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THE DISPERSAL OF GOLD AND RELATED ELEMENTS IN TILLS AND SOILS AT THE FOREST HILL GOLD DISTRICT GUYSBOROUGH COUNTY, NOVA SCOTIA

I.J. MacEachern
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IN MEMORIAM

Ian Joseph MacEachern, the senior author, died during the preparation of this report. He will be sorely missed by his friends and colleagues. In the short time that Ian worked in Nova Scotia, he became an expert in gold exploration in the Meguma Group. An accident cut short his promising career. This work is dedicated to his memory.

Critical Reader
R.N.W. DiLabio

R.R. Stea
Nova Scotia Department of Mines and Energy
1690 Hollis Street
Halifax, Nova Scotia
B3J 2X1

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THE DISPERSAL OF GOLD AND RELATED ELEMENTS IN TILLS AND SOILS AT THE FOREST HILL GOLD DISTRICT GUYSBOROUGH COUNTY, NOVA SCOTIA

Abstract

The till stratigraphy and gold distribution (in till) at the Forest Hill Gold District was extensively studied in an program designed to aid gold exploration in Nova Scotia. Trenches cut to bedrock provide a unique opportunity to study the three-dimensional dispersal of gold from a known bedrock source.

Three major surficial units characterize the study area. The oldest unit is a till (Unit I) overlain by an oxidized and cemented diamict. This sequence is overlain by Units II and III which are tills characterized by a sandy matrix and locally derived granitic and metasedimentary clasts. Unit II is compact and rests upon bedrock with southeastward-trending striations. Unit III is less compact and locally has a strong fabric indicating a southwestward ice movement. These tills are commonly separated by a reddish-brown alteration zone interpreted as a paleosol.

A poor correlation between the panning results and the geochemical data for gold was attributed to the nugget effect. It was concluded that both panning and geochemical exploration techniques should be used in gold exploration programs in Nova Scotia.

The coarse fraction (1-2 mm) of the tills directly reflects the elemental ratios and abundances inherent to the bedrock. However,the fine fraction (<0.063 mm) of the tills shows evidence of a hydromorphic redistribution of elements. This implies that the tills at Forest Hill are at least partially altered by post-depositional chemical processes.

The dispersal of gold at Forest Hill reflects mechanical dispersal by a major southeastward ice advance. The gold dispersal trains are three-dimensional bodies which come to the surface 200 to 300 m down-ice from gold-bearing veins. Gold in the till occurs as flakes and nuggets. The surfaces of these particles appear rough and pitted and exhibit little evidence of abrasive glacial transport.

Résumé

La stratigraphie du till et la répartition de l'or (dans le till) dans le district aurifère de Forest Hill ont fait l'objet d'une étude détaillée entreprise dans le cadre d'un programme visant à aider l'exploration de l'or en Nouvelle-Écosse. Des tranchées creusées jusqu'au socle rocheux ont permis d'étudier la répartition tridimensionnelle de l'or à partir d'une roche en place connue.

Trois grandes unités superficielles caractéristiques se présentent dans la région étudiée. L'unité I, la plus ancienne, est une unité de till sous-jacente à un diamicton oxydé et cimenté. Cette séquence repose sous les unités II et III qui sont des tills composés d'une matrice sableuse caractéristique et de fragments granitiques et métasédimentaires d'origine locale. L'unité II, compacte, repose sur de la roche en place marquée de stries à orientation sud-est. L'unité III est moins compacte et possède par endroits une structure et une texture marquées qui indiquent que la glace se déplaçait vers le sud-ouest. Ces tills sont normalement séparés les uns des autres par une zone d'altération brun rougeâtre qui représente vraisemblablement un paléosol.

La mauvaise corrélation qui existe entre les résultats obtenus par lavage de l'or à la battée et les données géochimiques est attribuée à l'effet des pépites. Les auteurs recommandent d'utiliser à la fois les méthodes d'exploration géochimiques et le lavage à la battée pour l'exploration de l'or en Nouvelle-Écosse.

La fraction grossière (1 à 2 mm) des tills reflète directement la proportion et l'abondance des éléments propres à la roche en place. Toutefois, la fraction fine (<0,063 mm) révèle qu'il y a eu redistribution hydromorphique des éléments, ce qui laisse supposer que les tills de Forest Hill ont subi une altération chimique au moins partielle après leur accumulation.

La répartition de l'or à Forest Hill reflète la répartition mécanique produite par une importante avancée glaciaire vers le sud-est. Les traînées d'or sont des masses tridimensionnelles affleurant de 200 à 300 m en aval des filons aurifères. L'or se présente dans le till sous forme de flocons et de pépites. Les surfaces de ces particules paraissent rugueuses et trouées et ne semblent pas avoir subi de transport glaciaire abrasif.

INTRODUCTION

General Statement

All of Nova Scotia's gold fields are overlain by till of differing thicknesses. This till cover was detrimental to the discovery of most of the 130 known gold occurrences (61 former producers) until the successful application of relatively unsophisticated drift prospecting techniques during the years 1860 through 1896. Recently, modern advances in drift exploration and high gold prices have stimulated a renewed interest in the neglected gold fields that occur beneath till-covered rocks of the Cambro-Ordovician Meguma Group. This interest has generated a demand for detailed information concerning the nature and distribution of gold in tills, particularly for exploration purposes.

The following study, part of the Canada-Nova Scotia Cooperative Mineral Program, 1981-84, was initiated in response to this demand. This integrated survey emphasizes the till stratigraphy and correlates bedrock, till and soil geochemistry. The purpose of this study is to develop and refine geochemical exploration techniques for locating new gold deposits and re-evaluating former gold producing areas in rocks of the Meguma Group.

During the summer and fall of 1982, an extensive trenching program conducted at the Forest Hill gold district by Seabright Resources Inc. exposed approximately 3.5 km of drift cut to bedrock. Exposure is along nine trenches oriented perpendicular to the strike of both the veins and host strata of the deposit. This afforded the authors a unique opportunity to study the till stratigraphy and the three-dimensional dispersal of gold and related elements from a known bedrock source by glacial and postglacial processes.

Location and Physiography

The Forest Hill gold district is located in the central part of Guysborough County at latitude 45°20′N and longitude 61°45′W (Fig. 1). It is 3 km south of the Salmon River Road which runs between Country Harbour Crossroads and the Town of Guysborough.

The study area is a bedrock-controlled topographic high, bounded to the north by drumlinized terrain and to the south by hummocky terrain. Several lakes north of the study area are generally oriented parallel with the long axes of the drumlins (155°) and probably occupy glacially scoured basins.

BEDROCK GEOLOGY

Regional Geology

The Forest Hill Gold District, is hosted by rocks of the Cambro-Ordovician Meguma Group (Fig. 1, 2) which underlies most of mainland Nova Scotia south of the Glooscap Fault. The Meguma Group is divisible into two formations; the basal Goldenville Formation, consisting of about 7 km of metawacke turbidites,conformably overlain by about 6 km of black slates known as the Halifax Formation (Schenk, 1970, 1978). The auriferous quartz veins occur mainly in the upper part of the Goldenville Formation (McBride, 1978; Henderson, 1983).

Deformation during the Devonian Acadian Orogeny resulted in the formation of northeastward-trending anticlines and synclines. The anticlinal axes, which are on average 5 km apart and from 10 to 160 km long, plunge to the east and west at numerous locations to form dome shaped structures. The domes are commonly associated with zones of gold enrichment and characterize many of the 61 former gold producing deposits in rocks of the Meguma Group (Faribault, 1913).

The rocks of the Meguma Group have been subjected to regional greenschist grade metamorphism. Local overprinting can be observed where the rocks are in contact with granitic plutons. These post-tectonic intrusions are of Middle Devonian to Early Carboniferous age and share a spatial relationship with the rocks of the Meguma Group.

Local Geology and Previous Work

At Forest Hill the Goldenville Formation forms an east-west trending lens which separates two large masses of granitic rocks (Siebert, 1949, Fig. 6). Here the rocks of the Goldenville Formation are folded into an overturned anticline which plunges gently to the east. The rocks of the area have been regionally metamorphosed to amphibolite facies and are extensively fractured and faulted. Numerous granitoid dykes have intruded the host rocks which are altered to andalusite, staurolite and garnetiferous schists (Malcolm, 1929).

Previous detailed work concerning gold in tills has not been extensive. Much of the pioneering work in this field, particularly in Nova Scotia, can be credited to W. H. Prest, the first geologist recorded in the literature to have recognized and outlined a three-dimensional ore dispersal plume in till. In a program conducted at the Blockhouse Gold District in 1896, Prest traced and located an auriferous quartz vein that

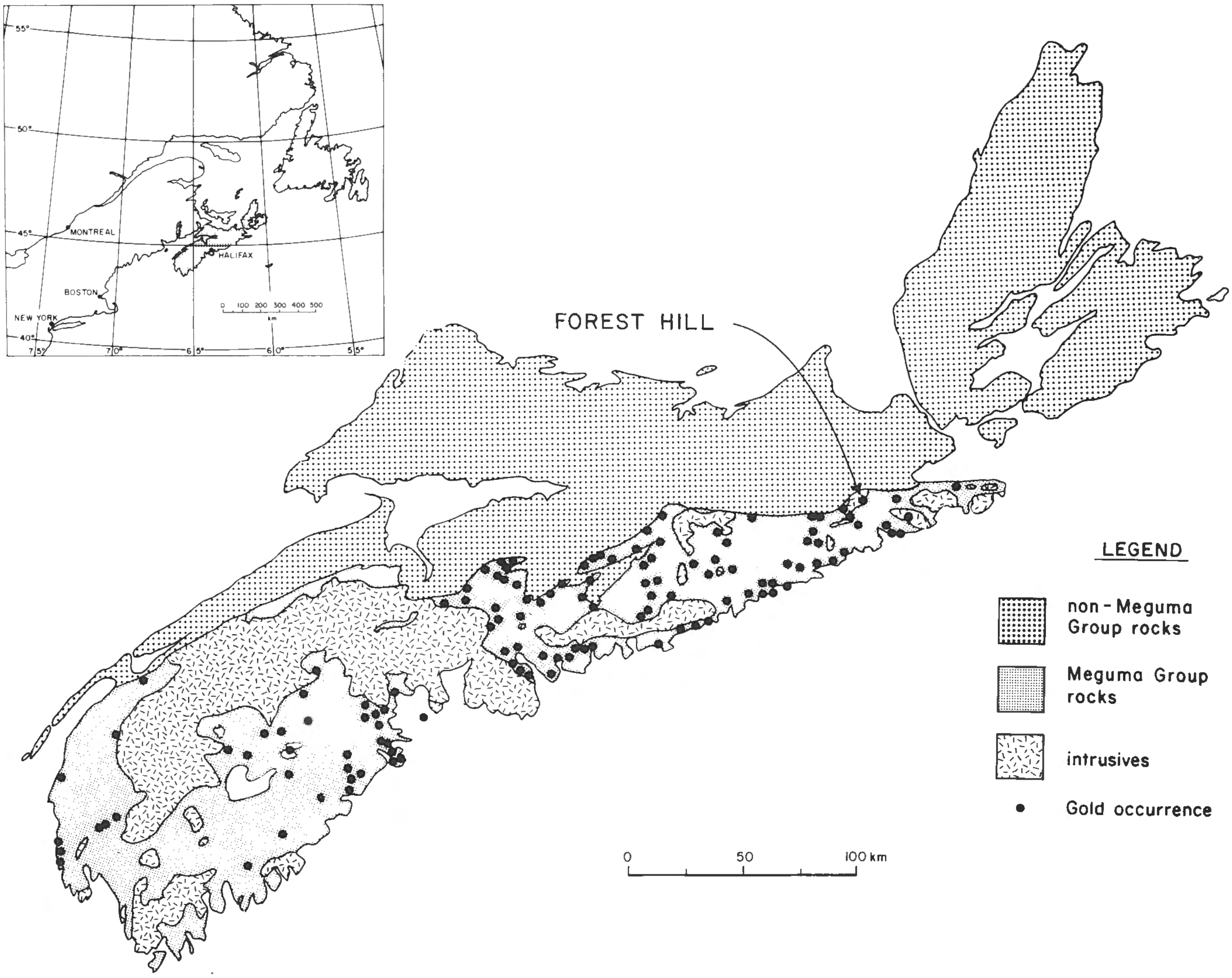


Figure 1. Generalized geological map of Nova Scotia and location of the Forest Hill gold district. Also shown is the spatial distribution of gold occurrences in the Meguma Terrane.

had eluded prospectors for over a decade (Fig. 3). He systematically sank reinforced shafts in the till and carefully mapped the gold dispersal as indicated through panning the vertical profiles. Prest (1911) emphasized the importance of a thorough understanding of both the regional and local Pleistocene geology in an effective drift prospecting program. He suggested a three-dimensional approach to drift exploration which involved deciphering the till stratigraphy and the effects of postglacial processes.

The most recent and relevant work on gold in till in Nova Scotia has been done by DiLabio (1982a, b) and MacEachern (1983). In 1981, DiLabio conducted two orientation surveys at both the Waverley and Oldham gold districts of Nova Scotia, the objectives being (1) to test the relationship between grain size and gold abundance in till, and (2) to study dispersal trains around known gold occurrences. DiLabio (1982a) concluded that the fine sand, silt, and clay fraction (<0.25 mm) of the till gave the best analytical results for gold close to the source. The silt/clay fraction (<0.063 mm) was preferred when sampling at distances greater than 250 m from the bedrock source. He attributed this result to the glacial comminution of gold.

MacEachern (1983) conducted a geochemical survey along trenches cut in till and soils at the Fifteen Mile Stream gold district of Nova Scotia to study the distribution, character and composition of gold in the till. Results of this study showed that (1) the distribution of gold in the till is affected by both chemical and mechanical processes, and (2) the average composition of gold flakes in the till (69% Cu, 10% Au, 9% Zn, 1% Ag), as determined using electron microprobe techniques, differs significantly from the average composition of primary gold from the deposit (91% Au, 9% Ag). This compositional difference was considered by MacEachern (1983) to be strong evidence supporting a hydromorphic redistribution of gold in till in the Fifteen Mile Stream area.

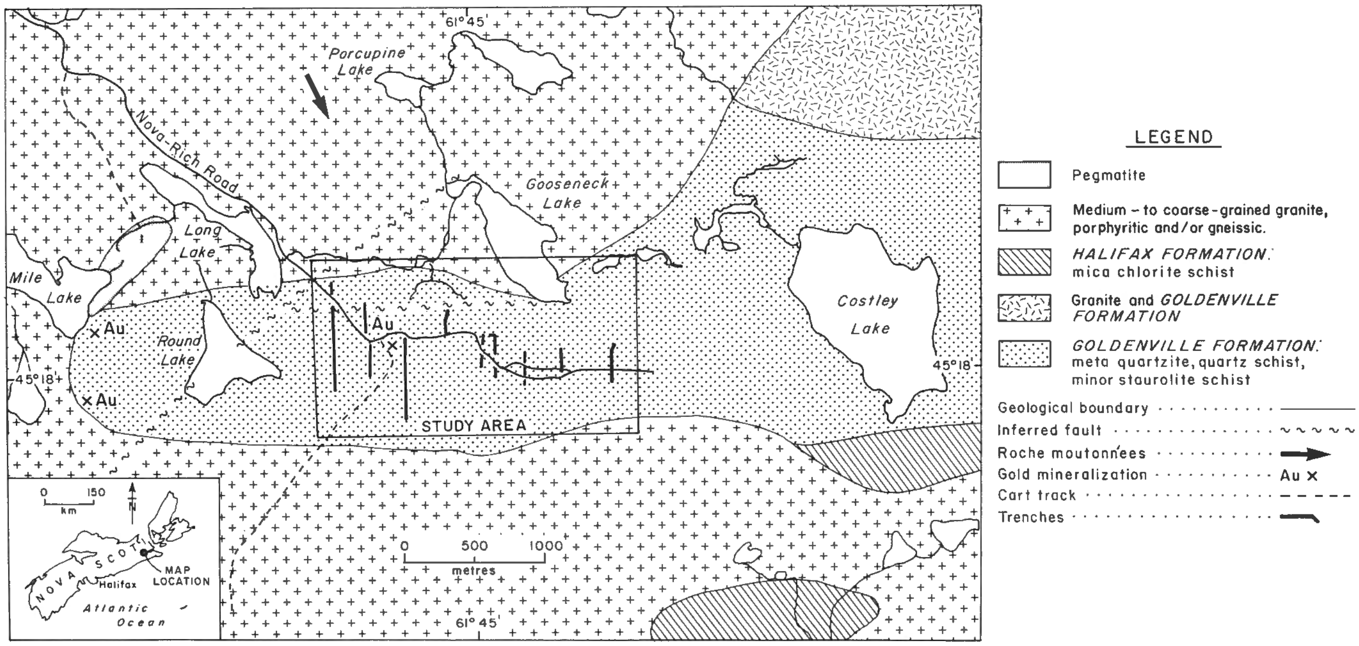


Figure 2. Local geology map of the Forest Hill area (compiled from Siebert, 1949, and Schiller, 1961).

