THE DISTRIBUTION, CHARACTER AND COMPOSITION OF GOLD IN TILL AT THE FIFTEEN MILE STREAM GOLD DISTRICT HALIFAX COUNTY, NOVA SCOTIA

by

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Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science at Dalhousie University, Halifax, Nova Scotia, April, 1983.

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THE DISTRIBUTION, CHARACTER AND COMPOSITION OF GOLD IN TILL AT THE FIFTEEN MILE STREAM GOLD DISTRICT HALIFAX COUNTY, NOVA SCOTIA

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Abstract

In a study carried out at the Fifteen Mile Stream gold district, Halifax County, to document the distribution, character, and composition of gold in till around the former gold mines, 21 sample sets of A, B, and C horizon material were collected from the soil profile. Sampling was conducted at 10 m intervals in till exposed by two trenches which are oriented perpendicular to the strike of both the veins and host strata.

Geochemical analyses for gold, silver, lead and arsenic were performed on samples of the B horizon and on 4 size fractions of the C horizon. Samples of the A horizon were analyzed for gold only.

The >2ϕ fraction of the C horizon with a mean gold content of 217 ppb contains higher concentrations of gold than other size fractions and horizons analyzed.

The gold occurs as foliated flakes which are morphologically similar to gold particles from the tailings of the mine. That the gold is not far-travelled is evident from the lack of surface

striations or other deformational features indicative of abrasive transport.

Microprobe analyses of gold from the till gave unexpected compositions which differed significantly from those of the presumed source. Gold from the till has an average composition of 69% copper, 10% gold, 9% zinc and 1% silver as compared with gold from the mine tailings which average 91% gold and 9% silver. This discrepancy in composition between the primary and secondary gold is thought to be due to a hydromorphic redistribution of gold in the till.

On the basis of correlation analysis performed on the geochemical results, and compositions determined using EMP analyses, gold, arsenic, copper, and zinc are considered the most important elements to be analyzed in pedogeochemical exploration for gold mineralization in rocks of the Meguma group.

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Acknowledgements

I would like to extend special thanks to Dr. Marcos Zentilli for his support as my thesis advisor. I would also like to thank Pan East Resources Inc. of Toronto for encouraging the study and contributing towards field and analytical expences.

Bob MacKay is thanked for his instruction and guidance with the microprobe. The critical comments and helpful suggestions of Dr. Martin Gibling and Dr. Clint Milligan are greatfully acknowledged. Mike Smith is thanked for his help in drafting the final copy of the area map. Dr. R.N.W. DiLabio is thanked for his useful suggestions in the early stages of the project.

My deepest appreciation is extended to Craig K. Miller, without whom this thesis would not have been possible.

Financial support for this study was provided by Pan East Resources and the Natural Sciences and Engineering Research Council of Canada, through a grant (A-9036) to Dr. M. Zentilli.

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CHAPTER 1

INTRODUCTION

1.1 General Statement

The rocks of the Meguma Group contain approximately 130 known gold occurrences, most of which were found by prospectors who sought out glacial drift rich in auriferous quartz and/or liberated gold grains which was then traced back to its source by careful prospecting. Upon isolating a source area, trenches were dug in the till to expose the gold bearing veins. Follow-up work usually consisted of sinking shafts on the "leads" (veins) and evaluating the grade of the mineralization by bulk testing.

Over 32,000,000 g (>1,000,000 oz.) of gold were produced from 57 gold districts during the years 1862 to 1941. During 1982, approximately 16,000 g (500 oz.) of gold were produced at Cochrane Hill by Northumberland Mines Ltd., the first gold production recorded in the province in over 40 years. With the price of gold averaging $Cdn 500.00 and projections of even higher prices, it has become economically attractive to explore for and mine low grade gold deposits. This fact has stimulated much renewed interest in the almost forgotten gold fields of Nova Scotia.

Because most known gold mineralization in the Meguma terrain was found by drift prospecting and all of Nova Scotia's goldfields are overlain by differing thicknesses of till, a demand has arisen for information concerning the nature of gold in the tills, particularly for exploration purposes.

During the summer of 1982, a trenching program conducted at the Fifteen Mile Stream gold district by the 15 Mile Stream Mining Company Ltd. exposed excellent 3-m-thick till profiles. When panned, the till was seen to be auriferous.

This thesis documents the distribution and character of gold in the soil column of two of the trenches.

1.2 Objectives of the Thesis

The objectives of the thesis are:

1. to describe the till profiles.
2. to document the distribution of gold in the till section.
3. to document the character of gold in the till section.
4. to compare the compositions of gold from the till with gold from the mine.
5. to study the relationship between gold, silver, lead and arsenic in the till to evaluate their usefulness as geochemical pathfinder elements.

It is anticipated that the results of this thesis will be helpful to exploration companies in determining the optimum sample medium for pedogeochemical prospecting over rocks of the Meguma terrain.

1.3 Location and Physiography

The Fifteen Mile Stream gold district (latitude 45 08' 00"N, longitude 62 31'20"W) is located 32 km N of Sheet Harbour, a major community and former seaport on the Eastern Shore of Nova Scotia. The study area is within the Liscomb Game Sanctuary near the boundary of Halifax and Guysborough Counties (Figure 1).

Access is via a good secondary paved and gravel road that runs north from Sheet Harbour towards Trafalgar through Lochaber Mines. Approximately 32 km N of Sheet Harbour, this road connects with the Sloan Lake Road which head east to the study area, 5 km E of the intersection. Both roads are suitable for two-wheel drive vehicles.

The study area is situated in the central southern part of a topographic depression bounded on all sides by hummocky terrain with relief of 5-15 m. The region is dotted with swamps and stillwaters and drainage is generally poor except near Sloan Brook, a small, sluggish brook that flows from Sloan Lake 1.2 km to the northeast. The brook flows just north of the mine and connects with Fifteen Mile Stream 1.5 km to the west of the mine area. The region is densely forested by a mixture of hardwood and softwood trees. Outcrop is generally absent except where exposed on the shores of rivers or lakes.

1.4 Mining History

The Fifteen Mile Stream gold district was discovered in 1867, however, due to its inaccessibility, mining on a major scale did not commence until 1885. The district operated intermittently under a number of owners from this time until 1941. The last private operation was halted in 1911 at which time the total accumulated production of

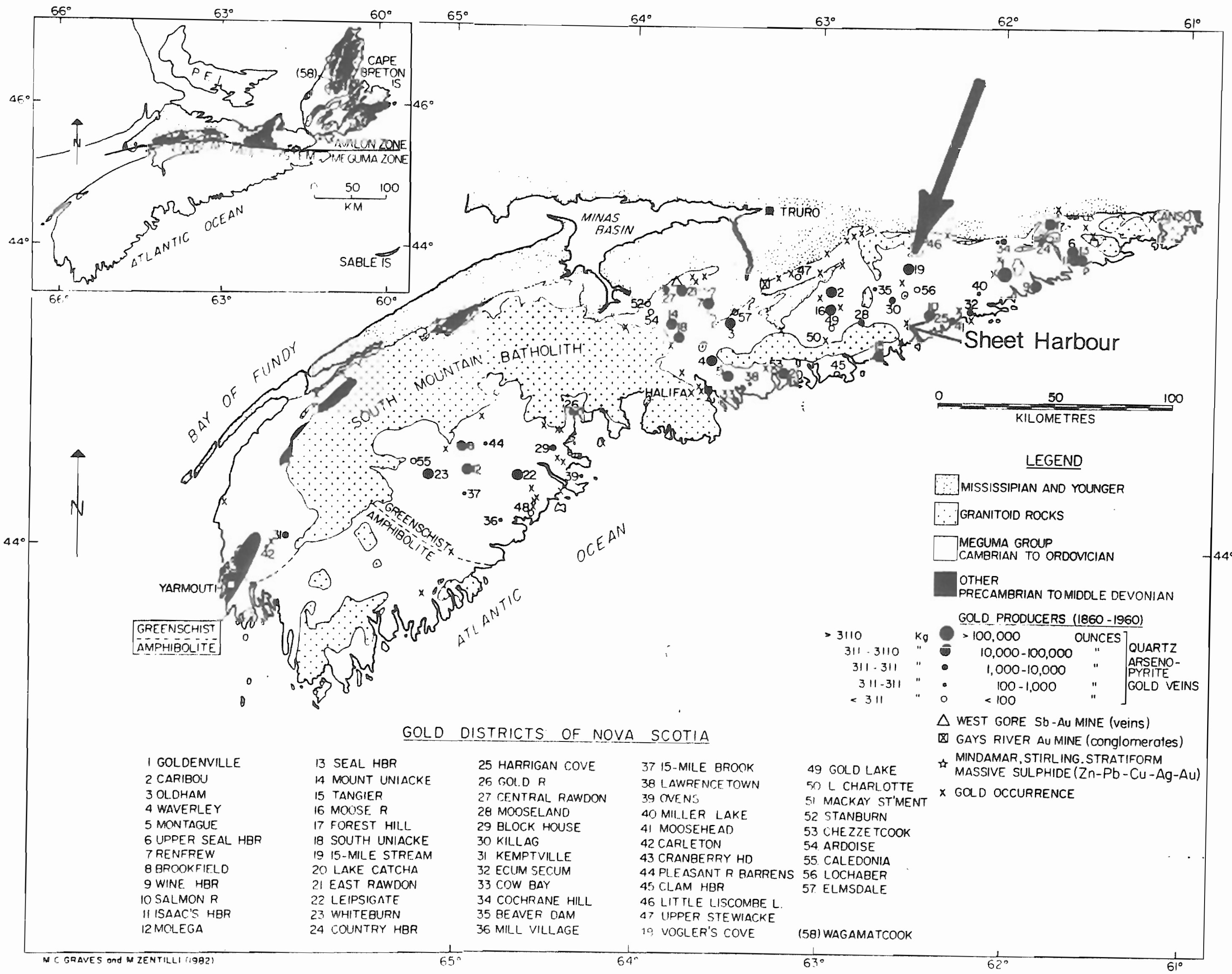


Figure 1. Location Map for the study area. Also shown is the spatial distribution of the gold districts of Nova Scotia. (modified after Graves and Zentilli, 1982)

the district amounted to 600,000 g (19,000 oz.) of gold from 40,813 tonnes (14.7 g/t).

In 1938, a rehabilitation project, jointly funded by the provincial and federal governments was initiated. The purposes of the project were (1) to test the economic potential of the Fifteen Mile Stream area and (2) to provide mining experience for a small number of unemployed men. Operations ceased in 1941 after producing 11,489 g (370.35 oz.) of gold from 9,083 tonnes of ore (1.3 g/t). For a detailed mining history see McNulty (1983).

1.5 Previous Research Relevant to the Thesis

Previous work directly concerning the natuure and distribution of gold in tills has not been extensive. The most recent and relevant work was done by R.W. DiLabio (1981, 1982) of the Geological Survey of Canada. In 1981 he conducted two orientation surveys at the Waverley and Oldham gold districts of Nova Scotia to test the relationship between gold abundance and grain size in till. The specific objectives of these studies were to: (1) find a representation grain size range for sample analysis and (2) define dispersal trains in the till near known gold occurrences. From these studies DiLabio (1981) concluded that the fine sand, silt, and clay fractions of the till gave the best results. He attributed this result to the grinding down of the host rocks by glacial comminution.

McNulty (1983) is documenting the mineralogy and geochemistry of the tailings at the Fifteen Mile Stream property as a Bachelor of Science thesis at Dalhousie University.

1.6 Recent Exploration Activity

In 1981, Pan East Resources Inc. of Toronto conducted an airborne magnetometer/VLF-EM survey over most of the district. Sulpetro Minerals Ltd. of Toronto conducted a stream-sediment sampling program east of the old workings in 1981 and followed-up this work in 1982 with a soil geochemistry survey of the A and B horizons. The 15 Mile Stream Mining Co. Ltd. carried out a trenching program near the old workings during the summer of 1982 in an attempt to gain information about the underlying bedrock. Upon acquiring the mineral rights to the area, Pan East Resources Inc. conducted a comprehensive humus geochemistry survey over most of the district during November, 1982.

CHAPTER 2

PROCEDURES

2.1 Field Work

A total of five days were spent at the study area during November, 1982. Samples were collected along two trenches, approximately 90 and 100 m long respectively, which are oriented N-S and perpendicular to the strike of the host strata. To ensure reasonable control, samples were collected at 10 m intervals as recommended by Boyle (1979). At every location, samples were taken from the A (humus), B and C horizons. Due to the variability in the amounts of A and B horizon material available between sample locations, samples of 0.3-0.5 kg were taken. Samples of the C horizon were taken at depths of 2.0-2.5 m to avoid weathered or altered material. Samples of 3.0-4.0 kg were taken of the C horizon to (1) allow sufficient material for further subdivision into four size fractions, and (2) minimize the so-called "nugget effect." The nugget effect occurs when a small but variable number of gold-rich grains controls the gold content of a large volume of sample." (DiLabio, 1981).

