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Preliminary Results of Till Petrographical and Till Geochemical Studies at Farley Lake

By E. Nielsen and D. C. Graham

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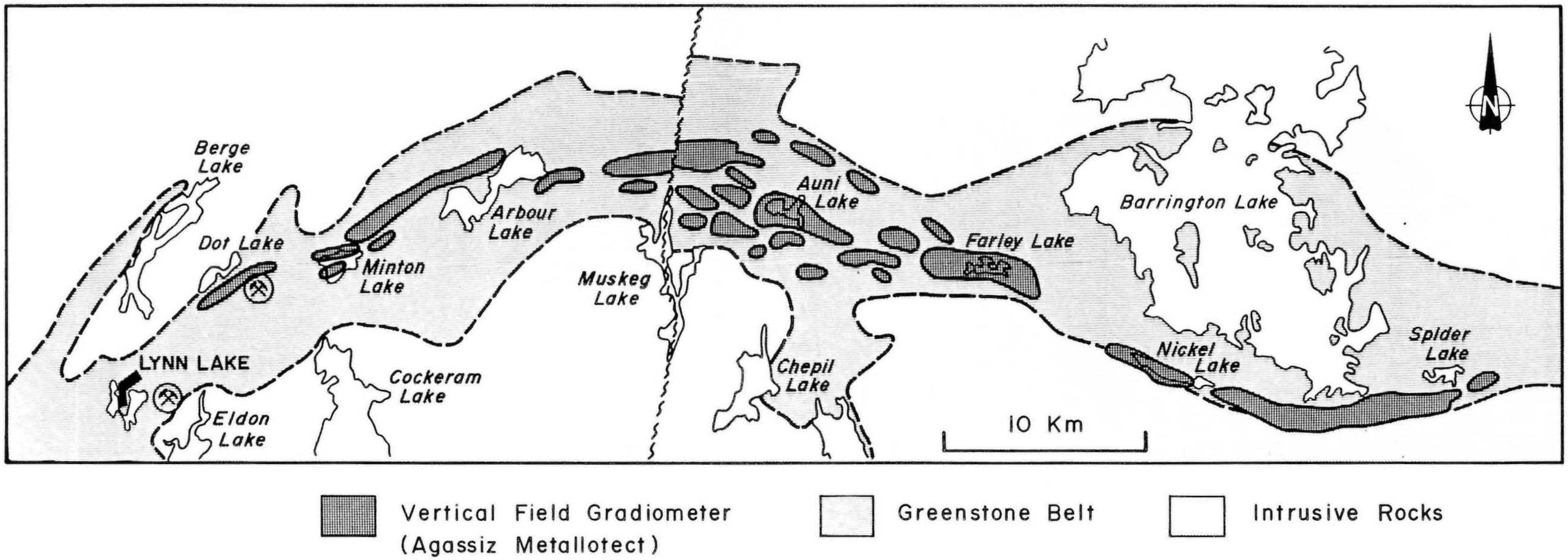

Figure 1: Location map of the Farley Lake area and the Agassiz metallotect (Fedikow unpublished map).

INTRODUCTION

Basal till geochemical investigations were undertaken in the Lynn Lake area to aid the mineral exploration industry in the search for gold mineralization in areas of little or no outcrop. The basal till program is part of a larger geochemical program (see Fedikow, 1984) undertaken to demonstrate the usefulness of low cost geochemical exploration techniques.

Initial investigations were started around the Agassiz Au-Ag deposit (Nielsen, 1982, 1983; Nielsen and Graham, 1984; Fedikow 1983, 1984; Fedikow et al. 1984). Although the initial results were favourable there is some concern that the vegetation has been contaminated by airborne detritus from the mine tailings at Lynn Lake located 7 km south of the deposit.

A second site at Farley Lake, 36 km east of the Agassiz deposit (Fig. 1) and with similar bedrock geology was selected in an effort to duplicate the original multi-medium geochemical study carried out around the Agassiz deposit. Black spruce needles and twigs and peat bog samples have been collected by Fedikow and will be reported on at a later date. This report details the results of the till investigation carried out in the area.

PREVIOUS WORK

There are few published reports on the geochemistry of tills in northern Manitoba. O'Donnell (1976a) analysed the -80 mesh fraction of 213 glaciolacustrine, esker and till samples for Cu, Zn and Ni from widely scattered areas around Lynn Lake and mapped the surficial geology of 64C/14 and 15 (O'Donnell 1976b, 1976c). The results of this investigation indicate that the surficial geology presents conditions favourable for drift prospecting in as much as

(1) the till is ubiquitous and generally thin
(2) the Quaternary stratigraphy is relatively simple
(3) there is generally only one direction of glacier transport and
(4) the ice flow direction is approximately transverse to the strike of the greenstone belt.

Dredge (1981) reported on the trace element geochemistry of 133 till and esker samples from the Jackfish Lake area in northern Manitoba. Dredge (1983a, 1983b) also reported on the trace element content of about 400 samples from northern Manitoba. These two studies report background values on analysis of the less than 2 micron fraction for a large area of northern Manitoba.

Shilts (1980) presented geochemical results on a limited number of samples from the area adjacent to Hudson Bay as part of a larger study on the geochemistry of till between Longlac, Ontario and Somerset Island, N.W.T.

To date there have been no detailed geochemical studies of till around known mineral occurences in Manitoba except those by Nielsen (1982, 1983) and Nielsen and Graham (1984). There have been no petrographic studies on tills in northern Manitoba to date.

BEDROCK GEOLOGY

The bedrock geology in the Farley Lake area was mapped by Gilbert (1980a, 1980b). The rocks of the Wasekwan Group at Farley Lake comprise the Northern Belt of the Lynn Lake greenstone belt. At Farley Lake the bedrock comprises mafic volcanic flows and flow-breccias, mafic tuff and lapilli tuff, and pyroclastic breccia (Fig. 2). Mafic tuffs comprise more than 50 per cent of the section north of Farley and White Owl Lakes. South of Farley Lake mafic volcanic rocks are strongly silicified and interlayered with amphibolite schist.

Gordon Lake and Farley Lake are situated in a major body of iron formation which gives rise to a magnetic anomaly 6.3 km long and 1.5 km wide (Barrington Lake area, Questor INPUT Survey Map, 1977). The iron formation consists of banded chert, argillite, siltstone and massive magnetite.

Wasekwan Group rocks outcropping in the Brooks Bay area northeast of Farley Lake probably extend west of the known outcrop into the area north of Farley Lake (Gilbert, pers. comm.).

Granite, tonalite and related gneisses are widespread both north and south of the Lynn Lake greenstone belt (Fig. 2).

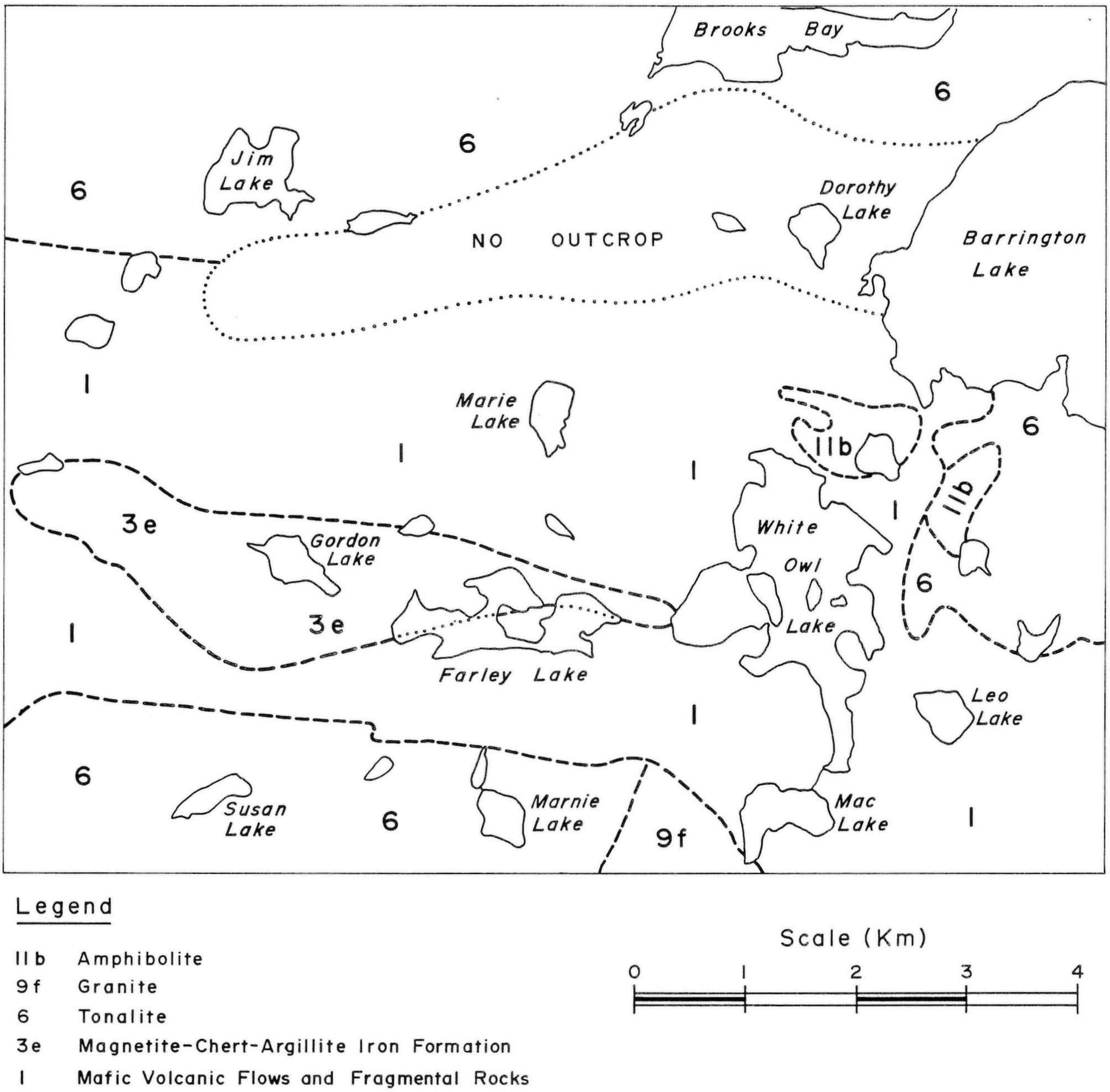

Figure 2: Bedrock geology in the Farley Lake area (simplified from Gilbert 1980a).

SURFICIAL GEOLOGY

Physiography

The area surrounding Farley Lake is one of low relief. Farley Lake is at an elevation of approximately 320 m (a.s.l.) and is surrounded by swamp along most of its shore (Fig. 3). The highest areas are hills southeast and southwest of Farley Lake which reach elevations of 350 m.

There is relatively little bedrock exposed in the area. Bedrock outcrops are generally situated on the top or on the north side of crag and tail hills (Fig. 4).

Ice Flow Direction

The Lynn Lake region including the Farley Lake area lies entirely within the area affected by glaciation from the Keewatin sector of the Laurentide Ice Sheet. Glacial striae, crag and tail features and drumlinoid ridges indicate the general ice flow was southerly throughout most of the area. Striae measurements in the Lynn Lake area indicate the main ice flow direction varied between 180^{o} and 225^{o}. In the eastern part of the area, including Farley Lake, the main ice flow was toward 190^{o} followed by a younger flow towards 140^{o}. The youngest ice flow was the result of late glacial readjustment of the ice margin in response to the formation of the interlobate moraine at Leaf Rapids. This interlobate moraine, previously termed an esker (Ringrose and Large, 1977), marks the confluence between Keewatin ice on the west and Labradorean or Hudsonian ice on the east as indicated by the difference in carbonate erratic content of the two regions. As the ice margin receded northward the ice flow direction changed and converged on the Leaf Rapids interlobate moraine from both the east and the

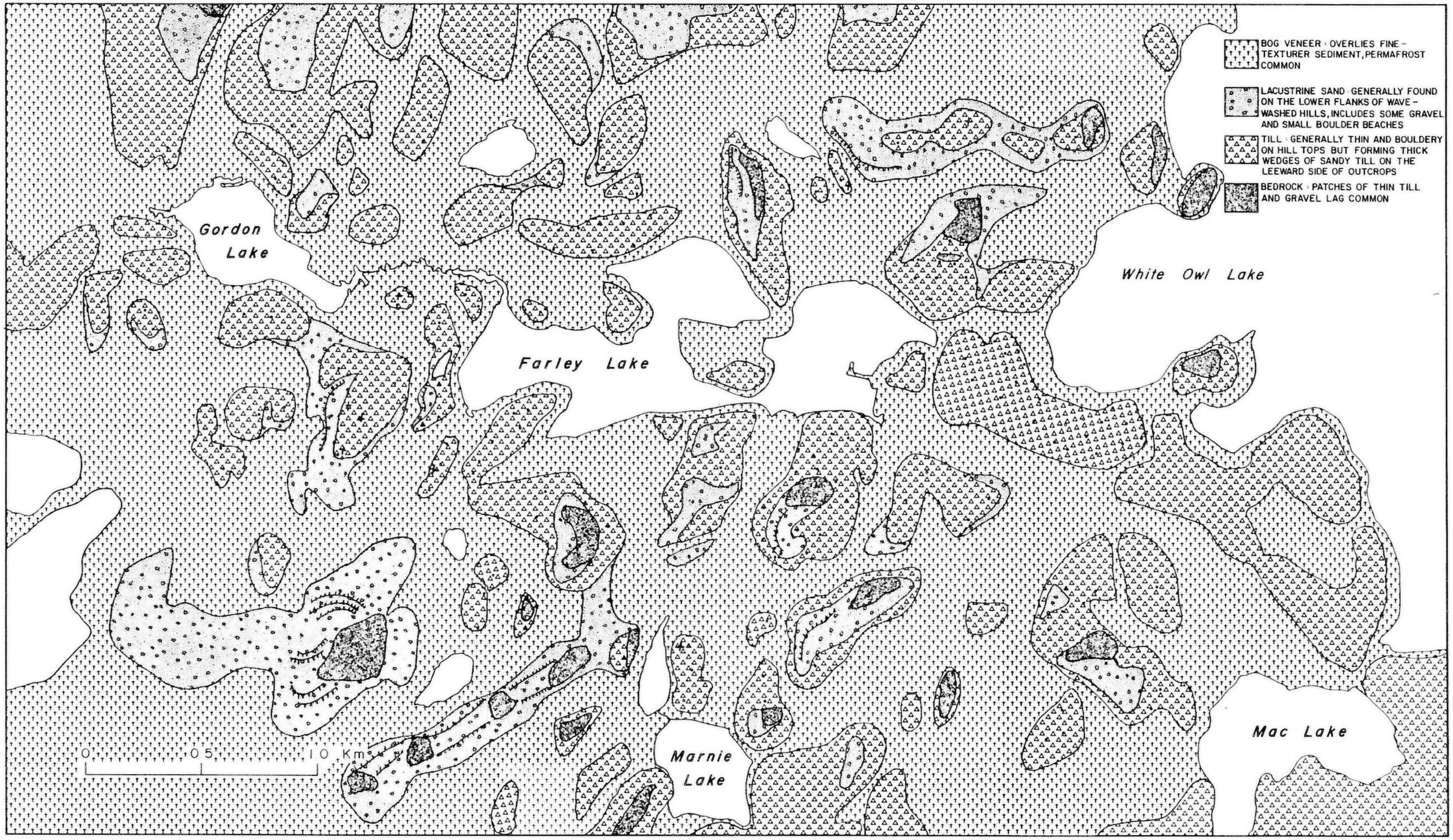

Figure 3: Surficial geology of the Farley Lake area.

