 100 | 130 | <20 | 7 | 3.1 |
| 63 | | 23 | 35 | 99 | 140 | 190 | NF | 13 | 0.80 |
| 64 | | 26 | 29 | 61 | 150 | 200 | NF | 7 | 0.83 |
| 65 | | NF | 38 | 130 | 130 | 98 | NF | 9 | 0.43 |
| 69 | | 28 | 37 | 120 | 120 | 190 | NF | 12 | 0.40 |
| 70 | | 94 | 51 | 94 | 60 | 64 | 40 | 9 | 0.81 |
| 71 | hypersthene diabase | 60 | 29 | 110 | 110 | 130 | 23 | 14 | 0.61 |
| 72 | | 64 | 34 | 140 | 230 | 130 | <20 | 11 | 0.21 |
| 73 | | 82 | 38 | 160 | 110 | 74 | 39 | 14 | 0.24 |
| 74 | | 92 | NF | 150 | 110 | 100 | 150 | 6 | 0.39 |
| 75 | | 75 | 25 | 100 | 100 | 98 | 99 | 5 | 0.51 |
| 76 | (60 m from contact) | 76 | 34 | 87 | 110 | 120 | 210 | 13 | 0.42 |

NF: not found

and the portion of the sheet traversed in the present study is shown in Figure 204.

The results of the trace element analyses of the traversed section are given in Table 84. The hypersthene diabase zone is exceptionally fresh, but the normal extensive deuteric alteration is present in the varied-texture and quartz diabases.

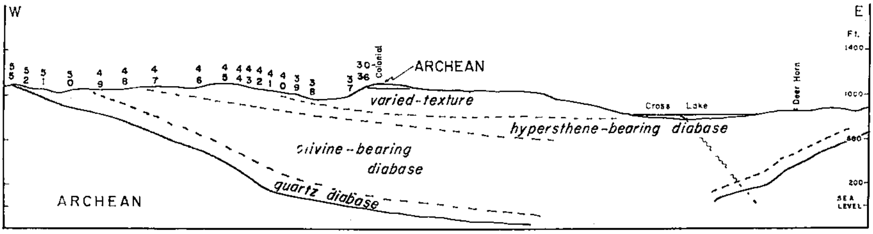

FIG. 204. Cross-section and sample positions of the Peterson Lake diabase traverse shown in Figure 202. Horizontal and vertical scales are identical. The configuration of the diabase varieties at depth is taken from Hriskevich (1952) and Colwell (1967). An abnormality is present in that hypersthene-bearing diabase is present to the bottom of the Deer Horn shaft (far right). The three-dimensional configuration of the bottom contact of the diabase is sufficiently basin-shaped that the eastward disappearance of the olivine-bearing zone is unexpected if a single continuous sheet is present (see also Lovell & Caine, 1970).

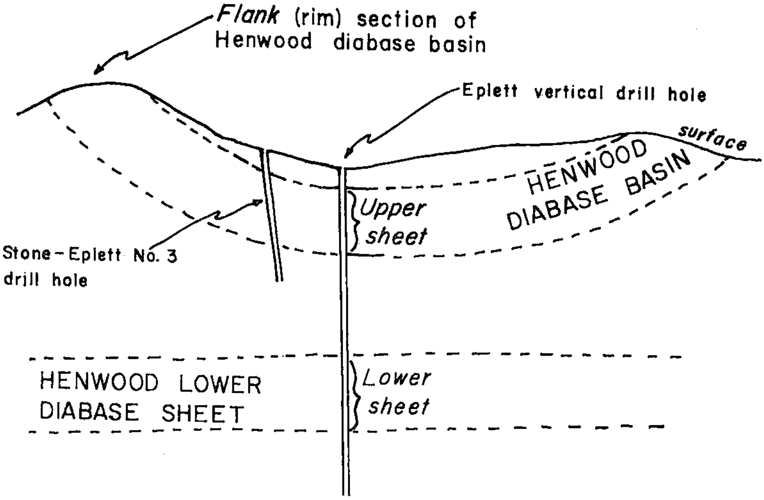

FIG. 205. Schematic diagram of the Henwood township diabase showing the relationship of the Eplett and Stone-Eplett No. 3 drill holes. Huronian sediments occur above, between, and below the intrusions.

### *Henwood township*

The nature of the diabase in Henwood township has already been dealt with a length (p. 50). As was previously mentioned, two separate intrusions are considered to be present, an upper basin-shaped sheet, and a lower sheet which is believed to be relatively flat-lying. They are respectively referred to as the Henwood diabase basin and the Henwood Lower sheet. The rim (Flank) of the diabase basin is exposed on surface, and the basin part was intersected in the Eplett vertical drill hole. An earlier inclined hole collared nearby also passed through the diabase basin. This inclined hole is called the Stone-Eplett No. 3. The relationships of the drill holes and the diabase sheets are schematically shown in Figure 205; detailed descriptions are given by Thomson (1966, 1968).

Core from the Stone-Eplett No. 3 hole was not seen by the present writer, but extensive geochemical data obtained from the diabase were kindly made available through the courtesy of R. W. Boyle. These data (Table 85) are useful for examining the trace element variations within

TABLE 84. TRACE ELEMENT CONTENT (PPM) OF THE PETERSON LAKE DIABASE, COBALT.

| JF69C– | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag | As* |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | roof quartz diabase | 91 | 45 | 160 | | 30 | 99 | 6 | 0.28 | 70 |
| 31 | | 75 | 37 | 100 | 110 | 230 | <20 | 49 | 0.25 | <4 |
| 32 | | 100 | 38 | 59 | | 230 | NF | 48 | 0.14 | <4 |
| 33 | varied-texture diabase | 75 | 36 | 92 | 130 | 190 | NF | 12 | 0.16 | <4 |
| 36 | | 66 | 36 | 59 | | 130 | 170 | 9 | 0.58 | |
| 37 | | 81 | 30 | 74 | | 190 | 130 | 5 | 0.19 | <4 |
| 38 | | 110 | 35 | 110 | 120 | 100 | 300 | 7 | 0.14 | <4 |
| 39 | | 85 | 42 | 180 | 100 | 120 | 24 | 9 | 0.12 | <4 |
| 41 | | 39 | 31 | 87 | 90 | 150 | <20 | 6 | 0.14 | <4 |
| 42 | hypersthene diabase | 93 | 31 | 88 | 140 | 69 | 320 | NF | 0.08 | <4 |
| 43 | | 210 | 31 | 200 | 100 | 57 | 500 | <5 | 0.11 | |
| 44 | | 71 | 32 | 140 | | 74 | 25 | NF | 0.12 | <4 |
| 45 | | 76 | 29 | 120 | 80 | 80 | 41 | NF | 0.12 | <4 |
| 46 | | 130 | 35 | 120 | 80 | 70 | 310 | NF | 0.10 | <4 |
| 47 | | 120 | 29 | 98 | 90 | 73 | 330 | NF | 0.14 | <4 |
| 48 | (olivine-bearing) | 130 | 42 | 57 | 110 | 86 | 400 | NF | 0.13 | <4 |
| 49 | | 130 | 36 | 67 | 80 | 240 | 360 | 10 | 0.24 | <4 |
| 50 | | 110 | 28 | 68 | 100 | 100 | 360 | 5 | 0.17 | <4 |
| 51 | | 110 | 32 | 80 | 100 | 140 | 310 | 5 | 0.14 | <4 |
| 53 | basal quartz diabase | 110 | 34 | 84 | 140 | 210 | 280 | 11 | 0.15 | |
| 54 | | 130 | 42 | 47 | 120 | 140 | 200 | 9 | 0.21 | <4 |
| 55 | | 130 | 42 | 110 | | 250 | 230 | 12 | 0.12 | <4 |

* Colourimetric analysis by Geochemistry Section, GSC. NF: not found; blanks: not determined.

Table 85. Trace Element Analyses of Nipissing Diabase in the Stone-Eplett No. 3 Drill Hole, Henwood Diabase Basin[1]

| Depth[2] | Rock type | Ni | Co | Cu | Ag | As | Sb | S* |
|---|---|---|---|---|---|---|---|---|
| 4 | Quartz diabase, | 120 | 25 | 560 | 0.24 | | 1.5 | 0.10 |
| 18 | progressively coarser | 110 | 35 | 88 | 0.20 | | 1.0 | 0.12 |
| 31 | | 110 | 30 | 100 | 0.20 | | 1.5 | 0.05 |
| 57 | | 95 | 30 | 46 | 0.08 | | 1.0 | 0.08 |
| 75 | | 110 | 35 | 60 | 0.17 | | 1.0 | 0.04 |
| 101 | | 60 | 35 | 220 | 0.21 | | 1.0 | 0.16 |
| 112 | varied-texture | 160 | 35 | 44 | 0.19 | | 1.0 | 0.15 |
| 127 | diabase | 150 | 30 | 100 | 0.24 | | 1.0 | 0.04 |
| 136 | | 25 | 30 | 96 | 0.07 | | | 0.06 |
| 156 | | 95 | 45 | 40 | 0.06 | 2 | | 0.08 |
| 160 | | 100 | 40 | 60 | 0.07 | 4 | | 0.14 |
| 170 | hypersthene diabase, | 80 | 30 | 88 | <0.05 | | | 0.08 |
| 170 | | 55 | 30 | 130 | 0.08 | | | 0.05 |
| 180 | | 55 | 35 | 110 | 0.16 | | | 0.04 |
| 193 | | 160 | 40 | 130 | 0.06 | | | 0.05 |
| 195 | | 170 | 40 | 92 | 0.15 | | | 0.07 |
| 228 | | 150 | 30 | 88 | 0.15 | | | 0.02 |
| 251 | | 120 | 20 | 84 | 0.13 | | | 0.05 |
| 273 | | 150 | 30 | 80 | 0.14 | | | 0.03 |
| 315 | | 150 | 30 | 80 | 0.12 | | | 0.03 |
| 352 | | 150 | 35 | 68 | <0.05 | | | 0.02 |
| 369 | | 110 | 30 | 64 | 0.09 | | | 0.03 |
| 374 | | 160 | 40 | 72 | <0.05 | | | 0.03 |
| 379 | | 110 | 40 | 44 | 0.09 | | | 0.03 |
| 421 | | 160 | 35 | 68 | <0.05 | | | 0.04 |
| 463 | | 170 | 35 | 72 | <0.05 | | 3.2 | 0.06 |
| 511 | | 160 | 35 | 64 | <0.05 | | | 0.04 |
| 556 | | 130 | 40 | 60 | <0.05 | | | 0.03 |
| 584 | | 160 | 40 | 60 | <0.05 | | | 0.05 |
| 593 | | 160 | 40 | 64 | 0.06 | | | 0.04 |
| 625 | quartz diabase, | 150 | 30 | 64 | <0.05 | | | 0.04 |
| 682 | progessively finer | 160 | 35 | 72 | <0.05 | | | 0.05 |
| 699 | | 150 | 35 | 68 | 0.07 | | | 0.06 |
| 716 | | 150 | 40 | 110 | 0.24 | | | 0.05 |
| 727 | | 160 | 40 | 76 | <0.05 | | | 0.08 |
| 728 | | 170 | 40 | 88 | 0.19 | | | 0.04 |
| 749 | bottom contact | | | | | | | |

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[1] Samples obtained through the courtesy of Robert Thomson, Ontario Dept. Mines. Data courtesy R. W. Boyle.