2.2 Sample Preparation

A total of 21 sample sets of the A, B and C horizons were collected. The A and B samples were left untouched and allowed to dry. The C samples were first dried before being sieved into four size-fractions. Silt/clay fractions were obtained by wet-sieving a portion of each sample through a 4ϕ stainless steel mesh. The remaining sample portions were washed free of 4ϕ material and dried. Every second sample was subsequently dry-sieved into course, medium and fine sand fractions as defined by Wentworth (1922) after Udden (1898).

Heavy mineral separates were obtained from the fine sand fractions and from surplus silt/clay material. Forty gold grains were hand separated from the heavy mineral separates with the aid of a binocular microscope.

2.3 Analysis

Geochemical analysis for gold, silver, arsenic and lead were performed at the Ottawa laboratories of Bondar-Clegg & Co., Ltd. The sample sets analyzed included samples of the A horizon, B horizon and four size-fractions of the C horizon.

Heavy mineral separates were analyzed using electron microprobe (EMP) and X-ray diffraction (XRD) techniques. The compositions of gold grains recovered from heavy separates of the silt-clay fractions were compared with the composition of gold recovered from the tailings of the mine. Using a binocular microscope, grain size analysis was conducted on the fine, medium, and course sand fractions.

The Minitab computer program (Ryan, Joiner and Ryan, 1976) was used in the statistical analysis of the geochemical data.

CHAPTER 3

GEOLOGY

3.1 Regional Geology

3.1a Stratigraphy and Rock Types

The Fifteen Mile Stream gold district, like all of the gold deposits of mainland Nova Scotia, is hosted by rocks of the Meguma Group. This group of rocks underlies most of mainland Nova Scotia south of the Glooscap Fault and extends out under sediments of the Scotian Shelf. "The group consists of quartz metawacke turbidites interstratified with black slate -- the basal half (Cambrian) being mainly thick turbidites, the upper half (Ordovician) mainly black slate..." (Schenk, 1978). The sediments were deposited into a deep-water cratonic basin from a large source area to the present south, possibly north-west Africa or South America. The Meguma Group has been divided into two formations which have a boundary defined by a sand:silt ratio of 1:1 (Schenk, 1970).

The thick basal unit of the Meguma Group is called the Goldenville Formation. It is composed of meta-greywacke and quartzite with alternating thin layers of slate. The Halifax Formation stratigraphically overlies the Goldenville Formation and consists of various types of slates with interbedded thin layers of meta-greywacke and quartzite which become more abundant near the base of the unit.

On the basis of graptolite fauna and K-Ar dates on detrital muscovite, the age of the group is Cambrian to Lower Ordovician.

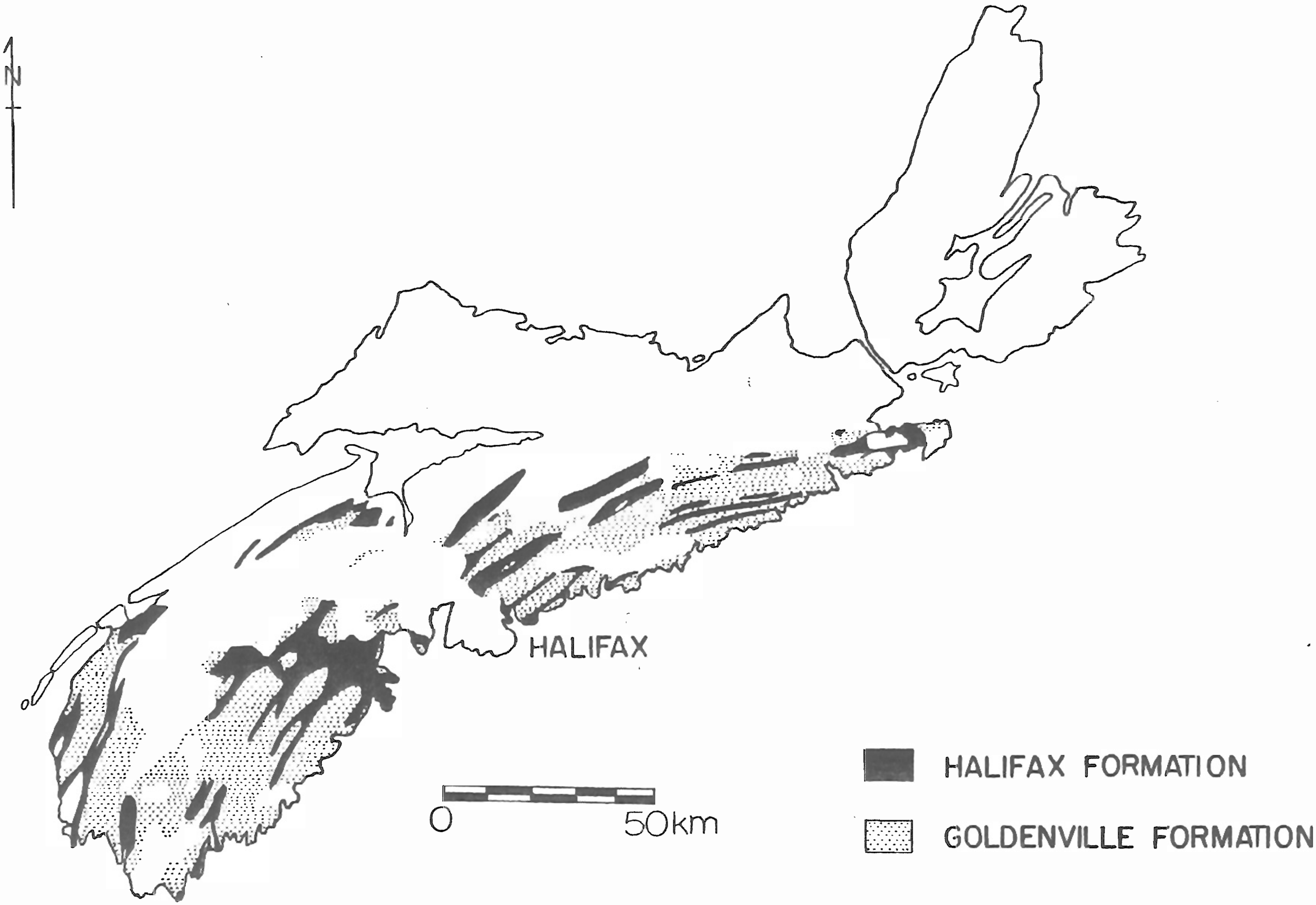
3.1b Structure

Deformation during the Acadian orogeny resulted in the formation of NE - trending anticlines and synclines. The anticlinal axes, which are on average 5 km apart and from 10-160 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 most of the known gold deposits in the rocks of the Meguma Group (Faribault, 1913). On any one anticline, the domes may be separated by 15-45 km. Generally, the rocks of the Goldenville Formation are exposed along the anticlines, and rocks of the Halifax Formation form NE trending belts occupying the synclines. The beds dip at high angles and in places are overturned (Malcolm, 1929). Slaty cleavage is well developed and is more pronounced in the slates than in the meta-greywackes.

3.1c Metamorphism

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 granite plutons. Graves and Zentilli (1982) contend that the process of regional greenschist grade metamorphism accounts for the mobilization and concentration of mesothermal gold bearing quartz veins and that the vein formation is part of the early metamorphic and deformational history of the Meguma domain.

Figure 2. The distribution of rocks of the Halifax and Goldenville Formations of the Meguma Group (after Schenk, 1976).


N
HALIFAX
0
50km
HALIFAX FORMATION
GOLDENVILLE FORMATION

3.1d Intrusions

Sharing a spatial relationship with rocks of the Meguma Group are numerous post-tectonic intrusions of Middle Devonian to Early Carboniferous age. These intrusions vary greatly in size, but the largest bodies occur in the western half of the province. The intrusions are genetically related and range in composition from granodiorite to adamellite to monzonite (Clarke and Halliday, 1980).

3.1e Glaciation

The rocks of the Meguma Group have undergone several episodes of glaciation, each resulting in widespread erosion and subsequent till deposition. The bulk of the glacial material in the province was deposited during the Wisconsinan stage of the Upper Pleistocene at the end of the last ice age. The Wisconsinan ice sheet moved across the province in a predominantly SE direction (Nielsen, 1976).

Till is the most widespread of all the surficial materials and covers most of the province (MacNeill, 1969). Moraines, kames, and drumlins are common landforms of glacial deposition in the region. In general, till deposits are thinner in the uplands of eastern Nova Scotia and thicker in the valleys and lowlands of the western part of the province. Nielsen (1976) has designated the Nova Scotia tills as ground moraine deposited by basal accumulation from moving ice or dropped from melting ice during recession.

Grant (1963, 1976), Nielsen (1976), and Stea and Fowler (1979) have shown that the composition of the till in Nova Scotia generally reflects that of the immediately underlying bedrock.

3.2 Local Geology

The Fifteen Mile Stream gold district is underlain by rocks of the Goldenville Formation and located along the Fifteen Mile Stream anticline (Area Map - in pocket). At Moose River, the Fifteen Mile Stream anticline merges with the Beaver Dam anticline to form the Waverley-Moose River anticline. The major fold at Fifteen Mile Stream is composed of three subordinate anticlines and two small adjacent synclines. Approximately 1000 m W of the main mine site, the east and west pitches of the anticline meet to form a domal structure. Characteristic rock types include dark-grey meta-greywackes, coarser light-grey meta-greywackes, black to light-grey slates, minor mica schists and auriferous quartz.

Intrusive granite bodies outcrop five km to the north, 13 km to the west and 10 km to the south of the property. If granite underlies the area, it must be at considerable depth since hand specimen and thin section examination of the mine dump material reveal no evidence of thermal metamorphism (McNulty, 1983).

A 3-4 m thick blanket of Pleistocene till covers the study area and restricts outcrops to the west end of the district where rocks are exposed on the eastern shore of East River Sheet Harbour.

3.3 Geology of the Tills

Boulton (1972) has defined till as "an aggregate whose components are brought together and deposited by the direct agency of glacier ice, which, though it may suffer post-depositional deformation by flow, does not undergo subsequent disaggregation and deposition." He has classified till in three types: (1) flowtill, which is released supraglacially and undergoes deformation as a result of flow; (2) melt out till, which is released supraglacially or subglacially from stagnant ice and (3) lodgement till, which is deposited beneath actively moving ice and undergoes shear deformation as a result of movement.

The three till types may be deposited by processes of ablation or lodgement: "Till may be deposited either as ablation till, by partial melting out of stagnant ice, or by deposition subglacially from active ice (basal till)." (Nielsen, 1976). See Table 1.

The position of the debris in the ice is an important factor in determining the type of deposit that will form. Lodgement tills will previal if most of the debris is carried subglacially; however, if the bulk of the material is carried englacially, ablation till will result.

In areas of basal melting where the glacial debris is subjected to equal forces of friction from the bed and traction by the ice, lodgement till will be deposited (Boulton, 1972). Lodgement till will

Till Classification
after Boulton (1972)

Supraglacial tills	-	(Ablation till)	-	Flow till
				Melt-out till
Subglacial tills	-	(Lodgement till)	-	Melt-out till
				Lodgement till

Table 1

be deposited most thickly when the frictional drag is increased due to a rough surface or permeable substratum. Thin ice favours the deposition of lodgement till, whereas thick ice produces an abundance of meltwater resulting from pressure melting. Initial deposition is against obstructions.

Ablation till is formed by the downwasting of the ice surface, which results in the accumulation of englacial debris. Ablation till can be sub-divided into melt-out till and flow-till.

Melt-out tills can form by two processes: (1) by the down-wasting of the ice sheets such that the englacial debris is deposited on the ice surface; and (2) by basal melting under stationary ice. Melt-out tills are characteristically not as compact as lodgement till nor is the fabric as well defined as in lodgement till (Boulton, 1970).

Flow-till is basically a melt-out till that has formed on the surface of the glacier and subsequently slipped down slope under the force of gravity. The factors controlling the formation of flow-till are grain size of the material, water content, topography, and whether or not the ice/ablation interface is frozen (Nielsen, 1976). It is common to find layering in this type of till as a result of flowing into a fluviatile or lacustrine environment. The layering is an important characteristic for distinguishing flow-till from melt-out till or lodgement till. Table 2 gives characteristics of ablation till and lodgement till.