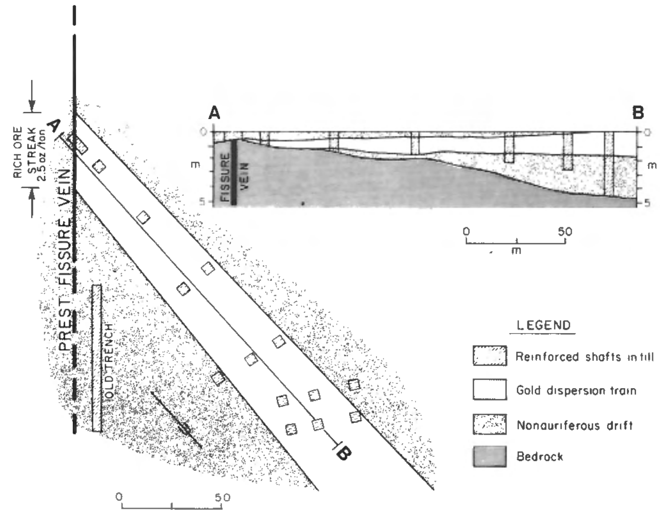


Figure 3. An illustration of the drift exploration techniques developed by W. H. Prest which he used successfully in discovering the Blockhouse Gold District in 1896 (after Prest, 1911; modified by G. A. O'Reilly).

In agreement with DiLabio (1982a), MacEachern found the optimum grain sizes to analyze for gold to be the fine sand, silt, and clay fractions of the till. MacEachern (1983) also found consistently high gold values in the coarse sand fraction, suggesting that the grain size distribution of gold in the till may be due largely to the inherent nature (grain size distribution) of the gold in the deposit, and not to the comminution process. MacEachern (1983) also noted that the lack of evidence for abrasion of the gold grains, studied under the scanning electron microscope, suggests minimal grain size reduction by comminution.

R. R. Stea and P. J. Rogers (personal communication, 1983) sampled two till sections in trench 8 (Fig. 4) at Forest Hill prior to the start of this study. They analyzed four grain size ranges from each till sample: >2 mm, 0.5 mm to 2 mm, 0.063 mm to 0.50 mm, and <0.063 mm. The main objectives of their survey were to assess vertical geochemical variations in the till profile and to study variations in trace element geochemistry associated with the different grain size ranges. Their results are presented in this report.

PROCEDURES

The till exposures at the study area were systematically sampled at 25 m intervals along the trenches (Fig. 4, 6a,b). Sampling was also conducted between trenches 3 and 4, and southward from trench 4, in pits dug to a depth of 1 m (Fig. 4). At each sample site the till stratigraphy was described, bedrock striations (if present) were mapped, and the drift section was sampled in profile at 1 m intervals and immediately above and below till unit contacts (Fig. 5). In addition, till from each sample location was panned using a standard 16-inch flat-bottomed gold pan to determine the presence of visible gold and obtain a heavy mineral concentrate for analysis. The coarse pebble fraction was removed using a gold pan sifter (grizzly) during the panning process, and at least 100 pebbles were counted and classified into lithological groups in the field. At every fifth site, till pebble fabrics were obtained through compass measurements of 50 or more elongated pebbles with a long/short axial ratio of at least 3:1. Till fabrics, pebble counts, and measurements of bedrock and boulder pavement striations were used to reconstruct glacier movements in the Forest Hill area.

The samples were thoroughly dried before a coned and quartered portion of each sample was dry-sieved to obtain a fine (<0.063 mm) and coarse (1.0-2.0 mm) fraction. These fractions were in turn coned and quartered to the size required

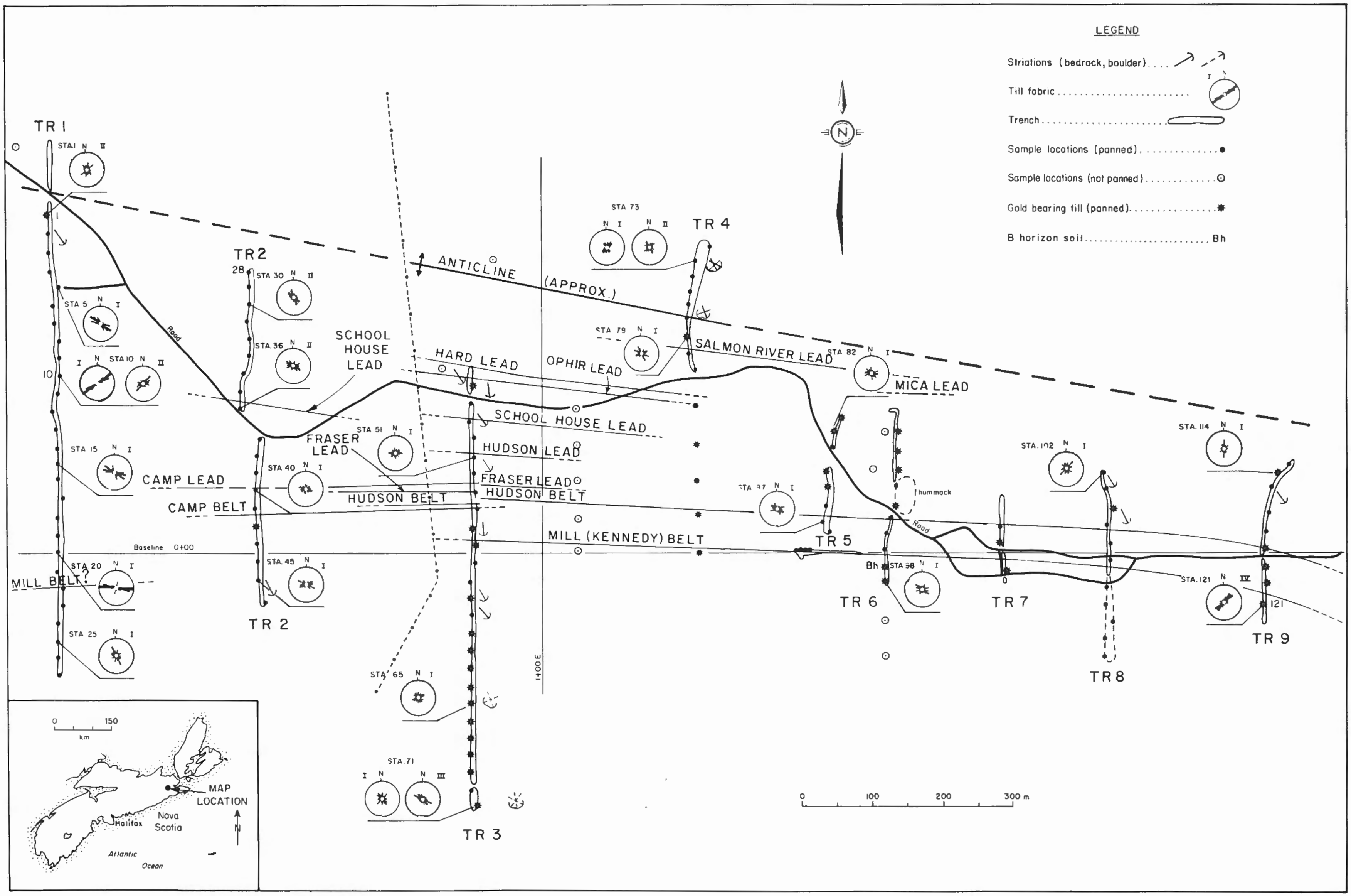


Figure 4. Map of the Forest Hill area illustrating the locations of the trenches, sample locations, major auriferous veins, and the trace of the anticlinal hinge. The results of the panning survey and till fabric analyses are also presented.

Table 1. Analyses of four surficial units at station 10 (westernmost trench), Forest Hill Gold district, Guysborough Co., Nova Scotia. Note the similarity in chemical values obtained for the modern B-horizon soil and the "reddish-brown layer" interpreted as a paleosol. Particle size distribution figures indicate that the matrix textures of the units are dominated by sand and silt. Analyses by the Research Branch, L.R.R.I., Analytical Services Laboratory.

		Ammonium Oxalate			Sodiumum Pyrophospate		Particle Size Distribution %							
Sample No.	Description	%C	%FE	%AL	% FE	%AL	Total sand	2-1 mm	1-.5 mm	5-.25 mm	.25-1 mm	.1-.05 mm	Silt	Clay
06-83	Modern Bh soil	0.92	0.29	0.61	0.15	0.36	67.4	11.7	11.1	7.7	16.8	20.0	31.0	1.6
07-83	Unaltered till (depositional event 11)	0.21	0.11	0.18	0.04	0.13	62.3	14.5	11.7	8.0	13.8	14.3	34.6	3.0
08-83	"Reddish-brown layer" (paleosol)	0.96	0.33	0.69	0.08	0.43	60.2	11.3	10.9	6.7	15.9	15.4	35.6	4.2
09-83	Unaltered till (depositional event 1)	0.23	0.19	0.29	0.04	0.14	61.7	13.3	11.9	7.7	13.7	15.5	34.0	4.3

Figure 5. An example of a typical sample station.

for geochemical analyses. The coarse fractions were later wet-sieved to wash adhering fine particles, allowed to dry, and then reduced to powder in a shatter-box.

Geochemical analyses for Ag, Cu, Pb, Zn, Ni, Cr, Mn, Fe and Hg were performed at the Ottawa laboratories of Bondar Clegg & Company Ltd by hot Lefort extraction and Atomic Absorption Spectrophotometry. Gold analysis was performed by fire assay preconcentration and the atomic absorption technique after digestion in aqua-regia. Ten gram samples were used so that a lower-detection-limit of 5 parts per billion (ppb) could be achieved. Colorimetry was used to analyze for As and W.

Panned heavy mineral concentrates known to contain gold were visually scrutinized with a binocular microscope and then hand separated for examination and photography with a scanning electron microscope (SEM). The gold and heavy mineral grains were analyzed using electron microprobe (EMP) techniques. The energy dispersion system of the EMP was used for qualitative compositional analyses and mineral identification and the wave length technique was used to determine quantitative compositional analyses for gold only.

The Statistical Package for the Social Sciences (SPSS) was used in the basic statistical analysis of the geochemical data. The Spearman Rank Correlation Coefficient (rho) was used to assess the relationships between trace elements. This nonparametric correlation method was chosen to avoid assumptions regarding the normality and homogeneity of variance of the data (Siegel, 1956).

Soil analytical data provided in Table 1 were analyzed using standard techniques outlined in the manual of the Canada Soil Survey Committee (1978).

Figure 6. a A view of the southern part of trench 3.
b A view of the northern end of trench 8.

PLEISTOCENE GEOLOGY

General Statement

The rocks of the Meguma Group have undergone several episodes of glaciation, evidenced by erosional and depositional glacial features. The bulk of the glacial material in Nova Scotia was deposited during the Wisconsinan Stage (Grant, 1977). Till is the most widespread of all the surficial materials and covers most of the province. In general, till deposits are thinner over the uplands of the eastern Meguma Group terrain and thicker in the valleys and lowlands of the western Meguma terrain (Malcolm, 1929; Stea and Fowler, 1979).

In the Forest Hill region, bedrock striations and roches moutonnées indicate a major period of southeastward ice flow (140°-160°). A thin till sheet (1-5 m) interrupted by several drumlin fields is associated with the southeastward flow. The resultant till (Stea and Fowler, 1979) is sandy and immature, and displays rapid transitions in lithological facies southeastward across bedrock contacts, illustrating the local nature of the material. Locally, a sandy till with water-worked layers is exposed in areas characterized by hummocky terrain (Stea and Fowler, 1979). It is not certain whether this till was formed during the southeast flow or a later flow phase. A regionally consistent striation set trending 180° cuts the southeastward trending striations on many outcrops in the region. Pebbles of Silurian fossiliferous sandstone, and distinctive volcanic rocks found along the Eastern Shore attest to a late period of ice flow that crossed or stemmed from the Antigonish Highlands (Stea and Fowler, 1979). In the Forest Hill area this ice flow, which transported Antigonish Highland erratics, was probably due south. Southeastward and southward trending striations were mapped at Forest Hill (Fig. 4). Southwestward trending eskers and striations (210°-230°) in the region were formed during the final phase of ice flow from an ice cap in the Antigonish area believed to be Late Wisconsinan in age (Stea and Finck, 1984).

Till Stratigraphy at Forest Hill

The surficial deposits within the study area indicate three major depositional events. Figure 7 presents the drift stratigraphy in trenches 1 to 3 and the interpretation of glacier events. The earliest episode is represented by both lodgment and ablation tills (Till units IA and IB) at a few locations but is most often characterized by the bouldery ablation phase only (Till unit IB) . Till unit 1B, however, is restricted to trenches 7, 8 and 9 (Fig. 4). Till unit 1A is a light yellowish-brown, compact, lodgment till possessing a fine sand/silt matrix. Till unit 1B overlies till unit IA and is locally present as a stony-till with a sandy matrix or as an Fe-Mn cemented stony till (Fig. 8). These units are observed most commonly in areas of topographic depression. This sequence is stratigraphically overlain by two till units (II and III) interpreted as lodgment and/or melt-out phases of deposition (Fig. 7). Till unit II is olive-brown and compact, and in some areas overlies bedrock inscribed with southeastward trending striations. Till unit II is the thickest and most widespread till unit varying from less than 1 to 3 m in thickness (Fig. 7). The clasts in this till are generally subangular and unstriated, but at some localities boulders embedded in the unit were found to be faceted on the down-glacier side and striated parallel to their long axes. This shape is characteristic of the lodgement process (Boulton, 1978 p. 783). In some areas a coarse stony phase overlies till unit II and is designated as unit IIB. This unit usually contains many granitic boulders.

Till unit III is yellowish brown, loose and sandy. It is usually present as a thin (less than 1 m) veneer over Till unit II. Till unit III has a strong fabric striking 230° to 250°, and some large boulders embedded in it have striations on their upper surface that trend 230° indicating that it was formed by a southwestward ice movement. Till units II and III are separated by a widespread but discontinuous 10 to 15 cm reddish-brown altered zone interpreted by the authors to be a paleosol (Fig. 9). Chemical analyses of samples from this zone support the contention that it is a remnant soil (D. Holmstrum, personal communication, 1983). Relative to

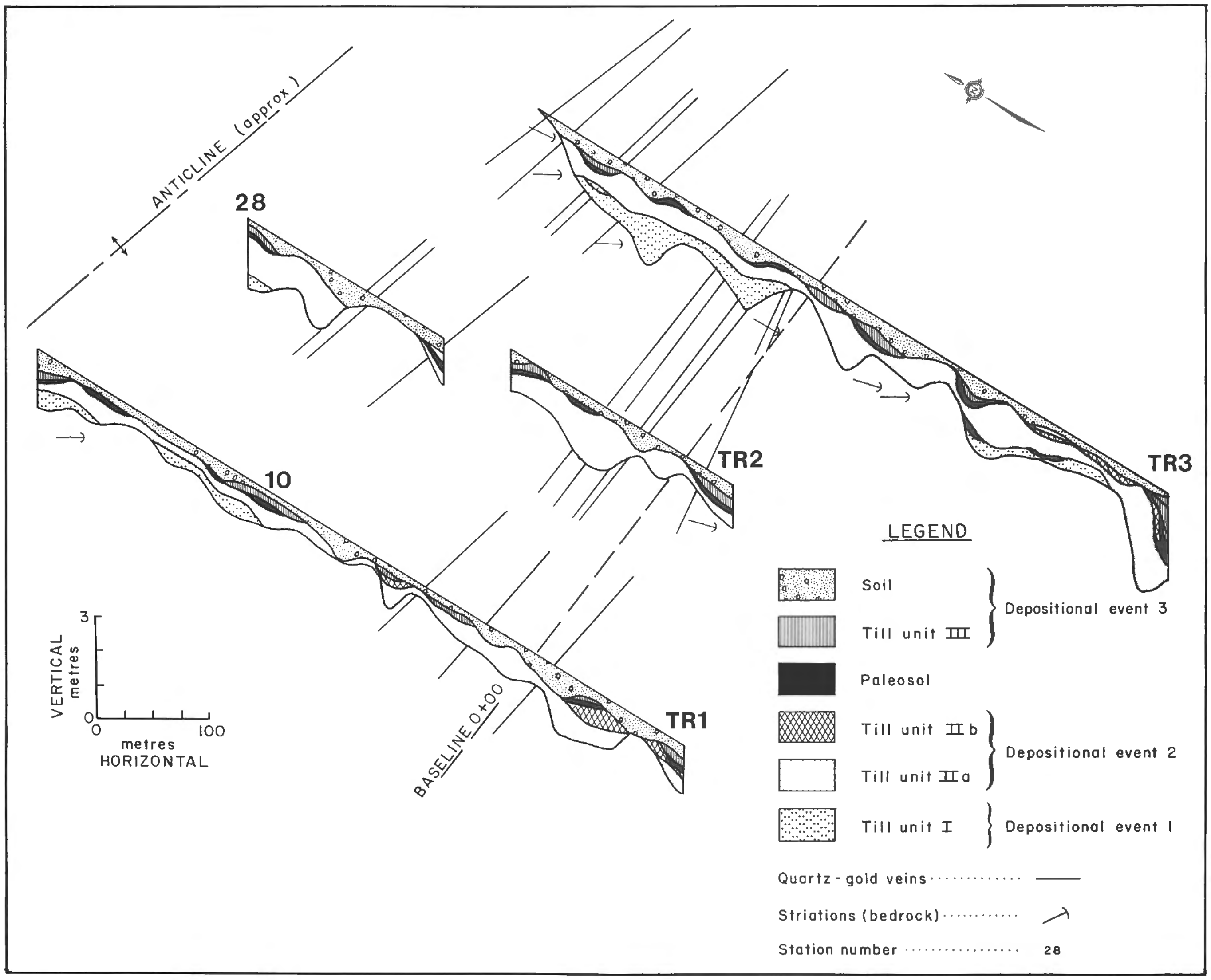


Figure 7. Fence diagram illustrating the till stratigraphy in trenches 1, 2 and 3 (see Fig. 1).

both the underlying and overlying tills the zone is enriched in organic carbon, iron and aluminum. Values obtained for the zone closely reflect those obtained from the corresponding modern B-horizon (Table 1). This interpretation implies that the latter two depositional events were separated by a period of climatic warming and ice retreat. The authors regard this altered zone as a time line and marker horizon. The drift surface over much of the Forest Hill area is mantled by granitic boulders. The modern soil is developed on this coarse phase.