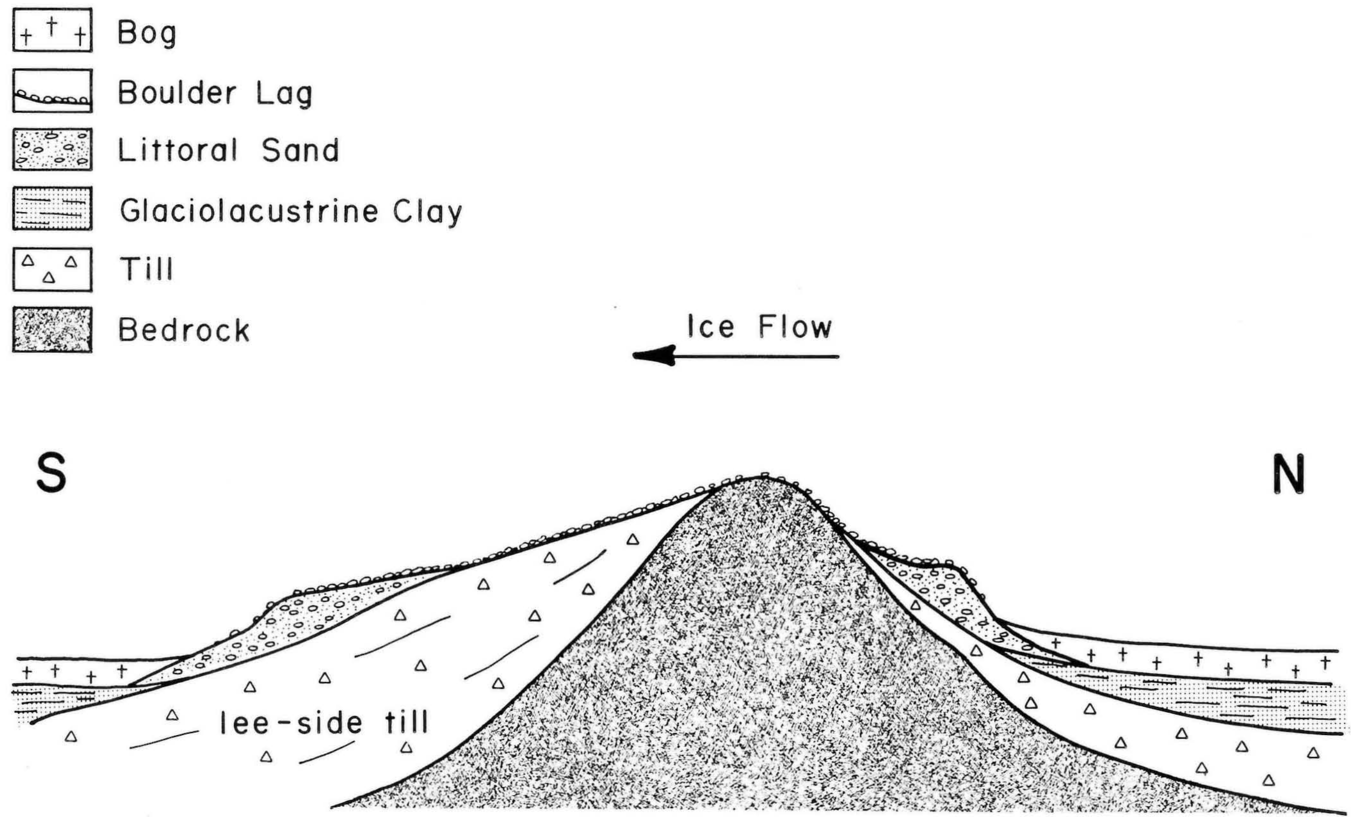

Figure 4: Schematic representation of the stratigraphy of the surficial sediments in the Lynn Lake area.

Figure 5: Typical till pit showing sandy till overlying sand at sample site 30.

west. The converging ice flow was in response to thinning ice and a calving bay which formed at the confluence of the two lobes. The drawdown of the ice margin as revealed by striae south of the Farley Lake area is not considered to have influenced the till composition significantly.

Stratigraphy

TILL DEPOSITS

The bedrock is mantled by a till sheet of variable thickness attributed to deposition by the main Keewatin ice flow during the Late Wisconsinan. The thickness of the till sheet ranges from zero over bedrock highs to in excess of several metres in the lee of bedrock outcrops. O'Donnell (1976d) indicated areas with as much as 15 m of till in the Lynn Lake region. In the Farley Lake area, however, the till is generally only a few metres thick.

The till sheet is generally homogeneous and has a sandy-silty texture (Fig.5). The boulder content of the till is highly variable. The till can in most cases be classified as basal till as indicated by the degree of compaction, striated clasts and clast fabric. Subglacial and subaqueous debris flow deposits with normally graded clasts similar to deposits described around Agassiz (Nielsen, 1983) are found in the area. These debris flows are not mappable units and are not considered to have affected the composition of the till significantly.

Subglacial debris flows were emplaced in cavities on the lee-side of bedrock obstacles and may be termed lee-side till. The lee-side till is in places interbedded with well sorted stratified sand. Elsewhere it contains deformed stringers of well sorted silt or sand (Fig. 5).

GLACIOLACUSTRINE DEPOSITS

In the low lying areas the till sheet is mantled by brownish-grey glaciolacustrine silt and clay. The clay is thickest under the bog veneer which covers the low lying areas and pinches out on the flanks of the hills. Texturally the glaciolacustrine sediment consists primarily of clay and fine silt although coarser material may also be present.

In the area to the east of Eden Lake and Barrington Lake the glaciolacustrine clay is very extensive and mantles many of the hills. To the west of this area including Farley Lake the clay veneer becomes thinner and is more localized in its distribution being generally restricted to low-lying areas.

The glaciolacustrine clay was deposited in proglacial Lake Agassiz after the northward retreat of the ice margin. Carbonate clasts constitute a significant proportion of the coarse fraction in the clays indicating the source of the ice rafted detritus was ice which flowed west from Hudson Bay. A Labradorean or Hudsonian source for the clay is also indicated by the brownish colour which is similar to the colour of the till matrix of Late Wisconsinan tills found in the Hudson Bay Lowlands (Nielsen and Dredge, 1982).

LITTORAL DEPOSITS

Topographic high areas are generally covered or encircled by littoral sand or gravelly sand deposits. These areas may be recognized by the flat surface and open bush consisting of open pine forest with a ground cover of lichen (Cladonia). In places terraces are well developed but beaches with recognizable berms are rare.

These relatively well sorted sediments were deposited during the regression of Lake Agassiz across the region.

During the regression of Lake Agassiz the till sheet was eroded extensively and became mantled with a boulder lag. The hilltops first became shoals when they were exposed to wave base. The till matrix was washed into the low-lying offshore regions where it accumulated over the deep water clay deposits. As the water level continued to drop the hilltops became subaereally exposed while shoreline processes continued to modify the surrounding slopes. Previously deposited littoral sediment was eroded and minor terrace scarps formed.

ORGANIC DEPOSITS

Black spruce bog and fen cover an estimated 60 per cent of the Farley Lake area (Fig. 3). The majority of the bogs are relatively shallow and are found overlying Lake Agassiz clay deposits between bedrock highs. Fedikow et al. (1984) indicate that the majority of the 344 peat cores collected from the area average less than a metre in length and that most of the cores terminated in clay. Palsa bogs in the Lynn Lake area, however, have 5 or more metres of peat; peat of this thickness may also occur in the Farley Lake area.

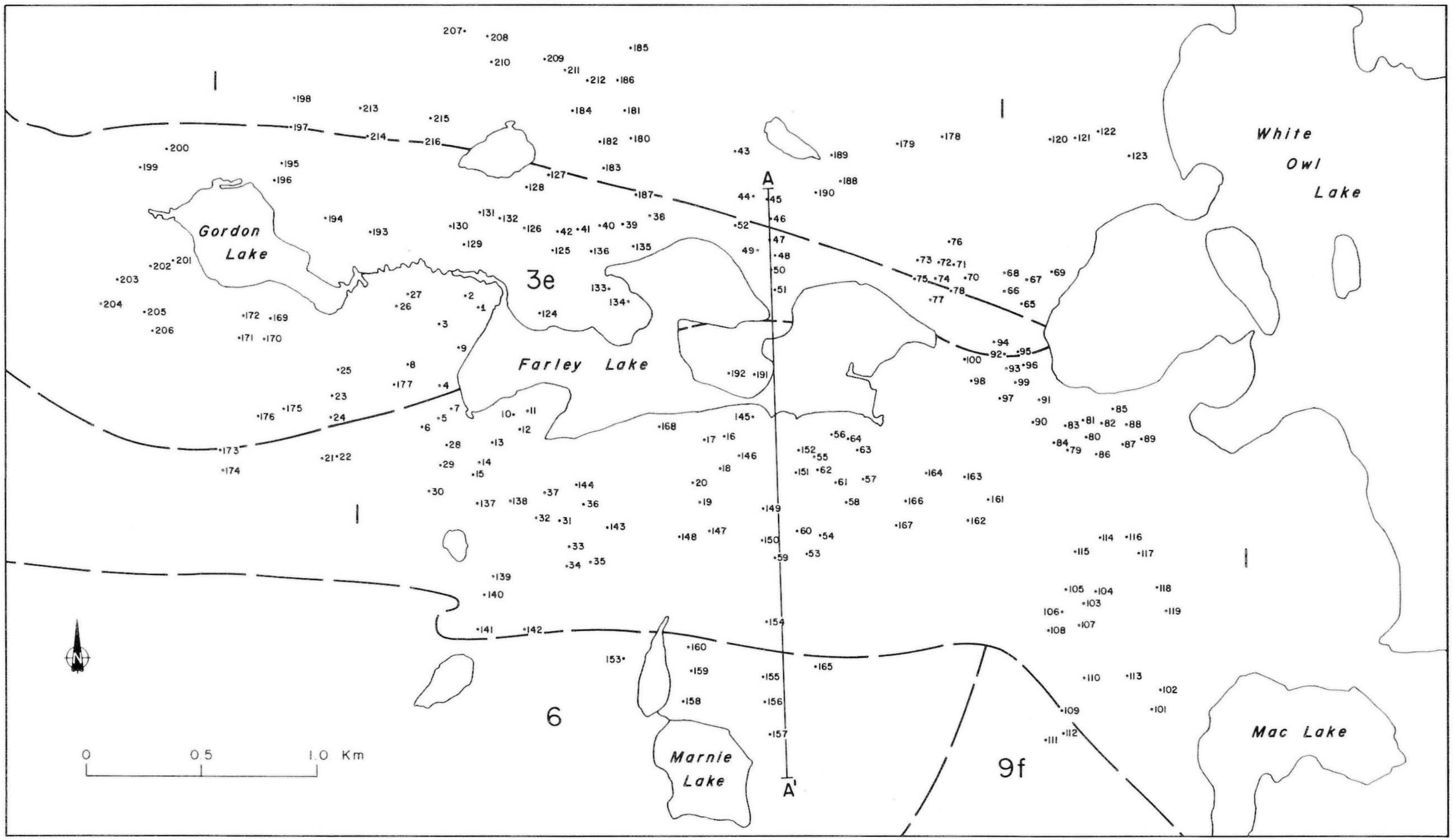

Figure 6: Till sampling sites.

METHODS

Field Methods

Preliminary work around the Agassiz deposit indicates the glacial dispersion train from the mineralized zone to be 200-300 m long and for this reason a sample spacing of 50-100 m was used in the Farley Lake area. With this sample spacing anomalous till areas would be sampled at least two or three times. A total of 244 till samples were collected from 216 hand dug holes (Fig. 6).

The holes varied in depth between 0.8 and 1.2 m. Bedrock or large boulders were encountered in 27 holes and three holes terminated in brown regolith. A thick layer of Lake Agassiz sediment was penetrated in 102 holes before the till was reached.

Samples consisted of from 5 to 10 kg of grey, generally unoxidized till. Although unoxidized till is desirable, oxidized till could not always be penetrated due to the depth of oxidation, groundwater percolation, frost, or an abundance of large boulders.

Laboratory Methods

The sample processing procedure used is illustrated in Figure 7. Initially the 5-10 kg bulk sample was split into three parts: a 1/4 split is in storage for reference or future analysis, 500 g was used for separation of the less than 2 micron fraction, and the rest of the sample was used for heavy mineral separation and petrographic analysis.

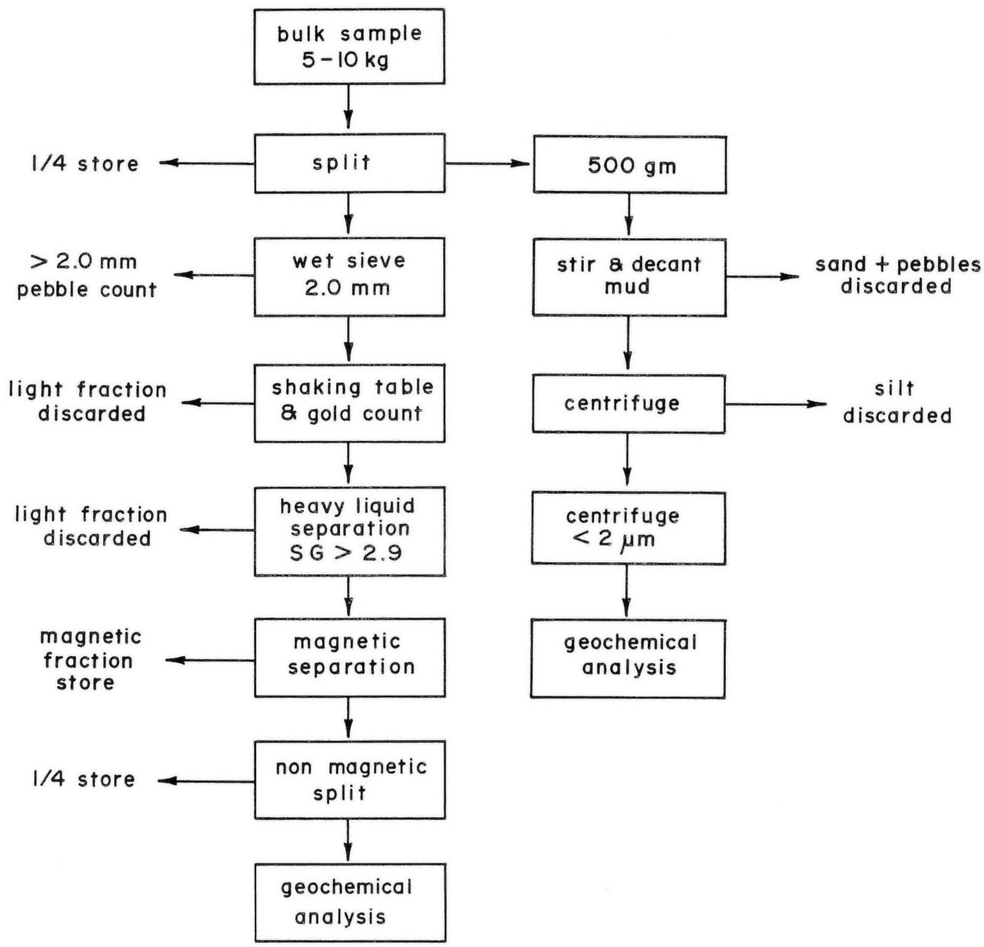

Figure 7: Sample processing flow sheet for the Farley Lake till samples.