CHARACTERISTICS OF TILL

After Nielsen (1976)

Lodgement Till

This is commonly recognized as having:

- a high proportion of silt and clay relative to ablation till in the same area
- a fissile structure where clayey
- rounded and striated clasts
- a high degree of compaction
- clasts generally oriented with the long axes parallel to the direction of the movement
- boulders are not common but cobbles occur in great numbers
- foliation may be present
- narrow lens-shaped layers of sand may be present
- a local origin

Ablation Till

Ablation till has been described as having the following characteristics as compared to lodgement till:

- looser and coarser grained than basal till
- boulders and cobbles are common
- clasts are commonly angular or subangular with no striations
- the proportion of sand and gravel is high while the amount of clay is low
- pebbles have a random orientation
- because of its loose texture it oxidizes quickly and is usually brown or yellowish brown in color

TABLE 2

3.4 Transport of Gold by Glacier Ice

A negative exponential curve is generally thought to depict the dispersion of material from its source by the movement of glacier ice (Stea, 1982). The findings of Kumbein (1933), Gillberg (1967), Shilts (1976) and DiLabio (1981, 1982) have demonstrated that abraided material is most abundant in till near its source; its abundance diminishes rapidly to background values with distance in the down-ice direction from the source.

The Oldham gold district, Nova Scotia (Figure 1), is considered to be representative of the gold deposits in the Meguma domain in both mineralization and glaciation. At Oldham, DiLabio (1982) was able to map dispersal trains for gold abundances >10 ppb for up to 1900 m in a down-ice direction from the source area. In an earlier study at the Waverley gold district, Nova Scotia, DiLabio (1981) determined that the down-ice gold abundances were greatest within 250 m from the presumed source area.

CHAPTER 4

THE GOLD CONTENT OF THE TILL

4.1 Description of the Tills

4.1a Overview

The study area is characterized by two till units: a 2-3m thick basal till, overlain by a 0.5-1.0 m thick till unit (Figure 3).

At several points along the trenches, water was observed trickling out at the sharp contact between the two tills indicating lower permeability for the basal unit. Both tills are poorly sorted and the clasts contained within them have neither striations nor an obvious preferred orientation.

The lower till unit is greenish-grey in colour, clay-rich, highly compacted, and relatively homogeneous in appearance. The predominant rock types are pebble to cobble size clasts of green, grey and black slates, white quartzite, blue-grey meta-greywacke and minor granitic rocks. The average clast size is approximately 6 cm but the size differs from <1-15 cm.

The top 20-25 cm of the upper till unit has undergone soil development resulting in the formation of an organic-rich A (humus) horizon, a leached layer, and a B horizon. The lower portion of the upper unit is brown to red-brown in colour and relatively unconsolidated owing to its lower clay content in comparison with the basal till.

Figure 3. Till sections of trench 1. (A) typical profile showing the distinct contact between the lower and upper tills. (B) part of the upper till characterized by boulders and many large cobbles. Note the knife edge contact between the lower till and the overlying till.

A

B

The upper till contains boulder and cobble-size clasts of rock-types similar to those in the basal till with, one notable difference; the upper till has a higher proportion of granitic rocks. The clast size in the upper till is highly variable but generally much larger than the clasts of the basal till. An idealized till section is shown in Figure 4.

4.1b The A Horizon

The A horizon has not developed uniformly over the study area. The samples differed from a black, fully decomposed plant material at some locations, to a brown, partially decayed mulch of moss and pine needles at other locations. This layer is almost totally organic in composition and usually is not more than 10 cm thick.

The leached zone, which is generally considered to be part of the A horizon, was not dealt with in this study as it was assumed to be relatively depleted in minerals of interest in geochemical exploration.

4.1c The B Horizon

The B horizon is generally 10 cm thick and this thickness is relatively consistent over the length of both trenches. However, where boulders are large and numerous near the surface, the B horizon is not present as a composite layer but rather as a hydromorphic accumulation between the boulders. This material is red to reddish-brown in colour and is composed of up to 5% pebble-sized clasts of quartz, meta-greywacke, quartzite, slate and granitic rocks.

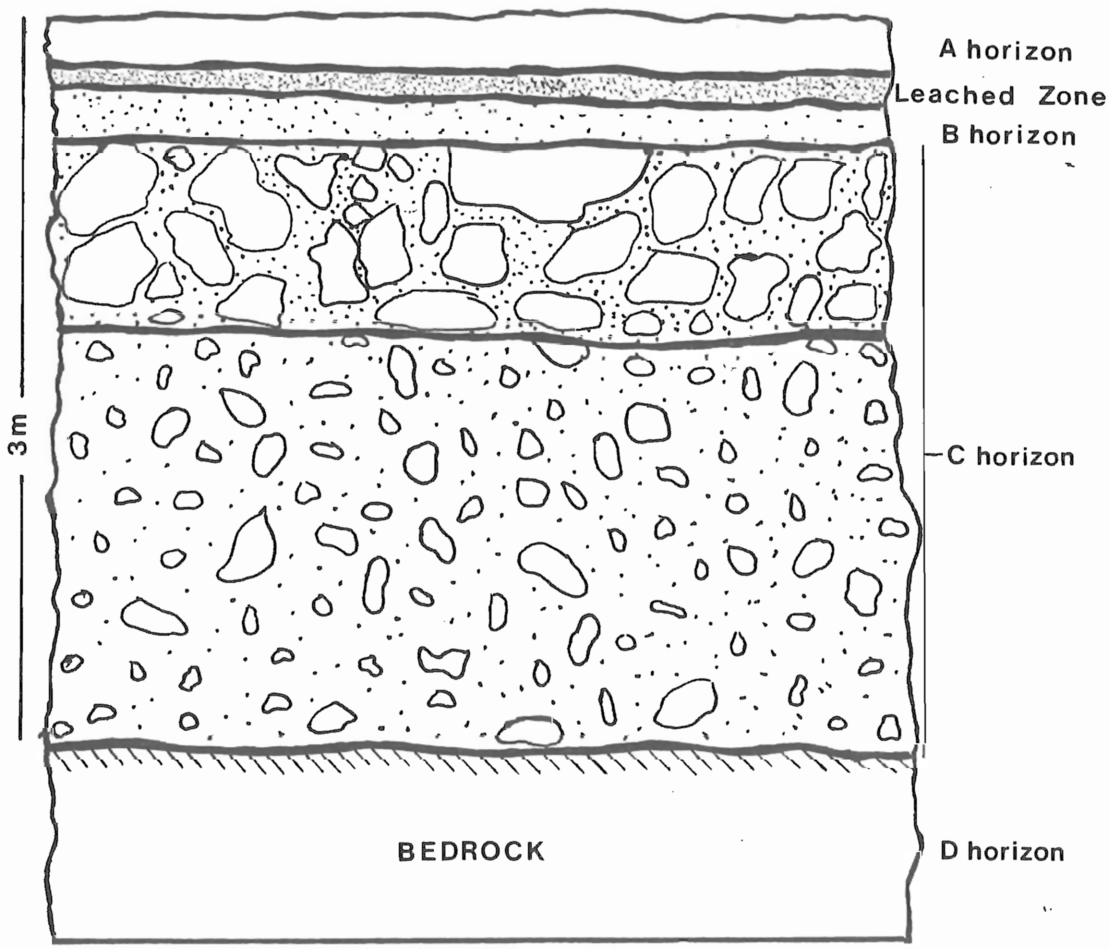


Figure 4. An idealized till profile at Fifteen Mile Stream

4.1d The C Horizon

Generalizations

Two generalizations can be made concerning the nature of the fine, medium, and coarse sand fractions obtained from the C horizon: (1) all of the grains are angular to sub-angular, or micaceous, depending upon the rock type or mineralogy of the individual grains, and (2) the proportions of mineral and/or rock constituents within each of the three sand fractions are very consistent over the study area. Therefore, averages have been taken of the mineral and/or rock proportions at each sample location, and a single pie diagram has been constructed for each sand fraction (Figure 5 a,b,c). The pie diagrams are considered by the author to be representative of the basal till in the sample area.

Coarse Sand Fraction

The Coarse sand fraction (-1 to +1ϕ) of the C horizon is composed mainly of mica schists, meta-greywacke, quartz, slate and granite. The proportions of these components are shown in Figure 5(a).

Medium Sand Fraction

The medium sand fraction (1 to 2ϕ) is composed chiefly of mineral fragments dominated by quartz, mica, ilmenite and garnet respectively. The proportions of these minerals are shown in Figure 5(b).

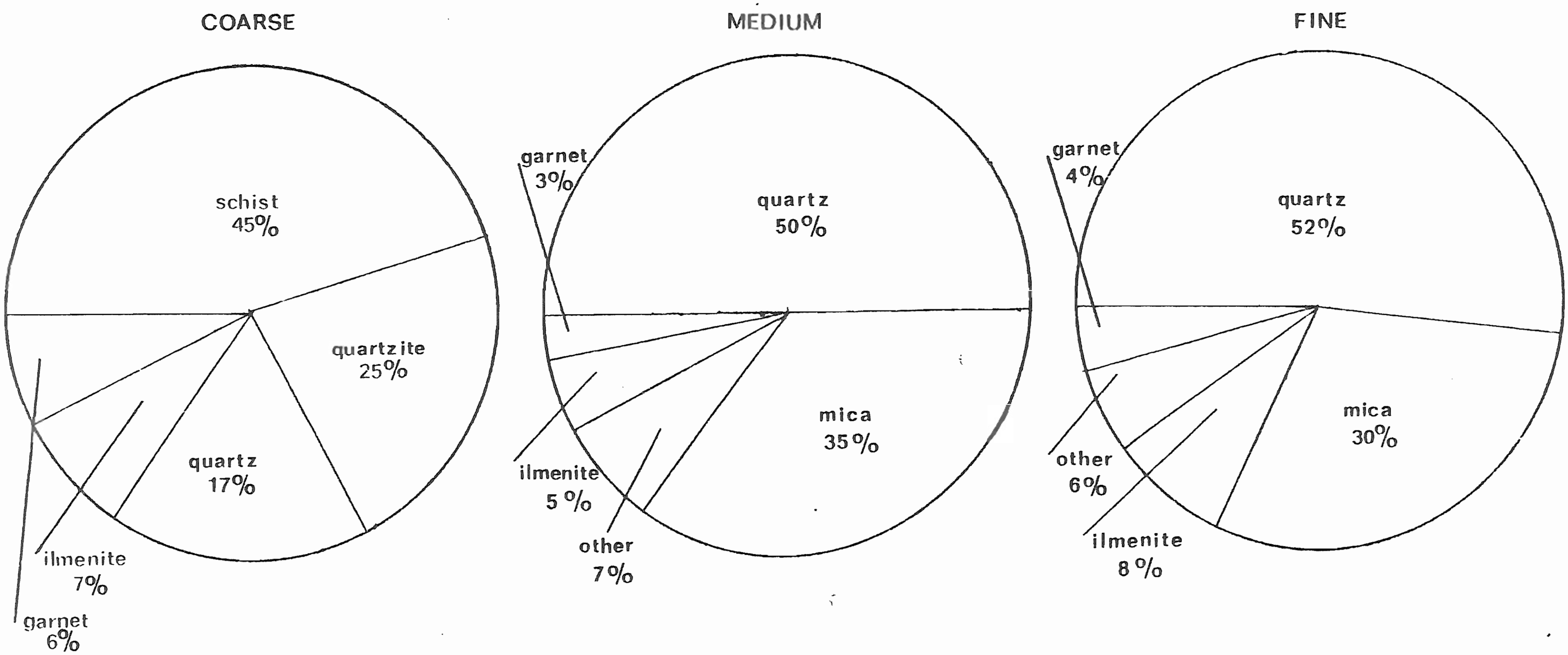


Figure 5. Pie diagrams illustrating the types and proportions of mineral and rock fragments found in the (A) coarse, (B) medium and (C) fine fractions of the C horizon.

Fine Sand Fraction

The fine sand fraction and the medium sand fraction are very similar in their make-up except for a small difference in the proportions of minerals, which are shown in Figure 5(c).

Heavy mineral separates obtained from all samples of the fine sand fraction were analyzed using X-ray diffraction (XRD) and electron microprobe (EMP) techniques to identify the minerals and get an accurate estimate of the proportions in which they occur (Figure 6).

The heavy mineral suites, as determined with XRD analysis were dominated by quartz, ilmenite, biotite, muscovite, chlorite, and garnet. Pyrite, pyrolusite and rutile were present in minor amounts. XRD analysis of tailings from the nearby mine by McNulty (1983) yielded similar results. One notable difference was the absence of garnet in the tailings material.