It is uncertain whether Till units I and II are part of the same glaciation or represent separate glacial events. An altered, stony till facies (unit IB) separates them. A regional southeastward ice advance believed to be of Early Wisconsinan age, formed Till unit II (Stea and Finck, 1984). The reddish zone developed on Till unit II may represent a non-glacial interval or glacier retreat succeeding the southeastward flow. Chemical alteration of the surface of Early

Figure 8. Unit IA in sharp contact with overlying Fe-Mn cemented Unit IB.

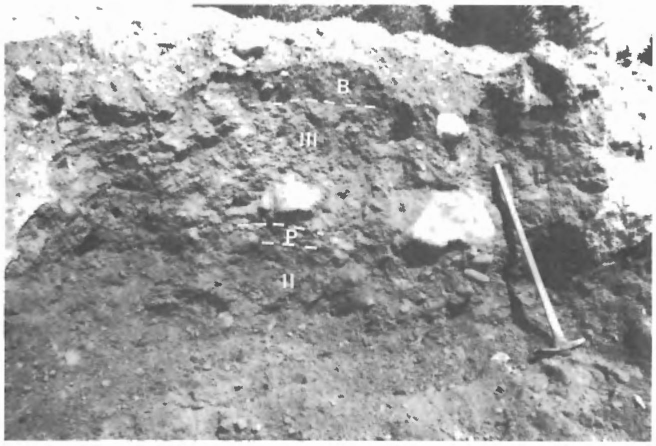


Figure 9. Photograph of Station 10 illustrating till stratigraphy. Unit II, P = Paleosol?; Unit III, B = B-horizon soil.

Wisconsinan? till has been noted in other parts of the province (Stea and Finck, 1984). Non-glacial marine beds of Middle Wisconsinan age separate Early and Late Wisconsinan tills at Salmon River, Yarmouth County (Grant, 1977) . Till unit III may have been formed during the period of local ice development that occurred during the Late Wisconsinan (Grant, 1977).

Till Lithology

The pebbles found in the tills at Forest Hill have been classified into seven major lithological groups: granite, metagreywacke, quartzite, schist, volcanic rocks, red sandstone, conglomerate, and quartz. Metagreywacke, quartzite and schist are the host rock types for the gold mineralization and they directly underlie the study area. The granitic erratics found in the till have their source in the Devonian intrusive bodies which nearly surround the Gold District (Fig. 2). The northern contact between the rocks of the Meguma Group and the granite is 100 m north of the westernmost trenches (Fig. 2). Volcanic rocks of Middle Devonian age occur 6 and 12 km to the north and 18 km to the northeast of Forest Hill. Hadrynian volcanic rocks are found 35 km to the northwest. The source of the red sandstone is probably in the early Carboniferous Horton Group, found 5 km to the northwest (Schiller, 1961). Some of the conglomerate may be derived from the Early Carboniferous Ainslie Formation which occurs 28 km to the north-northeast. Two further sources of conglomerate may be in the undifferentiated Devono-Carboniferous rocks 10 km to the northeast and northwest (Keppie, 1979).

The three main till units (units I, II, III) at the study area show very similar percentages of rock types and are all dominated by quartzite and metagreywacke (Fig. 10a, b, c).

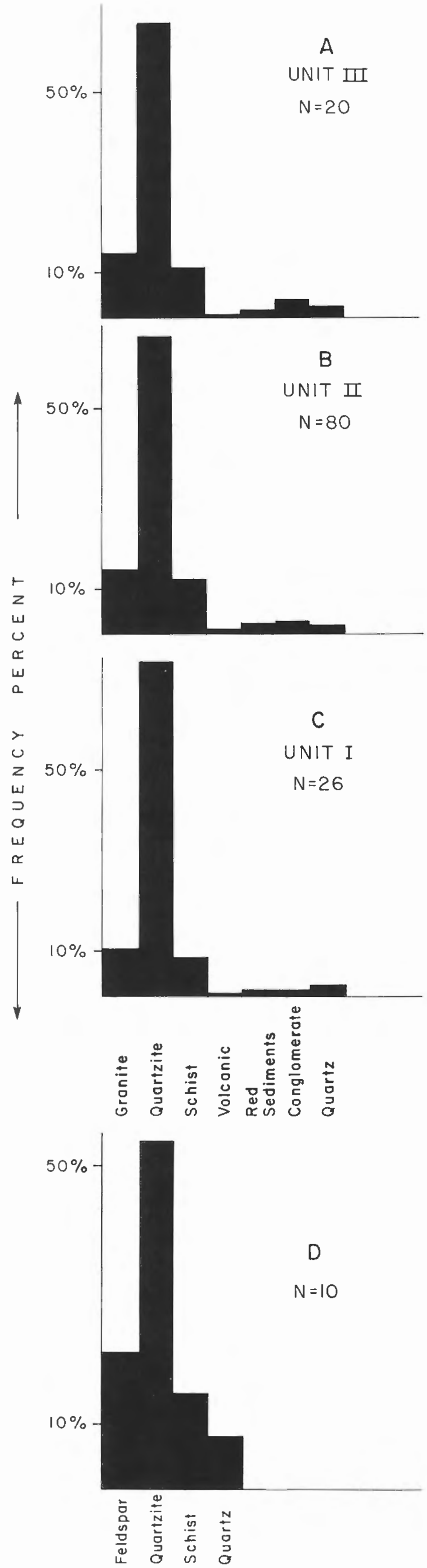


Figure 10. The distribution of bedrock lithologies in the till units based on till-pebble counts (a) Unit III, (b) Unit II, (c) Unit I) and coarse fraction grain counts (d) random sample grain counts (n = number of samples counted).

Unit I has the highest percentage of quartzite-metagreywacke clasts at >70 per cent. Unit II is similar, the only notable difference being slightly higher percentages of granitic, schistose, and Carboniferous clasts. Unit III has the highest percentage of Carboniferous conglomerate clasts. The lithological similarity of the three units and the dominance of local rock types suggest that they are of basal glacial origin or have been reworked from lodgment tills. The stony phase of unit II (unit IIB) and the mantle of boulders on unit III are almost exclusively granitic with the exception of a few Carboniferous conglomerate boulders. This indicates a greater distance of transport than is characteristic of material derived by basal processes. In essence this boulder mantle may represent a matrix-less ablation till as envisioned by Shilts (1973, p. 206). The percentage of granitic clasts generally decreases from northwest to southeast (major down-ice direction) across the map area. The highest percentage of granitic clasts is found in the westernmost trench (trench 1); however, there are some areas in trench 8 of anomalously high granitic erratic percentages which may relate to subcropping granitic plugs.

GEOCHEMISTRY

Sampling and Analytical Variation

To test the geochemical variation due to sampling in the field, 16 samples were taken from two stations 5 m apart. At each station, four pairs of samples horizontally separated by 0.5 m were taken from the vertical till profiles. The student t-test was used to statistically measure the variance between the sample pairs. The results of the t-test analyses indicate that trace element variation due to sampling is not significant in either the fine or coarse fractions of the material (Table 2).

The analytical error was determined by random splits in each batch of 20 samples sent for analysis. A total of 16 splits were created. Using the t-test, a significant variance at a 90% confidence level was found only in gold in the coarse fraction (Table 3).

The gold values for these duplicates and their corresponding samples are presented in Table 4. A high degree of variance can be seen in the sample values and their corresponding splits in both the coarse and fine fractions. The fine fraction generally shows a fair to good correlation between elevated values of samples and the splits with the exception of one highly spurious sample. In this case the split registered >14 000 ppb, but the sample from which it was created gave a value of only 25 ppb. The findings of the t-test on the set of analytical duplicate samples (Table 3) show that the overall correlation of samples and splits for gold in the coarse fraction is less pronounced than in the fine fraction.

In general, the correspondence between till units known to contain visible gold and geochemically anomalous samples from these units is moderate at best. Upon panning, 52 samples were found to be auriferous. From these sites, only 22 (42%) of the coarse fraction samples and 33 (63%) of the fine fraction samples were found to be geochemically 'anomalous' in gold (>20 ppb); and only 4 and 10 per cent of the coarse and fine fraction, respectively, indicated >100 ppb gold. Arsenic analyses indicated that 48 (92%) and 36 (69%) of the 52 samples were anomalous (>100 ppm). Sixteen (31%) of the fine fraction samples and only 1 (2%) of the coarse fraction samples were found to be highly anomalous (>500 ppm).

Ten till samples were taken over granitic and Carboniferous rocks within a 2 km radius to the north and northwest of Forest Hill to estimate the background values of

Table 2. T-test comparison of variance in field duplicate sample means in the coarse and fine fractions of the till.

	FINE (N=8)				COARSE (N=8)			
Element	Sample ($\bar{X}$)	Field Split ($\bar{X}$)	T	Significance	Sample ($\bar{X}$)	Field Split ($\bar{X}$)	T	Significance
Cu	13	12	.84	N.S.	15 ppm	18	−1.00	N.S.
Pb	8	8	− .17	N.S.	9	7	− .58	N.S.
Zn	37	26	− .83	N.S.	45	40	.78	N.S.
Ni	11	10	−1.55	N.S.	22	20	.6	N.S.
Cr	14	12	−1.29	N.S.	62	43	.06	N.S.
Mn	299	294	−.16	N.S.	485	528	1.21	N.S.
Ag	.05	.05	0.0	N.S.	.09	.15	−1.34	N.S.
Fe	1.3 pct	1.3	− .55	N.S.	2.8 pct	2.3	1.42	N.S.
As	49 ppm	46	− .84	N.S.	94 ppm	87	−1.07	N.S.
Hg	12 ppb	18	.76	N.S.	17 ppb	11	.72	N.S.
W	1 ppm	1	1.0	N.S.	1.4 ppm	1.4	.97	N.S.
Au	50 ppb	7	− .97	N.S.	13 ppb	18	− .85	N.S.

N.S. Not a significant difference at 90% confidence level.

Table 3. T-test comparison of samples and analytical split means in the coarse and fine fractions of the till.

	FINE (N = 16)								COARSE (N = 16)					
Element	Sample (X̄)		Analytical Split (X̄)	T	Significance		Sample (X̄)		Analytical Split (X̄)	T	Significance			
Cu	20	ppm	20	.02	N.S.		15	ppm	15	.05	N.S.			
Pb	15		16	.19	N.S.		9		26	.94	N.S.			
Zn	37		38	.12	N.S.		45		48	.57	N.S.			
Ni	15		15	–.27	N.S.		22		23	.92	N.S.			
Cr	22		22	–.20	N.S.		62		59	–.73	N.S.			
Mn	323		311	–.25	N.S.		485		466	–.34	N.S.			
Ag	.09		.08	–.31	N.S.		.09		.08	–.35	N.S.			
Fe	2.0	pct	2.0	–.06	N.S.		2.8	pct	2.8	–.10	N.S.			
As	237	ppm	235	–.03	N.S.		94	ppm	159	–.99	N.S.			
Hg	55	ppb	60	.17	N.S.		17	ppb	15	–.61	N.S.			
W	1.3	ppm	1.4	.36	N.S.		1.4	ppm	1.4	0.0	N.S.			
Au	20	ppb	680	.99	N.S.		13	ppb	30	1.94	*			

* Significant difference at a 90% confidence level.
N.S. Not a significant difference at 90% confidence level.

Table 4. Gold values for samples and analytical duplicate splits.

Au Fine (ppb)		Au Coarse (ppb)	
Split	Sample	Split	Sample
5	5	15	15
10	15	5	15
2	2	2	2
10	20	25	15
55	90	10	10
40	45	15	10
10	5	10	5
15	35	135	35
14,640	25	10	5
20	5	5	2
10	8	30	30
20	30	20	15
25	15	65	20
5	5	25	10
2	2	45	2
5	5	65	15

gold and arsenic in this unmineralized area. Mean values of 6 ppb Au and 64 ppm As were obtained from the fine fractions of these samples. The coarse fraction of the material yielded average values of 11 ppb Au and 30 ppm As. It is interesting to note that the two samples taken over granitic bedrock have As values which are at least one order of magnitude greater than the samples taken over Carboniferous bedrock. This effect is more pronounced in the fine fraction of the samples. There is, however, no corresponding trend in gold values.

Grain Size and Depth Variation

A vertical profile of till at Forest Hill was initially sampled by P. J. Rogers and R. R. Stea to investigate variations in metal concentrations related to grain size and depth. The till was partitioned into four grain size ranges. Figures 11a, b present the location of the till section in trench 8 and illustrate the grain size and depth variation in tills indicated in the geochemical data for several elements.

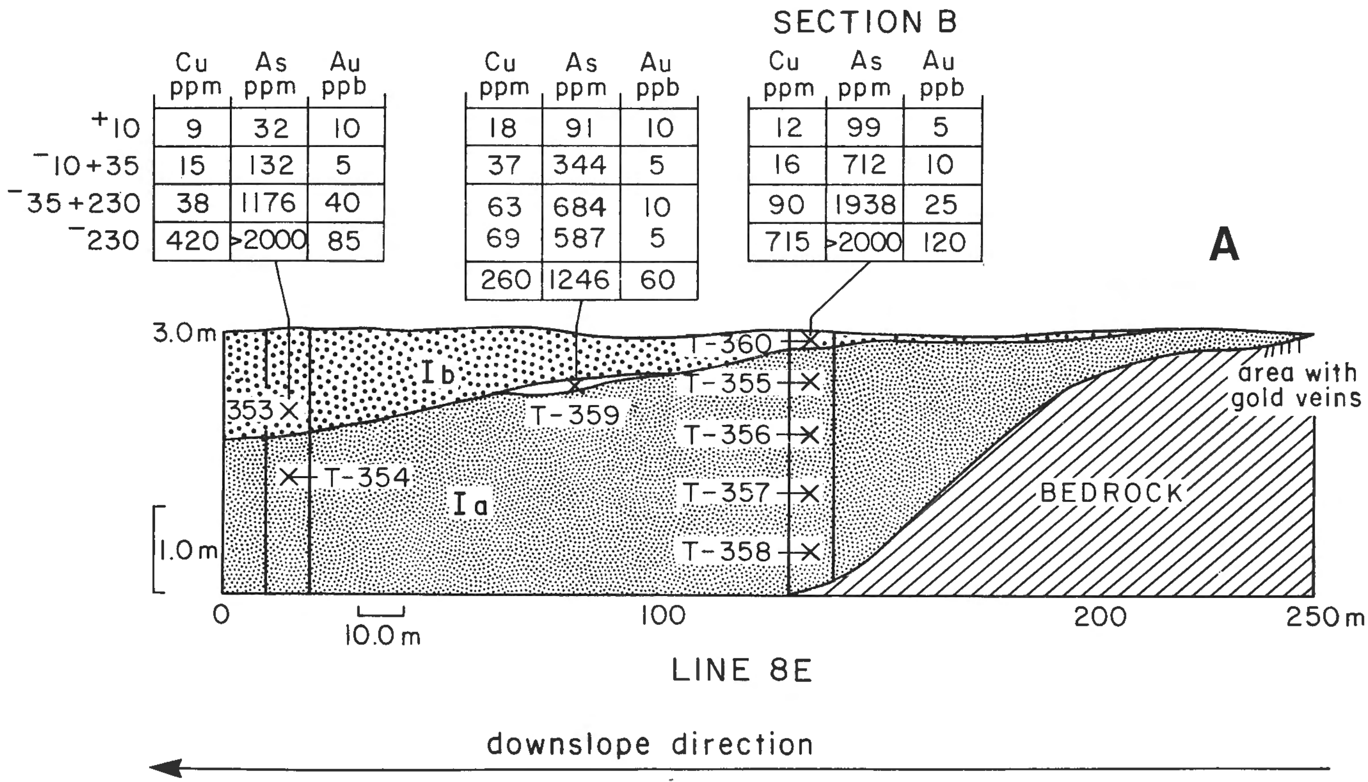
In Unit IA, a lodgment till exposed in trench 8 (Fig. 4), the elemental abundances of Cu, Pb, and Zn remain relatively constant with depth. Gold abundances, however, decrease in Unit IA towards the top of the unit from a peak near the base. In Unit IB, a coarse Fe-Mn oxide cemented diamicton, the values of all the elements increase radically upsection compared to Unit IA, especially in the finer size fractions. The elemental abundances of Au as well as As, Cu and Pb generally exhibit a negative correlation with grain size in both units. The <63 μm fraction generally exhibits the highest trace element values. This enhancement effect in the fine grain sizes is most marked, however, in Unit IB. Iron and manganese show the opposite relationship in Unit IA, with their highest values being in the coarsest (+2 mm) fraction.