[2] Vertical depth in feet from the top contact.

* All data in ppm except for sulphur, which is in per cent. Arsenic values are < 2 ppm, and antimony < 1 ppm except where specific values are given. Silver determined by emission spectrography and sulphur by a combustion method; all other elements determined by colourimetric methods by Geochemistry Section, GSC.

this particular core, but only the trends of variation are regarded as being comparable with newer analyses obtained in the present study. Except for the sulphur determinations, analytical procedures have been revised since the obtaining of the Stone-Eplett data.

Trace element results for the diabases traversed on surface and intersected in the Eplett vertical drill hole are given in Tables 86, 87 and 88.

TABLE 86. TRACE ELEMENT CONTENT (PPM) OF THE HENWOOD LOWER SHEET.

| Footage | Rock type | Mafic Index | Ni | Co | Cu | Sr | Ba | Cr | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 6186 | quartz diabase, | 59.5 | 120 | 66 | 310 | 170 | 110 | 93 | 0.07 |
| 6202 | progressively coarser | | 57 | 36 | 110 | 160 | 140 | 33 | 0.14 |
| 6208 | | | 63 | | 150 | 140 | 140 | 27 | 0.88 |
| 6215 | | | 79 | 51 | 150 | 180 | 100 | 67 | 0.09 |
| 6222 | | 65.0 | 59 | 39 | 110 | | 130 | 20 | 0.09 |
| 6240 | | | 61 | 38 | 120 | 140 | 100 | 23 | 0.14 |
| 6259 | | 66.1 | 70 | 54 | 230 | 140 | 120 | 20 | 0.15 |
| 6273 | varied-texture | | 85 | 41 | 260 | 130 | 120 | 38 | 0.19 |
| 6287 | diabase | | 55 | 37 | 150 | 120 | 140 | 20 | 0.18 |
| 6293 | | 66.8 | 51 | 37 | 140 | 130 | 160 | 20 | 0.09 |
| 6305 | | | 34 | 44 | 130 | 130 | 140 | NF | 0.29 |
| 6320 | | 61.3 | 80 | 44 | 140 | 130 | 170 | 97 | 0.12 |
| 6325 | | 75.3 | 27 | 35 | 150 | 100 | 120 | NF | 0.14 |
| 6359 | | | 100 | | 230 | 110 | 79 | 120 | 0.35 |
| 6384 | | 57.7 | 84 | 35 | 140 | 150 | 190 | 98 | 0.14 |
| 6429 | | | 48 | 41 | 440 | 180 | 110 | 20 | 0.33 |
| 6438 | | 57.9 | 88 | 48 | 32 | 105 | 140 | 110 | 0.12 |
| 6469 | hypersthene diabase | | 90 | 40 | 140 | 130 | 150 | 72 | 0.12 |
| 6498 | | 56.4 | 110 | 46 | 200 | 160 | 130 | 110 | 0.16 |
| 6530 | | 54.9 | 110 | 37 | 150 | 99 | 130 | 140 | 0.15 |
| 6580 | | 51.9 | 110 | 37 | 180 | 93 | 150 | 210 | 0.09 |
| 6613 | | 51.6 | 150 | 40 | 220 | 92 | 160 | 310 | 0.08 |
| 6670 | | 50.9 | 96 | 31 | 100 | 110 | 140 | 370 | 0.07 |
| 6780 | | 53.8 | 86 | 38 | 100 | 84 | 140 | 190 | 0.06 |
| 6816 | quartz diabase, | | 96 | 39 | 160 | 100 | 150 | 170 | <0.05 |
| 6856 | progressively finer | 54.4 | 120 | 45 | 130 | 100 | 130 | 190 | 0.16 |
| 6899 | | 51.0 | 180 | 49 | 140 | 97 | 150 | 120 | 0.06 |
| 6900 | albitized chill | 57.2 | 180 | 62 | 150 | | 180 | 180 | <0.05 |

Mafic index : $\frac{FeO + Fe_2O_3}{FeO + Fe_2O_3 + MgO} \times 100$ (see p. 67 for reference to rock analyses).

NF : not found ; blanks : not determined

TABLE 87. TRACE ELEMENT CONTENT (PPM) OF THE HENWOOD DIABASE BASIN. ANALYSES ARE FOR THE DEPRESSED (BASIN) PART INTERSECTED IN THE VERTICAL EPLETT DRILL HOLE.

| Footage | Rock type | Mafic Index | Ni | Co | Cu | Sr | Ba | Cr | Ag | As |
|---|---|---|---|---|---|---|---|---|---|---|
| 1672 | quartz diabase, | 87.9 | NF | 47 | 200 | 50 | 63 | <20 | 0.30 | <3 |
| 1673 | progressively coarser |  | 20 | 110 | 58 | 40 | 72 | NF | 0.55 | <3 |
| 1675 |  |  | 110 | 210 | 28 | <30 | 13 | 160 | 0.13 | 350 |
| 1680 |  | 58.6 | 79 | 47 | 180 | 70 | 120 | 150 | 0.18 | <3 |
| 1684 |  | 59.1 | 72 | 39 | 140 | 80 | 120 | 100 | 0.24 | <3 |
| 1685 | varied-texture |  | 86 | 45 | 65 | 80 | 110 | 160 | 0.08 | <3 |
| 1701 | diabase | 57.6 | 83 | 38 | 140 | 80 | 100 | 57 | 0.13 | <3 |
| 1718 |  | 54.1 | 78 | 32 | 150 | 80 | 130 | 210 | 0.15 | <3 |
| 1800 |  | 52.7 | 84 | 30 | 93 | 100 | 110 | 340 | 0.10 | <3 |
| 1821 |  | 51.5 | 100 | 40 | 140 | 70 | 100 | 420 | 0.16 | <3 |
| 1826 |  | 58.9 | 66 | 31 | 140 | 70 | 100 | <20 | 0.23 | <3 |
| 1831 |  | 67.3 | 63 | 49 | 110 | 85 | 140 | 33 | 0.23 |  |
| 1836 |  |  | 64 | 55 | 200 | 90 | 140 | NF | 0.19 | <3 |
| 1847 |  |  | 82 | 37 | 110 | 100 | 100 | 110 | 0.15 | <3 |
| 1850 | hypersthene | 52.4 | 87 | 30 | 99 | 100 | 110 | 330 | 0.11 | <3 |
| 1882 | diabase | 50.3 | 110 | 41 | 130 | 75 | 70 | 370 | 0.28 | <3 |
| 1907 |  |  | 47 | 47 | 210 | 90 | 26 | 83 | 0.13 | <3 |
| 1937 |  |  | 87 | 28 | 97 | 100 | 110 | 330 | 0.07 | <3 |
| 1945 |  | 50.0 | 98 | 33 | 110 | 90 | 71 | 270 | 0.10 | <3 |
| 1980 |  |  | 99 | 25 | 75 | 80 | 130 | 470 | 0.09 | <3 |
| 2002 |  |  | 120 | 30 | 110 | 110 | 62 | 330 | 0.06 | <3 |
| 2024 |  | 45.7 | 110 | 29 | 110 | 90 | 55 | 340 | 0.14 | <3 |
| 2066 |  | 43.2 | 120 | 32 | 150 | 100 | 57 | 560 | 0.15 | <3 |
| 2115 |  |  | 110 | 30 | 65 | 80 | 60 | 540 | 0.09 | <3 |
| 2125 |  | 45.5 | 110 | 31 | 85 | 90 | 70 | 450 | 0.12 | <3 |
| 2201 |  | 44.9 | 120 | 32 | 91 | 100 | 62 | 550 | 0.12 | <3 |
| 2301 |  | 44.4 | 130 | 39 | 79 | 90 | 59 | 550 | 0.11 | <3 |
| 2351 |  | 44.3 | 130 | 39 | 65 | 100 | 68 | 650 | 0.18 | <3 |
| 2372 |  |  | 98 | 29 | 75 | 90 | 97 | 580 | 0.07 | <3 |
| 2398 | quartz diabase, |  | 110 | 33 | 75 | 100 | 47 | 520 | 0.07 | <3 |
| 2419 | progressively finer | 49.7 | 130 | 34 | 77 | 90 | 86 | 500 | 0.08 | <3 |
| 2447 |  | 49.7 | 120 | 36 | 110 | 120 | 76 | 390 | 0.14 | <3 |
| 2475 |  | 53.6 | 110 | 40 | 110 | 90 | 88 | 190 | 0.10 | <3 |
| 2482 |  |  | 88 | 28 | 85 | 190 | 34 | 180 | <0.05 | <3 |
| 2491 |  |  | 110 | 40 | 110 | 100 | 88 | 190 |  | 5 |
| 2493 | albitized chill | 63.5 | 100 | 30 | 470 | <30 | 220 | 78 | 0.14 | 8 |

Arsenic determined by colourimetric methods by Geochemistry Section, GSC.
NF : not found ; blanks : not determined

In the Flank section the hypersthene zone is not readily identifiable in hand specimens. Most material is either quartz diabase or varied-texture diabase, but on the basis of thin section studies the two samples near the bottom of the sheet are transitional toward hypersthene diabase.

TABLE 88. TRACE ELEMENT CONTENT (PPM) OF THE HENWOOD DIABASE BASIN. ANALYSES ARE FOR THE ELEVATED RIM (FLANK) OF THE SHEET EXPOSED ON SURFACE.

| JF– | Rock type | Mafic Index | Ni | Co | Cu | Sr | Ba | Cr | B | Ag | S% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HF–13 | fine-grained quartz | 58.4 | 77 | 34 | 100 | 100 | 130 | 250 | 7 | 0.10 | 0.12 |
| HF–12 | diabase, top of sheet | 59.2 | 77 | 35 | 120 | 105 | 86 | 190 | <5 | 0.12 | 0.05 |
| HF–11 | varied texture | 61.8 | 83 | 41 | 130 | 110 | 91 | 180 | <5 | 0.08 | 0.07 |
| HF–10 | diabase with | 65.4 | 52 | 40 | 99 | 100 | 170 | <20 | 9 | 0.10 | 0.09 |
| HF–9 | abundant amphibole | 78.1 | <20 | 41 | 130 | 100 | 180 | NF | 7 | 0.33 | 0.13 |
| HF–7 | (11–4) | 67.4 | 33 | 49 | 130 | 105 | 160 | NF | 7 | 0.09 | 0.06 |
| HF–6 | | 67.4 | 56 | 55 | 180 | 110 | 130 | NF | 8 | 0.10 | 0.07 |
| HF–4 | | 67.2 | 37 | 37 | 130 | 105 | 190 | NF | 10 | 0.07 | 0.06 |
| HF–3 | hypersthene- | 59.6 | 64 | 28 | 110 | 120 | 100 | 100 | 13 | 0.09 | 0.06 |
| HF–1 | bearing diabase | 53.2 | 150 | 37 | 120 | 110 | 140 | 270 | 14 | 0.11 | 0.04 |