EMP analysis of the heavy minerals generally supported and supplemented the findings of the XRD analysis. Using this method of analysis, the heavy minerals were found to be dominated by ilmenite, mica, chloritoid, garnet, and quartz respectively. Hematite and/or magnetite, plagioclase, rutile, pyrite, topaz, and apatite were present in much smaller quantities. Scanning electron microscope (SEM) photographs of some of the minerals which characterize the heavy mineral separates are shown in Figure 7.

It was a surprise to the author to find micas, quartz and plagioclase as relatively important components of the heavy mineral separates. However, on close microscopic examination, it was noticed that many of the grains are polymineralic. Some grains are composed of approximately equal portions of mica, quartz and ilmenite, while many grains are dominated by ilmenite, with quartz, mica, or more rarely plagioclase being present as inclusions. The attachment of ilmenite to these lighter minerals allows them to settle out with the heavy minerals.

The heavy mineral separates were scanned briefly with a binocular microscope to check for visible gold. Flakes of gold were observed in all samples; however, the magnification of the microscope was too limited to allow the author to do a detailed description of the particles.

SEM photographs were taken of two of the larger gold particles and are shown in Figure 8.

Silt/Clay Fraction

One representative heavy mineral separate was obtained from the silt/clay material washed from eleven C-horizon samples. XRD and EMP analysis of the heavy mineral separate showed it to be identical in its mineral components and proportions to the average obtained from the heavy mineral separates of the fine sand fraction.

Examination under binocular microscope showed the heavy separate to be relatively abundant in visible gold. Thirty gold flakes were isolated by hand from the heavy separate and photographed under a scanning electron microscope. The photographs are presented in Figure 9.

The composition of gold from the till was compared with gold from the mine tailings using the wavelength techniques of the EMP. Ten gold grains from the silt/clay fraction, 1 gold grain from the fine sand fraction and 9 grains from the mine tailings (McNulty, 1983) were analyzed in this way. The results are shown in Table 6.

4.2 Geochemistry

4.2a Analytical Results

Material from the A and B horizons and the silt/clay fractions of the C horizon from each of the 21 sample locations were analyzed. Analysis of the fine, medium, and coarse sand fractions of the C horizon were performed on material from every second sample location. All samples were analyzed for gold, silver, lead and arsenic, except for the A horizon samples which were analyzed for gold only. The results are presented in Tables 3, 4, and 5.

Geochemical analyses of the B horizon samples gave moderate lead values and high arsenic values. Gold abundances ranged from 2-595 ppb. and gave a mean value that was moderate, relative to the other sample mediums analyzed.

As expected, the geochemical analyses of the coarse sand fraction, which is relatively deficient in metals, gave low readings for lead and arsenic; however, contrary to expections, the coarse sand fraction gave a high mean value for gold. The gold values varied unpredictably from <5 ppb. (lower detection limit) to 525 ppb.

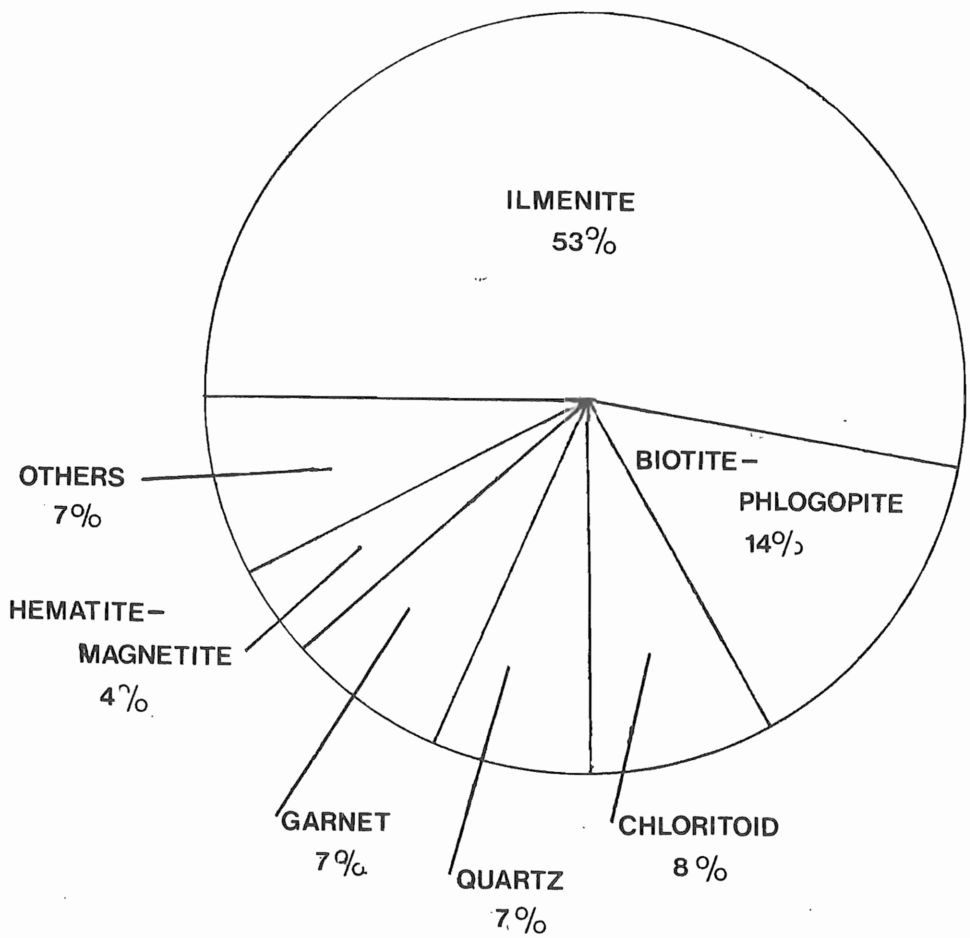
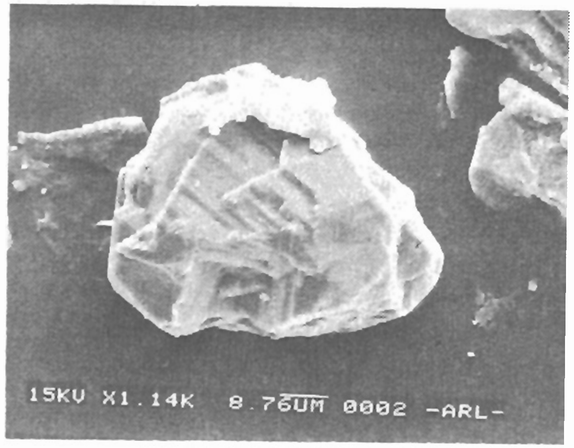
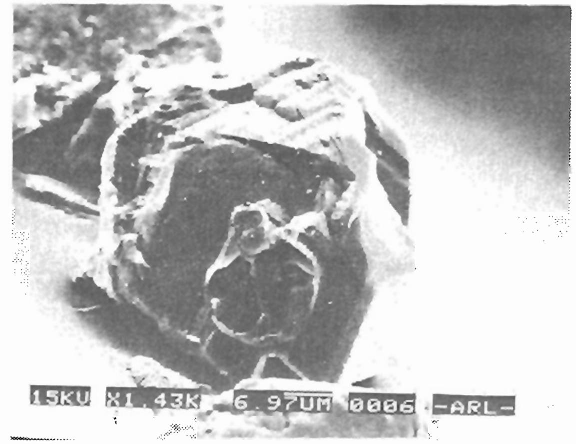


Figure 6. Pie diagram illustrating the heavy mineral components of the fine sand fraction.

Figure 7. Heavy minerals from the fine sand fraction of the C horizon. The identifications are tentatively: (A) magnetite (B) magnetite (C) tourmaline (D) ilmenorutile. Magnification and bar scales are shown at the bottom of each photograph.


15KV X1.14K 8.76UM 0002 -ARL-

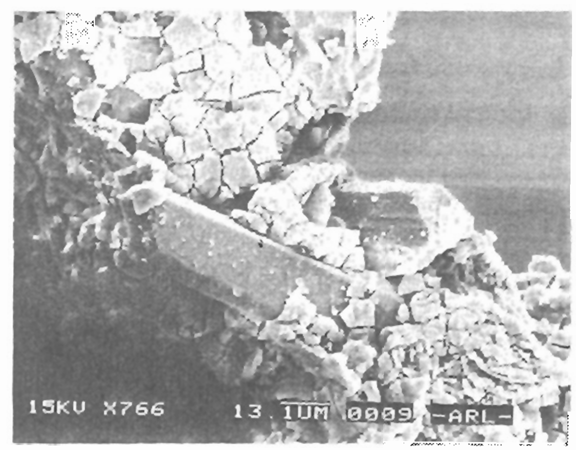
A


15KV X1.43K 6.97UM 0006 -ARL-

B


15KV X453 22.0UM 0005 -ARL-

C

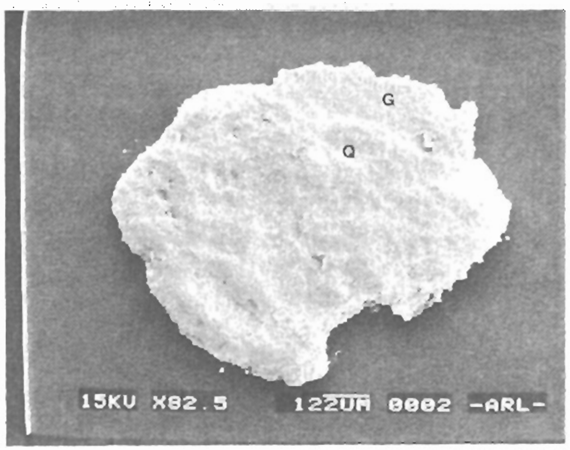

15KV X766 13.1UM 0009 -ARL-

D

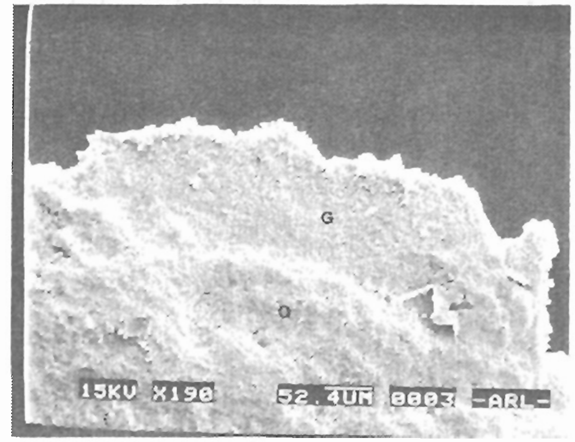
Figure 8. SEM photographs of gold from the fine sand fraction.

(a) and (b) are of the same grain at different magnifications (see bottom of photographs for bar scale and magnification). The photographs show a gold flake (G) in contact with a chip of quartzite (Q).

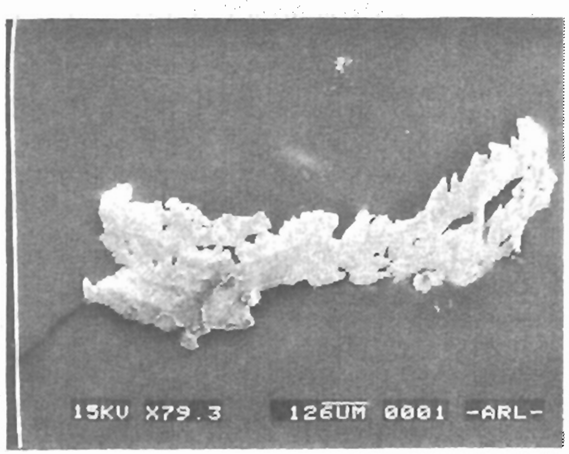
(c) gold flake exhibiting fragile and delicate features which characterize most of the gold particles.