Till Unit Variation

Units I, II and III

Basic statistics

Till units I, II and III are stratigraphic divisions based on physical properties. They are believed to represent the basal "phases" of glacial deposition of three depositional events. Lithological composition differs little between the till units (Fig. 12) and geochemical differences between the units with respect to Cu, Pb, Ni, Cr, Mn, Ag, Fe, Hg and W, are minimal in both the fine and coarse fractions of the material (Tables 5A, B).



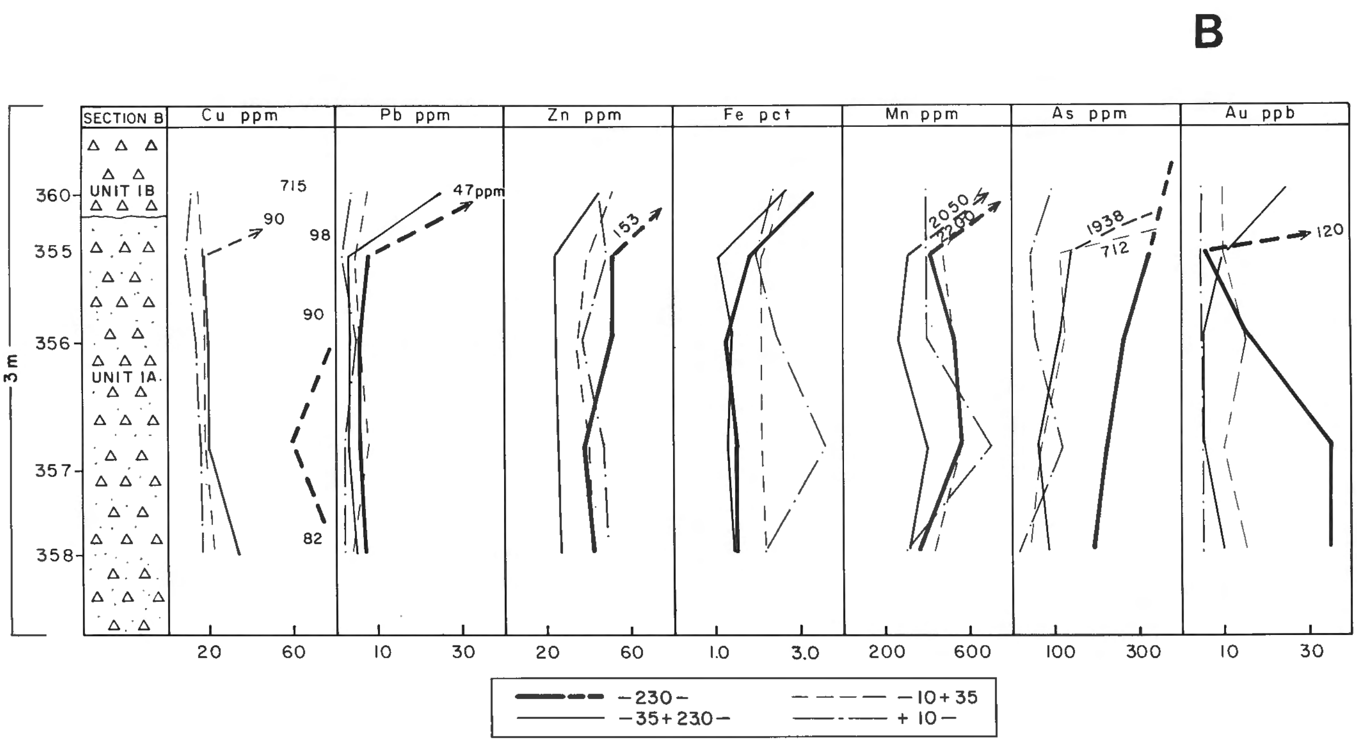


Figure 11.

A Diagrammatic cross-section of the north end of trench 8. The Cu, As and Au values for 4 grain size ranges are shown for three samples in the iron-cemented till unit (IB). Note the concomitant increases in Au, As and Cu in the fine (<230 mesh, <0.063 mm) fraction (after Stea and Rogers, personal communication, 1984).

B A vertical profile through the two till units (IA and IB) at section B in trench 8. Trace element values for four grain size ranges are given (after Stea and Rogers, personal communication, 1984).

Table 5(A). Fine Fraction.

Sample Type N = number of samples	Cu		Pb F		Zn F		Ni F		Cr F		Mn F		Ag F		Fe F		As F		Hg F		W F		Au F	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Units & Soils (n=251)	21	8	13	10	40	49	15	5	20	7	359	383	0.1	0.1	1.9	.6	242	267	46	64	1.3	.6	25	54
Soils (n= 55)	13	5	12	3	30	11	10	4	27	9	225	263	0.1	0.0	2.5	1.0	259	231	132	79	1.1	.5	16	19
Paleosol (n= 6)	14	8	10	3	30	11	12	6	25	4	181	66	0.1	0.0	2.0	0.3	333	223	87	44	1.6	0.5	18	11
Unit 3 (n= 31)	20	4	11	4	37	7	16	2	17	4	331	126	0.1	0.0	1.7	0.2	155	169	19	13	1.4	0.7	16	19
Unit 2B (n= 4)	21	4	15	4	59	30	16	5	15	3	179	19	0.1	0.0	1.6	0.1	62	34	13	7	1.0	0	8	8
Unit 2 (n=100)	23	7	14	5	40	17	17	4	17	4	360	125	0.1	0.1	1.8	0.3	206	234	17	14	1.3	0.6	23	35
Unit 1B (n= 12)	28	6	15	6	39	10	19	6	23	7	1033	443	0.1	.1	2.1	0.6	564	577	58	71	1.0	0	41	31
Unit 1A, 1 (n= 44)	24	6	12	4	56	12	18	4	18	4	395	170	0.1	0.1	1.9	0.4	283	260	18	14	1.3	0.4	47	111
Standard FH-1	58	2	14	10	40	2	19	1	21	1	524	36	0.1	0.1	1.9	0.0	450	170	135	33	1.3	0.4	72	52

Table 5(B). Coarse Fraction.

Sample Type N = number of samples	Cu		Pb		Zn		Ni		Cr		Mn		Ag		Fe		As		Hg		W		Au	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
All Units & Soils (n=251)	14	10	7	6	41	10	19	3	47	12	448	300	.1	.1	2.5	.5	120	203	15	10	1.3	.5	36	119
Soils (n= 55)	11	3	10	4	41	11	20	3	60	18	505	572	0.1	0.1	2.8	0.8	170	305	20	12	1.2	0.4	59	189
Paleosol (n= 6)	11	2	8	1	35	7	19	2	66	7	318	33	0.1	0.1	2.5	0.2	178	133	25	8	1.5	0.6	13	9
Unit 3 (n= 31)	15	10	6	2	39	5	19	3	43	8	438	170	0.1	0.0	2.4	0.3	102	121	13	7	1.3	0.5	10	10
Unit 2B (n= 4)	12	2	7	1	42	6	16	2	38	8	239	46	0.1	0.0	2.1	0.4	34	17	10	4	1.3	0.5	3	1
Unit 2 (n=100)	15	14	7	8	42	12	17	3	42	7	435	149	0.1	0.1	2.5	0.4	101	207	14	9	1.3	0.5	29	88
Unit 1B (n= 12)	13	3	8	5	40	6	20	3	49	8	435	152	0.1	0.1	2.5	0.4	133	65	17	13	1.6	0.5	15	11
Unit 1A, 1 (n= 44)	14	2	6	4	41	8	19	3	44	8	452	177	0.1	0.0	2.5	0.2	112	91	14	7	1.3	.6	51	136
Standard FH-1	59	16	11	2	40	3	20	2	21	5	583	19	0.1	0.1	2.0	0.1	399	186	106	69	1.3	0.4	80	91

The most notable variation between the three basal units is the higher Au concentrations in unit I (Tables 5A, B). The mean gold abundances in this unit are 47 ppb and 51 ppb, respectively in the fine and coarse fractions of the material. The mean gold values in unit II are 23 ppb (fine fraction) and 29 ppb (coarse). The mean gold values in unit I are approximately twice those in unit II and much higher than those in unit III, which has the lowest overall mean gold abundance (16 ppb, fine and 11 ppb, coarse). The standard deviations associated with the mean Au values are greatest in unit I and followed in order by units II and III. Unit I also has higher mean arsenic and zinc concentrations in the fine fraction than units II and III.

Elemental correlations

The nonparametric Spearman Rank Correlation Coefficient was used to evaluate the elemental correlations within the three basal units at Forest Hill. The most significant elemental correlations are presented in a circle diagram format in Figure 12a; the actual correlation coefficients are found in Table I.1, Appendix I. The circle diagrams graphically illustrate the significant inter-element correlations of the fine and coarse till fractions through tie lines between correlative elements and position relative to the centre of the circle. The more significant correlations are found in the centre of the circle.

In the combined fine fraction data of the three 'basal' till units (I, II and III) a strong Ni-Cr-Fe-Zn-Cu correlation, as well as a significant Au-As correlation, is indicated (Fig. 12a). A similar, but less pronounced, pattern (excluding Cr) is obvious in the coarse fraction.

In the fine fraction, Cr has >0.7 correlations with both Ni and Fe, and also has 0.54 and 0.53 correlations with Cu and Zn respectively. Somewhat higher Cu and Zn correlations of 0.65 and 0.69 exist with Ni. The correlations of Cu and Zn to Fe were found to be 0.54 and 0.66. A 0.67 correlation was shown to exist between Au and As.

In contrast to the fine fraction, there are no significant correlations involving Cr in the coarse fraction of the three main surficial units; however, the mean values of Cr in the coarse fraction are approximately twice as high as those in the fine fraction (Table 5). A >0.7 Fe-Zn correlation is the most significant elemental relationship in the coarse fraction. This is followed by a Ni-Fe correlation of 0.68 and a Ni-Zn correlation of 0.64. The correlations of Cu with Zn, Fe and Ni are between 0.5 and 0.6. The 0.52 Au-As correlation in the coarse fraction is lower than the fine fraction Au-As correlation.

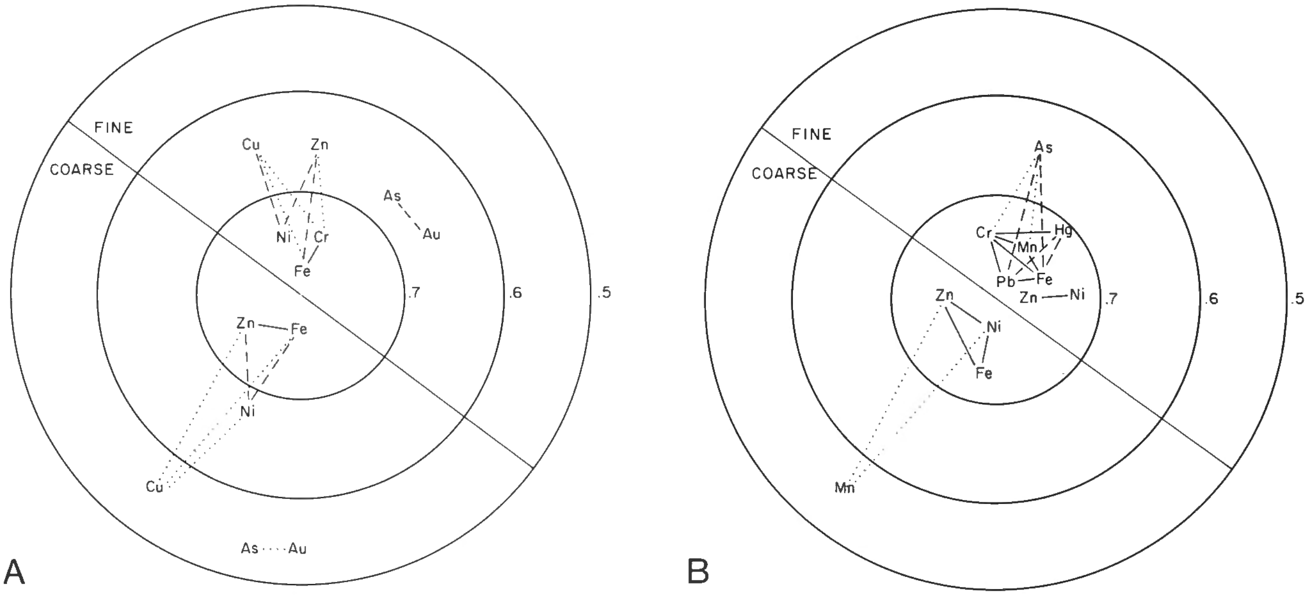
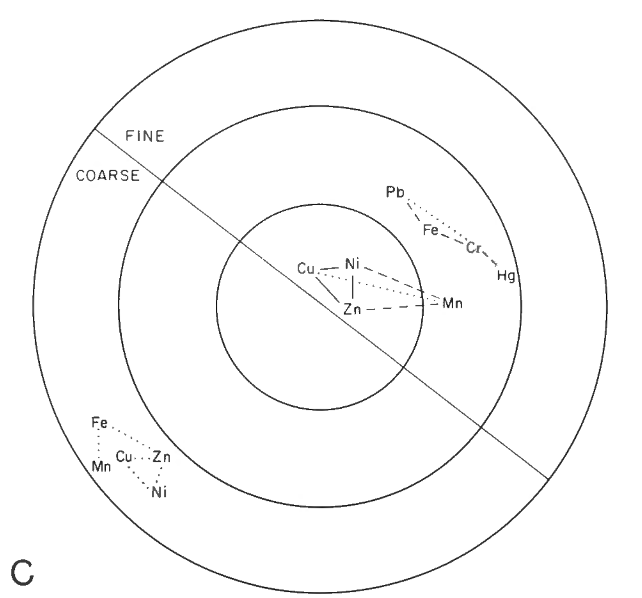


Figure 12.

A Diagram of significant inter-element correlations for the fine (<0.063 mm) and coarse (1-2 mm) fractions of the three 'basal' till units in the study area (I, II, III). A solid line joining two elements represents a 0.7 correlation; dashed 0.6; dotted 0.5.
B Diagram of significant inter-element correlations for the Fe-Mn cemented unit (IB). Elements within the inner circles represent stronger correlations.
C Significant correlations for soil samples.



Cu-Pb-Zn ratios

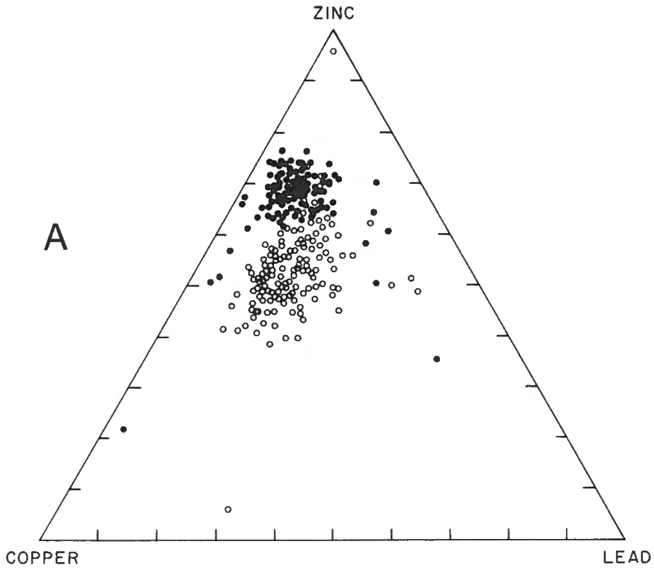
In an effort to explain differences in elemental correlations between size fractions, it was decided that several elements should be plotted on ternary diagrams so that possible trends could be visualized and interpreted. Because of their geochemical association in bedrock and differing mobilities in the secondary environment Cu, Pb and Zn were selected and plotted. The resultant ternary diagram for the 'basal' till units I, II and III is shown in Figure 13a. This diagram clearly shows that the fine and coarse fractions of the units form two separate and distinct clusters or populations. The fine fraction population indicates a relative enrichment in Cu and Pb, and depletion in Zn, compared to the coarse fraction population.

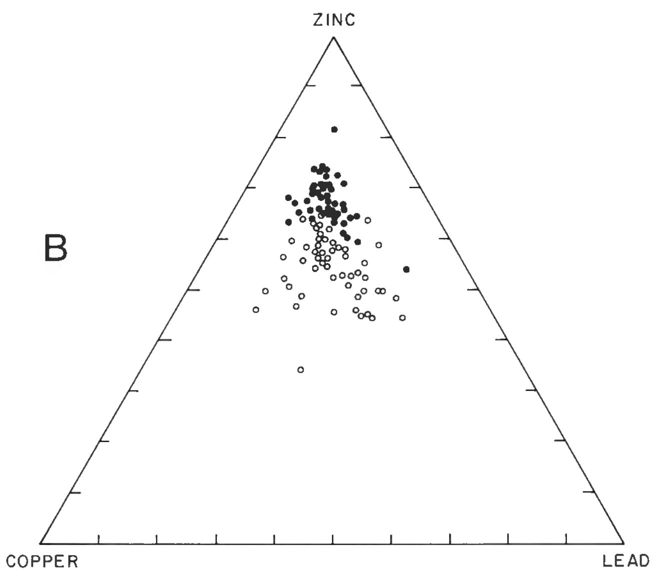
Unit IB (Fe-Mn-rich unit)

Basic statistics

The iron-cemented, stony facies that overlies Till unit I, designated unit IB, is geochemically distinct from the other surficial units at the study area. The mean values and standard deviations for Pb, Zn and Ni in unit IB are similar to the other units; however it is comparably enriched in Fe, Mn, As, Hg and to a lesser extent Au, Cu, Cr and Ag (Tables 5A, B).