TEXTURAL ANALYSIS

The 1/4 split of 12 samples from a north-south transect (Fig. 6) was used for grain size determinations. Samples from this transect were selected because the transect approximates the regional ice flow direction (190°) and because the samples overlie the three major bedrock lithologies in the area--namely mafic volcanic flows and fragmental rocks in the north, iron formation around Farley Lake and tonalite to the south.

Each sample was dried, weighed and split on a -2.0 phi (4.0 mm) screen. Material coarser than 4 mm was sieved at 1 phi intervals. An approximately 80 g split of the material less than 4 mm was wet sieved on a 4.0 phi (63 micron) screen. The silt plus clay fraction was pipetted at 1 phi intervals using the method described by Folk (1968). The 4.0-.063 mm fraction was dry sieved at 1 phi intervals.

PETROGRAPHIC ANALYSIS

The lithology of approximately 300 clasts between 4 and 16 mm in diameter was determined on 13 samples along the transect A-A' (Fig. 6).

HEAVY MINERAL ANALYSIS

The less than 2.0 mm fraction of the bulk samples was passed across a shaker table where visible gold counts were made. The heavy fraction from the shaker table was put through heavy liquids (specific gravity 2.96) for additional concentration. Magnetic minerals were removed with a hand magnet and stored and the 3/4 split crushed to -200 mesh and submitted for geochemical analysis. A small portion of heavy minerals from the 1/4 split of 13 samples from the transect A-A' (Fig.6) was sieved to concentrate material between 3 and 4 phi. This fraction was mounted in Canada balsam and point counted using the Fleet method (Carver, 1971). The number per cent of each mineral species in the samples was calculated from the point count data.

SILT-CLAY COMPOSITION

X-ray diffractograms were run on three size fractions of samples 45 and 150 to check for compositional differences in the silt and clay. The fractions analyzed were the 4 phi, 6 phi and 8 phi withdrawals from the pipette analysis.

FINE SEDIMENT SEPARATION

The 500 g split of the bulk samples was disaggregated in 1 litre of distilled water using a milk-shake mixer (Fig. 7). The silt and clay fraction was decanted into a 1 litre centrifuge bottle and centrifuged at 750 r.p.m. for 3 minutes. The less than 2 micron fraction was decanted into another 1 litre centrifuge bottle and centrifuged at 2300 r.p.m. for 15 minutes. After decanting the water the less than 2 micron fracton was scraped from the bottle, dried and crushed and submitted for geochemical analysis. The reasons for using the clay-sized fraction are documented in Shilts (1975, 1976, 1977), Klassen and Shilts (1977) and summarized by DiLabio et al. (1982) and Shilts (1984).

GEOCHEMISTRY

The clay-sized fraction of the samples received no prior treatment but the heavy mineral fraction was pulverized to -200 mesh. Cu, Pb, Zn, Ni, Co, Cr, Fe, and Mn in both fractions were analysed by atomic absorption spectrophotometry after hot nitric-hydrochloric acid extraction. Arsenic on both sets of samples was analyzed colorimetrically after nitric-perchloric acid digestion. Gold in the heavy mineral fraction was analyzed by fire assay and atomic absorption using an approximately 20 g sample.

The lower detection limits for all the elements is 1 or 2 ppm, except Fe and Au which have lower detection limits of 0.1 per cent and 5 ppb respectively.

RESULTS AND DISCUSSION

Textural Analysis

Results of 12 textural analyses are presented in Figures 8 and 9 and summarized in Table 1. The grain size distribution of all the samples is similar. The gravel content (based on a 2 kg sample) varies between 10.4% and 20.6%, the sand content between 45.4% and 54.1%, the silt content between 21.2% and 38.4% and the clay content between 5.8% and 11.2%. The grain size curves have the same general shape with a prominent mode between 2 and 3 phi. Several samples show a slight mode between -4 and -5 phi and are bimodal in their grain size distribution. Sample 49 is atypical because of the high (38.4%) silt content and low (5.8%) clay content.

Grain size variations in the underlying bedrock does not appear to have greatly influenced the grain size distribution of the 12 samples along the A-A' transect with the possible exception of sample 49. The shape of the grain size curves is similar to that described by Dreimanis and Vagners (1971) for tills consisting of igneous and metamorphic material that has undergone long distance transport. The coarse mode, which consists of rock fragments, is poorly developed or absent whereas the sand or terminal mode is well developed. The matrix or terminal mode has been enlarged at the expense of the coarse mode. The samples that are bimodal such as 150 and 156 might therefore be expected to have a higher proportion of local material than the unimodal samples but generally the grain size distribution indicates long distance transport with most of the material being derived from "granite" sources.

Petrographic Analysis

The 4-16 mm size fraction of the 13 till samples analyzed was divided into six groups;

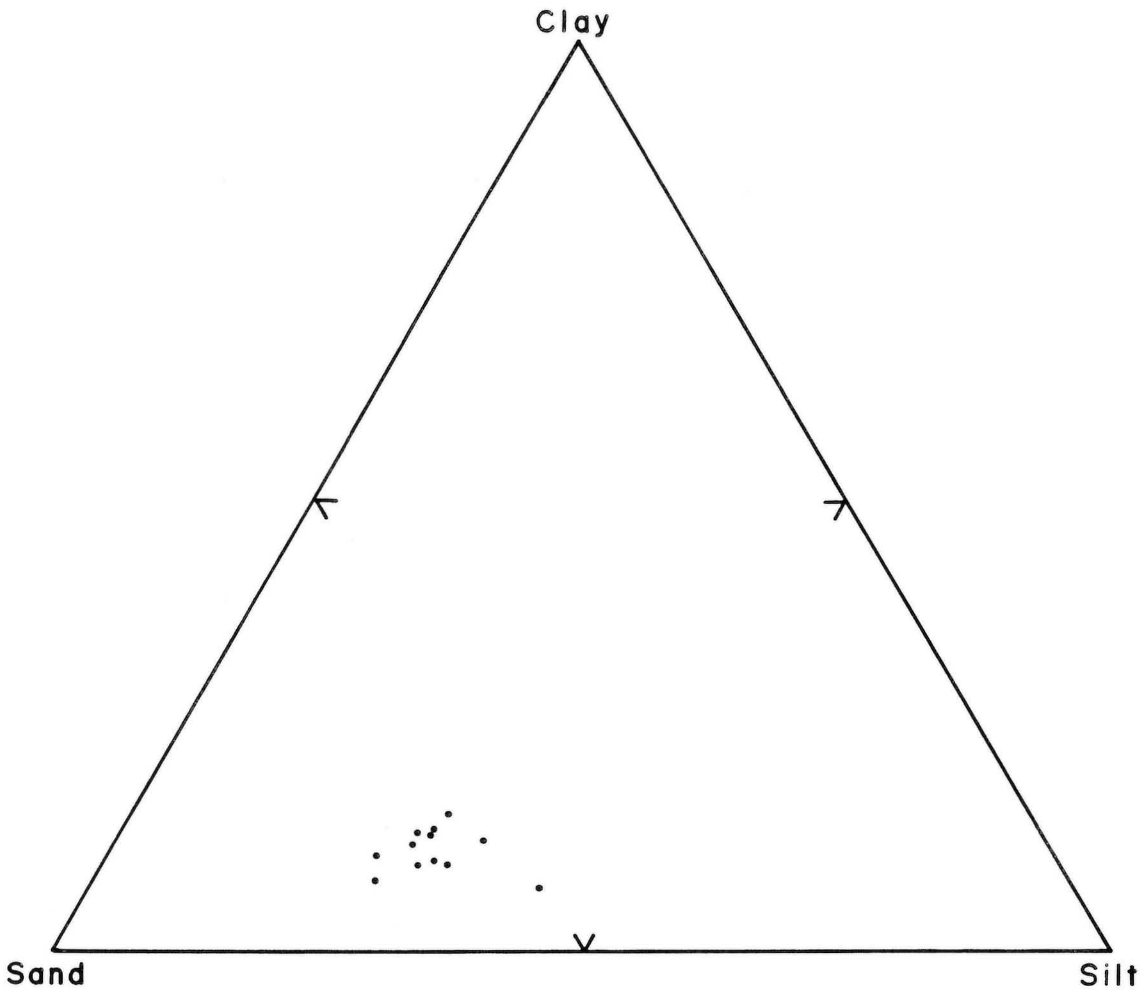

Figure 8: Grain size of Farley Lake till samples. Values are recalculated from the data in Table 1.

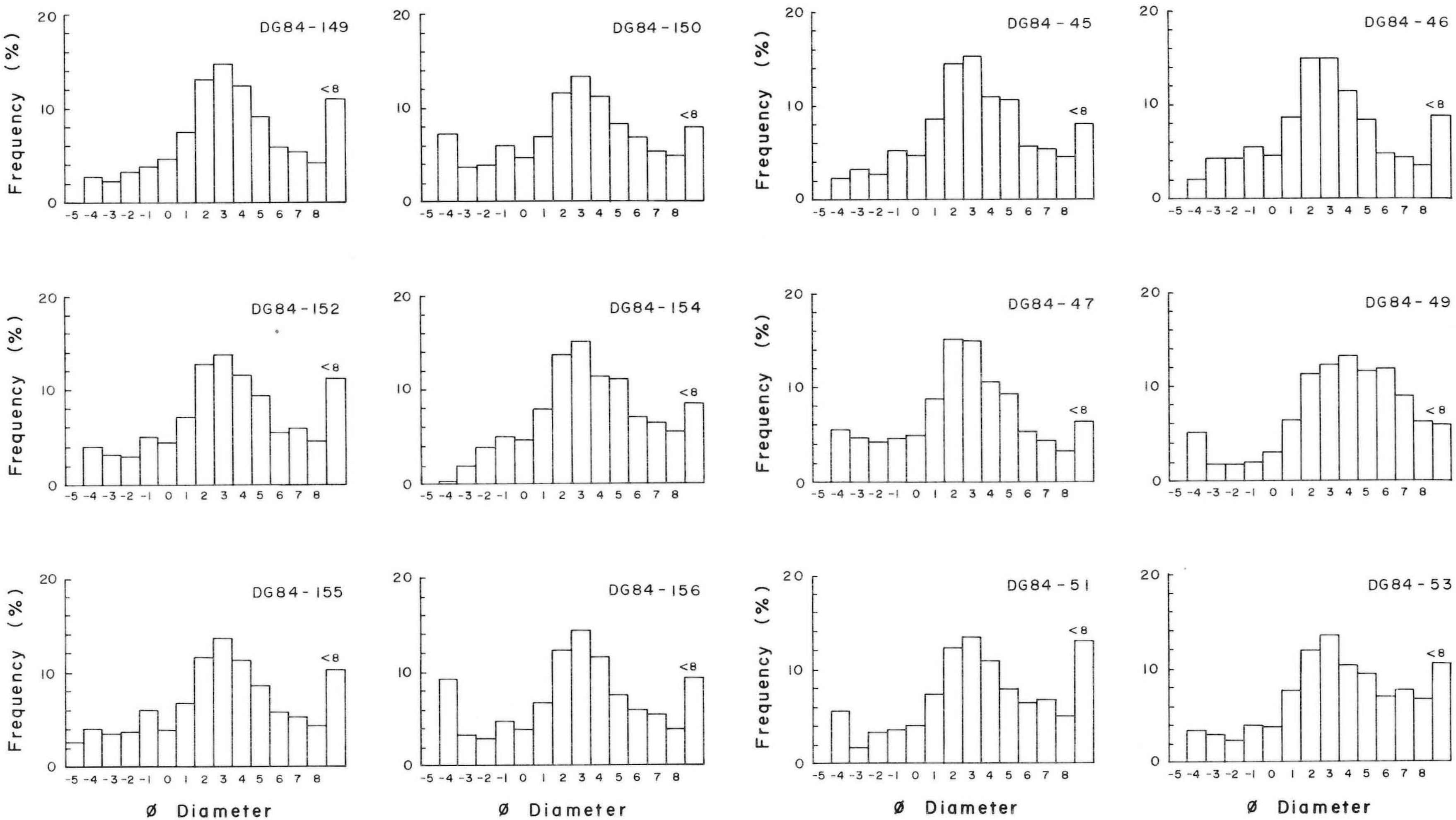

Figure 9: Histograms showing the grain size distribution of till samples along the transect A-A' in Fig. 3.

Table 1. Grain size distribution of till samples along the transect A-A'.

Sample Number	% Gravel	% Sand	% Silt	% Clay
DG84- 45	13.0	53.1	25.9	8.0
46	16.1	54.1	21.2	8.6
47	18.5	53.7	21.8	6.0
49	10.4	45.4	38.4	5.8
51	14.0	47.4	25.8	12.8
53	12.2	46.8	30.6	10.4
149	12.2	51.8	24.8	11.2
150	20.6	46.8	24.7	7.9
152	15.0	48.9	25.0	11.1
154	10.8	51.8	29.2	8.2
155	19.7	46.5	23.7	10.1
156	19.7	48.4	22.7	9.2

(1) undifferentiated intrusives (including quartz, plagioclase ± quartz porphyry, pegmatite, tonalite and hornblende ± biotite quartz diorite)

(2) granite and granodiorite

(3) biotite-hornblende greywacke and argillitic wacke

(4) siliceous siltstone

(5) mafic volcanics (including some gabbro) and

(6) mafic crystal tuff.

The intrusive rocks, groups 1 and 2, were derived from the extensive granitic terrane north of Farley Lake (Manitoba Mineral Resources Division, 1979). It is difficult to assign source areas to these lithologies because the pebbles are difficult to identify accurately and because the source areas are largely unmapped. The intrusive rocks constitute in excess of 80% of the 4-16 mm fraction (Table 2) and have undergone a minimum of 2.5 km of glacial transport.

The greywacke, group 3, was derived from the Southern Indian gneiss belt which outcrops in a broad area north of Farley Lake. The closest occurrence of this bedrock lithology along the ice flow direction is north of Melvin Lake, 35 km away (Gilbert, 1979). This lithology, which is very friable, constitutes between 4.6 and 13.2% of the pebble fraction.

The siliceous siltstone and volcanics, groups 4,5, and 6 were derived by the comminution of the underlying bedrock at Farley Lake and possibly in part from similar rocks in the Brooks Bay area 4.5 km north of Farley Lake (Gilbert, 1980b). These locally derived rocks constitute between 0.5 and 9.0% of the pebble fraction (Table 2).

Table 2. Petrography of the 4-16mm size fraction of till samples along the transect A-A'.