G
Q
15KV X82.5 122UM 0002 -ARL-

A

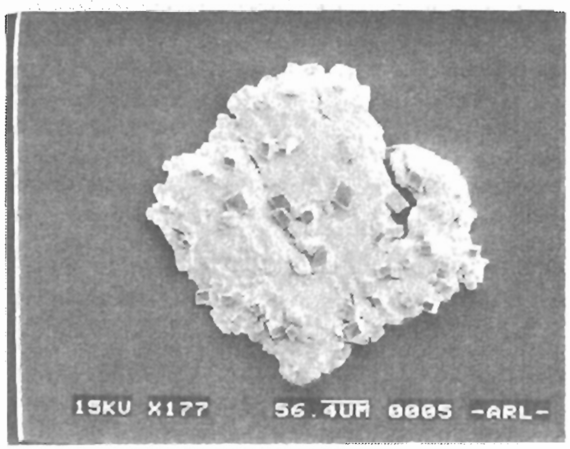

G
Q
15KV X190 52.4UM 0003 -ARL-

B

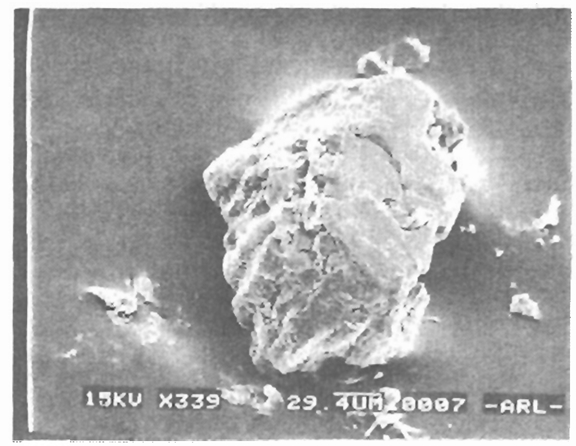

15KV X79.3 126UM 0001 -ARL-

C

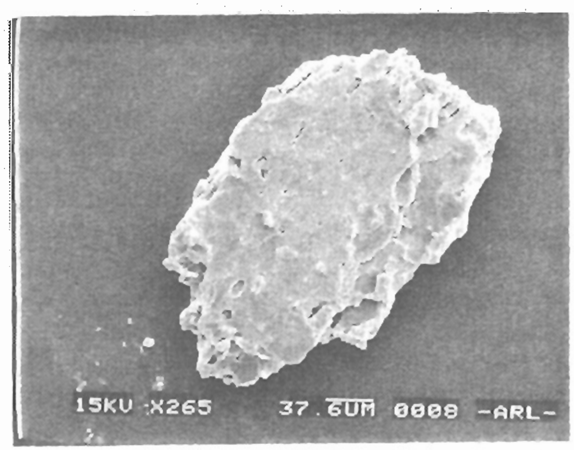
Figure 9. Gold flakes. Note the tabular, platy appearance and lack of striations on the grain surfaces. The rhombohedral crystals on the surface of (A) and (D) are calcite crystals, and occur as a result of contamination during separation.


15KV X177 56.4UM 0005 -ARL-

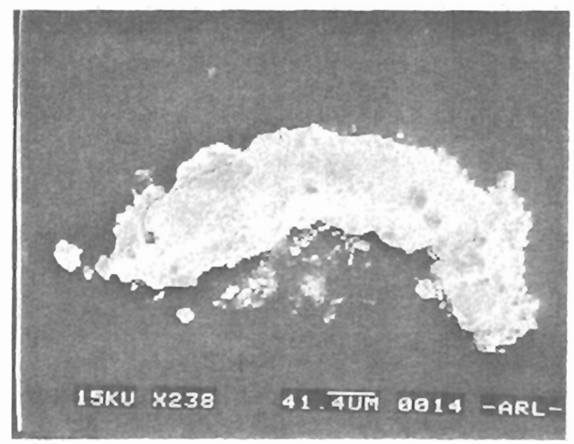
A


15KV X339 29.4UM 0007 -ARL-

B


15KV X265 37.6UM 0008 -ARL-

C


15KV X238 41.4UM 0014 -ARL-

D

GEOCHEMICAL ANALYSIS OF A AND B HORIZONS

SAMPLE NUMBER	ELEMENT UNITS	Au PPB	wt/Au GM	SAMPLE NUMBER	ELEMENT UNITS	Pb PPM	Ag PPM	As PPM	Au PPB
A-016		510		B-016		7	<0.1	32	595
A-017		76		B-017		11	<0.1	280	372
A-018		28		B-018		7	<0.1	296	341
A-019		66		B-019		24	0.2	1180	14
A-020		60		B-020		13	0.1	208	36
A-021		50		B-021		25	0.2	540	167
A-022		240		B-022		18	0.3	520	50
A-023		16		B-023		14	<0.1	94	42
A-024		75		B-024		18	0.1	320	24
A-025		28		B-025		19	0.3	152	78
A-026		8		B-026		15	0.3	240	194
A-027		12		B-027		15	<0.1	440	292
A-028		14		B-028		16	<0.1	176	4
A-029		10		B-029		20	0.2	152	14
A-030		14		B-030		14	0.1	192	6
A-031		26		B-031		15	0.1	667	2
A-032		16		B-032		14	0.1	128	12
A-033		10		B-033		17	0.7	288	4
A-034		16		B-034		21	<0.1	296	40
A-035		20		B-035		18	<0.1	61	22
A-036		6		B-036		17	<0.1	65	28
C1		C2		C3		C3		C4	C5

Table 3

GEOCHEMICAL ANALYSES OF THE C HORIZON

SAMPLE NUMBER	ELEMENT UNITS	Pb PPM	Ag PPM	As PPM	Au PPB
FMS-CS-016		11	0.1	216	140
FMS-CS-018		8	<0.1	240	15
FMS-CS-020		7	<0.1	114	25
FMS-CS-022		12	<0.1	368	525
FMS-CS-024		13	<0.1	272	95
FMS-CS-026		11	<0.1	240	125
FMS-CS-028		12	<0.1	76	<5
FMS-CS-030		10	<0.1	76	<5
FMS-CS-032		10	<0.1	168	495
FMS-CS-034		16	<0.1	200	5
FMS-CS-036		11	<0.1	116	5
FMS-CS-038		12	<0.1		
FMS-FS-016		7	<0.1	26	480
FMS-FS-018		11	<0.1	272	405
FMS-FS-020		11	<0.1	184	45
FMS-FS-022		17	<0.1	678	1275
FMS-FS-024		12	<0.1	248	550
FMS-FS-026		18	<0.1	384	395
FMS-FS-028		10	<0.1	152	35
FMS-FS-030		10	<0.1	128	10
FMS-FS-032		9	<0.1	208	85
FMS-FS-034		25	<0.1	425	5
FMS-FS-036		9	<0.1	64	65
FMS-FS-038		15		16	
FMS-MS-016		8	<0.1	55	15
FMS-MS-018		9	<0.1	240	150
FMS-MS-020		11	<0.1	104	45
FMS-MS-022		10	<0.1	360	25
FMS-MS-024		13	<0.1	216	50
FMS-MS-026		13	<0.1	264	50
FMS-MS-028		10	<0.1	82	10
FMS-MS-030		11	<0.1	108	20
FMS-MS-032		9	<0.1	184	5
FMS-MS-034		19	<0.1	384	55
FMS-MS-036		9	<0.1	52	45

Table 4

SAMPLE NUMBER	ELEMENT UNITS	Pb PPM	Ag PPM	As PPM	Au PPB
CF-016		18	<0.1	28	162
CF-017		25	<0.1	176	134
CF-018		22	<0.1	408	132
CF-019		24	0.1	320	208
CF-020		25	<0.1	408	142
CF-021		21	<0.1	655	1090
CF-022		24	<0.1	1058	432
CF-023		10	<0.1	104	88
CF-024		14	0.1	304	203
CF-025		16	<0.1	248	44
CF-026		21	<0.1	494	262
CF-027		24	<0.1	472	224
CF-028		51	<0.1	272	12
CF-029		23	<0.1	468	30
CF-030		18	<0.1	184	30
CF-031		15	<0.1	98	14
CF-032		15	<0.1	296	24
CF-033		22	<0.1	437	104
CF-034		46	<0.1	655	18
CF-035		18	<0.1	280	55
CF-036		13	<0.1	76	8
CF-037		16	<0.1	320	154
CF-038		16	<0.1	130	126

Table 5

Geochemical analyses of the medium sand fractions yielded the lowest mean values of all the analyzed fractions for lead and gold, and was second only to the coarse fraction for the lowest mean arsenic value.

The fine sand fraction gave the highest mean value for gold of the sample types that were analyzed; however, abundances ranged from 5-1275 ppb. A high mean value was also obtained for lead, while the mean arsenic value was average relative to the other fractions and horizons that were analyzed.

The highest mean values for both arsenic and lead were obtained from the silt/clay fraction. The mean gold value in this medium was second only to the value obtained from the fine sand fraction.

Figure 8(a) shows a piece of gold in intimate contact with a chip of quartzite, a rather uncommon association. Upon breaking the chip open, it was observed that the gold was present as a thin "sandwiched" layer throughout. Later EMP analysis of this gold gave high copper and zinc values and relatively low gold and silver values (Table 6A).

In general, the gold is present in flakes which exhibit a micaceous or platy habit. There is a virtual lack of surface striations or any other evidence of extensive glacial comminution.

Reflecting light microscopic examination of gold grains from the till and from the tailings dump of the mine showed the particles from both groups to be relatively heterogeneous in composition. Some grains exhibited an interesting feature which had remarkable likeness to exsolution lamellae. In reflected light, these grains were typically orange with parallel thin stripes of yellow. Other grains had a patchy appearance characterized by areas of orange, yellow, and white.

For this reason, the author decided to perform EMP analysis at several points on the grain surfaces of individual gold grains where possible. The results showed that the gold from both groups was heterogeneous in composition; however, the range in composition both within and between grains was most pronounced in gold from the till.

The composition of the gold from the till was very different from gold in the tailings (Table 6 (a) and (b)).

4.2b Statistical Description of Results

The Minitab computer program for statistical analysis was employed to do regression analysis and correlation of the geochemical data. These results will be discussed and interpreted in Chapter 5.

A visual representation of gold in the different sample mediums is presented in histogram form in Figures 10 and 11.

4.3 Gold in the Till - A Discussion

Gold values obtained from geochemical analysis of the A-horizon samples were exceptionally high but ranged from 6-510 ppb. Of the

ELECTRON MICROPROBE ANALYSIS OF GOLD

A. Gold from the C horizon

GRAIN	ELEMENTS:	Cu	Zn	Ag	Au	Total
		WT PCT				
A1		81.20	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
C1		83.01	13.09	.00	.00	96.10
C2		35.70	5.43	5.01	54.89	101.04
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)

	Cu	Zn	Ag	Au	Total
1a	0.41	0.00	9.13	92.39	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	1.28	0.00	8.33	88.92	98.53

TABLE 6A 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.

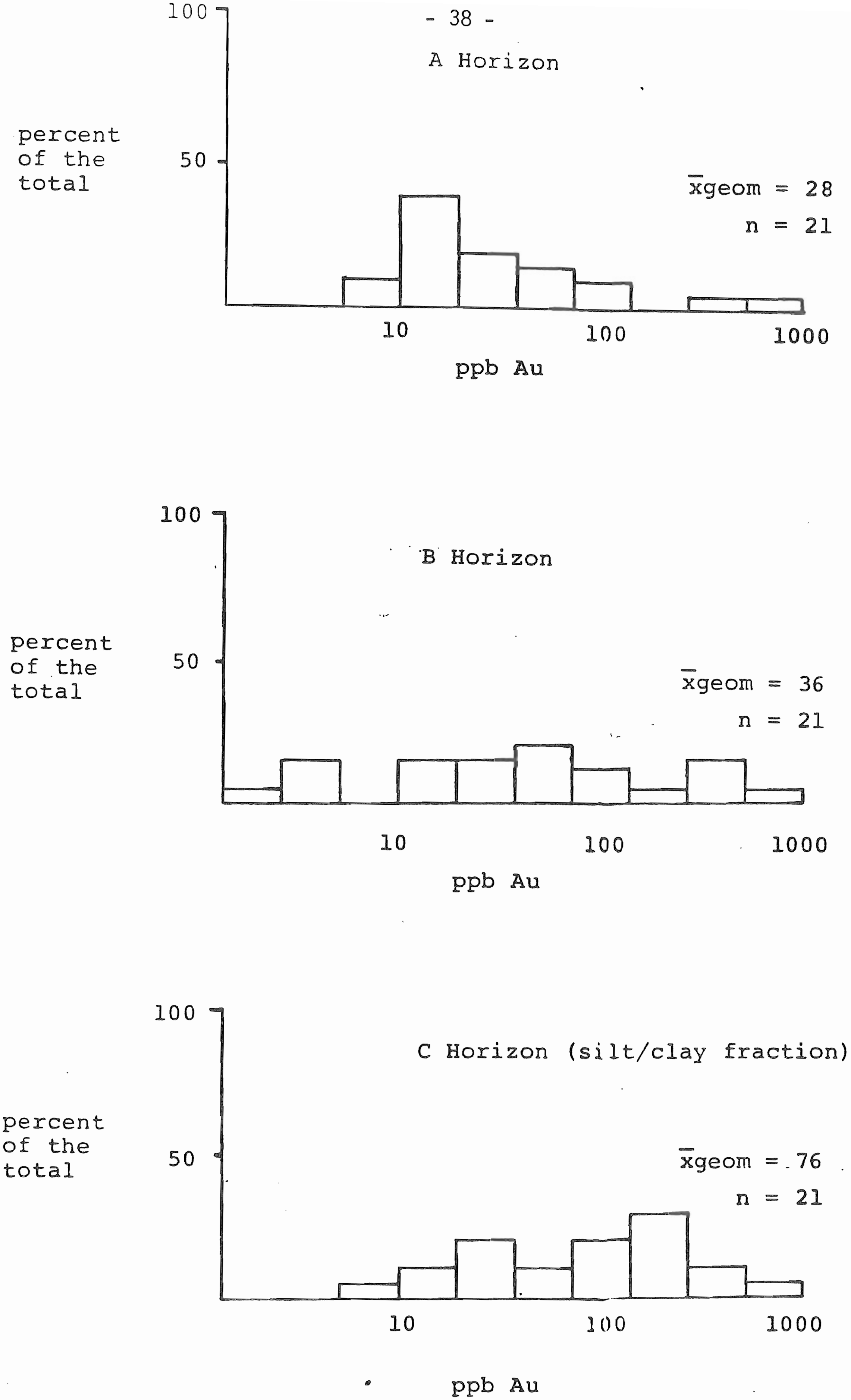


Figure 10 Geometric (log) distribution histograms and mean values for Au in the A and B horizons and the silt/clay fraction of the C horizon