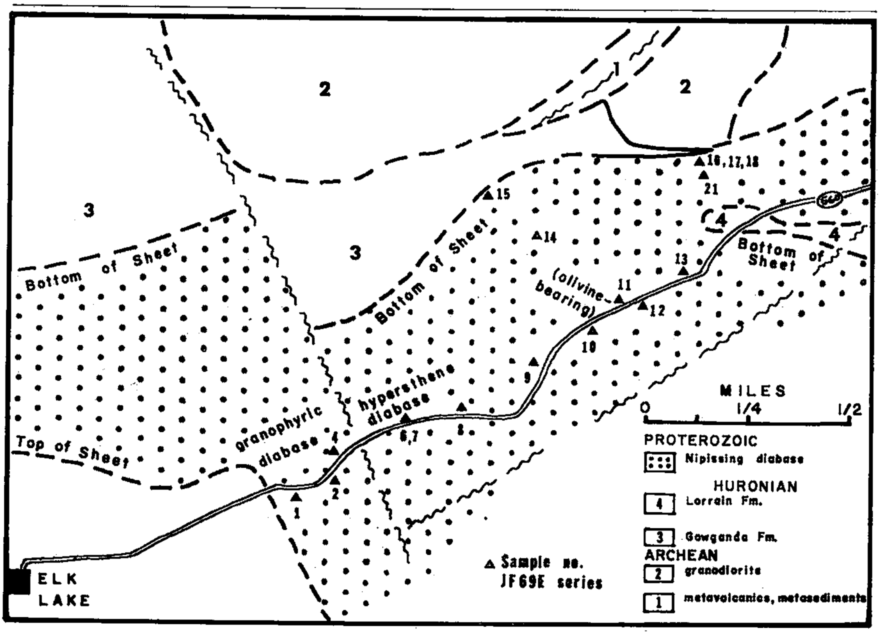

FIG. 206. Location of the Elk Lake diabase samples (geology by MacKean 1964).

### *Elk Lake*

The area of Nipissing diabase sampled at Elk Lake is shown in Figure 206. Along the east-west section there is a relatively abrupt change from granophyric and varied-texture diabase to hypersthene diabase which is in part olivine-bearing. On Ontario Department of Mines preliminary map P. 239, MacKean (1964) has shown a northwest fault which offsets the diabase for about 800 metres. The movement has apparently brought hypersthene diabase from the lower part of a sheet into juxtaposition with granophyric diabase from near the upper part of a sheet.

The results of the trace element analyses of the diabase are given in Table 89. The very fine-grained nature of sample 13 indicates that it is

TABLE 89. TRACE ELEMENT CONTENT (PPM) OF THE DIABASE AT ELK LAKE.

| JF69E– | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 1 | granophyric diabase (1–4) | NF | 18 | 13 | 70 | 50 | NF | 6 | 0.22 |
| 2 | | NF | 16 | 57 | 40 | 160 | NF | 8 | 0.12 |
| 3 | | NF | 22 | 64 | 80 | 250 | 210 | 15 | 0.12 |
| 4 | | NF | 33 | 130 | 80 | 160 | 170 | 29 | 1.5 |
| 5 | hypersthene diabase (5–12) | 50 | 34 | 86 | 120 | 190 | 130 | 19 | 0.10 |
| 6 | | 140 | 31 | 170 | 120 | 110 | 200 | 23 | 0.13 |
| 7 | | 92 | 27 | 170 | 130 | 130 | 42 | 16 | 0.12 |
| 8 | | 62 | 28 | 100 | 120 | 150 | 130 | 19 | 0.13 |
| 9 | | 79 | 30 | 90 | 130 | 78 | 230 | 7 | 0.06 |
| 10 | | 200 | 40 | 62 | 110 | 60 | 190 | 7 | 0.14 |
| 11 | | 84 | 27 | 55 | 110 | 140 | 320 | 18 | 0.09 |
| 12 | . . | 250 | 42 | 60 | 100 | 60 | 120 | 9 | 0.11 |
| 13 | fine-grained quartz diabase | 81 | 33 | 110 | 120 | 160 | 130 | 7 | 0.11 |
| 14 | hypersthene diabase | 200 | 43 | 84 | 90 | 110 | 170 | 12 | 0.14 |
| 15 | fine-grained quartz diabase | 110 | 35 | 94 | 110 | 150 | 180 | 14 | 0.16 |
| 16 | chilled quartz diabase | 43 | 35 | 190 | | 140 | 97 | 6 | 0.16 |
| 17 | chilled quartz diabase | | 37 | | | | | | |
| 18 | 1 m from contact | 44 | 37 | 87 | 130 | 190 | 97 | 12 | 0.16 |
| 19 | 20 m from contact; qtz. diabase | 45 | 40 | 280 | 130 | 340 | 74 | 19 | 1.6 |
| 20 | 50 m from contact; qtz. diabase | 43 | 37 | 94 | 130 | 290 | 96 | 25 | 0.40 |
| 21 | hypersthene diabase | 110 | 37 | 84 | 110 | 210 | 190 | 26 | 0.24 |

NF: not found; blanks: not determined

within a few metres of the bottom contact and suggests that the sheet is relatively flat-lying in this vicinity. Also of interest is the apparent iron-richness of the olivine ; an $x$-ray determination of the mineral's composition in sample 10 gave Fo 60.

### *Miller Lake basin*

The Miller Lake diabase at Gowganda was traversed in the area shown in Figure 207. The basal diabase was not found in outcrop, the first sample being of hypersthene diabase. Zoning in pyroxenes, typical in most of the Nipissing diabase, is exceptionally pronounced in the samples from this vicinity.

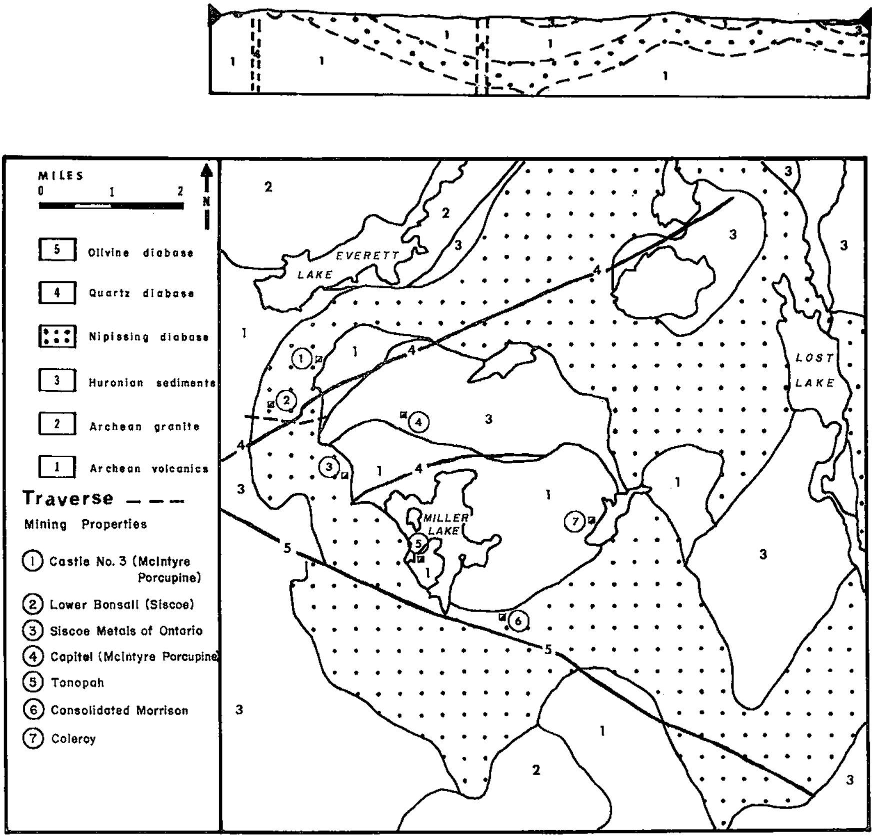

FIG. 207. Location of the Miller Lake sampling traverse. Geology and cross-section reproduced from Moore (1956).

The hypersthene diabase passes upwards into the varied-texture zone, but in many samples the variable grain size is not present and the rock could be simply classified as a quartz diabase. Outcrops from which samples 10 to 13 inclusive were taken are of varied-texture diabase, but the hypersthene-bearing variety reappears towards the top of the sheet. The results of the trace element analyses are given in Table 90.

### *Chilled Nipissing diabase*

Most Nipissing diabase chills are extensively altered. In order to supplement the data obtained from traverses across the diabase basins, several additional chill zones were also analyzed. Samples as large as a foot in diameter were taken from the contacts and slabbed with a diamond saw in order that the least fractured and altered material could be selected. The results of the analyses are given in Table 91. The average Ni, Co, and Cu contents in chilled Nipissing diabases in the Cobalt area were

TABLE 90. TRACE ELEMENT CONTENT (PPM) OF NIPISSING DIABASE, WEST SIDE OF MILLER LAKE BASIN, GOWGANDA.

| JF69G– | Rock type | Ni | Co | Cu | Sr | Ba | Cr | B | Ag |
|---|---|---|---|---|---|---|---|---|---|
| 18 | roof quartz diabase (18–17) | 64 | 42 | 130 | 100 | 290 | 110 | 23 | 1.4 |
| 17 | | 25 | 34 | 130 | 100 | 340 | <20 | 16 | 0.49 |
| 16 | hypersthene diabase (16–14) | 130 | 52 | 130 | 100 | 200 | 300 | 8 | 0.14 |
| 15 | | 100 | 33 | 84 | 30 | 140 | 440 | 5 | 0.26 |
| 14 | | 130 | 42 | 41 | 90 | 84 | 420 | 6 | 0.11 |
| 13 | quartz and varied-texture diabase (13–6) | 23 | 35 | 140 | 100 | 190 | NF | 5 | 0.40 |
| 12 | | 100 | 31 | 71 | 110 | 130 | 430 | 5 | 0.15 |
| 11 | | 130 | 53 | 190 | 90 | 170 | 150 | 8 | 0.14 |
| 10 | | 150 | NF | 140 | 140 | 120 | 430 | 5 | 0.12 |
| 9 | | 27 | 47 | 180 | 140 | 110 | <20 | 7 | 0.20 |
| 8 | | 21 | 39 | 140 | 100 | 150 | <20 | 6 | 0.19 |
| 7 | | 28 | 45 | 140 | 90 | 110 | <20 | 9 | 0.11 |
| 6 | | 27 | 39 | 140 | 70 | 190 | <20 | 8 | 0.39 |
| 5 | hypersthene diabase (5–1) | 28 | 160 | 540 | 90 | 31 | 490 | 5 | 1.3 |
| 4 | | 130 | 34 | 63 | 100 | 150 | 350 | 5 | 0.10 |
| 3 | | 150 | 43 | 77 | 90 | 190 | 250 | 14 | 0.09 |
| 2 | | 130 | 55 | 220 | 110 | 180 | 230 | 34 | 0.25 |
| 1 | | 93 | 32 | 90 | 110 | 220 | 210 | 17 | 0.15 |

determined by Hriskevich (1952) to be 139 ppm Ni, 46 ppm Co, and 76 ppm Cu. Colwell (1967) estimated the average to be 81 ppm Ni, 44 ppm Co, and 96 ppm Cu. No average values have been assigned in the present study.