Unit IB was observed at some locations in the field to be an Fe-Mn cemented gravel. It was expected that the geochemical analyses would indicate anomalous values in Fe and Mn. However, this enrichment, which is considerably higher than that of any of the other units, is found only in the fine fraction (<0.063 mm). The highest overall mean As and Hg values were also obtained from unit IB. High As and Hg concentrations were observed in both size fractions but were most pronounced in the fine fraction. The mean Au value obtained from the fine fraction of unit IB was 41 ppb, marginally less than the value for unit IA (see Table 5A). The coarse fraction (1-2 mm), however, has a low mean Au abundance (15 ppb). The mean abundances of Cu, Cr and Ag in the coarse fraction are slightly elevated relative to the other units. In the fine fraction only the mean Cr value is elevated and the mean values for Cu and Ag are comparable to the other units (Tables 5A, B).





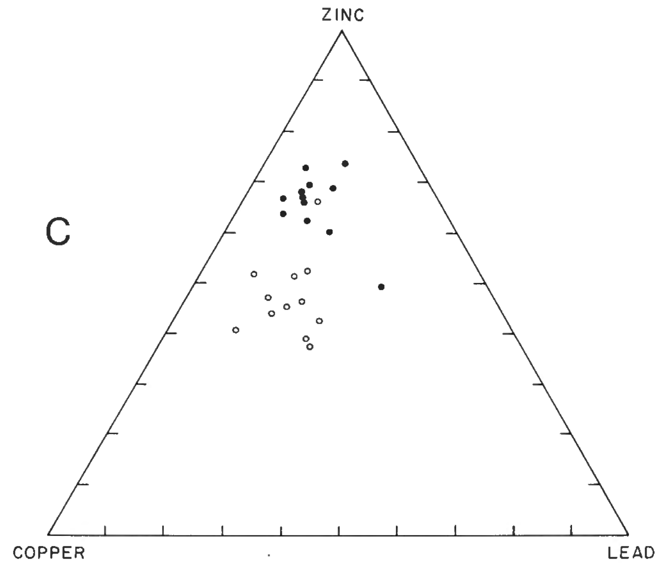


Figure 13.

A Plot of Cu-Pb-Zn ratios for three 'basal' till units (I, II, III). Solid dots = coarse fraction (1-2 mm); open dots = fine fraction (<0.063 mm).
B Cu-Pb-Zn ratio-plot of the Fe-Mn cemented unit (IB).
C Cu-Pb-Zn ratio-plot of soil samples.

Elemental correlation

The most significant elemental correlations (i.e. >0.5) in unit IB are presented in Figure 14b. The specific data are given in Table I.2, Appendix I. Robust correlations involving Cr, Fe, Mn, Pb, Hg and As as well as a very high Zn-Ni correlation are evident in the fine fraction. A strong Fe-Zn-Ni correlation, similar to that found within the basal till units (I, II and III), is prominent in the coarse fraction.

In the fine fraction, correlations of >0.7 exist within the following groups of elements: Cr-Fe-Mn-Pb, Cr-Hg and Zn-Ni. Mercury has 0.64 and 0.60 correlations with lead and iron respectively; these are similar to the 0.67 correlations of arsenic to both lead and iron. Arsenic also has a 0.59 correlation with chromium and a 0.57 correlation with manganese.

Chromium is a focal point of elemental correlations in the fine fraction of unit IB, but it appears to be insignificant in the coarse fraction although its mean Cr value is substantially higher than in the fine fraction. This discordance was also noted between the fine and coarse fractions of the three basal till units.

In the coarse fraction, Zn, Ni and Fe all share >0.7 correlations. Sharing 0.57 and 0.54 correlation with Mn are Zn and Ni respectively.

Cu-Pb-Zn ratios

The Cu-Pb-Zn ternary diagram generated from the unit IB data clearly shows two separate clusters of values for the fine and coarse fractions. Although the number of samples in the diagram is small, there is a separation of size fraction data similar to Figure 15a. When the fine and coarse fractions of unit IB are compared, a marked shift is apparent in the fine data toward Pb and Cu thus indicating an enrichment in these elements relative to Zn.

Soils

Basic statistics

Two types of soil samples, B-horizon samples, and paleosol samples were collected at Forest Hill. The resultant data from the geochemical analyses of these units are given in Tables 5A and B. Table 1 presents the results of soil chemical analyses performed on both units. Both data sets generally show the B horizon and paleosol to be geochemically similar.

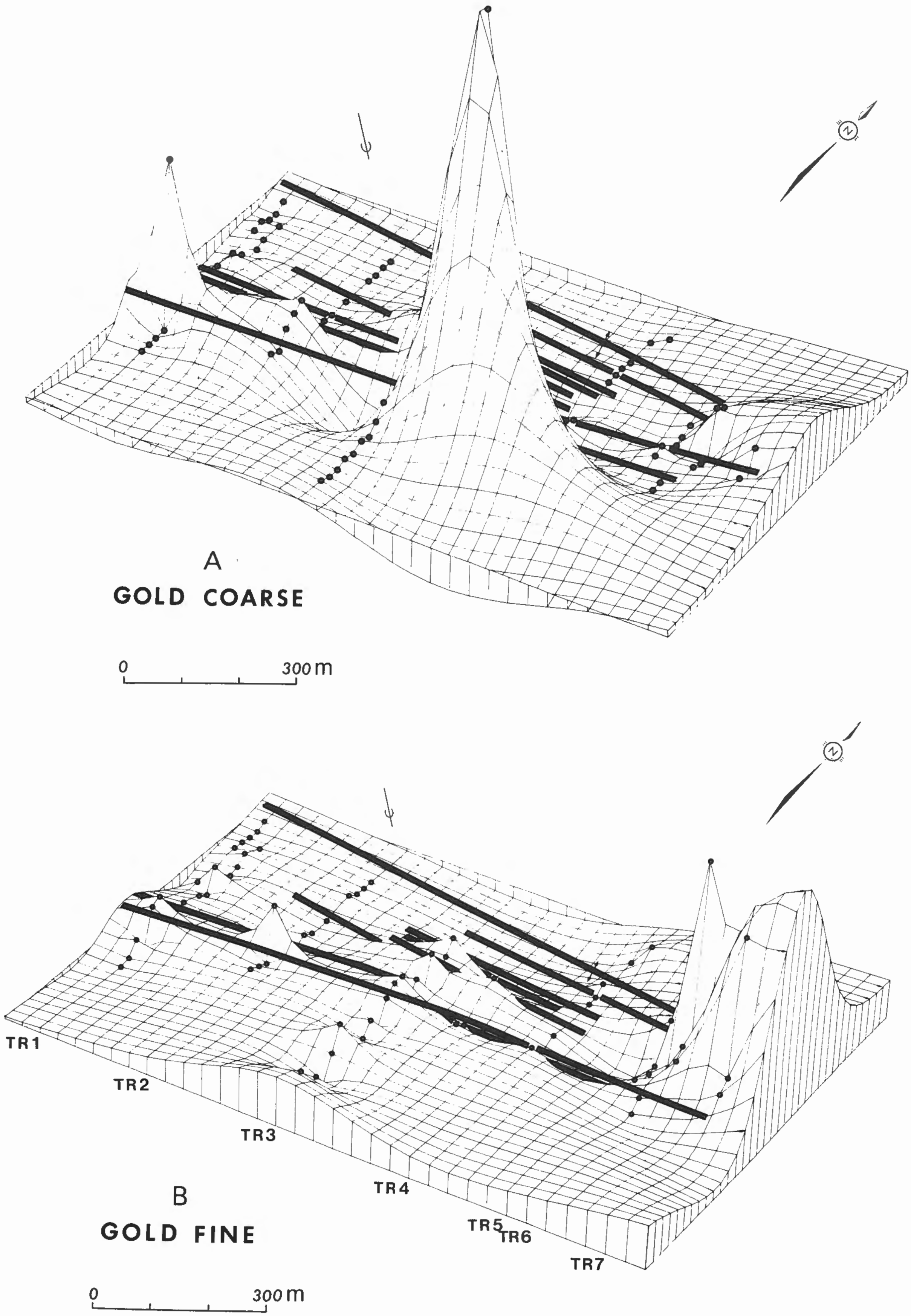


Figure 14. Perspective plots of gold data illustrating the dispersal of gold in the (a) coarse fraction (1-2 mm) and (b) fine fraction (<0.063 mm) of near surface till samples in trenches 1 to 7. The observer is given the perspective of looking in the up-ice direction (335°). Dots represent sample stations along the trenches. The trace of the anticlinal hinge and major auriferous veins are outlined by heavy lines.

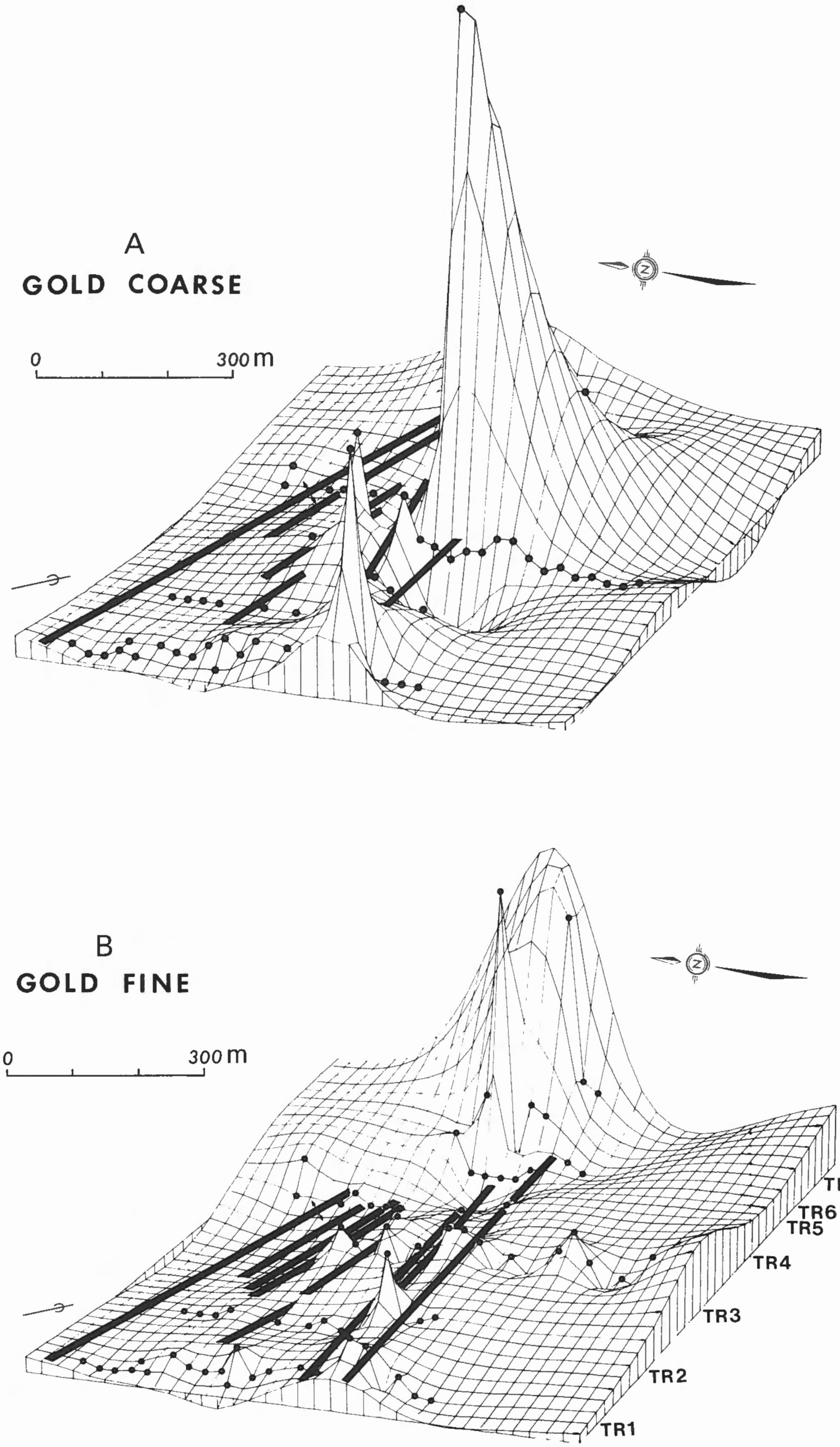


Figure 15. Perspective plots of gold data illustrating the dispersal of gold in the (a) coarse fraction (1-2 mm) and (b) fine fraction (<0.063 mm) of near surface till samples in trenches 1 to 7. The observer is given a perspective of looking perpendicular to the ice-flow direction (d065~). Dots represent sample stations along the trenches. The trace of the anticlinal hinge and major auriferous veins are outlined by heavy lines.

The fine fraction data (Table 4) show that both soils have similar concentrations of Cu, Pb, Zn, Ni, Cr, Ag, W and Au. Differences between the two units lie in higher As concentrations in the paleosol and higher Mn, Fe, and Hg concentrations in the B horizon.

The coarse fraction has the same general trend apparent in the fine fraction. Similar mean values for both soils were obtained for Cu, Pb, Zn, Ni, Ag, As, Hg, Cr and W. The significant differences between the soil types are in the mean values of Au and Mn, which are much higher in the B horizon. The mean Fe concentration is also higher in the B horizon than in the paleosol.

When grouped together and compared to the various till units, the soils have similar concentrations of Pb and W in both size fractions; however the concentrations of Zn and Ni of the soils compared to the tills are similar only in the coarse fraction (Tables 5A, B). In the fine fraction the values of Zn and Ni are significantly lower in the soils. The soils are generally lower in their Cu concentrations and higher in their Cr, Fe, As and Hg concentrations. Lower Ni and Mn concentrations were observed in the soils than in the tills.

Elemental correlations

The significant elemental correlations within the soils are illustrated in Figure 14c. The specific correlations are given in Table I.3, Appendix I.

In the coarse fraction, correlations of >0.7 exist between Cu, Zn and Ni. Mn is related to Ni and Zn by 0.64 correlation and Cr to Fe and Hg by a correlation of 0.62. Lead was shown to have a 0.65 correlation with Fe and a 0.58 correlation with Cr while Cu and Mn share a 0.54 correlation.

The Cu-Zn-Ni correlation in the coarse fraction is less pronounced than in the fine fraction. Iron is correlated to Mn and Zn in the coarse fraction only.

Cu-Pb-Zn ratios

The Cu-Pb-Zn ternary diagram of the soil data reflects the same population separation observed in the other surficial units (Fig. 15a, b, c). With respect to the coarse fraction, the fine fraction is enriched in Cu and Pb and depleted in Zn. In the soils, however, Pb enrichment appears to have been favoured over Cu.

DISCUSSION AND INTERPRETATION

The Nugget Effect

It is our opinion that the generally poor correspondence of gold values observed between the coarse fraction splits is largely due to the "nugget effect", where a small number of gold grains accounts for the gold content of a large volume of sample (DiLabio, 1982a, Averill, 1984). This effect is generally more pronounced in coarse than fine material, particularly in glacially comminuted debris. To illustrate this, imagine two large and equal volumes of barren sample, one of coarse material and the other of fine material. Then introduce gold to the coarse fraction in an amount that would constitute one gold particle as large as the average grain size of the coarse material. Add to the fine sample an equivalent weight of gold but as particles having the average grain size of the fine material. If each sample is then mixed and small subsamples taken, we will expect more consistent and reliable data from the fine fraction because many gold particles control the gold content of the sample. This increases the probability of a subsample being representative of the whole sample, thus the nugget effect is minimal. Conversely, the gold content of the coarse sample is controlled by only one gold particle, hence the nugget effect is extreme. For this reason, it is impossible to take a representative subsample of reasonable size of this material. A subsample of the coarse material would have a high probability of not containing the single gold particle. In the remote chance that the subsample contained the gold particle, a highly exaggerated value, not representative of the sample as a whole, would be obtained.

While the nugget effect in the coarse fraction may cause or contribute to the above noted disparities it is unlikely to explain the variations in the fine fraction (<0.063 mm) where one value of 25 ppb and another value of >14 000 ppb were obtained.

This suggests that the >14 000 ppb value or the 25 ppb value is an analytical error. The results of the panning survey suggest that the larger value is correct as abundant visible gold was recovered from the sample location.

Geochemistry vs Panning

The cause for the discrepancies that exist between the panning results of the survey and the geochemical data for Au probably have their basis in the nugget effect. The main factor responsible for the disparity in the two techniques is the volume of material in which the detection of gold is undertaken. Approximately 8 kg of till was used during the panning process while 2 to 4 kg was collected for geochemical analysis. It is not the form of detection itself, but the events that precede it which result in the poor correlation between the two methods. During the panning process the nugget effect is progressively minimized, whereas the nugget effect is progressively maximized during the sample preparation necessary before geochemical analysis of the material.