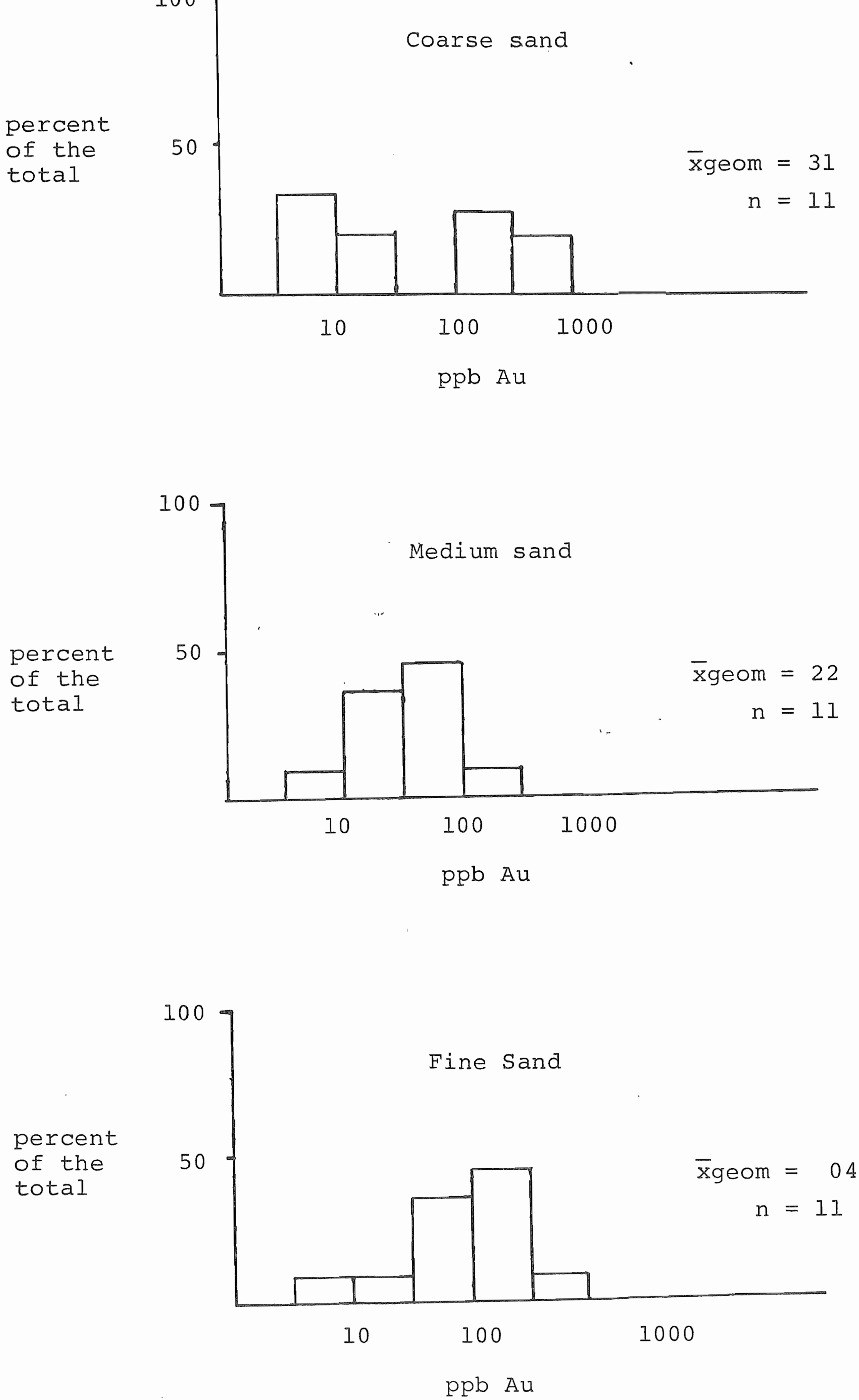


Figure 11 Geometric (log) distributions histograms and mean values for Au in the coarse, medium, and fine sand fractions of the C horizon.

fractions and horizons analyzed, the A horizon gave the second lowest mean value for gold.

Several generalizations can be made concerning the geochemical analyses of both the B and C horizon samples: (1) statistical analysis of the results showed a generally poor correlation between gold abundances and other elemental abundances. (2) Surprisingly, silver, which constitutes from 6-21% of the precious metal content in the veins of the primary deposit (McNulty, 1983), fell below the lower detection limit of 0.1 ppm. in most samples, and registered at the detection limit or just above it in only a few samples. (3) Profiles of the geochemical data (Figure 12 and 13), for gold show a relatively good correlation between the horizons and along the lateral extent of the trenches.

Grains from the tailings were relatively consistent in their compositions which averaged 91% gold and 9% silver.

The composition of grains from the till varied significantly from high percentages of copper and zinc, and no gold or silver, to relatively high percentages of gold and copper, and very little zinc and silver. Analysis of the grains using the energy dispersion technique of the EMP showed no presence of sulphur, arsenic or iron.

X-ray photographs of one of the heterogenous gold grains from the till illustrates the distribution of gold, silver, copper, and zinc (Figure 14).

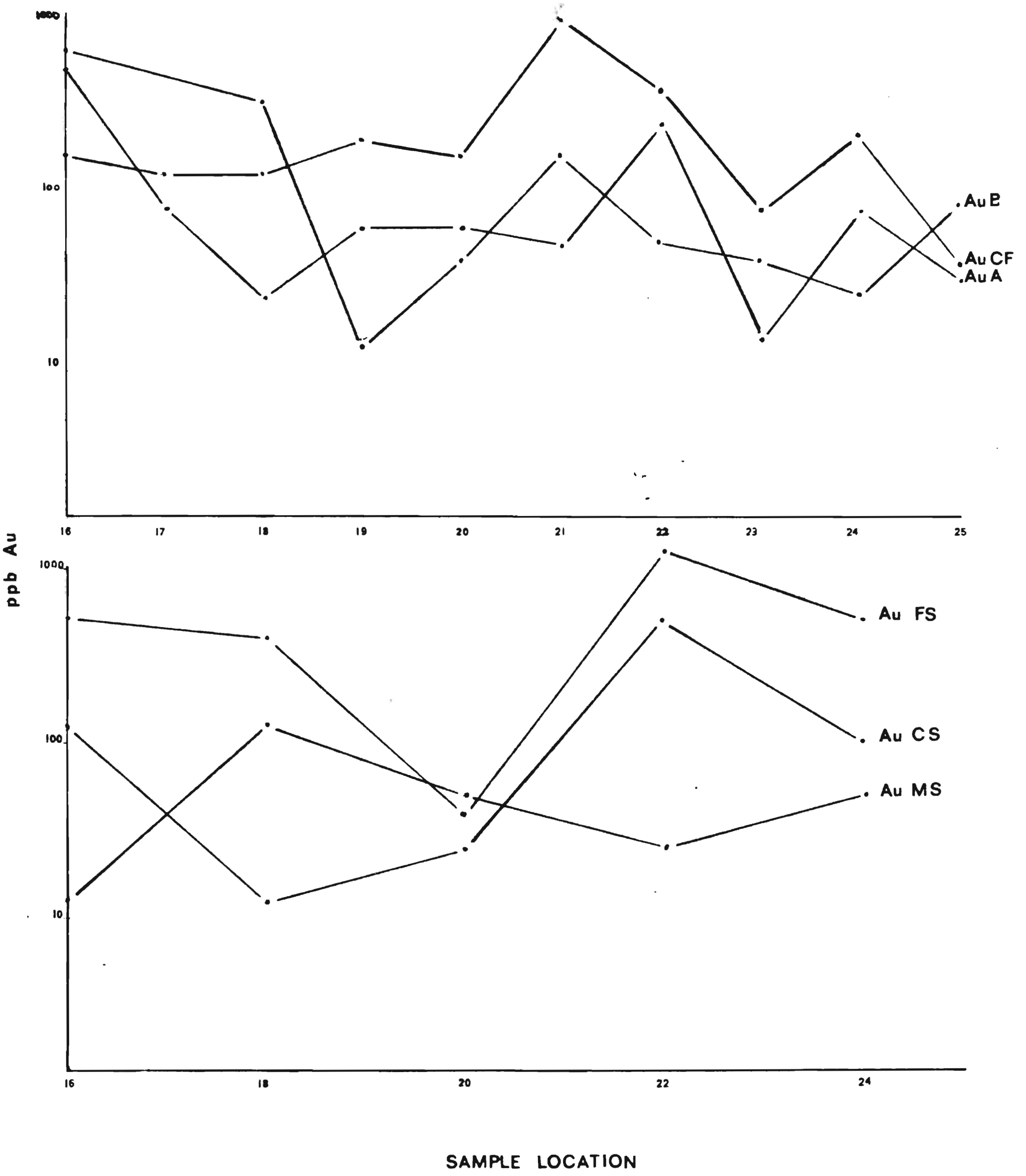


Figure 12. Geochemical profile diagrams illustrate the lateral distributions of gold along trench 1. (A) shows the distribution of gold in the A and B horizons and the silt/clay fraction of the C horizon. (B) shows the distributions of gold in the coarse sand, medium sand and fine sand fractions of the C horizon.