### *Granophyric diabases*

Moore (1956) concluded that granophyric diabase contains more silver than ordinary diabase, and this was checked in the present study by analyzing 16 additional samples of coarse-grained and granophyric diabases (Table 92). Most of the samples are from around Elk Lake, this area being notable in that granophyres are common, but economic veins are rare.

In addition to the data given in Table 92, mention should also be made of the results reported by George (1968) for the exploration program carried out on the Argentium Silver property in Whitson township, approximately 18 miles (29 km) south of Elk Lake. In this program a series of north-south lines 400 feet (~120 m) apart were sampled at 25-foot intervals, and 281 samples of diabase were analyzed by atomic absorption spectroscopy. From the description given by George (1968), there is no question that well-developed granophyric diabase is present (though the proportion is not known). The arithmetic mean content of silver in the diabase was 0.7 ppm, the range being from 0.0 to 7 ppm. No vein was visible in the 7 ppm sample area. For cobalt the maximum was 400 ppm and the mean 34 ppm ; for nickel 160 ppm and 43 ppm respectively.

## Element Variations

### *Chromium and nickel*

Chromium shows some well-defined trends which are readily apparent from inspection of the trace element data : (1) samples from the elevated portions of sheets, such as the North Lorrain, South Lorrain, and New Lake diabases, are characterized by being relatively low in chromium ; (2) the depressed or basin parts of sheets typically have a thick zone of hypersthene diabase which is rich in chromium ; (3) in all the intrusions the over-all trend is for chromium to decrease toward the interior of a sheet where the most differentiated diabase varieties occur. Thus, the lower parts of sheets which contain abundant orthopyroxene (± olivine) generally contain 200 to 400 ppm Cr whereas lower values are present in the quartz and varied-texture diabases. This type of distribution is entirely consistent with the geochemically known relationship that chromium is

TABLE 91. TRACE ELEMENT CONTENTS (PPM) OF CHILLED NIPISSING DIABASE.

| Area | Locality | No. | Position | Ni | Co | Cu | Ba | Cr | B | Ag | As |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cobalt | East side of Nicol Lake basin; contact with Lorrain granite | 68–143 | 8 cm from top contact | 130 | 48 | 150 | 76 | 250 |  | 0.12 | <4 |
|  |  | 68–149 | 15 cm from bottom contact | 91 | 34 | 110 | 110 | 190 | 10 | 0.09 | <4 |
|  |  | 68–144 | 45 cm from top contact | 82 | 31 | 100 | 100 | 190 | 7 | 0.15 | <4 |
|  |  | 68–145 | ~ 2 m from top contact | 69 | 30 | 100 | 130 | 200 | 5 | 0.41 | <4 |
|  |  | 68–150 | middle of sheet | 56 | 32 | 100 | 170 | 62 | 9 | 0.15 | <4 |
|  |  | 68–151 | middle of sheet | 40 | 36 | 120 | 170 | 20 | 10 | 0.23 | <4 |
| Cobalt | Silver Summit property; bottom contact with Cobalt sediments | 69–46B | absolute chill | 68 | 32 | 110 | 130 | 160 | 9 | 0.17 | <4 |
|  |  | 69–46M | 12 cm above 46B | 72 | 29 | 110 | 120 | 170 | 5 | 0.11 | <4 |
|  |  | 69–46T | 25 cm above 46B | 81 | 30 | 100 | 91 | 190 | 5 | 0.18 | <4 |
| Cobalt | Nipissing RL 407, 300 m west of 407 shaft; bottom contact with Cobalt sediments | 69–385T | 20 cm above contact (partly altered and albitized) | 100 | 37 | 38 | 33 | 230 | 5 | 0.27 | <4 |
|  |  | 69–386 | ~ 15 m above contact | 160 | 70 | 97 | 130 | 220 | 14 | 0.13 | <4 |
| Cobalt | Bucke tp.; bottom contact with Cobalt sediments | 68–1 | albitized basal chill | 90 | 36 | 12 | 140 | 230 | NF | 0.11 | <4 |
|  |  | 68–2 | 20 cm above 68–1 | 99 | 35 | 39 | 29 | 260 |  | 0.11 | <4 |
|  |  | 68–6 | 30 cm above 68–1 | 84 | 34 | 88 | 140 | 190 | <5 | 0.31 | <4 |
|  |  | 68–5 | 50 cm above 68–1 | 82 | 36 | 79 | 150 | 170 | 10 | 0.30 | <4 |
|  |  | 68–7 | 2 m above 68–1 | 76 | 30 | 110 | 140 | 180 | 6 | 0.66 | <4 |
| Gowganda | Lower Bonsall mine, Miller Lake basin; bottom contact with Archean | 68–332 | albitized absolute chill | 84 | 40 | 87 | 330 | 140 | 6 | 0.48 | 15 |
|  |  | 68–322B | 6 cm above contact | 90 | 34 | 110 | 460 | 140 | 12 | 0.50 | 10 |
|  |  | 68–333 | 1 m above contact |  |  |  |  |  | 8 | 0.12 | 8 |
|  |  | 68–335 | 5 m above contact | 110 | 28 | 60 | 450 | 150 | 21 | 0.47 | <4 |
|  | Bottom contact in drill core, ~ 800 ft. (245 m) south of Lower Bonsall shaft | 69G–20 | absolute chill | 80 | 62 | 120 | 77 | 130 | 10 | 0.75 |  |
|  |  | 69G–21 | 15 cm above contact | 150 | 120 | 250 | 75 | 160 | 13 | 0.41 |  |
|  |  | 69G–22 | 35 cm above contact | 70 | 31 | 74 | 140 | 230 | 14 | 2.1 |  |
|  |  | 69G–23 | Archean "intermediate" flow, 8 cm below contact of 69G–20 | 96 | 26 | 170 | 280 | 360 | 11 | 0.13 |  |
|  |  | 69G–24 | 15 cm below contact | 110 | 28 | 97 | 290 | 360 | 11 | 0.07 |  |
|  |  | 69G–25 | 30 cm below contact | 96 | 27 | 110 | 190 | 320 | 11 | 0.13 |  |
|  | Top contact with Archean, Siscoe mine, near No. 6 shaft, 350 level | 69G–19 |  | 90 | 43 | 110 | 210 | 110 | 12 | 0.58 | 19 |

TABLE 92. TRACE ELEMENT CONTENTS (PPM) OF COARSE-GRAINED DIABASE AND GRANOPHYRE FROM THE COBALT-GOWGANDA REGION.

| Area | Locality | No. | Type | Ni | Co | Cu | Ba | Sr | Cr | B | Ag | As |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cobalt | Lot 15, conc. III Coleman township | 68–33 | granophyre | 49 | 19 | 57 | 610 | | 39 | NF | 0.22 | <4 |
| Brigstocke township | West side of Anima Nipissing Lake | 68–462 | granophyric | 15 | 45 | 54 | 140 | 90 | NF | 6 | 0.12 | <3 |
| Elk Lake | Lot 4, conc. IV James township | 68–207 | varied texture, granophyric | 30 | 48 | 70 | 110 | | NF | 10 | 0.47 | 8 |
| | Shane Lake, lot 11, conc. IV, James township | 68–289 | granophyric | 19 | 51 | 140 | 190 | 70 | <20 | <5 | 0.32 | 3 |
| | | 68–282 | leucocratic | 14 | 21 | 1000 | 110 | | NF | NF | 0.31 | <3 |
| | | 68–284 | granophyre | 18 | 44 | 17 | 17 | 30 | <20 | <5 | 0.06 | <3 |
| | | 68–285 | granophyre | 12 | 25 | 90 | 90 | 30 | NF | <5 | 0.90 | 38 |
| | Silverclaim Lake Mickle township claim MR 16319 | 68–343 | granophyric | 60 | 76 | 130 | 580 | | <20 | 6 | 0.57 | 25 |
| | | 68–344 | coarse, not granophyric | 43 | 54 | 48 | 200 | 90 | <20 | 8 | 0.14 | <3 |
| | Claim MR 12890 | 68–346 | varied texture | 37 | 54 | 100 | 220 | 70 | <20 | 10 | 0.56 | 15 |
| | Claim MR 16294 | 68–347 | granophyric | 21 | 28 | 87 | 160 | <30 | NF | 5 | 4.0 | 8 |
| | Claim MR 16294 | 68–350 | granophyric | 19 | 10 | 240 | 50 | 30 | <20 | <5 | >5 | 8 |
| | Drill core, Cotley Mines property | 68–351 | granophyric | 18 | 34 | 18 | 410 | 80 | <20 | 13 | 0.22 | 3 |
| | | 68–352 | granophyric | 18 | 11 | 55 | 98 | 30 | <20 | <5 | >5 | 88 |
| Gowganda | Morrison property | 68–322 | granophyric | 56 | 54 | 200 | 870 | | <20 | 12 | 0.70 | <3 |
| | Coleroy property | 68–315 | granophyre | 15 | 37 | 24 | 71 | | NF | <5 | 0.76 | 20 |

NF : not found ; blanks : not determined ; As : determined colourimetrically, with limits stated as < 3 and < 4 ppm as indicated.

incorporated into early-formed spinels and pyroxenes. With progressive fractionation, therefore, chromium is depleted as is shown by a strong correlation with the mafic index. Among the various phases of the Nipissing diabase, granophyres typically have the highest mafic index and are characteristically low in chromium.

The relationships described above are exemplified by the diabase in Henwood township. For those rocks which have been chemically analyzed there is a good correlation between the mafic index and chromium content. In the Lower sheet (Fig. 208) the initial rapid drop in Cr content levels off at about 100 ppm when the mafic index is between 57 and 62, and then falls to < 20 ppm Cr before an index of 65 is reached. This levelling off appears to be absent in the Henwood diabase basin ; in the depressed part of the sheet, chromium reaches a maximum of over 600 ppm in the lower part of the hypersthene diabase zone and decreases toward the more salic differentiates and the quartz diabase margins. Although there is a scatter in the points (Fig. 208), the break evident in the Lower sheet seems to be absent in the Upper sheet. That the scatter in the individual points probably reflects a movement, during crystallization, of mafic material toward the depressed part of the sheet is suggested by the over-all lower mafic index and higher chromium content of the basinal rocks as compared with those of the elevated Flank.

Average nickel abundances in quartz-normative tholeiites are generally in the 70-76 ppm range (Prinz 1967). The element is typically enriched in early olivines and pyroxenes, and markedly decreases with fractionation.