During the panning process a large amount of material is reduced to a small heavy mineral concentrate, in which most of the gold from the original volume of material should be contained. Essentially the relative abundance of gold is greatly enhanced by this procedure. The gold is then easily isolated from the other minerals in the pan by a gentle washing motion. Recovery of silt-sized particles is possible through efficient panning; some gold grains recovered from the heavy mineral concentrates in this study were as small as 0.053 mm. One must be careful, however, not to over-estimate the efficiency of the panning method in concentrating very fine gold. Craig Miller (personal communication, 1983) has noted in past stream sediment surveys over the Meguma Group terrain, that when analyzed, material which did not contain visible gold upon panning commonly yielded higher gold values in whole silt samples than in their panned concentrate equivalents. In this case the gold may have been extremely fine grained and may have washed out during the panning process, or the gold formed part of other discrete mineral grains. Panning efficiency varies from person to person and from day to day with the same person, and so the panning results of this survey are subject to these unavoidable limitations.

An additional factor which may contribute to the low correlation between geochemical and panning gold exploration techniques may be the presence of discrete and discontinuous lenses of gold-rich till at some of the sample areas. DiLabio (1982b) has suggested that metal rich-lenses may exist in tills at the Oldham Gold District of Nova Scotia. DiLabio and Shilts (1978, p. 91) showed significant vertical variations in basal debris bands within a modern glacier. This may cause samples and panned material collected nearby to have vastly different gold concentrations. Indeed, at a few sites, where visible gold was recovered on the initial panning of the unit, repeated attempts to pan gold from the same location failed to yield additional gold. This result, however, was the exception rather than the rule.

In the geochemical analyses, the arsenic data are superior to the gold data in their ability to reflect the results of the panning survey; however, this fact must be considered within the context of the geochemical properties of arsenic in the till profile and its possible modes of occurrence in the bedrock.

Arsenic, by its nature and average abundances, is not as vulnerable to the nugget effect as gold, but it is the more mobile of the two elements in the soil column and is therefore more susceptible to hydromorphic redistribution. Depending on the characteristics of the surficial materials and groundwater conditions, this can result in very different gold and arsenic distributions. DiLabio (1982b) documented this effect at the Oldham Gold District.

It is important to note that bedrock arsenic mineralization can occur independently from gold mineralization. Boyle (1966) noted arsenopyrite-rich layers in the Goldenville Formation not associated with gold mineralization. MacEachern has observed bedrock of the Goldenville Formation in which 4 to 6 cm crystals of arsenopyrite were plentiful. The occurrence was in close proximity to three gold mines, but gold was not detected in assays of the material. It is because of the inherent high geochemical background values of arsenic that it may not be dependable as a pathfinder element for gold.

In our comparison and interpretation of geochemical and panning methods as exploration tools, we do not wish to downplay the importance of geochemical methods but rather emphasize the importance of panning. The techniques should by no means be regarded as mutually exclusive; both should be used in gold exploration in Nova Scotia. Simply put, geochemical analyses are expensive, panning is not; these techniques should be used to complement and supplement one another in the interest of trimming exploration costs and acquiring a maximum of information for the dollars spent.

Role of Hydromorphic Processes

The Cu, Pb and Zn ratio plots illustrated in Figure 15a, b and c, indicate the existence of different data populations for the two analysed size fractions in the tills and soils at Forest Hill. Similarities that exist between coarse fraction (1-2 mm) rock fragment counts (Fig. 12d) and till pebble counts (Fig. 12a, b, c) suggest that the Cu-Pb-Zn ratios in the coarse fraction probably reflect those of the local Meguma Group bedrock. The $<63\ \mu m$ fraction of tills, however, is largely composed of metal-poor quartz and feldspar with small percentages of phyllosilicates and Fe-Mn sesquioxides (Shilts, 1975; Stea and Fowler, 1979). The complete separation of the Cu-Pb-Zn ratio fields between the two size fractions for units I, II and III may be due to a hydromorphic redistribution and enrichment of Cu and Pb in the fine fraction of the tills. The same effect is noted in the Cu-Pb-Zn plots of the coarse and fine fractions of B-horizon soils (Fig. 15c) in which the fine fraction is made up of translocated Fe-Mn sesquioxides. These oxides are known to scavenge and co-precipitate metal cations. These clay-sized Fe-Mn oxides in addition to phyllosilicates may be responsible for the uptake of cations released through weathering, especially Cu and Pb, in the till units (Shilts, 1975; Piispanen, 1982).

Unit IB

At several locations in the study area, unit IB occurs as a Fe-Mn cemented gravelly-sand and diamicton (Fig. 10). Several similar cemented units have been observed in other areas of Nova Scotia by Stea (1978) who has noted that these units usually occur near granite contacts and are commonly dominated by clasts of granitic and pelitic lithologies. It is interesting to note that the locations at which unit IB is cemented occur only in the eastern part of the study area where the ratio of pelitic to quartzitic lithologies is greatest.

Figure 12c illustrates the geochemical signature of the cemented diamicton (unit IB). The difference in geochemical associations between the fine and coarse fractions is striking. The association of Cr, Hg, As and Pb with Fe and Mn in the fine fraction strongly implies chemical and hydromorphic processes. Figure 11a shows an apparent enrichment of metals in unit IB downslope from known bedrock mineralization. It is interesting to note that the Zn-Ni correlation, which is separate from the Fe-Mn metal assemblage in the fine fraction, persists in the coarse fraction of unit IB and is present in the coarse fraction of the main till units (Fig. 12a). This geochemical association may be inherent in Meguma Group rocks.

Acidic, oxidizing groundwater flowing through the unit lowered the pH sufficiently to mobilize elements in the metal-rich pelitic component of the debris. Metals were hydromorphically redistributed and enriched in the unit. Eventual coprecipitation of the metals with Fe-Mn sesquioxides was induced, either by evaporation of water in the unit or through contact with weathered granitic clasts and feldspar grains dispersed through the unit.

The statistical analyses of the geochemical data show that arsenic is the only element significantly correlated with the gold mineralization at Forest Hill (Fig. 12a, b, c). Among the other elements that were not related with any others were tungsten and silver. These elements rarely registered values greater than their respective lower analytical detection limits. MacEachern (1983) also noted that silver did not reflect gold anomalies in till at the Fifteen Mile Stream Gold District.

Chromium

It was noted previously that the values of chromium vary sympathetically with many other elements in the fine fraction of all the surficial units at the study area (Fig. 12a, b, c). The mean chromium concentrations in the coarse fraction, however, are more than twice those in the fine fraction, while most other elements are relatively less abundant in the coarse fraction (Table 5). Hydromorphic redistribution of chromium in the fine fraction may account for the elemental correlations especially the relationships with Fe and Mn. Hydromorphic effects are typically more pronounced in the finer fractions of tills and soils than the coarser fractions. If weathering of labile minerals has occurred in the surficial units at Forest Hill and is strong in the fine fraction but insignificant in the coarse fraction, it could conceivably account for the higher chromium values in the coarse fraction. Boyle (1979, p. 154) claimed that much of the chromium in chromium bearing minerals "appears in the hydrolysis products, probably as the hydrous sesquioxide, $Cr_3O_3nH_2O$, which is readily co-precipitated and/or absorbed by hydrous iron, alumina and other hydrosylates". This hypothesis is particularly attractive because of its ability to explain high chromium concentrations in the fine fraction of the Fe-Mn cemented unit IB. It should be noted that this interpretation implies that all of the surficial units are, to some extent, chemically altered. Saarnisto, et al. (1981) noted that the fine fraction of esker material showed simultaneous increases in Cu, Mn, Fe, Zn and Cr.

The comminution of various chromium-bearing minerals into select grain size ranges may explain or at least contribute to the differences in amounts of chromium in the two size fractions. Chromium is largely present in heavy minerals which are found in the fine till matrix; they are: chlorite, biotite, ilmenite and magnetite. Chemical breakdown of these heavy minerals, which are free in the fine fraction, may contribute to the relative depletion of chromium.

Gold

Figure 11 a, b illustrates the distribution of Cu, As and Au values in four grain size ranges throughout two till units. The most auriferous grain size appears to be the fine fraction (< 230 mesh, <0.063 mm) in both till units. The amounts of gold vary significantly between the unweathered till unit (IA) and the Fe-Mn cemented unit (IB). Gold shows concomitant increases with Mn and Cu in the cemented unit. The authors believe that the cement is secondary in origin so it is likely that metals within the fine fraction of the unit are bound in Fe-Mn oxide complexes. Gold may have been remobilized with the other metals in the primary deposit. Dilabio (1985, p.118) found that weathered till at Waverly, Nova Scotia exhibited gold enrichment in the fine fraction. He did not find evidence of discrete gold grains and concluded that at least some of the gold was present in an adsorbed form on Fe-Mn oxides.

DISPERSAL OF GOLD AND TRACE ELEMENTS

General Statement

In order to form an objective picture of the gold dispersal over most of the Forest Hill area, perspective plots of the analytical gold data were generated by computer (Fig. 14a, b; 15a, b). Only gold data from the till samples nearest the surface at each station were used to generate the diagrams.

Because dispersal trains are three-dimensional in structure, and the till stratigraphy has implications on the gold dispersal at Forest Hill, fence diagrams were constructed of trenches 1, 2, and 3, and the gold, arsenic and mercury data from the samples were plotted on the diagrams (Fig. 16, 17, 18, 19). Trenches 1, 2, and 3 were chosen for this type of illustration because of their extended lengths and proximity to the major veins which were mined.

Perspective Plots

The perspective plots show only the dispersal in the first seven trenches. The large size of several of the data peaks made it necessary to generate two sets of plots with different viewpoints so that all areas of interest could be made visible. Figures 14a and b illustrate the dispersal of gold in the coarse and fine fractions of the till from the perspective of looking in the up-ice direction (approx. 335°). Figure 15a, b present the observer with the same dispersal patterns as viewed from a position facing perpendicular to the general ice flow direction (065°).

In the western part of the study area both the fine and coarse fractions of the till reflect a mechanical dispersal of gold which approximates the major southeastward ice flow direction in the area. The dispersal distances in both size fractions are quite short, particularly in the coarse fraction. Peaks in gold abundances in the coarse fraction are generally within 100 m of the source veins, and peaks of abundances in the fine fraction are within 200 to 300 m of the respective source veins. These differences may result from transport of the fine fraction, or progressive down-ice comminution of the gold in the basal zone, or a combination of both processes.

In the western part of the district the peaks of gold abundances are much higher in the coarse fraction relative to the fine fraction. This is probably due to the nugget effect.

In the eastern part of the gold district, the dispersal is not at all like that of the western part of the district; the whole area is elevated in its gold concentrations in the fine fraction. There is a similar, but much less pronounced reflection of high gold concentrations in the coarse fraction. This elevated area is typified by relatively consistent values compared to the erratic peaks that characterize gold values in the western areas of Forest Hill. It is important to note that most of this enriched

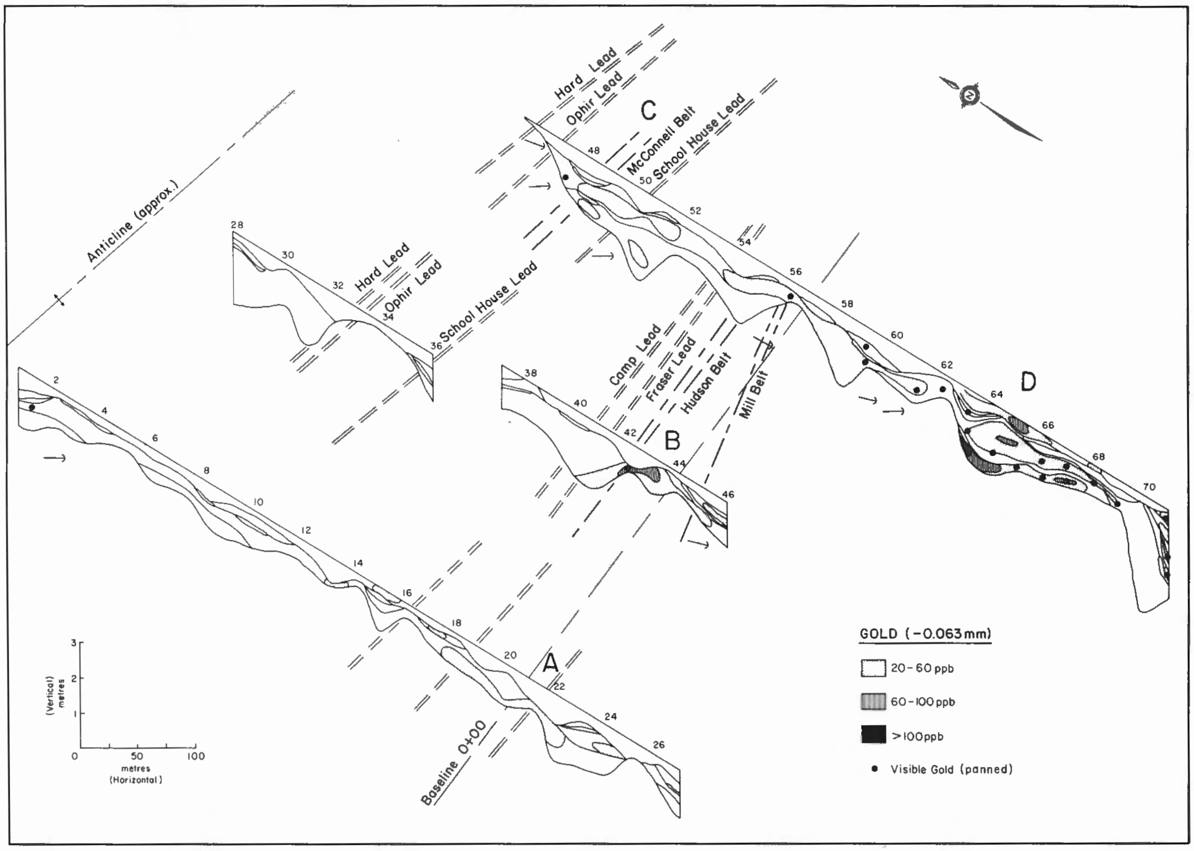


Figure 16. Fence diagram illustration of gold dispersal in trenches 1, 2 and 3 from contoured gold values of the fine fraction (<0.063 mm).

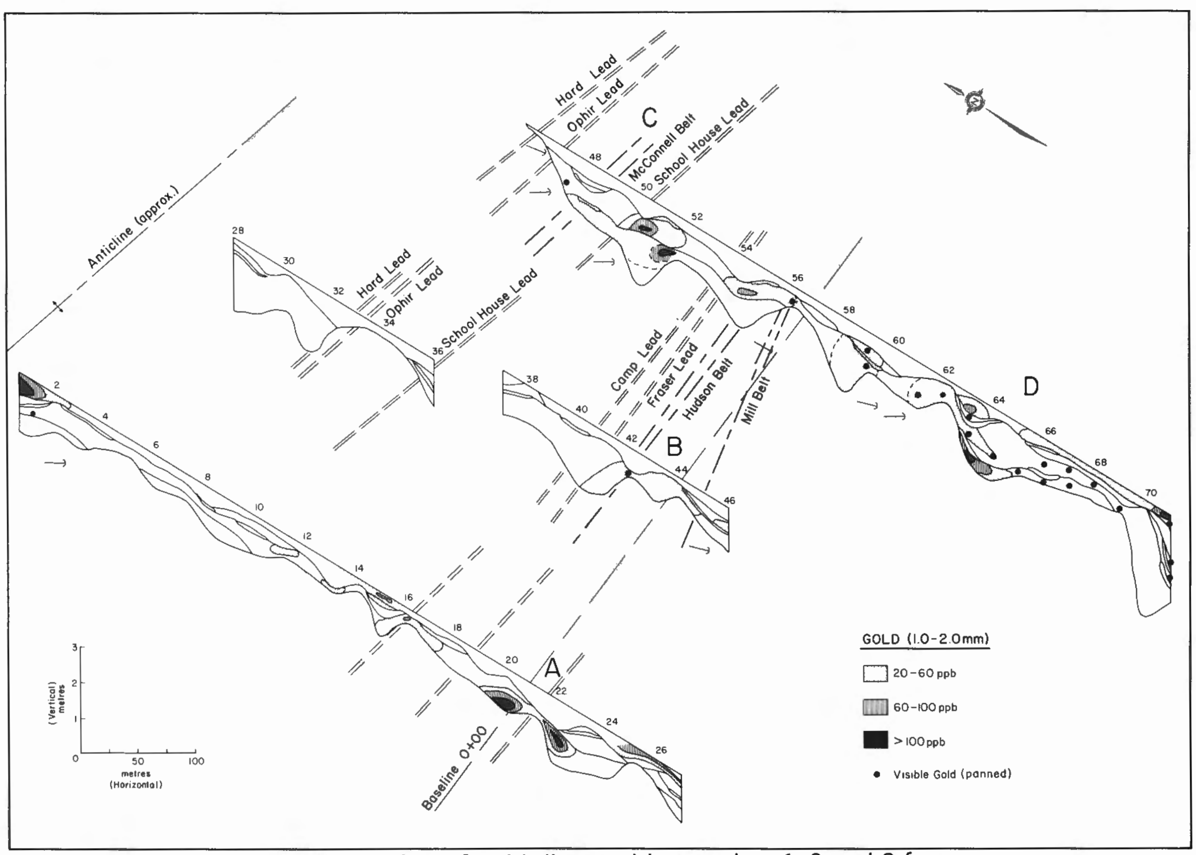


Figure 17. Fence diagram illustration of gold dispersal in trenches 1, 2 and 3 from contoured gold values of the coarse fraction (1-2mm).