Sample No.	% Granodiorite	% Undif. Intrusives	% Hornblende Greywacke + Argillite Wacke	% Siliceous Siltstone	% Mafic Volcanics	% Mafic Tuff	Total (N.)
DG84-							
45	12.5	79.4	4.8	.1	1.9	1.2	832
46	11.9	83.0	4.6	0.0	.3	.2	1022
47	11.9	81.9	4.9	.1	1.1	.2	1112
49	12.9	76.7	6.1	0.0	.6	3.6	618
51	12.6	76.9	7.7	0.0	2.6	.2	1009
53	13.3	68.2	13.2	.3	4.1	.8	629
149	13.2	74.8	5.1	.8	5.9	.3	903
150	11.1	71.4	8.1	.4	8.3	.3	919
151	12.3	73.5	10.6	.2	3.0	.4	1183
152	12.1	78.1	7.6	.2	1.6	.3	972
154	12.0	76.0	9.1	.2	2.1	.6	1236
155	14.0	70.3	8.7	.2	6.4	.4	895
156	9.4	74.8	8.0	.6	6.3	.9	1021

The general long distance transport of the pebble fraction reflects both the durability and the size of the source areas. The largest source area is the granitic terrane followed by the gneissic terrane and the greenstone belt.

The long distance transport of the pebble fraction is similar to that at Agassiz and is in keeping with the poorly developed pebble mode indicated by the textural analysis.

Heavy Mineral Analysis

During the heavy mineral separations visible gold grains were identified in seven till samples. The shape and dimensions of the seven grains is indicated in Table 3. The delicate and irregular shaped grains have probably undergone at least some glacial transport although experience from the Agassiz deposit indicates the transport distance was not more than 200-300 m.

Point counting of the 13 heavy mineral samples along the transect A-A' (Fig. 6) indicates the heavy fraction consists of the ten minerals listed in Table 4.

Opaques (mainly ilmenite), hornblende and epidote were derived from the underlying iron formation and volcanic rocks around Farley Lake. This local suite of minerals constitute more than 60% of the non-magnetic heavy mineral fraction (Fig. 10).

Table 3. Characteristics of visible gold grains from till samples.

Sample No.	Grain Shape	Dimensions (microns)
DG84-		
53	Irregular	200 x 250
118	Irregular	100 x 100
165	Irregular	50 x 100
171	Abraded	100 x 150
180	Delicate	100 x 300
198	Abraded	200 x 250
213	Abraded	100 x 150

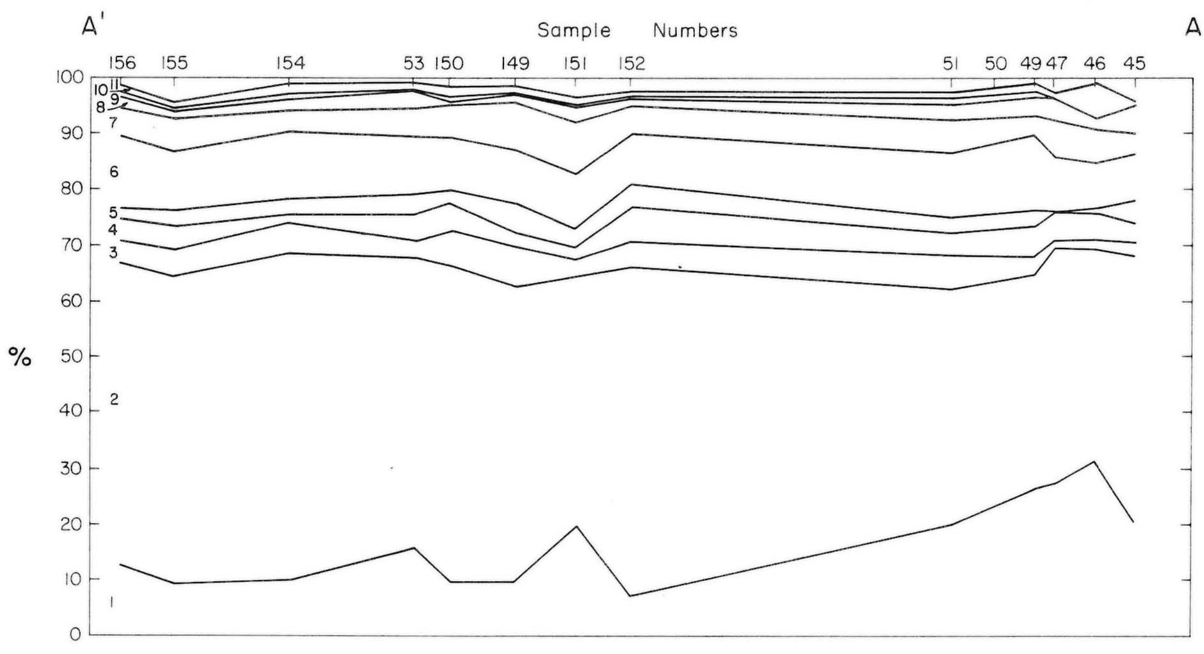

Figure 10: Mineralogy of the heavy mineral fraction of samples along the transect A-A'. The minerals are (1) opaques, (2) hornblende, (3) epidote, (4) hypersthene, (5) clinopyroxene, (6) garnet, (7) apatite, (8) zircon, (9) rutile, (10) sphene, (11) others.

Table 4. Mineralogy of the heavy mineral fraction of till samples along the transect A-A'.

	SAMPLE NUMBER												
Mineral	45	46	47	49	51	53	149	150	151	152	154	155	156
Opaques	20.4	31.8	27.6	26.7	20.0	15.9	9.8	9.7	19.8	7.5	10.0	9.6	12.7
Hornblende	47.7	37.6	42.2	38.1	42.3	51.9	52.8	56.6	44.7	58.7	58.5	54.8	53.8
Epidote	3.1	1.8	1.3	3.2	5.4	3.2	7.2	5.7	3.3	5.0	5.3	5.0	3.8
Garnet	8.0	8.1	10.1	13.7	11.8	10.1	9.8	9.7	9.8	9.3	12.1	10.9	13.0
Hypersthene	3.1	4.6	4.9	5.5	4.6	4.6	2.7	5.0	2.1	5.9	1.5	4.3	4.1
Clinopyroxene	4.0	1.0	0.0	2.6	2.6	3.7	5.0	2.5	3.2	3.6	2.9	2.3	1.9
Apatite	4.0	6.1	6.5	3.5	5.7	5.2	8.5	6.1	9.5	4.9	3.8	5.6	5.4
Zircon	5.0	1.8	0.3	3.5	2.9	3.2	1.6	0.3	2.4	1.6	2.4	1.7	1.9
Rutile	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.3	0.3	0.3	0.3	0.3	0.3
Sphene	0.6	6.5	1.0	1.5	1.1	1.2	1.3	2.2	1.5	1.0	2.1	1.0	1.6
Other	4.0	0.6	2.6	0.9	2.9	1.2	1.3	1.8	3.6	2.3	1.2	4.6	1.3

The remaining heavy minerals were derived from multiple sources north of Farley Lake and are indicators of provenance of the far-travelled component of the till.

Garnet which constitutes between 8 and 13% of the non-magnetic heavy mineral fraction was probably derived from the South Indian gneiss belt and may be associated with the greywacke identified in the pebble fraction. The metasediments in the Brooks Bay area may also have contributed garnet to the till in the Farley Lake area although it is questionable if these sediments extend far enough west to have affected the Farley Lake region which contains garnetiferous till throughout.

Hypersthene and clinopyroxene were probably derived from the Melvin Lake area 30 km north of Farley Lake (Gilbert, pers. comm.) although the clinopyroxene may have been derived in part from various intrusive bodies north of the South Indian gneisses (Schledewitz, pers. comm.).

Apatite, zircon, rutile and sphene, which constitute 7.8% to 14.4% of the non-magnetic fraction, were probably derived from the intrusive and gneissic terranes to the north.

The high concentration of locally derived heavy minerals (62.3-72.0%), as compared to the low concentration of locally derived pebbles in the coarse fraction (0.5-9.0%), is a function of the durability of the different rock types and differences in the heavy mineral content of the source rocks. The intrusive rocks which constitute the bulk of the till consist primarily of quartz and feldspar with accessory minerals forming only a few per cent of the total composition. The volcanic rocks and the iron formation, on the other hand, consist of 30-50% heavy minerals. Consequently, the addition of only a small amount of local material would contribute significantly to the heavy mineral fraction.

Silt and Clay Composition

X-ray diffraction patterns of the coarse fraction of the samples analyzed indicates they consist primarily of quartz, K-feldspar, plagioclase with minor amounts of muscovite, chlorite and amphibole. This is consistent with observations made during sieve analysis which indicated the fine sand fraction is composed primarily of quartz and feldspar with minor heavy minerals. Comparison of the X-ray diffractograms of the coarse silt, fine silt and clay-sized fractions (Fig. 11) indicates a gradual decrease in the height of the quartz peaks and a corresponding increase in the chlorite peak with decreasing grain size.

Although most of the fine fractions are composed primarily of quartz and feldspar, a decrease in these minerals is accompanied by a relative increase in chlorite and muscovite. The increase in phyllosilicates with their high cation absorption properties in the fine fractions favours geochemical analysis of the less than 2 micron fraction.

Geochemistry

HEAVY MINERAL FRACTION

The results of the geochemical analysis of 244 till samples are listed in Appendix I. Diagrams showing the frequency distribution of the ten elements are shown in Figure 12 and the summary statistics are listed in Table 5.

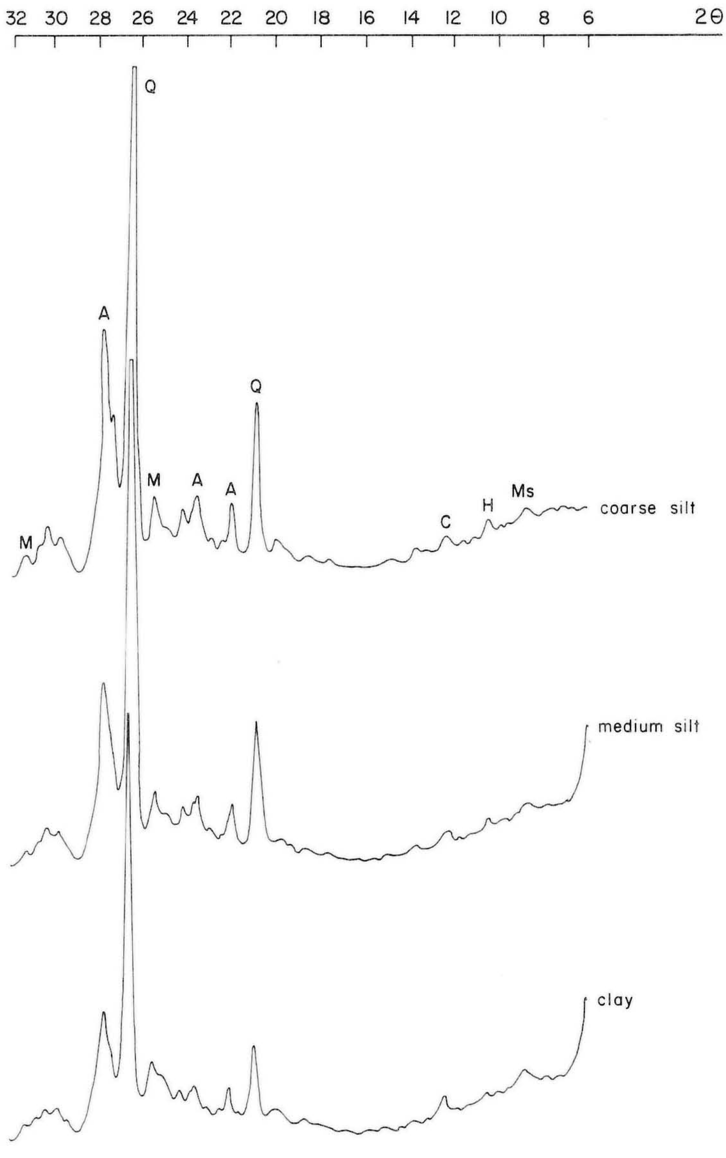

Figure 11: X-ray diffractograms of the different silt and clay-sized fractions of sample 45. The peaks are (Q) quartz, (A) albite, (H) hornblende, (M) microcline, (MS) muscovite, and (C) chlorite.

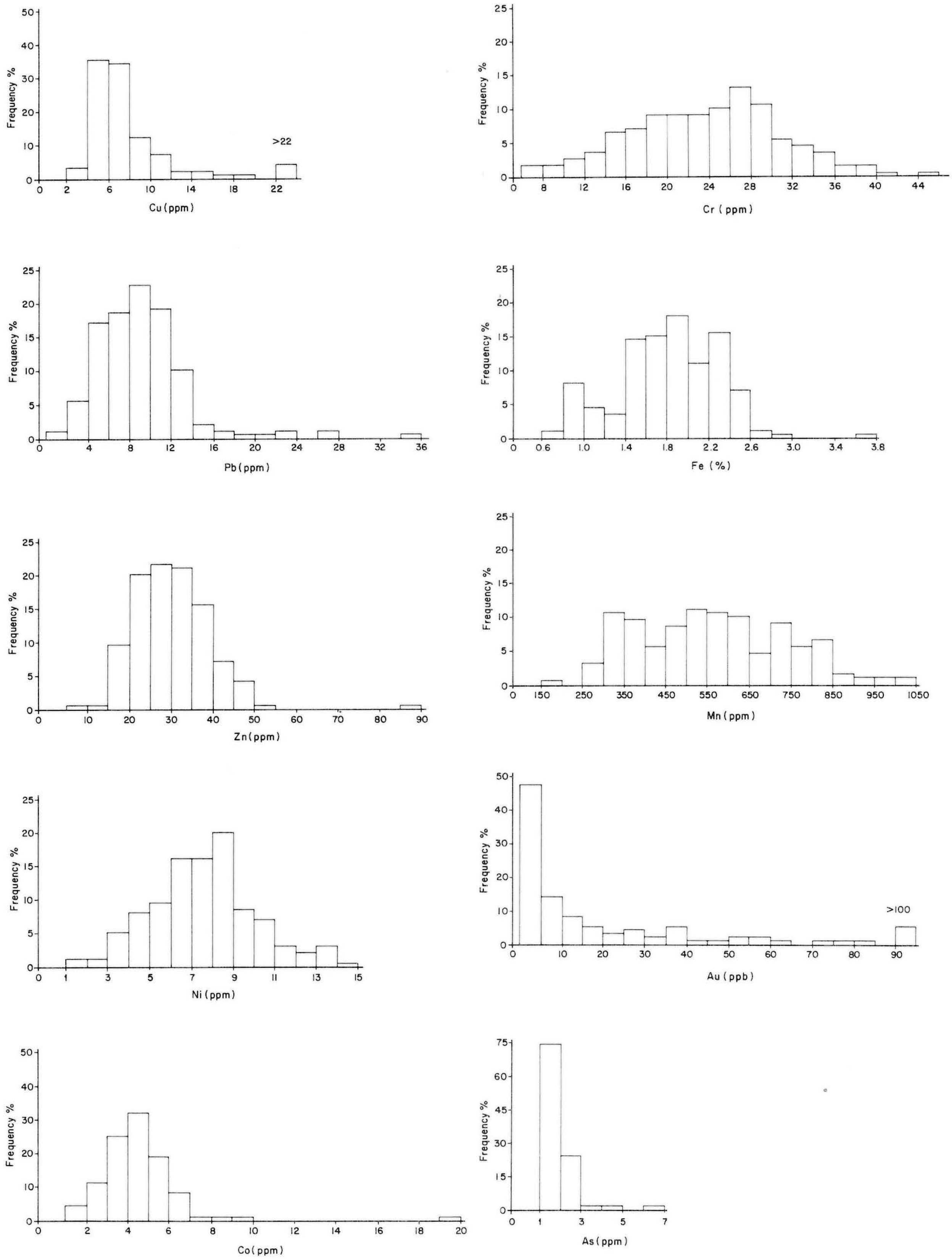

Figure 12: The distribution of element concentration in 244 heavy mineral concentrates.