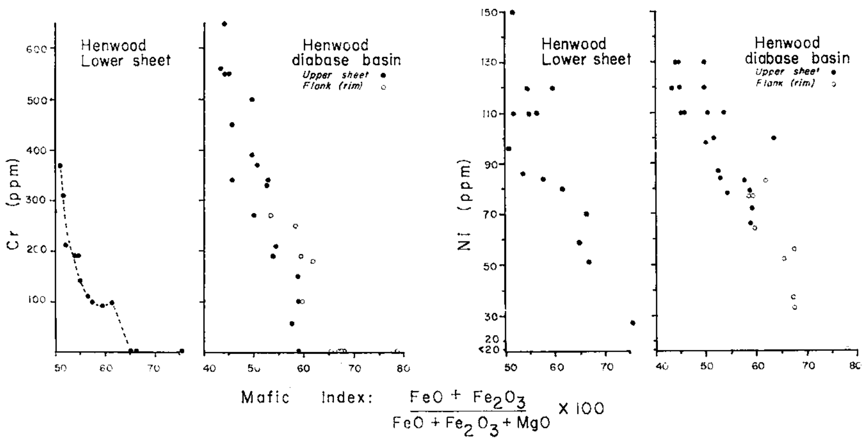

FIG. 208. Variation of Cr and Ni in the Henwood diabases.

Nickel abundances in the Henwood intrusions are related to the mafic index as shown in Figure 208. In both the diabase basin and the Lower sheet, the highest nickel contents are present in rocks having the lowest (least fractionated) mafic index. These rocks are typically the hypersthene diabases. In the Flank section of the diabase basin most of the rocks are relatively high in mafic index and correspondingly low in nickel.

In addition to the data accumulated by the present writer, two cross-sections of the diabase at Cobalt were spectrographically analyzed by Colwell (1967). These sections are from the Nasco property in the North Lorrain basin (Fig. 202) and the Rix-Athabasca property (about 305 m east of the Colonial as shown in Fig. 204). Colwell's data have been used to construct Figure 209, which shows Ni versus mafic index for the two sections. The mafic index in this case is the ratio of total iron as FeO divided by the sum of this FeO plus MgO (with the product multiplied by 100).

In the present study the mafic index is not available for most of the diabase sheets which have been analyzed for their trace element content. It was, however, previously shown in Figure 208 that a relationship between chromium abundance and mafic index is present in the diabases, and on this basis chromium and nickel should also be inter-related. This is shown

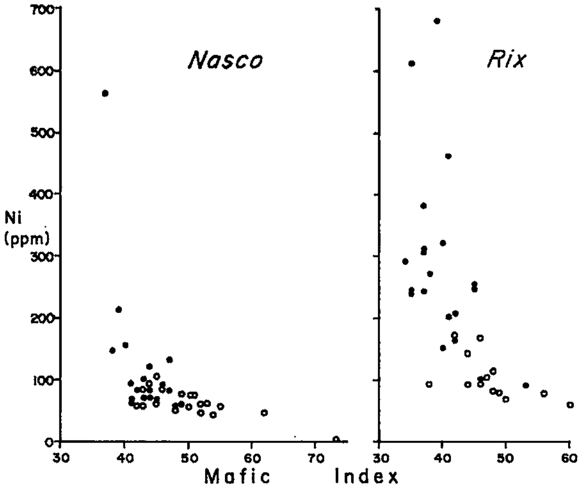

FIG. 209. Variation of nickel with mafic index in the Nasco drill core and Rix-Athabasca cross-section, Cobalt. Open circles represent samples above the hypersthene diabase zone; filled circles are samples extending from the top of this zone to the bottom contact.

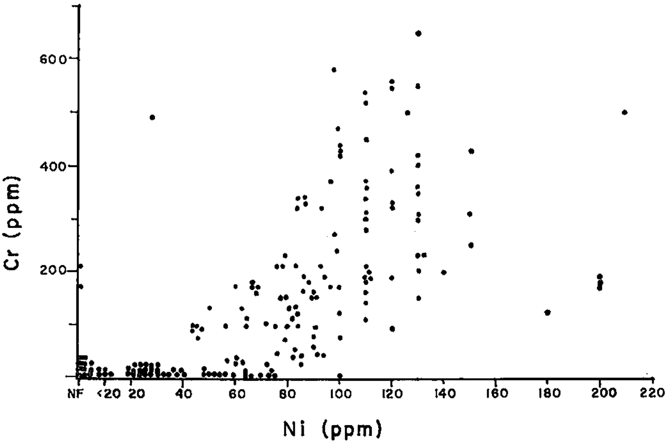

FIG. 210. Relationship of nickel and chromium in diabase in the Cobalt-Gowganda region.

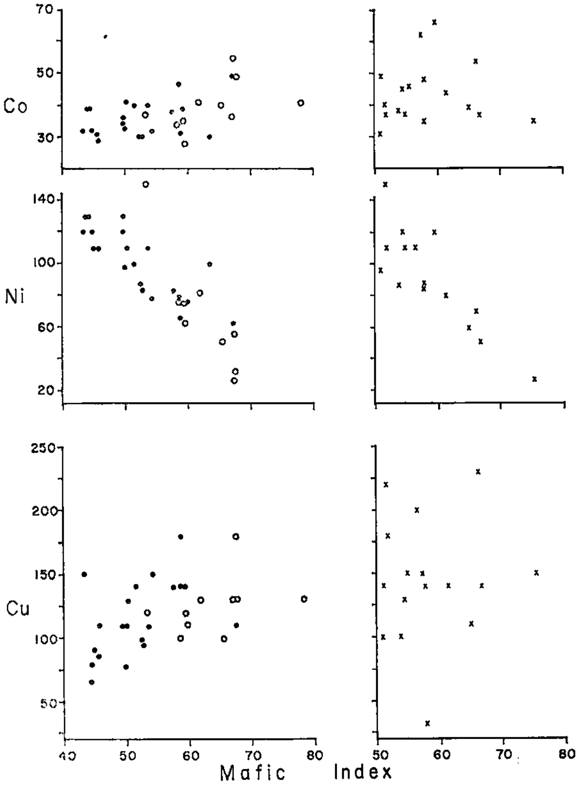

FIG. 211. Cobalt, nickel, and copper (ppm) versus mafic index of the Henwood diabase basin (left) and Lower sheet (right).

in Figure 210. The over-all impression is that nickel is closely related to the early rock-forming minerals, especially the oxides and pyroxenes.

Because alteration is almost, if not always, present in the chilled diabases of the region, no specific trace element values have been assigned to the chills. Nickel abundances in most cases, however, fall within a range of 75 to 100 ppm. The apparent normality of nickel in some thoroughly albitized chills (Table 91) is surprising.

### *Cobalt*

The average cobalt content of the Nipissing diabase is less than 40 ppm. Most of the values higher than this were obtained from varied-texture diabases and quartz diabases. The exception to the generalization is the Miller Lake diabase at Gowganda, where half the analyzed samples (Table 90) exceed 40 ppm Co.

Cobalt decreases with fractionation in most mafic intrusions (Wager & Mitchell 1951; Nockolds & Allen 1956; Tiller 1959; McDougall & Lovering 1963; Rösler & Voland 1965; Greenland & Lovering 1966). The variation in cobalt with mafic index in the Henwood intrusions is shown in Figure 211. In the Lower sheet the two highest values (66 and 62 ppm) occur at the top and bottom contacts. In the Henwood diabase basin, both

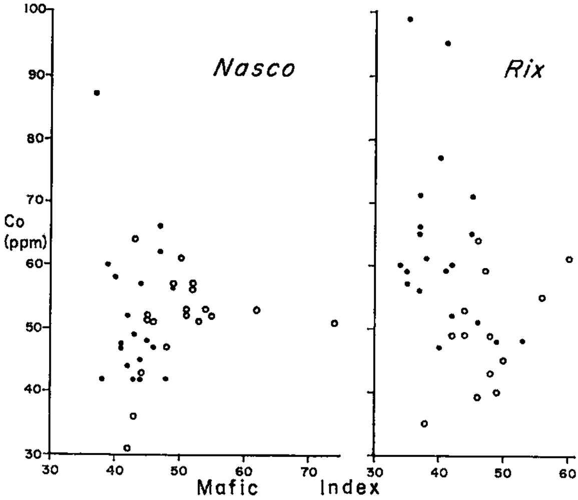

FIG. 212. Cobalt versus mafic index in single cross-sections of the Nasco and Rix-Athabasca diabases, Cobalt. Open circles represent samples above the hypersthene diabase zone; filled circles are samples from the top of this zone to the bottom contact.

the Upper sheet and Flank sections show a slight increase in cobalt with increasing mafic index. The most salic parts of the intrusion are thus enriched in cobalt, this being opposite to what is normally found.

Colwell's (1967) data for the Nasco and Rix sections have been plotted against the mafic index as was done for nickel. Considerable scatter is present in the Nasco data (Fig. 212), but the Rix section more clearly

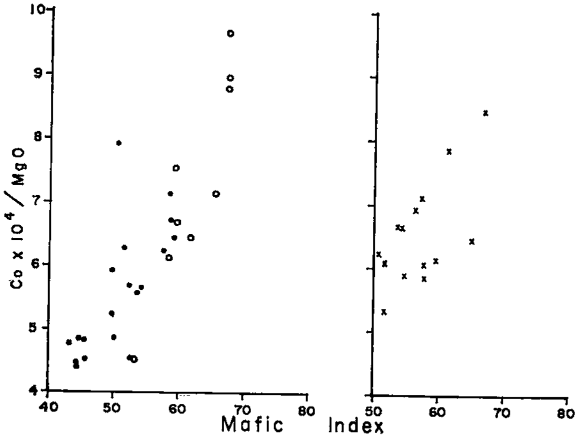

FIG. 213. Variation of Co/MgO with mafic index in the Henwood diabase basin (left) and Lower sheet (right). Filled circles are samples from the Upper sheet intersected in the Eplett vertical drill hole; open circles are Flank samples.

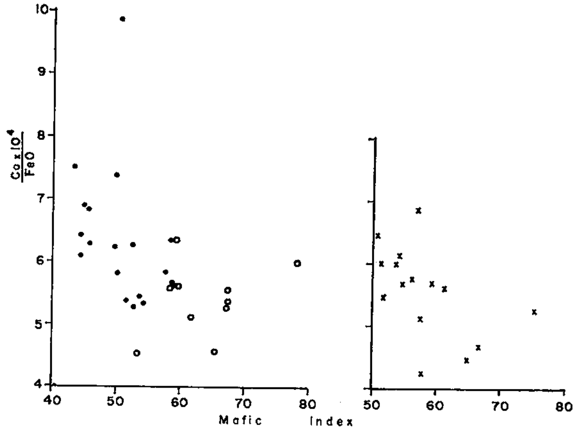

FIG. 214. Variation of Co/FeO with mafic index in the Henwood diabase basin (left) and Lower sheet (right).

shows that the main trend is for cobalt to decline with progressive fractionation. Because this is not the trend found in the Henwood diabases, data from the rocks occurring in the upper parts of the Rix and Nasco sections were distinguished from those in the lower parts; in Fig. 212 the rocks above the hypersthene diabase zone are shown as open circles. The resultant differences indicate that cobalt does not behave uniformly throughout the intrusions.

The association of cobalt with magnesium and iron in the Henwood diabases is shown in Figures 213 and 214. In both the Lower sheet and diabase basin, a more coherent trend is present with magnesium than iron. The slope of the Co/MgO trend steepens to the extent that it is almost vertical at high mafic index values characteristic of varied-texture and granophyric diabase. Throughout the Cobalt-Gowganda region individual specimens of these rock types have been found to be either relatively high or low in cobalt, presumably reflecting the presence or absence of erratically-distributed sulphides which are very commonly megascopically visible. The possibly significant aspect is that high cobalt values occur more frequently in the varied-texture zone than in hypersthene diabase.