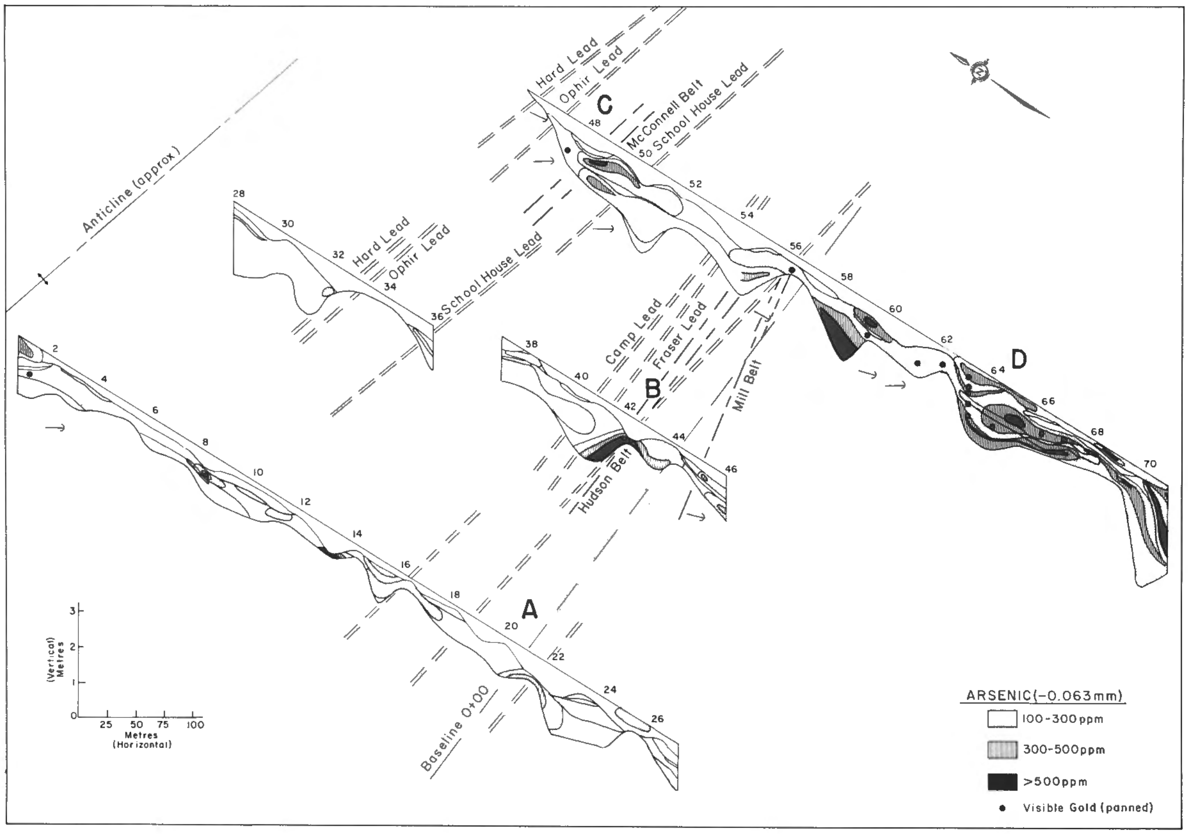


Figure 18. Fence diagram illustration of arsenic dispersal in the fine fraction (<0.063 mm) of the tills in trenches 1, 2, and 3.

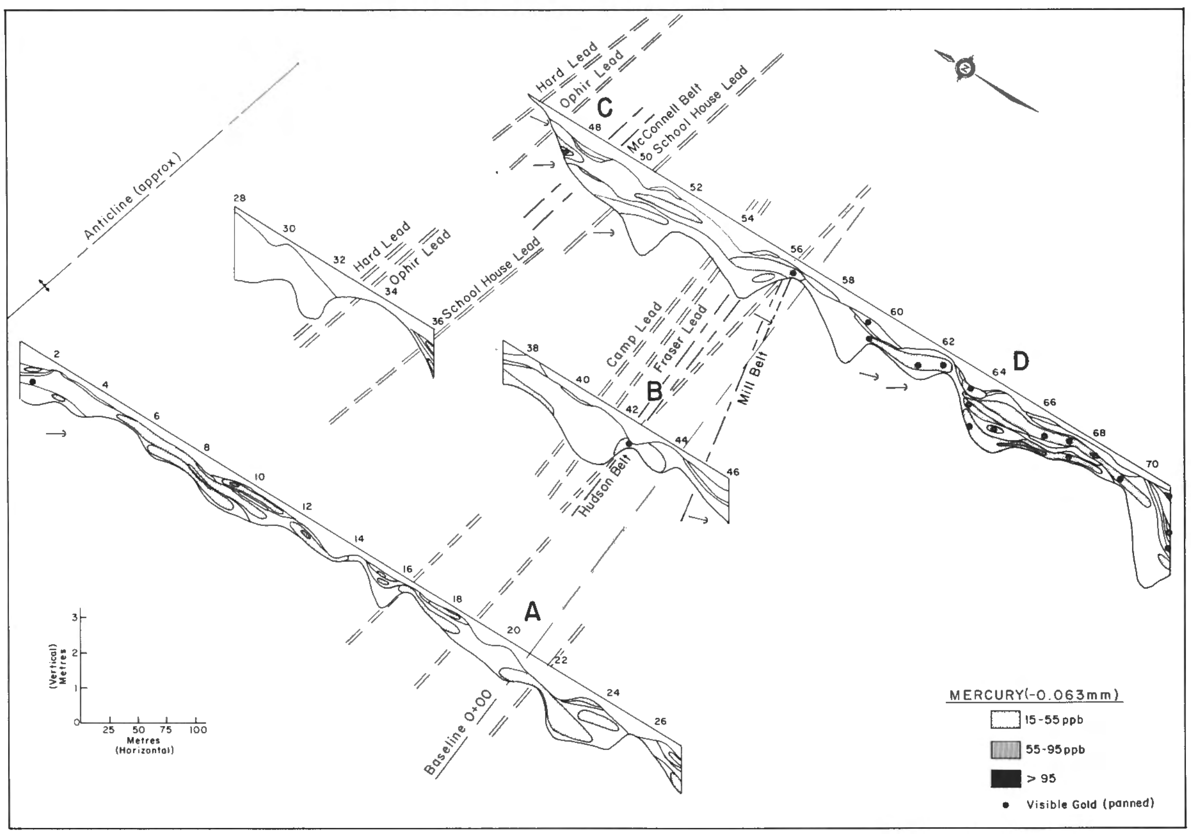


Figure 19. Fence diagram illustration of mercury dispersal in the fine fraction (<0.063 mm) of the tills in trenches 1, 2, and 3.

area lies on, or north of the auriferous veins of the gold district which would imply a further source of gold to the northwest or dispersal of gold in a direction opposite to that of the apparent ice flows. There should be no additional source of gold to the north because the anticline which hosts the veins is overturned and its north-facing limb has been eroded away. There is the possibility that the eastern extension of the anticlinal structure at Forest Hill may have suffered transform faulting which could have displaced the auriferous veins in this part of the district northward; however there is no additional evidence to support this hypothesis. Unit IB, the Fe-Mn cemented diamict, outcrops in this area, and was probably a former conduit of groundwater flow. The composition of gold recovered from unit IB generally has a smaller Au/Ag ratio than gold recovered from the other surficial units at Forest Hill (Table I.1, Appendix I). This evidence tends to support a hydromorphic redistribution of gold in the till in the eastern part of the study area, the dispersal of which is determined by downslope movement and water drainage in unit IB. The landscape in this area slopes to the north.

Three-dimensional Outline of Dispersal

Figures 16, 17, 18 and 19 display the three-dimensional dispersal of Au, As, and Hg within the individual stratigraphic units of trenches 1, 2 and 3. Arsenic and Hg were determined to best reflect the anomalous values of gold upon contouring of all the geochemical data. The locations of the trenches are shown in Figure 4, and the stratigraphic legend is presented in Figure 7. Many of the gold anomalies appear to occur within till unit II which is the most continuous and widely distributed surficial unit in the Forest Hill area. The dispersal of gold in this till generally reflects a southeastward ice-flow from gold-bearing quartz veins verifying the panning results (Fig. 20). The later southwestward ice flow which deposited till unit III does not appear to have redistributed the gold.

In general the gold dispersal reflected in the fence diagrams (Fig. 16, 17) has the same basic patterns outlined by the perspective plots (Fig. 15a, b). A mechanical dispersal of gold is implied by the contoured gold values which indicate that anomalies extend in the down-ice direction from known auriferous veins. The fence diagrams, like the perspective plots, indicate a short distance of transport of the gold, especially in the coarse fraction (Fig. 16, 17). Most of the anomalies are within 100 m of the source veins; however, the gold-rich areas near the southern end of trench 3 indicate longer dispersal distances on the order of 200 to 300 m. This may be due to increased abundances of gold made available for transport from the erosion of high grade ore in the Mill Belt or the close grouping of belts and leads (veins) between trenches 2 and 3. This interpretation is supported by the relatively abundant and consistent recovery of gold from the panning of the units (see visible gold locations, Fig. 17, and overall panning results, Fig. 20). Another explanation could be the existence of undiscovered auriferous veins lying to the south of the Mill Belt. The high gold values in soil at the end of trench 3 suggest a progressive upward displacement of gold from the bedrock source to the surface in the direction of dispersal. Upward displacements of the ore in till sheets have been noted in previous studies (Prest, 1911; Garrett, 1971; Skinner *in* Shilts, 1976).

The limited dispersal train of gold at Forest Hill is not unique to the area, as evidenced at Blockhouse (Fig. 3), or to Nova Scotia. Sheehan and Gleeson (1984, p. 24) noted that the dispersal train of gold from the Williams gold deposit in Ontario was less than 200 m.

Differences in gold values between the coarse and fine fractions in Figure 18 are minimal; the same anomalies are indicated in both size fractions. The only notable difference is a gold anomaly in the coarse fraction of the soil at station 1, trench 1 which is not reflected in the fine fraction. Arsenic values are elevated in the fine fraction at this site (Fig.18) which suggests either that the gold occurs only as coarse particles or that gold was not present in the subsample of the fine fraction which was analyzed; a result of the nugget effect.

In general, the fence diagrams of the arsenic and mercury values in the coarse fraction reflect the same anomalous areas as do the gold values. There are, however, weak to moderate mercury anomalies between stations 5 and 11 in trench 1 that are not reflected in either the arsenic or gold data. The relatively good association between the gold and mercury diagrams is surprising since the results of the statistical analyses of the data did not indicate a strong correlation between the two elements. Background noise may have dampened the statistical correlation between Hg and Au, which may be significant only at elevated values of both elements.

CHARACTER AND COMPOSITION OF GOLD IN TILL

Character of Gold

At Forest Hill the gold in the till occurs both as small flakes and small nuggets. With a scanning electron microscope the gold grains appear rough and pitted (Fig. 21a, b, c), and exhibit little evidence indicative of abrasive glacial transport. This is also true of the other heavy minerals recovered from the till (MacEachern et al., 1984).

In a study carried out at the Fifteen Mile Stream Gold District,Nova Scotia, MacEachern (1983) documented the distribution, character and composition of gold in till. The gold in the till at the Fifteen Mile Stream Gold District occurs predominantly as unworn foliated flakes and nuggets which often exhibit delicate extensions of grain edges (Fig. 22a, b, c). Although some of the gold grains from the till at Forest Hill have similar hook-like extensions at grain edges, these features are not as common or as well defined as those on the gold grains from the till at Fifteen Mile Stream. The absence of micaceous foliations in gold particles from the tills at Forest Hill further distinguishes these gold particles from those recovered at the Fifteen Mile Stream area.

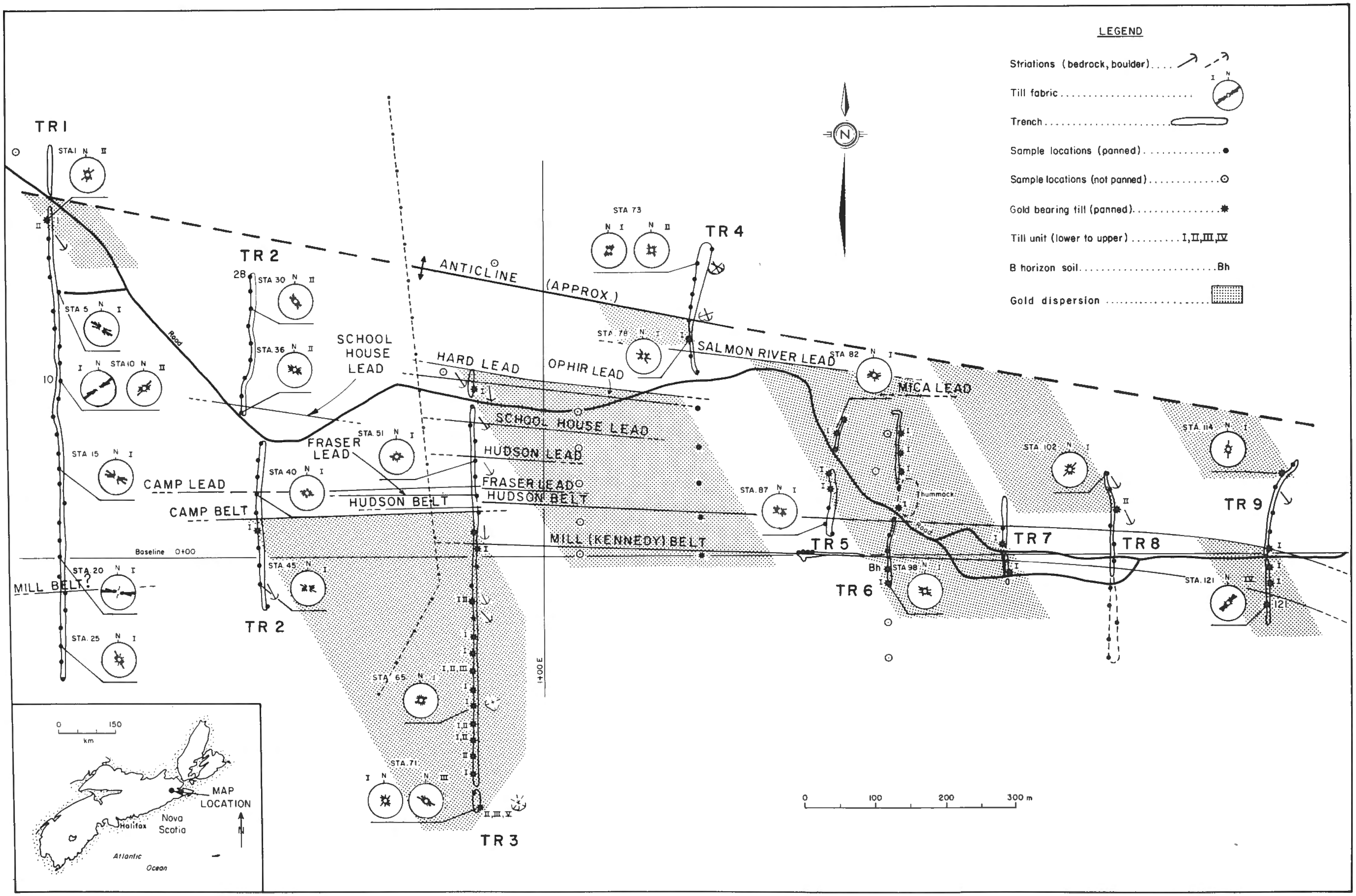
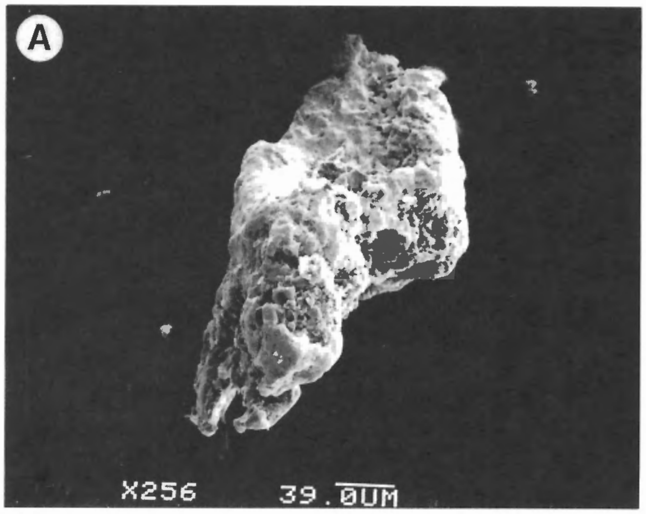


Figure 20. Dispersal of gold-rich drift at Forest Hill as indicated by the panning results of the study.