Table 5. Summary statistics for 244 heavy mineral concentrates.

VARIABLE:	Cu	Pb	Zn	Ni	Co	Cr	Fe	Mn	Au	As
NUMBER OF OBSERVATIONS:	244	244	244	244	244	239	244	244	243	243
MINIMUM:	3.000	1.000	5.000	1.000	1.000	6.000	0.700	180.000	2.000	1.000
MAXIMUM:	58.000	34.000	89.000	14.000	19.000	45.000	3.700	1,000.000	1,030.000	6.000
MEAN:	7.738	8.299	29.791	7.111	3.910	22.958	1.763	556.607	25.210	1.292
STANDARD ERROR OF MEAN:	0.411	0.269	0.567	0.157	0.105	0.454	0.031	11.259	5.491	0.037
STANDARD DEVIATION:	6.415	4.194	8.856	2.453	1.641	7.026	0.491	175.877	85.594	0.576
COEFFICIENT OF VARIATION:	82.911	50.540	29.727	34.496	41.960	30.605	27.838	31.598	339.525	44.566
SKEWNESS:	4.248	1.912	1.326	0.224	3.240	-0.013	-0.039	0.243	8.635	3.245
KURTOSIS:	22.380	7.677	6.920	0.076	27.816	-0.218	0.327	-0.750	87.293	18.632

Note: Au analysis is in ppb and Fe analysis is in per cent. The rest of the analyses are in ppm.

Vertical variations in the geochemistry of the heavy mineral fracion in profile number 26 are shown in Figure 13. Cu, Pb, Zn, Ni and Fe have high values in the Lake Agassiz sediment at the top of the section. Cr and Ni show a slight increase toward the bottom of the hole; otherwise, there appears to be no systematic trends through the profile. Gold in the heavy mineral fraction has a characteristically spiky distribution that is independent of sampling depth similar to the vertical distribution found in profiles at Agassiz.

Anomalous gold values are found in a number of areas, notably at sites 53, 180, 213, 198 and 118 where high gold values are associated with the occurrence of visible gold (Fig. 14). However, the shape of the anomalies does not indicate any significant glacial transport. The anomalies, based on the characteristics of the visible gold grains and from comparison with gold anomalies and sample spacing at the Agassiz deposit, are believed to be reflecting mineralized bedrock within 100-200 m of the anomaly in the up-ice direction.

Gold is not correlated at a significant level with the other elements (Table 6).

CLAY-SIZED FRACTION

The results of the geochemical analyses of the 244 till samples are listed in Appendix II. The frequency distribution of nine elements are shown in Figure 15 and the summary statistics are listed in Table 7.

There is significant vertical variation in the geochemistry of the less than 2 micron fraction as indicated by the profile at site 26 (Fig. 16). Cu, Zn, Co, Cr, Mn, Fe and As show significant increases in concentration with

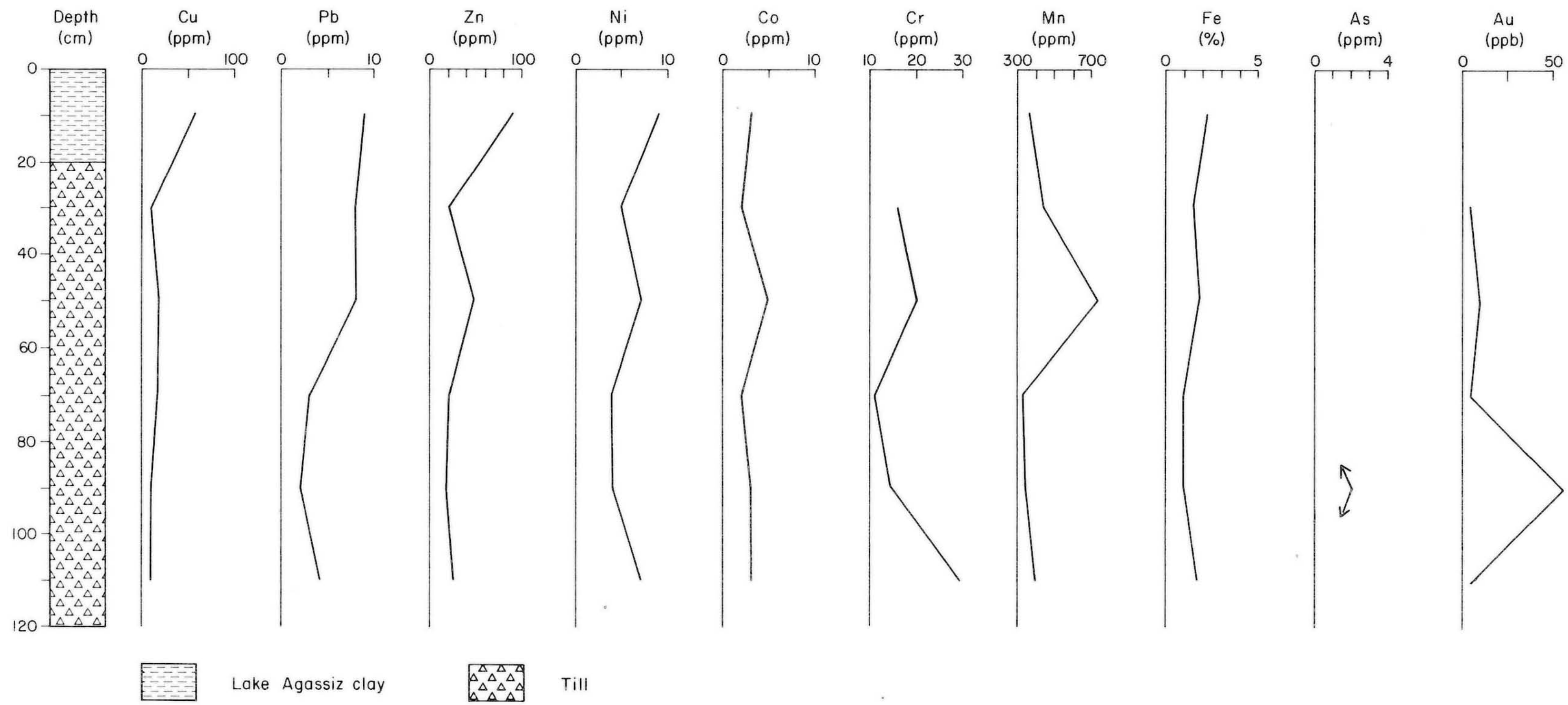

Figure 13: Vertical variation in the element concentration of heavy minerals at site 26.

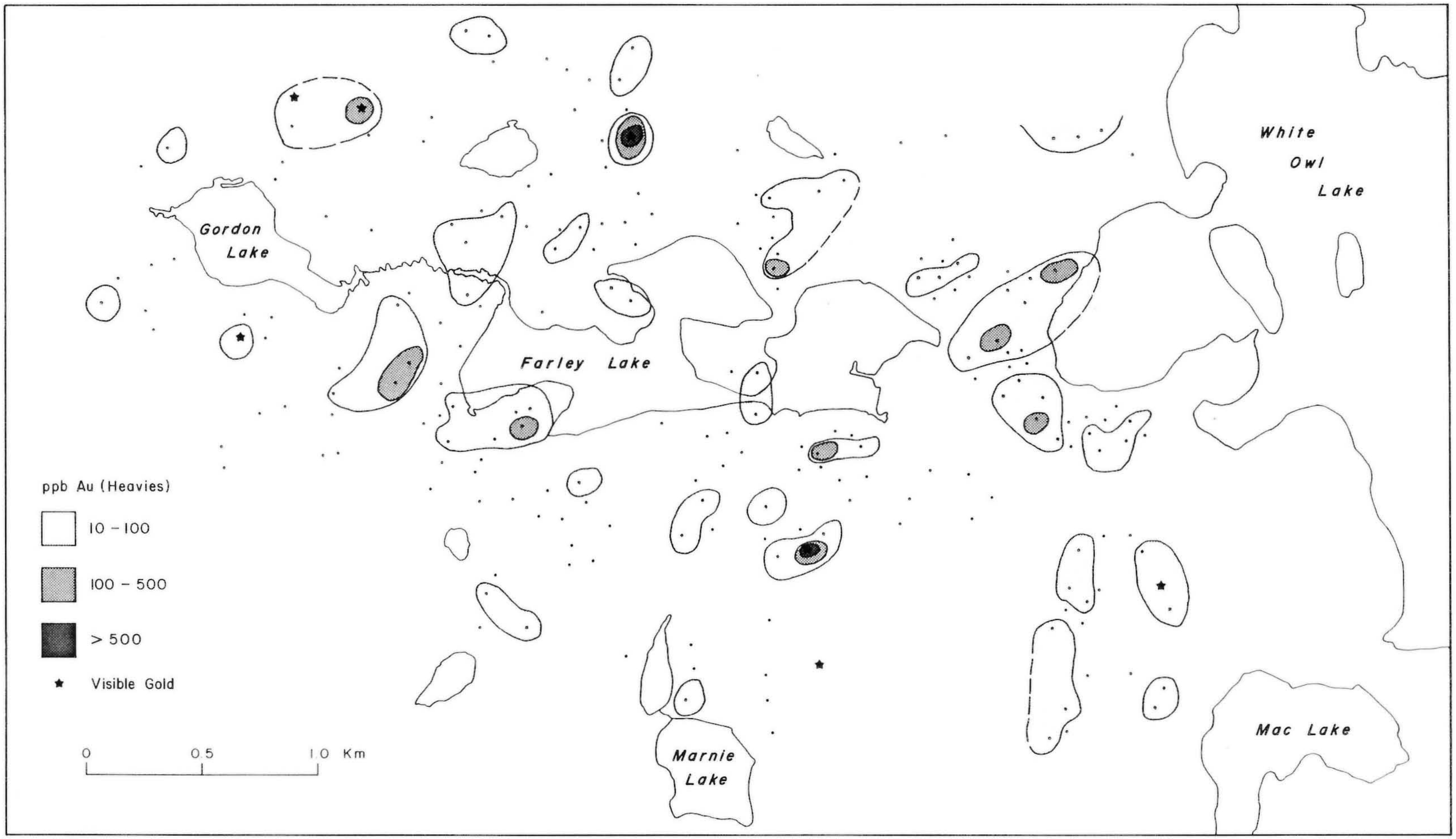

Figure 14: Regional variation in the gold content of heavy mineral samples.

Table 6. Pearson linear correlation matrix for heavy mineral concentrates of 244 till samples.

	Cu	Pb	Zn	Co	Ni	Cr	Mn	Fe	Au	As
Cu	1.000	-0.022	0.269	0.095	0.083	0.070	-0.105	-0.015	0.085	-0.044
Pb		1.000	0.177	0.086	-0.140	-0.057	-0.453	0.436	0.076	-0.048
Zn			1.00	0.493	0.460	0.602	0.636	0.610	0.038	0.184
Co				1.000	0.485	0.563	0.494	0.527	0.048	0.146
Ni					1.000	0.785	0.424	0.336	0.014	0.139
Cr						1.000	0.547	0.551	0.014	0.180
Mn							1.000	0.833	0.013	0.179
Fe								1.000	0.083	0.181
Au									1.000	0.204
As										1.000

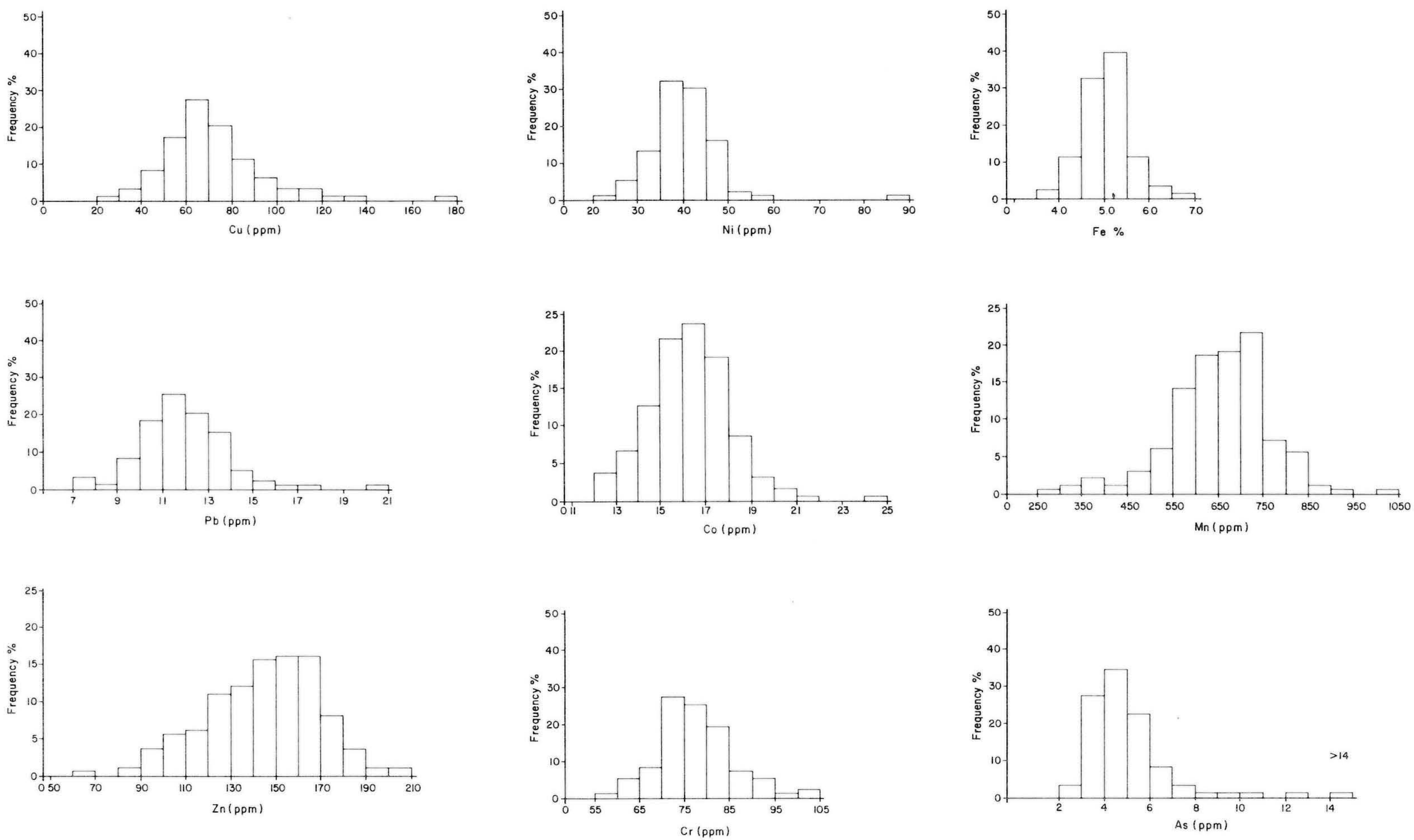

Figure 15: The distribution of element concentration in 244 clay-sized samples.

Table 7. Summary statistics for 244 analyses on the less than 2 micron fraction.