### *Copper*

McDougall & Lovering (1963) and Greenland & Lovering (1966) have shown that copper in Tasmanian dolerites markedly increases to a peak in silicic dolerites and then decreases in the granophyric phases. Insufficient data are available to explain the nature of the copper behaviour of the Nipissing diabases, but as a general rule the element has a somewhat irregular distribution because of its common occurrence as a sulphide phase. Some Nipissing granophyres contain megascopic disseminated grains of chalcopyrite, but in others the copper content is very low.

Copper in the Henwood township Lower sheet is considerably erratic with respect to the mafic index (Fig. 211), and position within the sheet (Fig. 216). In the Henwood diabase basin, however, the over-all trend is for copper to increase as the mafic index increases. The scatter along this trend is considerable (Fig. 211). On the other hand, plots of copper versus height in the diabase basin show that some relatively orderly features are present. In the depressed part of the basin intersected by the Stone-Eplett No. 3 and Eplett drill holes, copper increases toward the top of the sheet (Figs. 215, 217). The sequence in the sheet is for copper to decrease upwards as the basal quartz diabase passes into the hypersthene diabase; not until the upper half of the sheet is reached is there any marked change, but as the varied-texture zone is approached and entered, the frequency of relatively high copper values increases and the over-all distribution becomes considerably more erratic. This pattern of behaviour also occurs at the upper contact, and is presumably an indication of copper sulphide crystallization. Although relatively few points are available for the Flank section, a slight enrichment in copper appears to be present in this part of the intrusion.

### *Silver*

Reference has already been made to the earlier work by Moore (1934, 1956), Fairbairn *et al.* (1953), and Boyle (1968) on silver determinations in the Nipissing diabase. Boyle (1968) has summarized and added to the scanty data available for silver abundances in igneous rocks. In addition, Nesterenko *et al.* (1969) have reported that traps of the Siberian platform

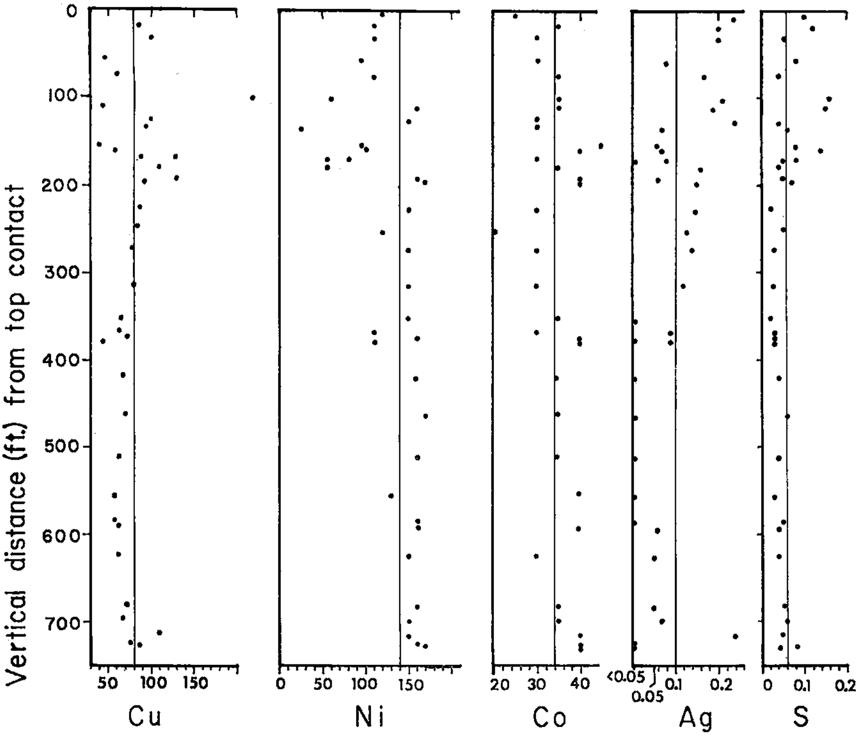

FIG. 215. Variation in Cu, Ni, Co, Ag (ppm) and S (%) in the Stone-Eplett No. 3 drill core, Henwood township. Vertical reference lines are arbitrarily positioned.

contain an average of 0.037 ppm silver, with 0.028 ppm in basalts and 0.042 ppm in gabbro-dolerites.

As has also been mentioned, absolute data for the Stone-Eplett No. 3 drill hole are not directly comparable with results obtained in this study because of interim revisions in the analytical procedures. The trace element trends should nevertheless remain valid. Silver variation in the Stone-Eplett No. 3 drill core is shown in Figure 215. The profile is similar to that of copper, with both elements being least abundant in the hypersthene diabase zone and increasing toward the top of the sheet.

In the Henwood Lower sheet (Fig. 216) the increase in silver toward the top is again evident. Maximum abundances occur in the varied-texture zone, and a single anomalously high value is present near the top contact.

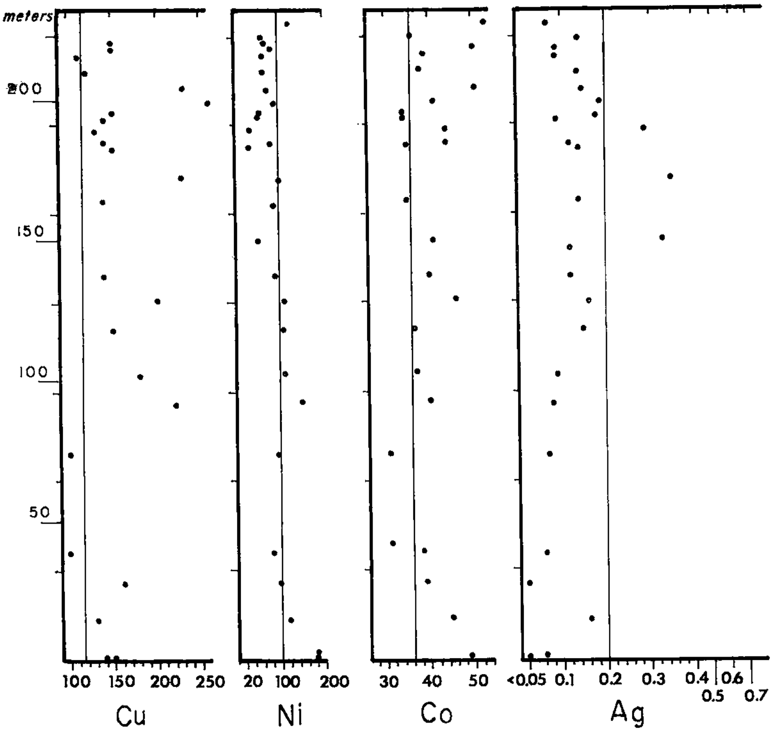

FIG. 216. Variation in Cu, Ni, Co, and Ag (ppm) with height above the bottom contact of the Henwood Lower sheet (subsidiary scale in hundreds of feet). Vertical reference lines may be used for comparison with data for the overlying diabase basin (Figure 217).

The distribution of silver in the Henwood Upper sheet is relatively orderly (Fig. 217), with maximum abundances occurring near the top of the sheet. The trends obtained from the Eplett and Stone-Eplett No. 3 drill holes are approximately congruous. Silver abundance in the Flank section is evidently greatest in the most fractionated rock, with the over-all abundance being similar to that of the Upper sheet. Within the limitations of the sampling, silver in the basin as a whole appears to have reached its peak abundances not only in the varied-texture zone, but also at the top contact of the depressed part of the sheet.

Among the silver profiles of other intrusions in the region, that of the New Lake basin at Cobalt is outstanding. The general trend is again for silver to be least abundant in the hypersthene diabase zone (Table 83),

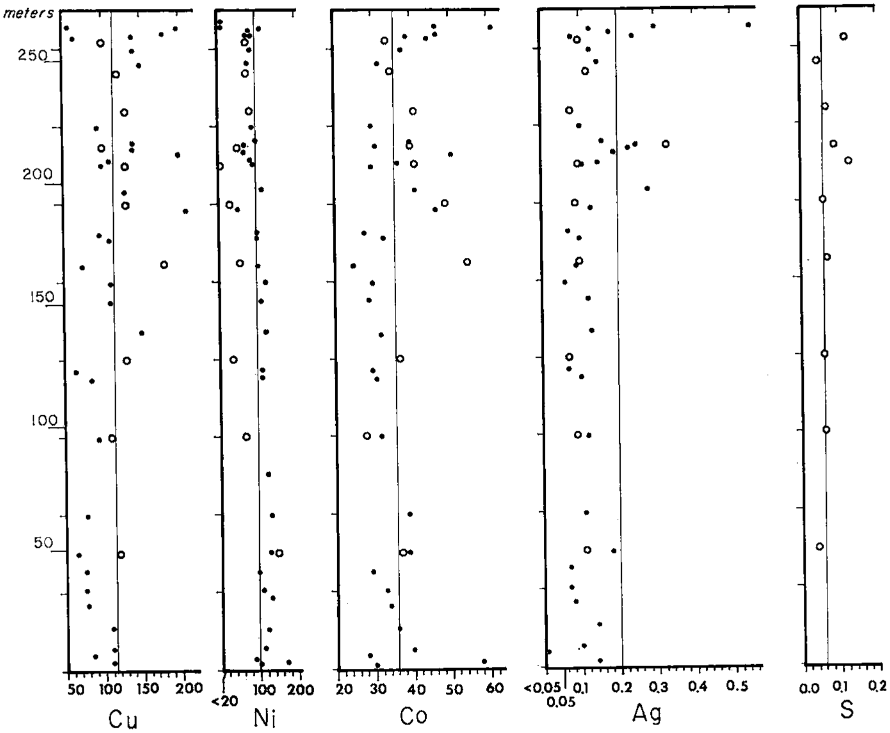

FIG. 217. Variation in Cu, Ni, Co, Ag (ppm) and S (%) with height above the bottom contact of the Henwood diabase basin (subsidiary scale in hundreds of feet). Vertical reference lines are at the same positions as those for the Lower sheet (Figure 216). Open circles represent samples from the Flank section and filled circles represent samples from the Upper sheet as interested in the Eplett drill hole.

but in all parts of the intrusion silver abundances are at a relatively high level, particularly in the varied-texture zone. In the adjacent Peterson Lake basin, however, the silver values are normal to low. The meaning of these variations is not readily evident, but it is clear that the first necessity is to obtain additional profiles along new traverse routes in order to determine whether the trends found here are consistent, characteristic features.

### *Antimony and arsenic*

The average content of antimony in igneous rocks is 0.2 ppm, and 0.1-0.2 ppm in basic rocks (Wedepohl 1969). Data for antimony in the Nipissing diabase are available only for samples of the Stone-Eplett No. 3 drill core. The results (Table 85) indicate that the average antimony content of the diabase is less than 1 ppm, and most of the element is concentrated near the top of the sheet.