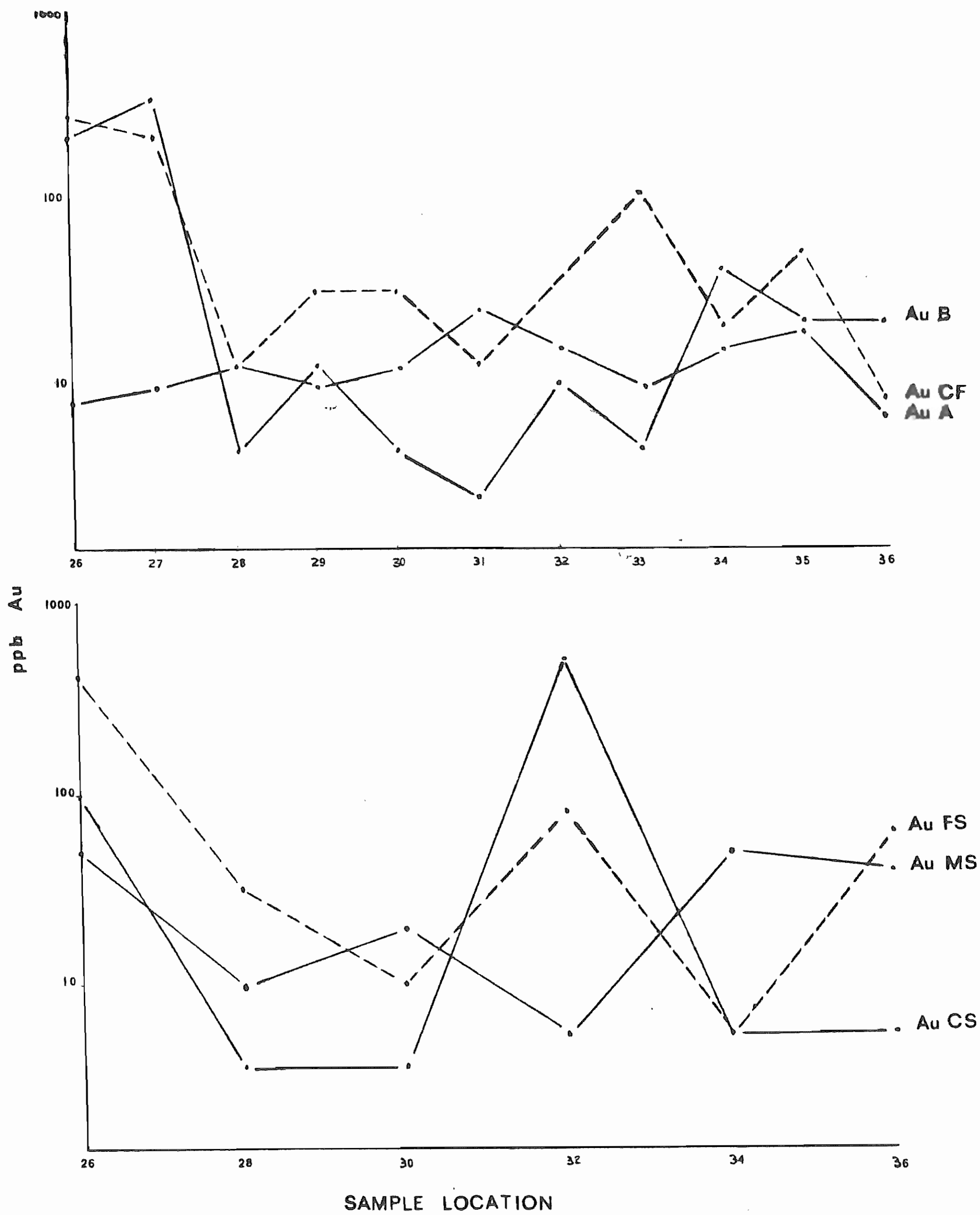
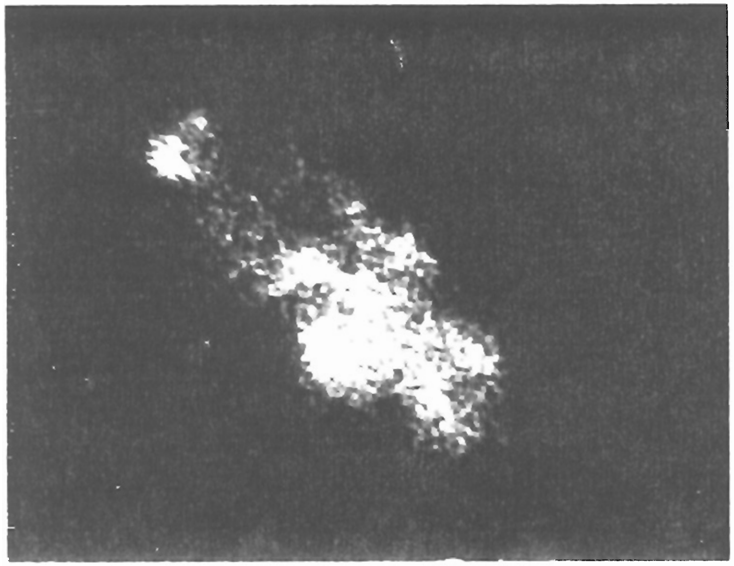
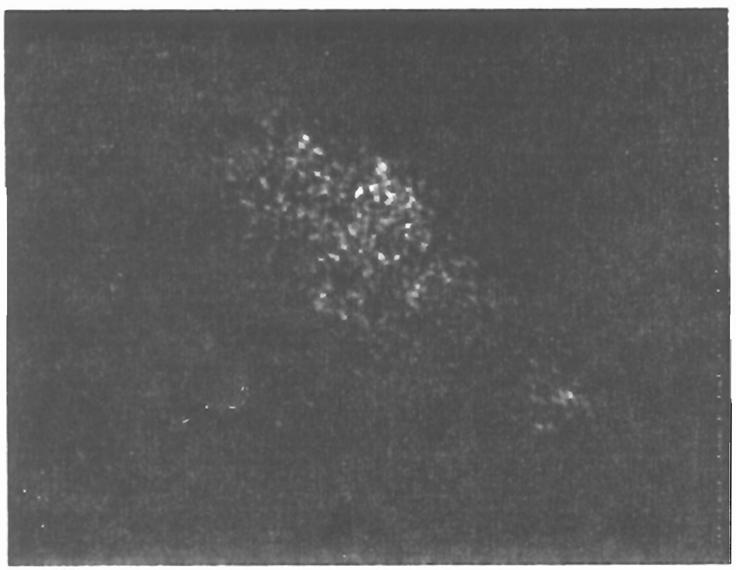


Figure 13. The lateral distributions of gold along trench 2. (A) shows the distributions of gold in the A and B horizons, and the silt/clay fraction of the C horizon. (B) shows the distributions of gold in the coarse sand, medium sand, and fine sand fractions of the C horizon.

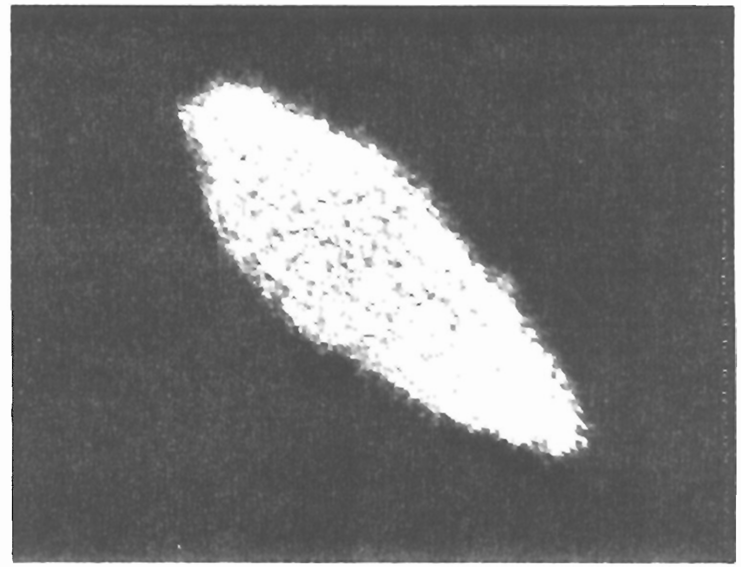
Figure 14 (A), (B), (C), and (D) show photographs of electron scanning images across one gold grain from the C horizon. Illustrated are the distributions of gold, silver, copper and zinc respectively. The brightness of the photographs is a function of exposure time, not relative abundances. Magnification is 1000 X.



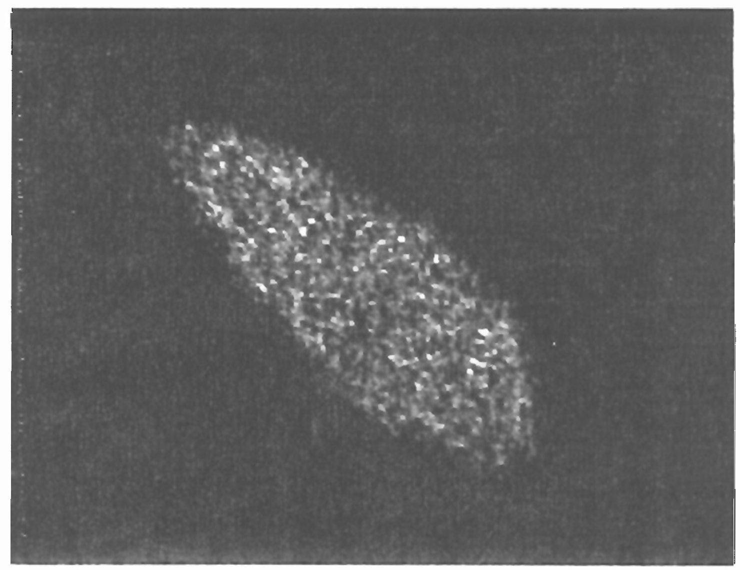
A gold



B silver



C copper



D zinc

CHAPTER 5

INTERPRETATION AND DISCUSSION

5.1 The Tills

On the basis of the characteristics given in Table 2, the author has designated the basal till unit of the study area as a lodgement till, and the upper till unit as an ablation till. However, this interpretation is tentative, since R. R. Stea (personal communication, 1983) has pointed out that ice-flow-direction indicators show a convergence of ice movement directions to the SE and SW on the area. This implies that the upper till unit could have been deposited by a later ice advance from a different direction and ice centre than the lower unit (Figure 15).

Samples for the present study were collected before the author was aware of this possibility, and therefore, sampling of the C horizon was confined to the lower till only.

By definition, tills formed by processes of ablation can contain a very high percentage of far-travelled material, while tills formed through lodgement processes are usually dominated by local rock types (Dreimanis, 1976). The author was further prompted to exclude the ablation unit from the sampling program because of a limited budget for analysis and a preference to sample below weathered or otherwise altered material.

Regardless of its origin, the upper unit should be sampled and

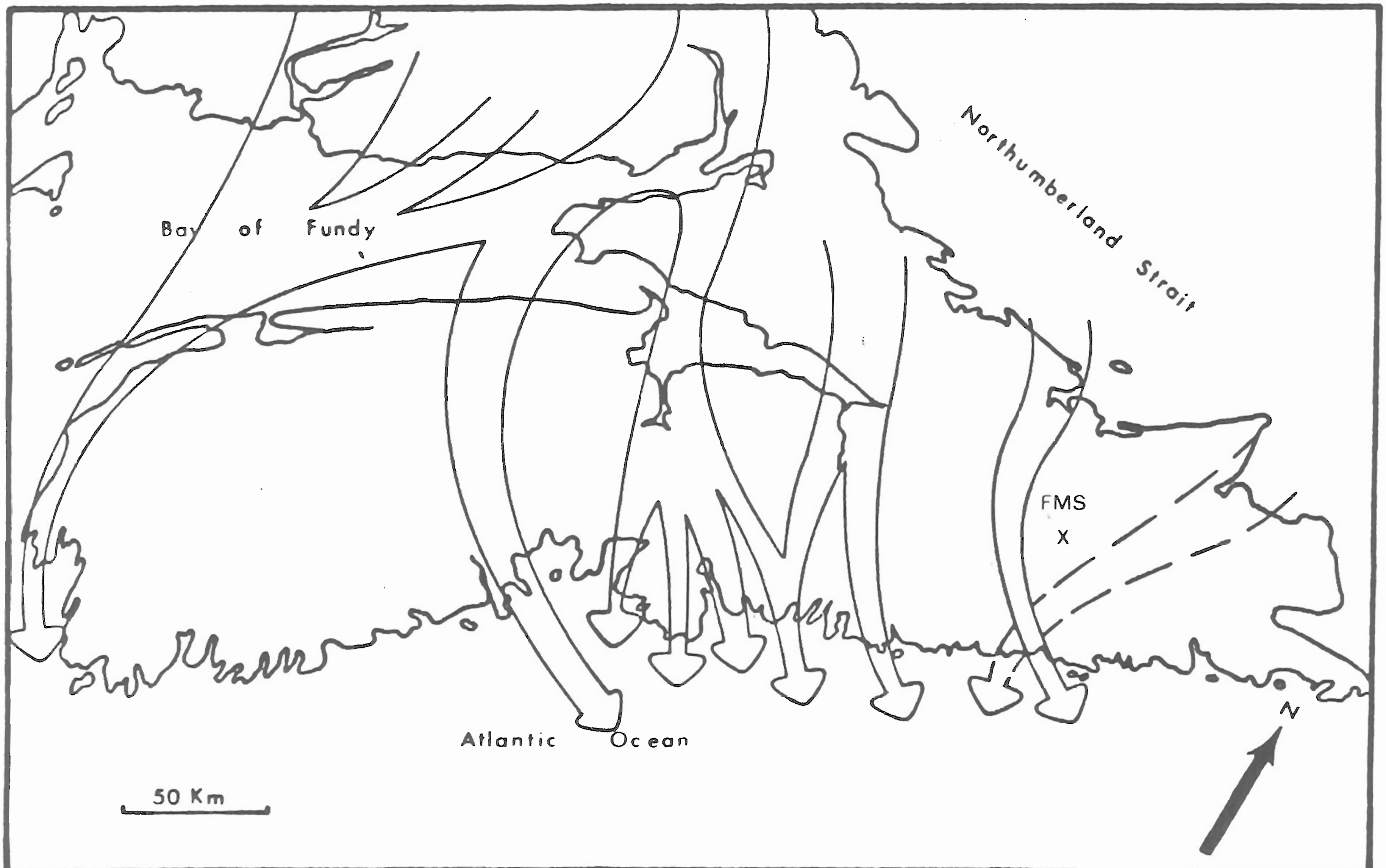


Figure 15 Hypothetical ice currents across Nova Scotia (redrawn from Grant, 1963).

analyzed, and compared to the other units dealt with in this study so that the overall till profile "picture" of the area can be completed.

5.2 Gold Distribution

From the geochemical analyses of the A and B horizons, and the 4 fractions of the C horizon (coarse sand (CS), medium sand (MS), fine sand (FS), and silt/clay (CF)), the mean values for gold abundances rank as follows: MS $<$ AH $<$ BH $<$ CS $<$ CF $<$ FS.