VARIABLE:	Cu	Pb	Zn	Ni	Co	Cr	Fe	Mn	As
NUMBER OF OBSERVATIONS:	244	244	244	244	244	244	244	244	243
MINIMUM:	26.000	7.000	64.000	23.000	12.000	57.000	3.700	280.000	2.000
MAXIMUM:	172.000	20.000	203.000	85.000	24.000	104.000	6.600	1,000.000	73.000
MEAN:	69.398	11.369	144.307	39.336	15.770	76.701	4.991	646.844	4.656
STANDARD ERROR OF MEAN:	1.265	0.120	1.564	0.430	0.115	0.520	0.031	6.754	0.301
STANDARD DEVIATION:	19.758	1.867	24.436	6.725	1.793	8.126	0.486	105.497	4.705
COEFFICIENT OF VARIATION:	28.471	16.420	16.934	17.095	11.369	10.595	9.736	16.310	101.056
SKEWNESS:	1.116	0.714	-0.340	1.247	0.422	0.414	0.043	-0.527	12.659
KURTOSIS:	3.035	3.091	-0.201	7.741	1.316	0.749	0.445	1.289	179.678

Note: Fe analysis is in per cent. All other analyses are in ppm.

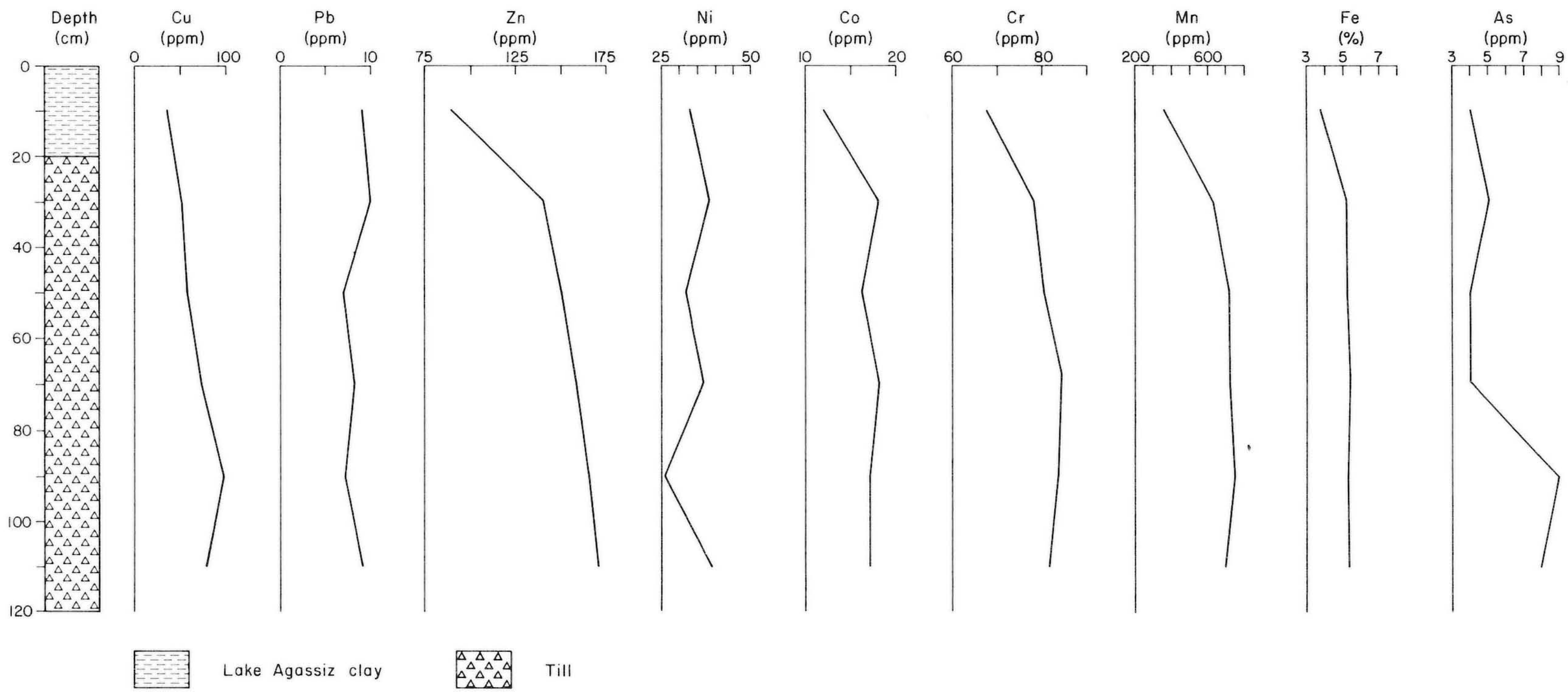

Figure 16: Vertical variation in the element concentration of the less than 2 micron size fraction at site 26.

depth. Arsenic especially shows increased concentrations below a depth of 80 cm, emphasizing the need for obtaining relatively unoxidized grey till. Experience in the Lynn Lake area has shown that samples collected from a depth of 80-100 cm are usually adequate.

There is only slight regional variation in the distribution of As (Fig. 17). Comparison of As anomalies in the clay-sized fraction with gold anomalies in the heavy mineral fraction (Fig.14) shows some similarities although many of the gold anomalies do not have corresponding arsenic anomalies. None of the samples with visible gold have anomalous arsenic values associated with them.

Table 8 shows the correlation between the nine elements that were analyzed on the clay-sized fraction. There is no significant correlation between arsenic and the other elements.

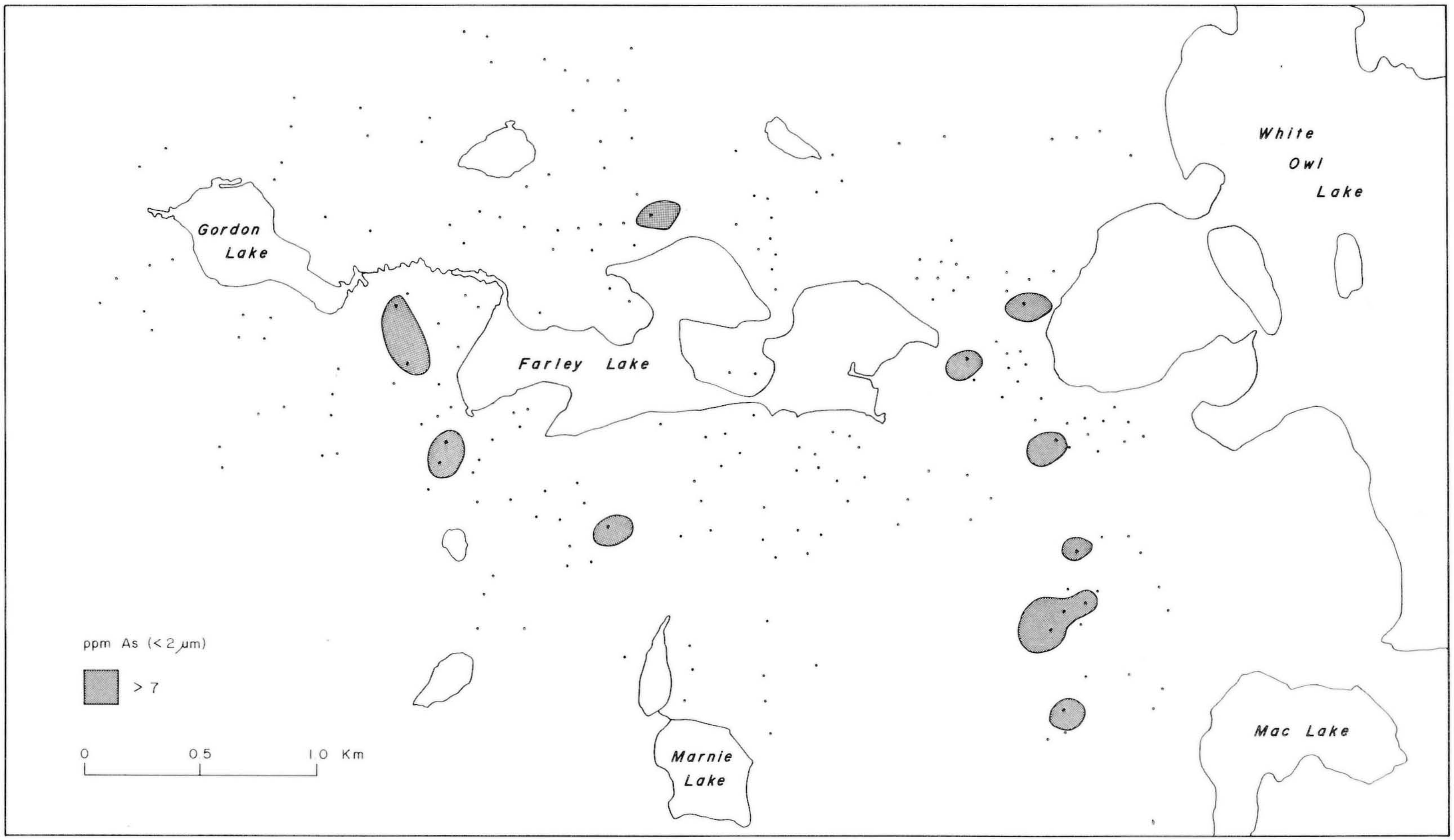

Figure 17: Regional variation in the arsenic content of the clay-sized fraction.

Table 8. Pearson linear correlation matrix for the clay-sized fraction of 244 till samples.

	Cu	Pb	Zn	Co	Ni	Cr	Mn	Fe	As
Cu	1.000	0.026	0.160	0.104	0.277	0.080	0.227	0.248	0.253
Pb		1.000	0.016	0.032	0.041	-0.172	-0.072	0.095	0.101
Zn			1.000	0.140	0.481	0.481	0.575	0.737	-0.043
Co				1.000	0.223	0.335	0.451	0.332	0.058
Ni					1.000	0.425	0.315	0.376	0.074
Cr						1.000	0.419	0.688	-.012
Mn							1.000	0.483	-0.053
Fe								1.000	0.092
As									1.000

CONCLUSIONS

Analysis of the pebble, the heavy mineral and silt plus clay fractions, as well as the grain size distribution of a limited number of samples, indicates the till in the Farley Lake area was derived primarily by the comminution of material derived from the area north of the greenstone belt. Only a small fraction of the till was derived from the underlying bedrock. The heavy mineral fraction is preferentially enriched in locally derived material because of the high heavy mineral content of the local bedrock compared to that of the areas to the north. The clay-sized fraction, because of its cation absorption properties and its relative depletion in quartz and feldspar, is also a useful fraction for geochemical analysis.

There is some vertical variation in the distribution of elements through the upper metre of till and care must be taken to obtain relatively fresh, grey till for analysis of the less than 2 micron fracion. This is especially true for arsenic. The gold content in the profile is variable and both oxidized and unoxidized till may be sampled if the heavy mineral concentrates are analyzed.

Arsenic analysis of the clay-sized fraction, a technique which proved effective around the Agassiz deposit, does not indicate the presence of extensive gold mineralization outcropping at the surface in the Farley Lake area. Gold counts and gold analysis on the heavy mineral fraction indicates several anomalous areas located both north and south of Farley Lake. Several areas notably around sample sites 53, 180, 198, 213 and 118 have indications of mineralization and warrant further detailed sampling. There is no distinctive glacial dispersion train associated with the gold anomalies. The general lack of evidence of glacial dispersion is believed to be the result of the relatively short distance of dispersion of the local component of the till and the relatively large sample spacing compared to the size of the anomalies.

REFERENCES

Carver, R. E. (ed.)

1971: Procedures in sedimentary petrology; Wiley-Interscience, Toronto, 653 p.

DiLabio, R.N.W., Rencz, A.N., and Egginton, P.A.

1982: Biogeochemical expression of a classic dispersal train of metalliferous till near Hopetown, Ontario; Canadian Journal of Earth Sciences, V. 19, p. 2297-2305.

Dredge, L.A.

1981: Trace elements in till and esker sediments in northwestern Manitoba; in Current Research, Part A, Geological Survey of Canada, Paper 81-1A, p. 377-381.

1983a: Uranium and base metal concentrations in till samples from northern Manitoba; Geological Survey of Canada, Open File 931.

1983b: Uranium and base metal concentrations in till samples from northern Manitoba; in Current Reserch, Part B, Geological Survey of Canada, Paper 83-1B, p. 303-307.

Dreimanis, A. and Vagners, U. J.

1971: Bimodal distribution of rock and mineral fragments in basal till; in Till /a symposium. Edited by R. P. Goldthwait, Ohio State University Press, p. 237-250.

Fedikow, M.A.F.

1983: Geological and geochemical Studies at the Agassiz Au-Ag deposit, Lynn Lake, Manitoba; in Manitoba Mineral Resources Division, Report of Field Activities, 1983, p. 94 - 97.

1984: Preliminary results of biogeochemical studies in the Lynn Lake area; Manitoba Mineral Resources Division, Open File Report OF84 1, 104 p.

Fedikow, M.A.F., Kramarchuk, B. and Charlesworth R. B.

1984: Geochemical studies along the Agassiz Metallotect; in Manitoba Mineral Resources Division, Report of Field Activities, 1984, p.29-31.

Folk, R. L.

1968: Petrology of sedimentary rocks; Hemphill's University of Texas, Austin, Tesas, 170 p.

Gilbert, H.P.

1979: Preliminary map 1979L-2., Melvin Lake Area (64F/1);Manitoba Mineral Resources Division.

1980a:Preliminary map 1980L-1, Barrington Lake (64C/16); Manitoba Mineral Resources Division.

1980b:Melvin Lake Project (64B/13 & 64C/16); in Manitoba Mineral Resources Division, Report of Field Activities, 1980, p.8 - 13.

Klassen, R.A., and Shilts, W.W.

1977: Glacial dispersal of uranium: District of Keewatin, Canada; in Prospecting in areas of glaciated terrain, 1977. Institution of Mining and Metallurgy, London, England, p. 80-88.

Manitoba Mineral Resources Division

1979: Geological Map of Manitoba, Scale 1:1 000 000 Map 79-2.

Nielsen, E.

1982: Overburden sampling in the Lynn Lake area; in Manitoba Mineral Resources Division, Report of Field Activities, 1982, p. 81-83

1983: Overburden sampling in the Lynn Lake area; in Manitoba Mineral Resources Division, Report of Field Activities, 1983, p. 98-100.

Nielsen E. and Dredge, L.A.

1982: Quaternery stratigraphy and geomorphology of a part of the lower Nelson River; Geological Association of Canada, Field Trip Guidebook, Winnipeg, 46 p.

Nielsen, E. and Graham, D. C.

1984: Till geochemical investigations in the Lynn Lake and Flin Flon areas; in Manitoba Mineral Resources Division, Report of Field Activities, 1984, p. 32-36.

O'Donnell, N.D.

1976(a): Pleistocene geology of the Lynn Lake area; in Manitoba Mineral Resources Division, Report of Field Activities, 1976, p. 45-46.

1976(b): Preliminary map 1976P-1 Quaternary geology of the Lynn Lake area 64C/14; Mineral Resources Division.

1976(c): Preliminary map 1976P-2 Quaternary geology of the Cockeram Lake area 64C/15: Mineral Resources Division.

1976(d): Quaternary geology of the Lynn Lake area; unpublished report.

Questor

1977: Airborne INPUT Survey, Lynn Lake and Barrington Lake areas (Phase I and II); Manitoba Mineral Resources Division, Miscellaneous Publication.

Ringrose, S. and Large, P.