The average content of arsenic in igneous rocks is 1.5 ppm As (Wedepohl 1969). Arsenic in the Skaergaard intrusion (Esson *et al.* 1965) averages less than 1 ppm As in all rock types. The arsenic contents of the Nipissing diabases are also low. Of twenty specimens from the Peterson Lake basin, Cobalt, the only one above the 4 ppm lower limit of detection is JF 69C-30 (Table 84). This specimen, which is close to the upper contact, was found to contain 70 ppm As. In the Stone-Eplett No. 3 and Eplett drill holes, only six analyses are above the detection limit; two occur in the varied-texture zone (Tables 85 and 87), and three near the diabase contacts. Detectable arsenic is common in granophyric diabase (Table 92).

### *Sulphur*

Sulphur analyses are available only for the Henwood diabase basin. The element remains fairly constant in the lower half of the Stone-Eplett No. 3 drill core (Fig. 215), and reaches its maximum abundance in the varied-texture zone near the top of the sheet. The few analyses available for the Flank indicate that sulphur has a similar distribution but is slightly enriched in comparison to the depressed part of the sheet. Sulphur thus appears to have migrated to the most fractionated and the most elevated parts of the intrusion.

### *Strontium and rubidium*

The strontium values in the diabase sheets throughout the region are relatively uniform in that nearly all determinations fall within the range of 50 to 150 ppm Sr. In a drill hole which passed through the sheet in the Miller Lake basin, Gowganda, Fairbairn *et al.* (1969) found Sr to be fairly constant at about 140 ppm. Samples collected from the same sheet in the present study give lower Sr values (Tables 90), but the data are comparable relative to the much higher median of 400 ppm Sr for quartz-normative tholeiites surveyed by Prinz (1967).

Strontium in diabase is generally considered to substitute in calcium-rich minerals, especially the calcic plagioclase feldspars. Accordingly, the Nipissing granophyres, though they contain large amounts of plagioclase, are not enriched in strontium because they contain albite as the principal feldspar. There is, on the other hand, no obvious coherence between Sr and Ca in the Henwood diabases (Fig. 218), a situation which has also been noted by Gunn (1966) in Antarctic tholeiites. In the Henwood Lower sheet strontium does increase with fractionation measured in terms of the mafic index (Fig. 219), but there are also strong indications that strontium abundances differ from sheet to sheet. This is especially evident in Figure 220, which shows that the Henwood Lower sheet contains more strontium than the overlying diabase basin regardless of the prevailing rock type. This difference is considered to be additional evidence that the diabase basin and Lower sheet are separate intrusions.

Rubidium analyses have not been tabulated, but the data for the Henwood diabases are shown in Figure 221. The element increases in abundance toward the tops of the sheets. As is the case with strontium, the values obtained in this study are lower than those reported by Fairbairn *et al.* (1969) for the Miller Lake sheet; in all cases, however, the

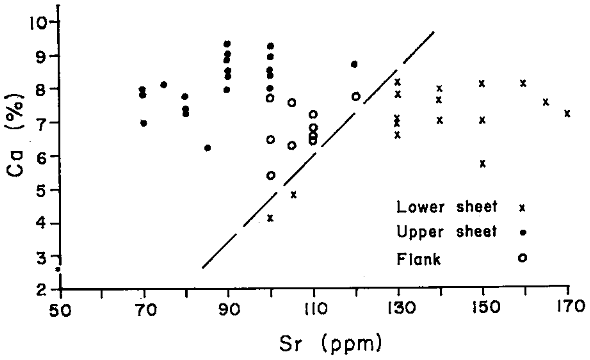

FIG. 218. Calcium versus strontium in the Henwood diabases. The dashed line separates data for the Lower sheet from data in the overlying diabase basin (Upper sheet plus Flank).

trend is for Rb to increase in abundance with height. In the Henwood sheets, the general trend of rubidium and potassium coherence is evident from Figure 221. Although rubidium enters the K-position in micas in preference to feldspars, the previously demonstrated sympathetic increase in $K_2O$ with increasing Ab contents of the plagioclases may account for a part of the potash and concomitant rubidium increases with height.

### *Barium*

Although barium values in the Nipissing diabase throughout the Cobalt-Gowganda region commonly seem to be erratic, the New Lake and Peterson Lake sheets show that in some cases there is a fairly well-defined increase in barium with fractionation. This relationship is particularly evident in the Henwood diabase basin (Fig. 219). The Upper sheet has the lowest $Ba/K_2O$ ratio and shows the closest coherence with potassium (filled circles, Fig. 222). For rocks containing less than 1 per cent $K_2O$, barium in the Lower sheet is consistently more abundant than in the Upper sheet. The Flank section contains more barium than the depressed part of the basin, with this effect being in part attributable to the fact that more plagioclase of intermediate composition occurs in the Flank. Substitution of Ba for K in such feldspars may be important as they are relatively enriched in $K_2O$.

### *Boron*

Analyses for boron in the present study may seem to be an incongruous choice in view of the limited number of elements investigated. However,

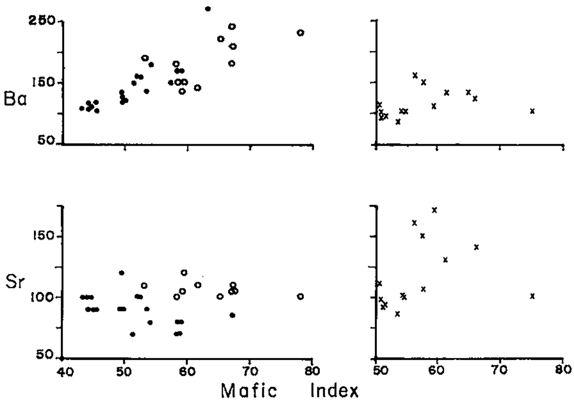

FIG. 219. Variation of strontium and barium with differentiation in the Henwood Lower sheet (right) and diabase basin (left, with solid circles representing the Upper sheet and open circles the Flank).

the boron silicate axinite has been noted in several ore-bearing veins, and the mineral also occurs in post-ore faults and in pre-ore veins in the Archean. The behaviour of boron with diabase fractionation was therefore considered to be germane.

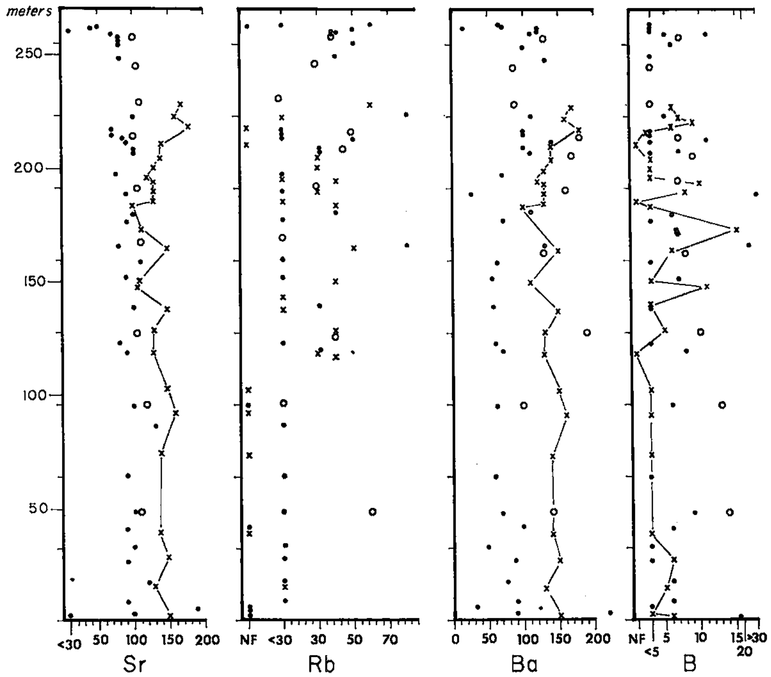

FIG. 220. Sr, Rb, Ba, and B (ppm) versus height above the bottom contacts of the Henwood diabases (subsidiary scale in hundreds of feet). (Lower sheet x ; Upper sheet ● ; Flank O).

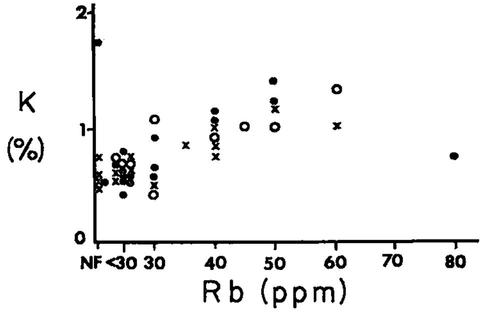

FIG. 221. Rubidium versus potassium in the Henwood diabases. Symbols are as given for Figure 220.

In the Palisades sill, Walker (1969) noted that boron was concentrated in residual melts, with values above 20 ppm occurring only in rocks of later fractionation stages. In the diabases of the Cobalt-Gowganda region a single general pattern seems to be absent. In some intrusions, such as the Peterson Lake diabase, boron does show an increase toward the top of the sheet. A slight upward increase is also present in the Henwood sheet (Fig. 220), but is not readily apparent in the Upper sheet of the overlying basin. The Flank, however, is enriched in boron. This enrichment lessens upward, and in this respect the trend is similar to that of $Al_2O_3$ in the Flank. The over-all behaviour of boron in the Henwood intrusions suggests that the element is not incorporated into the early-formed minerals. At a middle stage of fractionation, however, the element is rapidly extracted from the magma, probably as $(BO_4)$ replacing $(AlO_4)$ in the intermediate plagioclases.

## SIGNIFICANCE OF THE MINOR ELEMENT DISTRIBUTION

The principal purpose of the study of the minor elements in the Nipissing diabase was to determine whether the diabase could be reasonably eliminated as a potential source of the metals present in the ore veins.

No element has remained static during the fractionation of the diabase. Because more chemical and minor element information is available for the Henwood diabases, discussion of the variations has centered on these intrusions. The gross relationships for many elements nevertheless appear to be generally applicable to the other diabase basins in the region. The information from this reconnaissance study indicates that the most pro-

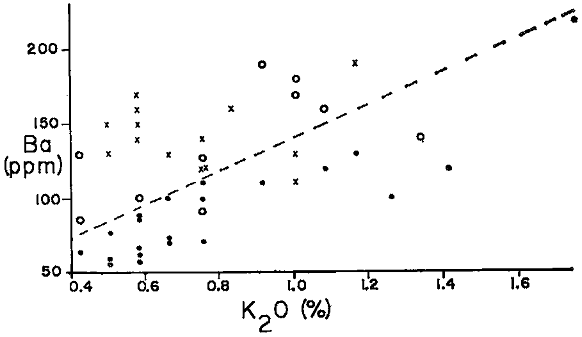

FIG. 222. Barium versus potassium in the Henwood diabases. Symbols are as given for Figure 220. All points for the Upper sheet (filled circles) fall below the dashed line.

fitable results in future work might be obtained by focusing additional attention on the intrusions at Cobalt, namely, the New Lake and Peterson Lake basins.