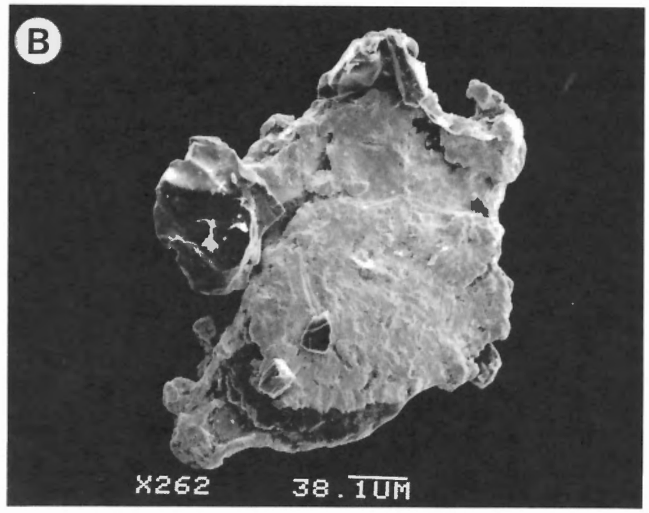


Figure 21. Scanning electron microscope photomicrographs of gold grains recovered from pan concentrates of tills at the Forest Hill Gold District. Magnification and bar scales are shown on each photograph.
A Gold nugget
B Gold flake, note slender, delicate extensions at grain edges indicating minimal deformation during glacial transport
C Gold nugget

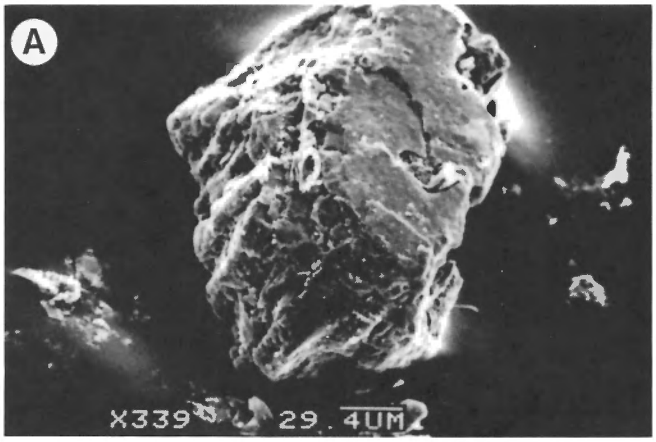
Composition of Gold

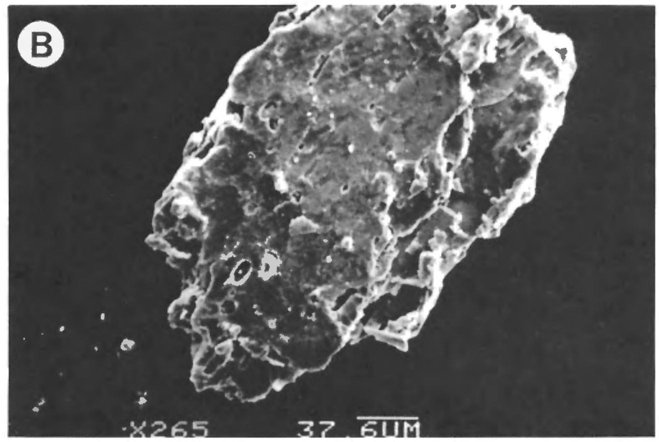
Electron microprobe analysis (EMP) of gold grains recovered at the Forest Hill and Fifteen Mile Stream gold districts indicates highly significant compositional differences between gold particles recovered from the two areas.

The composition of gold in the tills at Forest Hill is relatively consistent over the study area with an average value of about 96 per cent Au and 4 per cent Ag (Table II.1, Appendix II). Gold grains recovered from the iron-cemented unit 1B, however, were characterized by a smaller Au/Ag ratio than those obtained from the other surficial units. Variations in composition within individual grains of gold were also found to be minimal. Further compositional analyses were conducted on gold recovered from vein-quartz and mine tailings at Forest Hill (Tables II.2A and B, Appendix II). When compared to the compositions of gold from the till, only minimal differences were found to exist.

Conversely, the gold recovered from the till at the Fifteen Mile Stream gold district (MacEachern, 1983) indicated heterogeneous within-grain elemental distributions and highly significant compositional differences from gold obtained from the mine tailings (Tables II.3A and B, Appendix II). Gold in the mine tailings, which should be representative of the composition of gold in the primary deposit, gave consistent values which average 91 per cent Au and 9 per cent Ag. The composition of gold grains in the till averaged 70 per cent Cu, 10 per cent Zn, 10 per cent Au and <1 per cent Ag. The absence of any detectable elements other than gold, silver, copper and zinc in these "gold" grains suggests that they are alloys, and not sulphides. Iviolov et al., (1982) have observed a similar phenomenon in modern and ancient placers in the Soviet Union, and they have suggested that "copper in the gold is not in the form of native copper or its compounds, but is probably connected with gold as a heterogeneous solid solution". MacEachern (1983) suggested that the peculiar compositional differences between gold from the till and gold from the bedrock can best be explained as a manifestation of a hydromorphic redistribution of gold in till at the Fifteen Mile Stream area.

It is our opinion that hydromorphic processes have not affected the composition of the gold in unweathered till at Forest Hill as they have at Fifteen Mile stream because of differences that exist in groundwater conditions at the respective localities. Because of the high topographic relief at Forest Hill, much of the area is above the regional water table. The Fifteen Mile Stream gold district, however, lies in a gentle and broad topographic trough characterized by poor drainage and a high water table. Geochemical conditions beneath the water table may contribute to the remobilization of gold in the till at the Fifteen Mile Stream site.





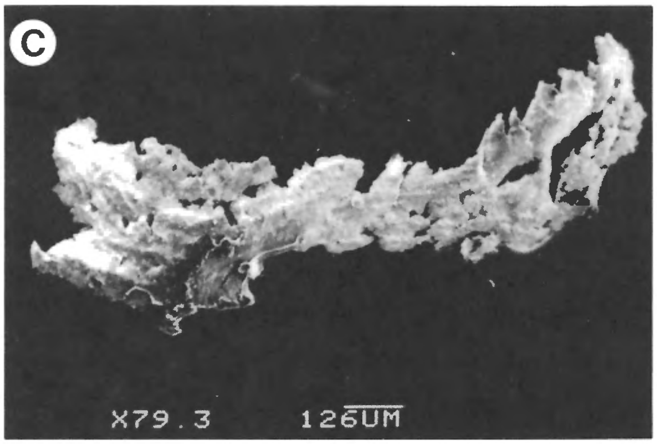


Figure 22. Scanning electron microscope photomicrographs of gold grains recovered from heavy mineral concentrates of tills at the Fifteen Mile Stream Gold District. Magnification and bar scales are shown on each photograph.
A Gold nugget, note the foliated appearance of the exposed side
B Gold flake, note micaceous appearance
C Gold flake

CONCLUSIONS

1. The surficial deposits within the Forest Hill area indicate three major depositional events. The earliest episode is represented by both lodgement and ablation phases (units IA and IB) at a few locations but is most often characterized by the ablation phase which consists of an Fe-Mn cemented diamicton. This sequence is overlain by two till units (II and III) characterized by a sandy matrix and locally derived granitic and metasedimentary clasts. The lower till is compact and rests upon bedrock with southeastward-trending striations. The upper till is less compact and locally has a strong fabric indicating a southwestward ice movement. These tills are commonly separated by a reddish-brown alteration zone interpreted as a paleosol. Till unit II is believed to have been deposited during a regional southeastward ice flow of Early Wisconsinan age. Till unit III probably represents the deposit of a local ice cap of Late Wisconsinan age.

2. At Forest Hill, geochemical variation due to sampling was found to be insignificant. Analytical variance was found to be significant only for Au in the coarse fraction (1.0-2.0 mm). This poor correlation of gold values between the duplicate sample splits and the samples from which they were created is believed to be enhanced by the nugget effect. Because of the significance of the nugget effect in the coarse material, the fine fraction of the till (<63 μm) is suggested as the best size range for analysis in gold exploration over the Meguma Group rocks of Nova Scotia.

3. The cause for the poor to fair correlation that exists between the panning results of the survey and the geochemical data for Au probably has its basis in the nugget effect. The nugget effect is progressively minimized during the panning process; however it is maximized by the sample preparation necessary before geochemical analysis of the material. Geochemical and panning techniques of gold exploration in Nova Scotia should be used to complement one another in the interest of acquiring the maximum information at the lowest cost.

4. Ternary diagrams generated for the Cu, Pb, Zn values from the study and lithology histograms indicate that the coarse fraction (1.0-2.0 mm) of the "basal" tills (units I, II and III) largely reflects the composition of the bedrock. The fine fraction (<0.063 mm) is relatively enriched in Cu and Pb and may have been altered or affected by hydromorphic processes. Soils and an Fe-Mn cemented unit demonstrate similar partitioning relationships. The fine fraction of an Fe-Mn cemented unit, enriched in Cu, Pb, Zn and As also has elevated values of gold. The coarser fractions of this unit are not enriched in gold. The authors believe that the matrix of the sediment is secondary, implying a hydromorphic origin for the gold.

5. The general distribution of gold in the western parts of the study area suggests southeastward dispersal from gold-bearing quartz veins resulting chiefly from glacial erosion, transport, and deposition during the major ice advance that deposited unit II. The subsequent southwestward ice-advance that deposited unit III does not appear to have redistributed the gold to any great extent. The distribution of gold in the extreme eastern part of the study area, where the Fe-Mn cemented unit outcrops, may be a manifestation of a hydromorphic redistribution of the element. The gold peaks in the fine fraction occur north of the outcropping veins in a downslope direction.

6. The dispersal trains in the till at Forest Hill gradually come to the surface in the down-ice direction from the gold-bearing veins and can therefore be considered three dimensional bodies. The distance of transport for this gold-rich till is on the order of 100 to 300 m.

7. Gold in the till occurs both as flakes and nuggets. The surfaces of these particles appear rough and pitted and exhibit little evidence indicative of abrasive glacial transport.

8. Microanalysis of gold from the till resulted in an average value of 96 per cent Au and 4 per cent Ag. This is essentially identical to the values obtained for gold from both vein-quartz and mine tailings at the study area.

9. The results of this study suggest that gold and arsenic are the best elements to analyze for in detailed geochemical exploration programs for gold. Silver and tungsten are not useful pathfinder elements for gold mineralization in the Forest Hill area because they rarely are present in quantities greater than the lower detection limits of their respective analytical techniques. Elevated mercury values appear to be associated with gold anomalies, but statistical analysis did not indicate a correlation between the two elements at low levels.

10. Panning is recommended as part of any gold exploration program using tills in Nova Scotia. The panning results of the survey delineated a gold dispersal fan of at least 300 m comparible with the till geochemical results. The nugget effect and analytical problems in gold analysis make the panning procedure useful in the immediate assessment of prospects.

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APPENDIX I

Table I.1(A)

Units	Variables	Corr >0.5
I, II, III	Cu, Ni	.6562
	Cu, Cr	.5433
	Cu, Fe	.5580
	Zn, Ni	.6878
	Zn, Cr	.5229
	Zn, Fe	.6582
	Ni, Cr	.7624
	Cr, Fe	.8344
	As, Au	.6686

Table I.1(B)

Units	Variables	Corr >0.5
I, II, III	Cu, Zn	.5114
	Cu, Ni	.5906
	Cu, Fe	.5370
	Zn, Ni	.6409
	Zn, Fe	.7004
	Ni, Fe	.6811
	As, Au	.5220

Table I.2(B)

Units	Variables	Corr >0.5
I	Cu, W	1.000
	Pb, Cr	.8163
	Pb, Mn	.8713
	Pb, Fe	.9023
	Pb, As	.6690
	Pb, Hg	.6406
	Pb, W	1.000
	Zn, Ni	.8818
	Zn, W	1.000
	Ni, W	1.000
	Cr, Mn	.7118
	Cr, Fe	.8389
	Cr, As	.5860
	Cr, Hg	.9007
	Cr, W	1.000
	Mn, Fe	.8057
	Mn, As	.5709
	Mn, W	1.000
	Ag, W	1.000
	Fe, As	.6737
	Fe, Hg	.6025
	Fe, W	1.000
	As, W	1.000
	Hg, W	1.000
	W, Au	1.000

Table I.2(B)

I	Cu, W	.6729
	Zn, Ni	.8504
	Zn, Mn	.5679
	Zn, Fe	.9244
	Ni, Mn	.5451
	Ni, Fe	.9259

Table I.3(B)

Units	Variables	Corr >0.5
Soil, Paleosol	Cu, Zn	.7250
	Cu, Ni	.8006
	Cu, Mn	.5452
	Pb, Cr	.5834
	Pb, Fe	.6525
	Zn, Ni	.8356
	Zn, Mn	.6481
	Ni, Mn	.6322
	Cr, Fe	.6203
	Cr, Hg	.6232

Table I.3(B)

Units	Variables	Corr >0.5
Soil, Paleosol	Cu, Zn	.5609
	Cu, Ni	.5741
	Zn, Ni	.5893
	Zn, Fe	.5164
	Mn, Fe	.5097

APPENDIX II

Table II.1 Electron microprobe analysis of gold grains panned from till at Forest Hill.

Station	Unit	X%AU*	X%AG*
56	II	94.06	7.21
59	II	91.09	10.26
63	III	97.0	3.50
63	II	95.96	5.36
63	I	96.60	4.39
64	II	93.52	7.61
67	II	92.48	7.96
67	I	94.56	5.97
68	II	97.91	5.13
69	II	100.48	3.41
71	III	97.20	3.2
84	II	89.88	11.67
89	II	97.06	3.61
100	I	95.70	5.00
104	I	94.75	5.40
114	I	93.08	8.36
119	I	97.24	3.08
121	I	91.50	9.20
121	I	89.42	12.61
132	II	97.07	3.49

*Note: percentage values represents the mean of several measurements made at different locations on the grain.

Table II.2 Electron microprobe analysis of gold grains from quartz veins and tailings.

Source	X%Au*	CX%Ag*
Veins	96.16	4.50
Veins	96.17	4.64
Veins	96.07	4.63
Veins	96.73	3.70
Veins	96.60	4.11
Veins	96.52	4.20
Veins	96.31	4.29
Veins	96.07	4.43
Veins	96.70	3.94
Veins	97.07	3.89
Veins	93.30	4.10
Veins	96.08	4.21
Tailings	97.01	3.36
Tailings	97.50	3.10
Tailings	96.95	3.68
Tailings	98.41	3.14
Tailings	95.32	6.18
Tailings	89.24	13.5
Tailings	95.51	5.00
Tailings	97.75	3.00
Tailings	94.93	6.12
Tailings	95.65	5.43
Tailings	96.01	4.50
Tailings	96.17	4.63
Tailings	96.07	4.48
Tailings	96.73	3.70
Tailings	96.52	4.20
Tailings	96.31	4.29
Tailings	96.07	4.43
Tailings	96.08	4.21
Tailings	96.70	3.94
Tailings	97.06	3.89
Tailings	92.82	4.19
Tailings	93.78	4.01

Tables II.3(A) and (B). Comparison of gold from the mine tailings with gold from the till using EMP analysis. Note that results from analyses of different parts of single grains vary.

(A). Gold from the C till

GRAIN	ELEMENTS:	WEIGHT (PER CENT) Cu	Zn	Ag	Au	Total
Al		82.20	12.17	.00	.00	93.37
A2		64.82	10.17	.00	.00	74.99
B		69.62	10.74	1.21	9.46	91.03
Ci		83.01	13.09	.00	.00	96.10
C2		35.70	5.43	5.01	54.89	101.40
C3		83.21	12.24	.00	.00	94.46
*D1		63.25	9.59	2.08	22.89	97.81
D2		74.23	11.36	.68	9.06	95.33
E1		69.83	10.71	1.17	12.16	93.88
E2		77.24	11.53	.13	3.36	92.96
F1		35.70	.00	3.77	49.86	89.33
F2		31.69	.00	.46	8.19	40.34
G		79.20	.00	.00	.00	79.21
H		82.77	.00	.00	.00	82.77
I1		78.84	13.46	.00	.00	91.86
I2		74.45	12.40	.12	4.10	91.07
J		77.66	13.59	.00	.00	91.26
K		77.32	13.33	.00	.00	90.65

* metal in quartzite chip

(B). Gold from mine tailings (from McNulty, 1983)

GRAIN	Cu	Zn	Ag	Au	Total
1A	0.41	0.00	9.13	92.36	102.03
1B	0.48	0.00	8.78	90.10	99.35
1C	0.36	0.00	9.04	91.94	101.34
2A	0.54	0.00	6.48	93.87	101.05
2B	0.50	0.00	7.80	90.11	98.41
3A	0.52	0.00	10.44	88.98	99.93
3B	0.39	0.00	8.64	90.43	99.46
4A	1.17	0.00	8.77	90.83	100.77
4B	2.83	0.23	8.93	88.43	100.41
5A	0.73	0.00	4.65	95.40	100.78
5B	0.73	0.00	3.96	95.33	99.65
6	0.36	0.00	8.98	90.95	100.29
7A	0.23	0.00	4.87	92.11	97.22
7B	0.26	0.00	5.62	91.86	97.74
8	0.28	0.00	8.33	88.92	98.53

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