1977: Quarternary geology and gravel resources of the Leaf Rapids Local Government District; Manitoba Mineral Resources Division, Geological Report GR77-2, 93 p.

Shilts, W.W.

1975: Principles of geochemical exploraton for sulphide deposits using shallow samples of glacial drift; Canadian Institute of Mining and Metallurgy Bulletin, 68, p. 73-80.

1976: Mineral exploration and till; in Glacial till. Edited by R. F. Legget. Royal Society of Canada, Special Publicaton 12, p. 205-224.

1977: Geochemistry of till in perennially frozen terrain of the Canadian Shield, application to prospecting; Boreas, 5, p. 203-212.

1984: Till Geochemistry in Finland and Canada; Journal of Geochemical Exploration, 21,p. 95 -117.

Shilts, W.W. and Rencz, A.N.

1980: Nickel in soils and vegetation of glaciated terrains; in Nickel in the environment. Edited by J.O. Nriagu. John Wiley and Sons, Toronto, Ontario, p. 151-188.

APPENDIX I

RESULTS OF GEOCHEMICAL ANALYSIS ON THE HEAVY MINERAL FRACTION.

ELEMENT

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
PREFIX DG84-										
1	9	6	20	3	6	20	340	1.2	5	L2
2	4	2	21	1	5	18	335	0.8	25	L2
3	4	6	39	5	8	28	880	2.5	L 5	L2
4	5	8	36	5	10	28	760	2.5	L 5	L2
5	7	4	23	4	6	32	300	1.4	L 5	L2
6(A)	5	7	31	5	11	26	600	1.8	L 5	L2
6(B)	5	6	43	8	11	36	780	2.3	L 5	L2
7	5	34	36	4	8	26	645	1.9	15	L2
8	7	6	33	6	8	28	720	2.3	130	2
9	5	6	20	3	6	28	300	1.3	L 5	L2
10	6	5	18	2	5	26	260	1.1	15	L2
11	4	2	20	3	5	16	290	0.9	10	L2
12	4	4	17	2	5	21	260	1.2	115	L2
13	4	7	36	5	7	27	650	2.0	80	L2
14	6	8	19	3	6	21	325	1.4	5	L2
15	5	7	19	2	7	22	340	1.5	L 5	L2
16	5	3	18	4	6	27	320	1.5	5	L2
17	5	5	17	2	6	25	380	1.6	L 5	L2
18	6	3	24	3	9	38	365	1.7	L 5	L2
19	5	10	30	4	5	22	720	2.0	10	2
20	6	6	35	4	9	26	800	2.3	L 5	L2
21	4	5	19	2	6	23	290	1.3	L 5	L2
22	5	3	17	2	6	22	290	1.2	L 5	L2
23	5	8	31	3	6	22	580	1.9	20	L2
24	5	4	22	2	5	18	400	1.7	L 5	2
25	10	5	17	1	6	25	270	1.4	L 5	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
26	8	4	26	2	6	12	350	1.0	35	L2
26 (0-20 cm)	58	9	89	3	9	-	365	2.2	IS	IS
26 (100-120 cm)	8	4	24	3	7	29	390	1.6	L 5	L2
26 (20-40 cm)	10	8	21	2	5	16	440	1.5	L 5	L2
26(40-60 cm)	17	8	50	5	7	20	730	1.7	10	L2
26(60-80 cm)	14	3	21	2	4	11	320	0.9	L 5	L2
26(80-100 cm)	9	2	19	3	4	14	330	0.9	55	2
27	11	7	20	4	6	26	350	1.7	L 5	2
28	23	2	18	2	6	28	360	1.4	20	L2
29	12	4	19	4	8	27	365	1.4	5	L2
30	5	4	18	2	4	14	265	1.0	5	2
30 (40-60 cm)	5	5	21	3	8	29	365	1.5	L 5	L2
30 (60-80 cm)	7	5	22	3	7	30	360	1.6	L 5	L2
30(0-20 cm)	5	4	19	3	3	9	310	1.1	5	L2
30(20-40 cm)	3	4	18	1	4	9	330	1.0	L 5	2
30(80-100 cm)	7	4	17	1	4	7	300	0.8	L10	L2
31	5	4	19	2	5	21	320	1.5	5	L2
32	6	5	22	3	5	18	365	1.5	10	L2
33	6	6	24	3	5	18	380	1.5	5	L2
34	6	5	21	3	7	23	330	1.6	L 5	L2
35	7	4	26	5	8	25	450	1.9	5	L2
36	7	5	28	3	9	23	460	2.0	L 5	L2
37	6	5	29	5	8	-	500	2.0	L 5	L2
38	5	9	34	5	7	18	640	2.8	10	L2
39	6	6	34	5	7	20	540	2.5	5	L2
40	7	11	45	6	12	26	765	3.0	L 5	L2
41	6	12	34	4	7	20	560	2.4	50	L2
42	17	8	34	6	9	-	515	2.2	L 5	L2
43	7	6	32	4	7	20	520	2.3	L 5	2
44	8	10	29	4	9	24	540	2.1	L 5	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
45	7	6	28	4	7	24	565	2.1	20	L2
46	7	8	28	4	7	20	590	2.0	L 5	2
47	7	6	33	4	7	26	670	2.2	L 5	L2
48	6	15	49	6	9	-	1000	3.7	35	L2
49	10	4	18	1	2	6	375	0.8	L 5	L2
50	10	5	28	3	4	11	495	1.2	140	L2
50(10-35 cm)	3	3	14	1	3	6	180	0.7	25	L2
50(35-45 cm)	3	4	19	2	4	10	360	1.0	L 5	2
50(45-65 cm)	5	3	27	3	5	11	360	1.0	L 5	2
50(65-85 cm)	6	4	25	4	6	14	365	1.0	L 5	L2
50(85-105 cm)	5	L2	22	3	7	15	330	0.9	L 5	L2
50(105-125 cm)	8	L2	25	4	8	17	310	1.0	L 5	L2
51	7	10	34	4	7	22	740	2.4	5	2
52	4	11	30	3	4	21	520	2.2	L 5	L2
53	6	8	34	3	8	30	720	2.4	620	2
54	6	10	33	6	8	30	720	2.5	50	2
55	6	L2	26	3	8	14	365	1.1	185	2
56	7	6	46	6	10	34	830	2.5	5	L2
57	6	9	29	4	6	18	800	2.2	L 5	L2
58	6	12	20	2	3	12	530	1.7	L 5	L2
59	7	8	33	5	8	-	700	2.4	15	L2
60	5	13	27	4	3	17	780	2.3	L 5	2
61	4	14	20	3	3	13	530	1.9	L 5	L2
62	4	13	25	4	4	14	600	2.0	L 5	2
63	5	10	22	3	3	13	470	1.8	90	2
64	7	10	32	5	8	27	700	2.3	5	L2
65	12	6	31	5	8	30	620	2.2	25	L2
66	4	10	30	4	6	23	640	2.1	10	L2
67	5	11	33	4	5	26	660	2.4	50	L2
68	8	10	33	9	8	26	760	2.5	5	2
69	13	2	36	5	7	28	560	2.2	245	2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
70	4	8	42	4	2	16	760	2.7	L 5	L2
71	9	5	29	3	5	23	490	1.9	25	L2
72	5	17	26	3	L2	14	740	2.3	L10	L2
73	3	13	21	1	3	11	470	1.8	L 5	2
74	4	16	23	2	3	15	1000	2.4	55	L2
75	4	20	22	3	6	19	850	2.6	10	L2
76	9	7	26	4	7	28	460	1.8	5	2
77	7	5	34	3	5	24	540	1.9	5	2
78	6	6	42	5	11	31	605	2.2	5	2
79	6	4	28	4	8	28	545	2.0	5	2
80	6	23	28	4	5	19	955	2.6	30	L2
81	6	5	33	5	9	28	600	2.2	L 5	2
82	6	7	31	19	9	31	560	2.0	L 5	L2
83	6	6	27	5	8	24	470	1.8	5	L2
84	10	5	25	4	7	22	420	1.7	15	6
85	4	3	18	2	8	16	300	0.8	5	L2
86	3	4	21	2	5	14	330	0.8	35	L2
87	4	3	21	2	6	16	310	0.8	15	L2
88	5	4	22	3	8	18	305	0.8	15	L2
89	5	14	35	5	10	34	640	2.3	L 5	2
90	4	22	26	4	4	14	700	2.2	120	L2
91	5	16	15	2	L2	8	425	1.5	L10	L2
92	6	19	18	3	2	12	500	1.8	75	L2
93	4	26	22	2	4	19	910	2.6	L 5	L2
94	6	26	28	4	4	17	960	2.7	115	L2
94(10-30 cm)	3	12	21	3	4	8	340	1.8	L 5	L2
94(30-50 cm)	4	9	38	4	6	22	550	1.9	60	2
94(50-70 cm)	6	11	39	4	6	20	695	2.0	50	L2
94(70-90 cm)	6	10	47	6	8	27	720	2.2	70	3
94(90-110 cm)	18	9	35	4	6	20	500	1.5	35	L2
95	5	8	27	3	6	21	445	1.6	50	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
96	7	10	39	5	13	34	780	2.5	L 5	2
97	22	10	35	5	8	26	600	1.7	30	L2
98	4	5	23	2	3	13	310	0.8	L 5	L2
99	5	9	46	5	10	28	800	2.2	10	L2
100	30	10	36	4	6	19	520	1.6	35	L2
101	8	4	25	1	8	18	360	1.0	10	L2
102	17	10	32	6	8	24	585	1.8	15	L2
103	18	10	32	5	8	26	525	1.8	25	2
103(110-130 cm)	7	9	42	5	8	32	860	2.3	5	L2
103(30-50 cm)	36	10	27	6	8	24	555	1.8	40	L2
103(50-70 cm)	38	12	36	5	10	32	565	2.0	35	L2
103(70-90 cm)	8	8	32	5	8	27	540	1.8	35	L2
103(90-110 cm)	10	9	40	6	8	31	660	2.0	10	L2
104	6	8	29	4	6	26	680	1.9	L 5	L2
105	8	8	24	5	8	24	475	1.5	10	L2
106	6	7	35	5	10	32	840	2.2	L 5	2
107	8	8	29	5	7	25	720	1.8	L 5	L2
108	7	7	5	5	10	26	560	1.6	60	L2
109	5	4	20	2	7	16	300	0.7	30	L2
110	4	7	34	4	11	32	770	2.0	L 5	2
111	4	8	27	3	9	28	600	1.8	25	L2
112	10	12	32	5	10	30	700	2.0	5	L2
113	4	9	33	6	13	38	920	2.2	L 5	2
114	8	8	31	4	11	28	720	2.0	L 5	2
115	9	8	37	5	14	36	760	2.1	10	2
116	10	8	26	4	8	24	530	1.5	5	L2
117	10	9	28	4	7	24	475	1.5	25	L2
118	7	7	27	3	7	22	457	1.6	20	2
119	15	9	36	4	8	28	590	1.8	15	L2
120	18	12	30	4	7	27	525	1.7	55	L2
121	38	6	28	4	7	22	450	1.6	20	L2
122	9	7	22	4	6	20	415	1.5	30	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
123	5	11	25	3	9	24	720	1.8	L 5	L2
124	6	10	31	4	6	19	550	1.5	L 5	L2
125	6	9	32	4	6	21	600	1.7	15	L2
126	4	10	27	4	9	23	630	1.8	L 5	L2
127	6	10	32	5	8	26	600	1.8	L 5	L2
128	5	11	34	3	10	29	760	1.9	L 5	L2
129	8	10	34	6	8	26	650	1.9	25	L2
130	4	4	23	3	7	16	360	0.9	10	L2
131	30	8	32	4	8	26	525	1.6	5	L2
132	4	6	20	3	7	17	315	0.8	10	L2
133	3	4	24	3	6	16	360	0.9	10	L2
134	8	10	32	4	6	20	505	1.5	15	L2
135	3	7	23	1	7	14	370	0.8	L 5	L2
136	10	12	30	3	9	26	720	1.8	L 5	L2
137	10	10	28	4	6	22	435	1.5	L 5	L2
138	6	7	41	6	12	35	900	2.2	5	2
139	10	10	28	3	5	16	400	1.3	L 5	L2
140	5	8	29	4	10	25	560	1.5	15	2
141	6	6	21	3	8	18	365	0.9	5	L2
142	6	4	23	3	8	18	310	0.8	20	L2
143	5	11	37	3	7	28	820	2.0	L 5	L2
144	40	9	26	4	7	20	410	1.4	25	L2
145	5	8	31	3	9	23	600	1.6	35	2
146	6	8	26	3	8	25	600	1.7	L 5	2
147	8	6	26	3	9	26	600	1.5	5	2
148	6	9	32	4	7	24	525	1.7	30	2
149	5	6	43	7	13	38	840	2.3	45	2
150	5	6	30	3	11	26	560	1.6	L 5	2
151	8	9	24	4	6	18	370	1.3	L 5	L2
152	7	9	30	4	8	24	540	1.7	L 5	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
153	8	9	30	4	8	25	550	1.6	L 5	L2
154	7	8	24	4	8	24	500	1.5	L 5	L2
155	6	9	29	3	10	26	600	1.6	10	L2
156	6	8	31	5	13	29	680	1.8	5	L2
157	5	8	26	3	8	24	480	1.5	L 5	L2
158	6	10	30	4	13	29	800	2.0	35	L2
159	7	8	39	4	7	28	720	1.9	L 5	2
160	4	6	34	5	8	30	680	2.2	L 5	2
161	8	8	24	4	6	18	410	1.3	L 5	L2
162	8	10	45	4	7	22	525	1.6	10	L2
163	7	8	28	4	5	18	475	1.6	L 5	L2
164	11	8	24	4	6	18	425	1.4	L 5	2
165	6	9	47	6	9	45	740	2.3	10	2
166	22	8	27	4	7	22	450	1.5	5	L2
167	6	10	26	3	7	21	495	1.5	L 5	L2
168	6	10	28	3	5	17	475	1.4	L 5	L2
169	5	10	28	3	6	21	445	1.4	L 5	L2
170	4	7	48	5	7	26	840	2.3	5	L2
171	6	12	43	4	8	25	735	1.9	20	L2
172	6	12	36	5	10	32	620	1.9	L 5	L2
173	7	10	40	6	8	35	780	2.2	L 5	L2
174	5	12	37	5	8	30	630	1.9	L 5	2
175	5	8	42	6	9	35	880	2.3	L 5	4
176	5	10	44	5	13	34	840	2.2	L 5	2
177	8	10	35	5	9	29	600	1.9	110	2
178	6	10	40	5	6	23	570	1.8	L 5	L2
179	13	8	36	6	10	31	610	1.8	L 5	2
180	15	12	35	6	10	28	556	2.1	1030	3
181	11	10	39	5	8	28	700	1.9	5	L2
182	5	12	39	5	5	21	700	1.9	L 5	2
183	5	10	36	4	7	23	660	1.8	10	L2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
184	5	12	45	4	6	24	600	1.6	5	2
185	6	13	36	4	5	19	560	1.8	80	L2
186	6	14	32	4	5	18	550	1.7	35	L2
187	4	8	41	5	12	31	840	2.2	L 5	L2
188	8	6	48	6	10	34	880	2.3	40	2
189	7	5	23	2	10	17	330	0.8	L 5	L2
190	8	12	34	4	6	20	565	1.7	35	L2
191	8	12	36	4	4	18	580	1.8	55	L2
192	11	10	41	4	5	20	590	1.7	L 5	L2
193	6	8	39	4	8	32	810	2.3	L 5	L2
194	4	12	27	3	4	14	500	1.7	L 5	2
195	5	8	42	4	6	24	800	2.2	5	2
196	5	6	38	5	7	28	780	2.1	5	L2
197	6	10	31	4	12	32	590	1.8	15	L2
198	5	7	28	4	7	23	429	1.6	10	L2
199	5	7	37	6	11	32	760	2.4	L 5	L2
200	9	3	32	7	12	32	580	2.0	55	L2
201	6	6	42	5	9	36	770	2.1	L 5	L2
202	6	11	37	4	9	26	640	2.0	L 5	L2
203	5	6	36	3	9	30	570	1.8	5	2
204	4	5	39	4	6	26	660	2.1	20	L2
205	6	5	36	5	7	28	640	2.0	L 5	L2
206	14	7	35	5	8	27	840	2.2	L 5	2
207	4	12	22	3	4	17	400	1.4	25	L2
208	6	10	24	3	4	14	450	1.4	10	L2
209	8	10	24	4	8	16	475	1.5	L 5	L2
210	6	12	28	3	4	15	505	1.6	L 5	L2
211	4	12	20	2	3	12	500	1.7	L 5	2

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	Au ppb	As ppm
212	5	6	38	5	10	33	800	2.2	L 5	2
213	5	14	22	3	4	14	450	1.8	440	L2
214	5	7	41	4	13	40	720	2.2	L 5	L2
215	6	11	20	3	3	12	500	1.7	5	L2
216	5	12	19	2	3	10	455	1.5	L 5	L2

Note: The prefix L indicates less than.