The most abundant constituents of the ore minerals are cobalt, nickel, iron, copper, silver, arsenic, and sulphur. Antimony is also commonly present, but it is not a principal component and is unimportant in comparison to arsenic. Bismuth is present in some veins, but its distribution has not been studied, partly because the element is inconsequential relative to the above components. Although iron was not discussed in this paper, its variation in the Henwood intrusions is shown in Figures 26 and 27 (p. 68 & 69). For the important ore elements, the basic pattern which has emerged from the present study can be summarized as follows :

1. Of the ore elements Co, Ni, Fe, Cu, Ag, As, S, and Sb, all except Ni either increase with diabase fractionation or have migrated to the upper parts of the intrusions.
2. The most common places for enrichment anomalies in the diabases are near the contacts, and in the varied-texture zone.

Although it is recognized that the data for antimony in particular are sparse, the above-cited relationships indicate that all of the ore elements were mobile during diabase fractionation. The distribution of the elements has, however, been governed by two somewhat different, though related, processes. The first of these may be broadly referred to as the initial magmatic stage in which the main rock-forming minerals crystallize, and the second is the deuteric to hydrothermal stage in which many of the original minerals are partly altered or changed to new minerals which are commonly hydrous and characteristically represent lower temperature species. It has been shown that nickel methodically decreases with fractionation, and this behaviour militates against its being concentrated in late-stage veins. There is, however, the problem of accounting for the nickel content of granophyric diabase and the presence of erratic values in the varied-texture zones of the intrusions. This type of variability initially suggests that some nickel may be present in "sulphide" form. To test this possibility, the ascorbic acid leach method (Smirnova & Al'mukhamedov 1967; Smirnova *et al.* 1968) was used on the diabase samples from the Peterson Lake basin, Cobalt. The leach method used in this study is described in complete detail in Cameron *et al.* (1970). The treatment utilizes an ascorbic acid-hydrogen peroxide mixture which preferentially attacks sulphides and native metals rather than silicates and oxides.

The results of the leach treatment of the Peterson Lake samples are given in Table 93. Because it was necessary to determine nickel in the resulting solutions by atomic absorption spectroscopy, the nickel contents

TABLE 93. ASCORBIC ACID-HYDROGEN PEROXIDE LEACH TESTS OF DIABASE FROM THE PETERSON LAKE BASIN, COBALT.

| Sample | HF–HClO$_4$ Attack | Ascorbic Acid-H$_2$O$_2$ Leachable Fraction | | Sample | HF–HClO$_4$ Attack | Ascorbic Acid-H$_2$O$_2$ Leachable Fraction | |
|---|---|---|---|---|---|---|---|
| JF69C– | Ni (ppm) | Ni (ppm) | % | JF69C– | Ni (ppm) | Ni (ppm) | % |
| 30 | 113 | 66 | 58 | 46 | 181 | 80 | 44 |
| 31 | 113 | 82 | 73 | 47 | 181 | 52 | 29 |
| 32 | 130 | 48 | 37 | 48 | 202 | 64 | 32 |
| 33 | 116 | 48 | 41 | 49 | 146 | 64 | 44 |
| 37 | 126 | 62 | 49 | 50 | 142 | 58 | 41 |
| 38 | 133 | 56 | 42 | 51 | 172 | 59 | 34 |
| 39 | 129 | 60 | 47 | 52 | 192 | 50 | 26 |
| 41 | 81 | 45 | 56 | 53 | 181 | 42 | 23 |
| 42 | 160 | 51 | 32 | 54 | 184 | 48 | 26 |
| 44 | 124 | 50 | 40 | 55 | 175 | 47 | 30 |
| 45 | 155 | 56 | 36 | | | | |

Analyses by Geochemistry Section, GSC.

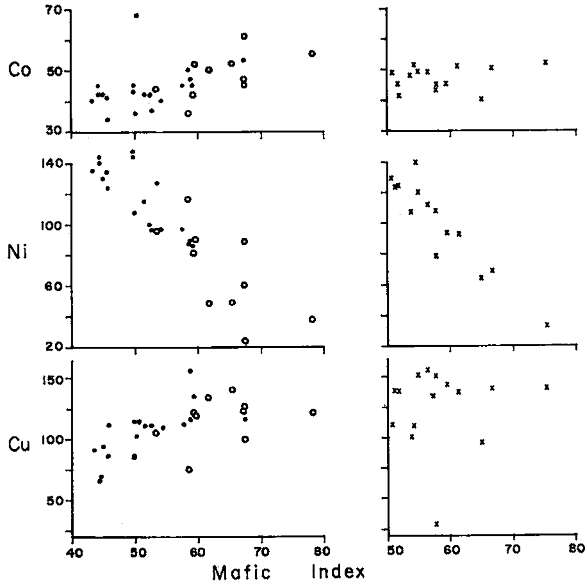

FIG. 223. Variations in mafic index versus Co, Ni, and Cu (ppm) in the Henwood diabases, with trace elements determined by atomic absorbtion analyses.
(Upper sheet ● ; Flank ○ ; Lower sheet x).

of the untreated samples were also determined by an $HF-HNO_3-HClO_4$ attack followed by atomic absorption spectroscopy. Without exception, the nickel results obtained by the A.A. method were higher than those obtained by optical spectroscopy. The new results ranged from +11 to +52 per cent higher, the average being +22. Because of this, the Henwood diabases were re-analyzed by the A.A. method, but no significant changes in the trends occurred. The scatter of points was in some cases reduced (Fig. 223), but the distribution patterns in the Lower sheet and overlying basin remain essentially unchanged.

The results of the leach tests on the Peterson Lake samples are shown in Figure 224. Total nickel in the rock decreases with fractionation, but the percentage of the total which is present in "sulphide" form actually increases toward the top of the intrusion. The net effect is that the amount of nickel in "sulphide" form is fairly constantly around 50 to 60 ppm throughout the sheet. Thus sulphides account for most of the nickel in granophyric and other salic varieties of the diabase. The distribution of this element therefore reflects both the initial extraction of the element from the magma into the early-formed silicates and oxides, and also the

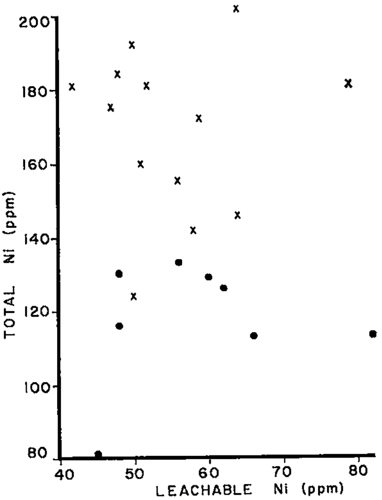

FIG. 224. Total nickel versus leachable nickel in the Peterson Lake diabase, Cobalt. Samples above the hypersthene diabase zone are shown by a solid circle; those in and below the hypersthene zone by an x.

relatively increasing importance of the sulphide form with progressive fractionation in the broadest sense.

In the Henwood diabases the indications are that the distribution of the ore elements is strongly affected by the configuration of the intrusion. The variation of Fe, Cu, Ni, Co, Ag and S in the diabase basin is most interesting because the information available shows that these elements have behaved differently; thus Ag may have possibly "peaked" near the top of the depressed part of the sheet (Fig. 217). Although the situation with respect to "sulphide" nickel is uncertain, the other elements seem to have susceptible to migration toward the elevated rim of the intrusion. This upward trend is readily apparent for Co, and is obvious for Fe.

All writers who have considered the relative proportions of the various elements in the ore veins have had difficulty in agreeing upon an "average" abundance of the major components. Bastin (1939), however, made much of the fact that at Cobalt the proportion of cobalt to nickel was greater than one, and hence the ratio was atypical of ores in basic rocks but more akin to ores associated with salic intrusions. This was one of several reasons why Bastin argued that the ores came not from the Nipissing diabase, but from a more salic magmatic parent.

The cobalt-nickel ratios of the diabase intrusions in Henwood township are shown in Figure 225. Fleischer (1968) has shown that Ni/Co normally decreases with fractionation, and this is also the trend in the Henwood intrusions; cobalt here eventually exceeds nickel in the most salic differentiates and the Co/Ni ratios ascribed to the ores are attained.

Metal abundance in the rocks intruded by the Nipissing diabase have not been investigated in the present study, but analyses of these have

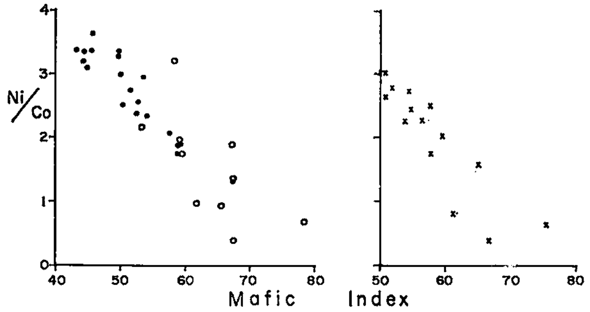

Fig. 225. Variation in Ni/Co ratios with the mafic index of the Henwood diabase basin (left) and lower sheet (right).

been published by Boyle (1968a, 1968b), Boyle *et al.* (1969), and Boyle & Johnston (1970). The present writer is grateful to Dr. Boyle for making available the samples used in compiling the data shown in Table 94. In connection with the previous discussion of the Stone-Eplett No. 3 drill core, it has already been mentioned that interim revisions in the analytical procedures for silver have occurred; the composite samples listed in Table 94 were therefore re-analyzed for silver in order to obtain a direct comparison with the diabases of the present study. The results obtained from two splits from each composite sample are given in Table 94. The data show that silver abundances in Archean volcanic and pyritiferous sedimentary rocks are not much different from those in the Nipissing diabase.

It was stated at the beginning of this section that the principal purpose of this study was to determine whether the Nipissing diabase could be eliminated as a potential source of the ore elements. It has been shown that the metals present in the ore veins are also present in the diabase. More important, it has been shown that the relevant elements have been mobile and have been concentrated in certain parts of the intrusions. It is concluded that the Nipissing diabase is a potential source of the elements found in the veins.

TABLE 94. ANALYSES OF ROCKS FROM COBALT AND SOUTH LORRAIN (AFTER BOYLE 1968a).

| Description of samples | Ni | Co | Cu | Zn | Pb | Ag | As | Sb | S | Ag* |
|---|---|---|---|---|---|---|---|---|---|---|
| Composite sample of Keewatin greenstone, South Lorrain[1] | 130 | 67 | 330 | 95 | <5 | 0.30 | 15 | 2.5 | 1700 | 0.09<br>0.11 |
| Composite sample of Keewatin greenstone, Cobalt area | 105 | 69 | 120 | 215 | <5 | 0.19 | 2 | 0.5 | 775 | 0.09<br>0.07 |
| Composite sample of Cobalt conglomerate and greywacke, Cobalt area | 60 | 25 | 20 | 20 | <5 | <0.05 | <2 | <1 | 180 | 0.05<br><0.05 |
| Composite sample of Keewatin black pyritiferous slate, schist, and greywacke, Cobalt area[2] | 160 | 74 | 420 | 2400 | 75 | 0.83 | 140 | 12.5 | ~6% | 0.34<br>0.30 |

All values in ppm except where noted.

[1] Contains visible sulphides, including some chalcopyrite.

[2] Hudson Bay mine area, Cobalt.

* Re-analyzed for comparison with the diabases of the present study.