APPENDIX II.

RESULTS OF GEOCHEMICAL ANALYSIS ON THE LESS THAN 2 MICRON SIZE FRACTION.

ELEMENT

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
PREFIX DG84-									
1	54	11	159	19	39	78	700	5.0	4
2	61	14	161	14	41	82	660	5.5	5
3	57	11	170	18	40	90	700	6.0	5
4	45	8	100	16	28	70	485	4.2	3
5	41	13	108	16	37	75	460	4.4	4
6(A)	40	10	107	14	29	70	560	4.3	3
6(B)	73	17	153	17	45	90	710	5.5	3
7	48	9	149	18	36	79	860	5.2	3
8	88	10	122	17	40	86	570	5.1	7
9	31	11	114	15	34	78	470	4.5	3
10	64	14	127	16	31	75	800	4.7	3
11	52	10	107	17	30	76	540	4.8	4
12	43	10	118	18	30	74	600	4.7	4
13	70	9	170	17	36	98	820	5.9	4
14	68	10	150	16	42	83	640	5.5	5
15	56	10	156	20	39	93	760	5.6	5
16	86	9	122	16	32	87	660	5.0	6
17	64	9	135	15	27	80	600	4.9	4
18	46	10	110	17	25	80	520	5.1	5
19	74	10	123	18	38	68	640	4.5	4
20	81	9	138	16	37	85	620	5.3	6
21	70	9	149	18	36	80	660	5.1	5
22	60	11	112	16	49	74	570	4.3	6
23	72	11	130	18	38	70	760	4.4	3
24	65	10	159	16	32	86	745	5.9	4
25	38	20	98	15	35	70	365	4.2	3
26(0-20 cm)	36	9	89	12	33	68	360	3.8	4

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
26(20-40 cm)	50	10	140	18	38	78	660	5.2	5
26(40-60 cm)	54	7	149	16	31	80	720	5.3	4
26(60-80 cm)	72	8	157	18	36	84	730	5.4	4
26(80-100 cm)	96	7	164	17	25	83	745	5.3	9
26(100-120 cm)	78	9	168	17	38	81	700	5.4	8
27	84	8	162	15	43	78	680	5.1	6
28	72	10	130	18	44	84	700	4.9	8
29	63	7	127	24	85	90	650	4.8	14
30(0-20 cm)	26	15	87	13	37	67	300	3.8	5
30(20-40 cm)	35	12	106	14	35	72	415	4.2	4
30(60-80 cm)	76	11	155	16	50	88	740	5.3	4
30(80-100 cm)	110	11	174	18	55	104	730	5.6	6
31	60	10	145	17	37	78	700	4.8	3
32	56	9	145	14	33	80	580	4.8	3
33	72	14	194	19	41	100	780	6.0	5
34	68	9	91	12	24	78	310	4.3	3
35	57	11	100	18	33	71	640	4.2	4
36	54	12	103	16	37	72	700	4.1	4
37	36	12	123	14	35	76	535	4.7	3
38	60	13	193	17	49	91	820	6.0	7
39	57	15	166	16	41	90	650	5.7	6
40	65	13	164	17	47	86	770	5.4	6
41	62	12	109	17	47	102	760	6.1	6
42	54	12	135	15	33	81	640	5.0	4
43	61	15	155	21	41	67	1000	5.0	4
44	76	15	107	15	37	72	490	4.3	5
45	63	12	129	19	36	80	700	5.1	4
46	69	14	185	18	45	95	840	6.2	4
47	56	11	176	17	40	96	715	5.6	3
48	69	7	117	16	38	84	820	4.4	3

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
49	63	10	129	17	33	90	860	4.7	3
50	96	9	169	18	48	90	820	5.4	4
50(10-35 cm)	34	12	100	15	35	74	390	4.7	4
50(35-45 cm)	52	12	111	16	37	84	480	5.0	4
50(45-60 cm)	54	10	123	17	33	80	660	4.6	3
50(65-85 cm)	75	11	145	17	38	88	760	5.1	3
50(85-105 cm)	82	10	149	16	47	82	700	5.0	5
50(105-125 cm)	92	10	169	20	49	84	760	5.3	4
51	60	11	159	17	40	90	700	5.4	3
52	44	12	96	16	30	60	390	3.8	4
53	46	7	113	14	33	70	540	4.4	4
54	82	12	140	16	40	80	640	5.4	4
55	66	12	140	17	32	77	670	5.6	4
56	88	11	134	15	38	86	570	5.3	5
57	80	12	130	17	40	74	600	5.4	4
58	53	9	119	17	37	72	660	4.6	4
59	87	9	155	17	44	85	660	5.2	4
60	60	10	96	14	35	70	420	4.2	5
61	58	13	127	16	35	71	520	4.7	4
62	43	7	110	14	31	64	570	4.2	3
63	84	11	139	16	35	79	600	5.2	5
64	70	10	150	15	42	78	590	5.3	4
65	128	12	146	16	48	74	640	5.6	7
66	62	11	138	16	32	79	690	5.2	4
67	68	11	149	16	30	74	580	5.3	5
68	48	11	124	16	28	75	590	4.8	4
69	54	13	132	15	30	71	600	4.8	5
70	92	12	189	19	48	90	800	6.4	4
71	68	12	139	16	37	80	580	5.5	5
72	78	11	108	15	32	68	480	4.2	4
73	64	9	145	16	36	79	660	5.2	4

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
74	70	10	154	15	40	78	580	5.4	5
75	70	10	132	16	40	77	630	5.2	4
76	132	7	99	12	35	72	480	4.5	4
77	66	13	155	19	41	74	720	5.5	5
78	72	11	142	16	40	80	600	5.3	4
79	70	10	155	17	40	74	690	5.2	4
80	116	9	133	15	37	71	680	5.2	6
81	92	11	152	17	39	78	700	5.2	5
82	76	9	138	15	40	72	580	4.9	4
83	100	11	156	18	40	74	670	5.0	5
84	115	13	127	15	39	72	600	5.2	73
85	67	13	149	16	46	72	620	5.0	5
86	48	14	168	17	40	69	760	5.0	4
87	64	13	135	16	41	70	580	5.2	5
88	76	12	129	12	40	72	520	5.0	5
89	72	13	173	14	41	74	680	5.2	5
90	43	11	122	16	29	58	720	3.7	3
91	85	12	143	15	35	64	540	4.8	5
92	70	12	167	13	42	72	590	5.2	5
93	50	12	121	17	33	68	660	4.4	3
94(10-30 cm)	36	14	106	14	23	66	370	4.6	4
94(30-50 cm)	42	13	121	18	26	66	680	4.6	3
94(50-70 cm)	76	14	144	20	33	70	800	5.8	5
94(70-90 cm)	71	16	154	17	42	73	660	5.5	5
94(90-110 cm)	65	13	176	14	43	74	600	5.5	5
95	60	14	146	15	40	75	560	5.0	6
96	86	11	117	14	35	72	540	4.7	4
97	60	11	139	15	41	74	650	4.9	3
98	70	13	158	17	37	68	730	5.5	5
99	73	13	201	15	42	72	670	5.2	6
100	72	14	164	16	38	70	725	5.4	7
101	80	13	147	16	40	70	760	4.8	5

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
102	80	11	151	13	35	66	580	4.6	5
103	104	13	127	15	36	60	630	4.4	6
103(30-50 cm)	136	20	64	20	38	62	280	5.0	14
103(70-90 cm)	100	13	108	17	31	60	700	4.0	5
103(90-110 cm)	105	12	117	17	36	65	620	4.4	5
103(110-130 cm)	112	14	148	14	35	70	680	4.9	8
104	108	11	140	14	38	75	570	4.9	6
105	53	12	94	14	30	60	430	4.1	6
106	110	13	134	14	37	73	580	5.0	12
107	95	13	128	17	31	71	725	4.7	6
108	103	11	159	17	48	80	600	5.0	7
109	95	12	159	17	54	82	680	5.0	7
110	52	12	126	15	36	70	720	4.5	3
111	76	12	122	17	40	76	610	4.6	5
112	92	10	129	14	45	78	620	4.7	5
113	56	11	92	13	29	57	520	4.0	2
114	76	13	136	16	38	70	680	4.8	3
115	95	11	160	15	44	68	730	4.9	12
116	87	10	158	15	37	68	620	4.9	4
117	75	11	148	15	40	68	600	4.8	5
118	64	10	94	16	26	57	520	3.8	2
119	80	11	150	14	45	70	590	4.8	4
120	88	11	153	14	36	64	620	4.8	4
121	92	10	130	15	37	60	565	4.5	3
122	92	11	127	17	35	64	780	4.7	3
123	83	12	121	16	32	72	520	4.7	3
124	65	11	165	15	39	80	700	5.2	5
125	59	11	192	18	45	88	680	5.8	6
126	43	11	130	16	28	76	680	4.8	4
127	64	10	181	15	48	78	750	5.2	4
128	65	13	173	18	49	76	820	5.2	3
129	69	12	173	17	46	78	740	5.2	3

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
130	57	11	165	14	42	72	660	4.8	3
131	70	11	168	16	40	81	680	5.4	3
132	67	10	166	15	35	73	650	4.8	3
133	40	10	136	16	33	68	710	4.5	4
134	56	9	186	17	34	84	700	5.5	4
135	72	12	203	19	43	94	740	6.6	6
136	59	10	169	13	37	80	700	5.1	3
137	61	10	145	18	38	74	700	4.8	3
138	72	10	148	16	44	78	690	5.1	5
139	45	12	114	16	37	73	620	4.6	5
140	75	11	180	16	49	78	600	4.9	4
141	70	10	132	14	36	78	560	4.6	4
142	90	10	178	16	48	88	730	5.4	3
143	57	11	178	16	41	80	660	5.4	7
144	80	12	166	17	52	84	740	5.4	4
145	58	13	169	16	39	76	780	5.5	3
146	62	10	110	13	32	60	760	3.9	3
147	64	12	140	13	39	82	700	4.8	3
148	78	12	159	17	47	79	760	5.0	4
149	90	11	137	17	46	90	800	5.2	4
150	87	12	142	18	43	88	720	4.9	4
151	70	13	162	15	42	80	660	5.0	4
152	78	12	161	17	43	76	680	5.0	3
153	79	9	158	15	53	78	670	5.0	3
154	48	10	139	15	38	71	780	4.3	3
155	94	11	150	15	51	82	660	5.2	3
156	102	13	169	14	47	80	720	5.4	5
157	75	12	146	16	48	80	650	4.9	5
158	60	12	152	12	44	74	630	5.0	5
159	66	11	163	16	46	76	680	4.9	3
160	75	10	118	15	35	80	640	5.0	3
161	65	11	148	13	41	72	610	4.9	4
162	46	11	130	17	40	73	745	4.8	3

SAMPLE NUMBER	Cu pp,	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
163	65	14	151	15	49	70	740	5.2	4
164	65	12	164	15	41	75	700	5.2	3
165	80	11	137	14	44	70	600	4.7	3
166	68	12	144	14	42	68	660	4.8	4
167	65	11	132	13	39	64	580	4.8	3
168	88	13	170	16	40	86	800	5.7	4
169	64	10	163	13	35	74	545	5.0	4
170	64	13	181	12	40	74	590	5.6	4
171	60	13	187	16	35	76	680	5.9	5
172	65	14	167	15	46	76	570	5.2	3
173	60	13	146	14	39	76	640	4.9	4
174	52	13	146	12	39	68	600	4.3	3
175	82	11	155	13	45	78	610	5.0	4
176	67	13	141	15	45	74	580	4.8	5
177	84	10	149	18	44	82	720	5.2	4
178	78	12	176	16	41	76	710	5.6	6
179	72	12	133	15	40	72	710	4.7	4
180	172	13	166	19	45	82	900	5.4	2
181	68	12	145	13	41	75	600	4.8	3
182	51	12	135	15	42	71	530	4.7	3
183	74	13	161	17	50	78	670	5.0	5
184	68	12	157	15	46	76	680	4.8	4
185	56	12	152	15	37	68	520	5.0	3
186	55	10	161	16	41	78	580	5.2	3
187	38	12	125	13	39	70	630	4.3	4
188	114	13	129	13	38	72	700	4.8	2
189	112	11	164	15	42	75	780	4.7	5
190	64	14	178	15	41	84	800	5.9	5
191	70	12	180	15	45	88	800	6.0	4
192	43	11	126	12	40	82	550	4.6	4
193	53	11	153	14	38	74	580	4.8	3

SAMPLE NUMBER	Cu ppm	Pb ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	Mn ppm	Fe pct	As ppm
194	60	13	174	13	35	75	610	5.2	5
195	54	11	166	15	37	74	580	5.0	4
196	55	11	163	15	40	76	600	4.7	3
197	82	11	170	14	44	88	760	5.6	4
198	60	12	152	15	40	81	600	5.0	4
199	58	15	115	17	36	75	525	4.5	6
200	76	10	127	16	39	83	740	4.9	3
201	58	11	160	17	41	80	740	4.9	3
202	52	12	170	16	38	74	550	5.3	5
203	65	10	151	15	42	78	560	4.9	3
204	53	12	157	14	40	78	640	4.9	4
205	86	11	167	15	46	82	610	5.2	3
206	56	13	170	18	38	76	680	4.8	4
207	52	10	146	14	37	78	640	4.4	4
208	58	11	149	16	47	78	730	4.6	2
209	60	12	146	17	42	78	700	4.9	4
210	60	9	177	17	48	84	660	5.6	4
211	67	11	154	14	43	78	620	5.0	3
212	68	11	159	14	42	76	615	4.8	3
213	62	11	163	15	44	78	570	5.1	3
214	54	10	168	16	44	80	580	5.0	2
215	76	10	171	13	49	81	660	5.3	3
216	68	11	156	16	49	80	640	5.4	2