These results differ somewhat from those obtained by DiLabio (1981) in his study at the Waverley gold district. He found that all fractions of the C horizon $>1\phi$ (i.e. MS to CF) were the most auriferous size fractions at or near the source. This contrasts with the relatively low values found in the medium sand fraction (1 to 2ϕ) at Fifteen Mile Stream.

The geochemical profiles of the trenches are shown in Figures 12 and 13. They are difficult to interpret; however, they definitely show correlations in gold abundances between the horizons and fractions. While the trends in the diagrams show a good relative correlation between most of the horizons and fractions, the actual abundances can differ by as much as several orders of magnitude. The reason for this is not understood but may be due to the nugget effect. With the exception of MS, most size fractions and horizons reflect high gold abundacnes at sample locations 16 and 21-22 in trench 1, and sample locations 26-27 and 33 at trench 2. These peaks of abundances could be: (1) indicative of liberated gold corresponding to auriferous quartz veins which strike perpendicular to the direction of the trenches; (2) due to a concentration of gold at these points as a result of precipitation caused by a change in the pH of ground water solutions in the proximity of carbonate associated with the quartz veins; or (3) sites of gold precipitation unrelated to the location of quartz veins, but instead, corresponding to small localized reducing conditions produced by the decomposition of organic matter (ex. tree roots).

The feasibility of the latter suggestion was realized by experimentation. Boyle (1979) has stated that decomposing wood has an ability to concentrate gold. To test this claim a sample of rotting wood was recovered from a tailings pile near the mine site and sent for geochemical analysis. The wood was subsequently found to contain 240 ppb, a value 24 times greater than background (- 10 ppb).

5.3 Character of Gold in the Till

DiLabio (1981, 1982) has suggested that the higher abundances of gold in the fine fraction of till is a result of the glacial comminution of gold and host rocks. He has based his assumption on reports which indicate that the gold recovered from the deposits of mainland Nova Scotia was relatively coarse in nature. He has concluded that because the highest gold values are found in the very fine fractions of the till, the gold must have been extensively abraided by glacial comminution. However, there is much evidence to suggest the contrary. While mining reports do indeed attest to the relatively coarse nature of the gold, they also record that the majority of veins worked in most deposits were only those which contained coarse visible gold, while those veins which did not have visible gold were usually not worked. Although coarse gold was recovered, this does not necessarily mean that the gold deposits should, or in fact, can be classified as coarse-gold-deposits.

Upon using mortar and pestle techniques to crush pieces of quartz from both the mine dump and the till, it has been found that many pieces of quartz having no visible gold will yield considerable amounts of very fine or micron-sized gold. (C.K. Miller, personal communication). Indeed, even gold from the tailings piles at the mine site is often very similar in size and morphology to gold from the till. This process of crushing does not abrade the gold grains but merely liberates them from the quartz. SEM pictures of more than 20 gold grains showed neither striations nor other evidence consistent with an extensive abrasion of the gold (Figure 9).

This may suggest that there is a considerable component of fine gold, both in veins containing coarse visible gold and veins without visible gold. This is in agreement with the results of the geochemical analyses of the C horizon which give very high gold abundances for the finest size fractions, but also, high values for the coarse sand fraction.

5.4 Composition of Gold in the Till

The peculiar composition of the gold grains in the till is difficult to explain. Where the copper and zinc come from, and what processes are at work, are questions that can only be answered by further and more detailed study.

The absence of any detectable elements other than gold, silver, copper, and zinc in these heterogeneous gold grains suggest that they are alloys of some type and not sulphides. However, relatively low elemental totals from microanalysis suggest that oxygen may be present, thus introducing the possibility of the grains being oxides (Table 6). Russian researchers have observed a similar phenomenon in modern and ancient placers in the Soviet Union and 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" (Ivoilov et al, 1982). Photographs of X-ray-electron scanning images for gold, silver, copper and zinc support this hypothesis (Figure 15).

The processes that may be responsible for the composition of the gold grains are too numerous and complex for detailed discussion here; however, several of the more plausible explanations are presented below.

Copper and zinc may become separated from sulphides by some unknown ion complexing process. These elements are relatively mobile in the soil column. It is possible that the complexed ions may concentrate and precipate on contact with gold. There is, however, no evidence to support this possibility.

The possibility of contamination has been considered by the author, but this seems unlikely. Mine tailings and dump material are located relatively close to trench 1 (- 60 m). However, gold from the tailings does not show copper or zinc contaimination. In addition, samples of the C horizon were collected at depths of 1.5 - 2.0 m in an effort to avoid contamination by surficial materials.

A further possibility is that the gold in the till may have been transported from another gold deposit or occurrence. This is not likely, since the gold deposits of the surrounding areas are known for their uniform fineness (purity).

In studies at the Waverley and Oldham gold districts, DiLabio (1981, 1982) has suggested that gold in the till is being hydromorphically redistributed. The evidence cited at Waverley to support this assertion lies in the very different distribution of scheelite and gold in the till. DiLabio (1981) has assumed that both minerals have a common bedrock source. Since the scheelite is present as a clastic component of the till, he has proposed that the gold has attained a different distribution by hydromorphic redistribution.

By mapping the dispersal trains for gold and arsenic in till at the Oldham gold district, DiLabio (1982) has found unexpected differences in the dispersal of these minerals. He has proposed that this difference is further "circumstantial evidence" for the hydromorphic redistribution of gold in till.

To date, the evidence for gold distribution has strongly favoured mechanical processes of abrasive transport by glacier ice. However, the author suggests that peculiar compositional differences between gold from the till and gold from the bedrock can best be explained as a manifestation of hydromorphic redistribution of gold in the till.

5.5 Indicators for Gold

The comparison of the mean values of gold in the till profile clearly indicates the relative abundances of gold in the various horizons; however, another technique was employed to: (1) allow a quantitative comparison of these values; and (2) evaluate the importance of arsenic and lead as geochemical pathfinder elements for gold.

The Minitab computer program for statistical analysis was used on the geochemical data. The objectives were to perform regression and correlation analysis of gold with lead and arsenic within and among the individual horizons and fractions.

Since relationships of this sort are typically not obvious enough to simply plot the points on a graph and draw a line or curve through them, another method of interpretation had to be used. Brookes et al. (1966) has suggested a method whereby the correlation coefficient (r) is given a probability value based on its n-2 degrees of freedom. This value is obtained from a table formulated by Brookes, and gives the probability that a relationship does not exist.

Brookes has divided the level of significance into a number of divisions based on various values of the probability function: Probability greater than 0.1, not significant (NS); between 0.10 and 0.05, possibly significant (PS); between 0.05 and 0.01, significant (S);

between 0.01 and 0.001, highly significant (S^1); probability less than 0.001, very highly significant (S^2). The data are shown in Table 7.

Using this method, the correlation between gold values in the silt/clay fraction and fine sand fraction is very highly significant. The correlation between gold values in the silt/clay fraction and arsenic values in the silt/clay fraction, B horizon, and the fine sand fraction is significant, while the correlation with arsenic in the coarse fraction is highly significant. Gold in the A horizon has a good direct relationship to lead in the B horizon and a possible inverse correlation to gold in the fine sand fraction. Gold in the fine sand fraction has a significant association with arsenic in the medium sand fraction.

It appears that the fine sand fraction and the silt/clay fraction, which have the highest overall gold abundances, also have the best correlation of any two horizons or fractions. While gold in both the A and B horizons have a good correlation, the values are much lower than the values found in the fine sand and silt/clay fractions, and they have the added disadvantage of not being uniformly developed, even over small areas. This presents a problem in extensive geochemical surveys which utilize the A horizon and/or B horizon as sampling mediums.

It is suggested that gold-oriented geochemical surveys over the Fifteen Mile Stream district should include and emphasize the collection of C (lodgement) horizon samples, which in preparation for geochemical analysis should be wet-sieved through a $^+2\phi$ mesh to

Statistical Data for Correlation of Au with Pb and

As in A, B and C Horizons

(A)

Group	n	Au versus	r	p*	Significance
A	11	PbB	-0.434	>0.10	NS
A	11	AsB	-0.109	>0.10	NS
A	11	AuB	0.728	0.02-0.01	S
A	11	PbCF	-0.187	>0.10	NS
A	11	AsCF	-0.050	>0.10	NS
A	11	AuCF	0.432	>0.10	NS
A	11	PbCS	0.035	>0.10	NS
A	11	AsCS	0.399	>0.10	NS
A	11	AuCS	0.288	>0.10	NS
A	11	PbFS	-0.236	>0.10	NS
A	11	AsFS	-0.061	>0.10	NS
A	11	AuFS	0.523	0.10-0.05	PS
A	11	PbMS	-0.352	>0.10	NS
A	11	AsMS	-0.143	>0.10	NS
A	11	AuMS	-0.256	>0.10	NS
B	11	PbB	0.285	0.01-0.001	S
B	11	AsB	0.292	>0.10	NS
B	11	PbCF	-0.204	>0.10	NS
B	11	AsCF	-0.268	>0.10	NS
B	11	AuCF	0.211	>0.10	NS
B	11	PbCS	-0.195	>0.10	NS
B	11	AsCS	0.280	>0.10	NS
B	11	AuCS	-0.069	>0.10	NS
B	11	PbFS	-0.242	>0.10	NS
B	11	AsFS	-0236	>0.10	NS
B	11	AuFS	0.245	>0.10	NS
B	11	PbMS	-0.339	>0.10	NS
B	11	AsMS	-0.158	>0.10	NS
B	11	AuMS	0.276	>0.10	NS
CF	11	PbB	0.000	>0.10	NS
CF	11	AsB	0.682	0.02-0.01	S
CF	11	PbCF	-0.241	>0.10	NS
CF	11	AsCF	0.654	0.05-0.02	S
CF	11	PbCS	-0.025	>0.10	NS
CF	11	AsCS	0.841	0.01-0.001	S
CF	11	AuCS	0.514	>0.10	NS
CF	11	PbFS	0.255	>0.10	NS
CF	11	AsFS	0.685	0.02-0.01	S
CF	11	AuFS	0.924	<0.001	S[2]
CF	11	PbMS	-0.076	>0.10	NS
CF	11	AsMS	0.475	>0.10	NS
CF	11	AuMS	0.075	>0.10	NS
CS	11	PbCS	0.021	>0.10	NS
CS	11	AsCS	0.560	0.10-0.05	PS
CS	11	PbFS	0.027	>0.10	NS
CS	11	AsFS	0.509	>0.10	NS
CS	11	AuFS	0.604	0.05-0.02	NS
CS	11	PbMS	-0.272	>0.10	NS
CS	11	AsMS	0.362	>0.10	NS
CS	11	AuMS	-0.370	>0.10	NS
FS	11	PbMS	0.167	>0.10	NS
FS	11	AsMS	0.658	0.05-0.02	S
FS	11	PbFS	-0.189	>0.10	NS
FS	11	AsFS	0.468	>0.10	NS
FS	11	AuFS	0.066	>0.10	NS
MS	11	PbMS	0.096	>0.10	NS
MS	11	AsMS	0.306	>0.10	NS

(B)

Group	n	Au versus	r	p*	Significance
A	21	PbB	-0.358	>0.10	NS
	11		-0.434	>0.10	NS
A	21	AsB	-0.052	>0.10	NS
	11		-0.104	>0.10	NS
A	21	AuB	0.622	0.01-0.001	S^1
	11		0.728	0.02-0.001	S
A	21	PbCF	-0.086	>0.10	NS
	11		-0.187	>0.10	NS
A	21	AsCF	-0.018	>0.10	NS
	11		-0.050	>0.10	NS
A	21	AuCF	0.169	>0.10	NS
	11		0.432	>0.10	NS
B	21	PbB	-0.568	0.01-0.001	S^1
	11		0.285	0.01-0.001	S
B	21	AsB	-0.144	>0.10	NS
	11		0.292	>0.10	NS
B	21	PbCF	-0.037	>0.10	NS
	11		-0.204	>0.10	NS
B	21	AsCF	-0.142	>0.10	NS
	11		-0.268	>0.10	NS
B	21	AuCF	0.202	>0.10	NS
	11		0.211	>0.10	NS
CF	21	PbB	0.382	0.10-0.05	PS
	11		0.000	>0.10	NS
CF†	21	AsB	0.357	>0.10	NS
	11		0.682	0.02-0.01	S
CF	21	PbCF	-0.057	>0.10	NS
	11		-0.241	>0.10	NS
CF	21	AsCF	0.519	0.02-0.01	S
	11		0.654	0.05-0.02	S

* where p	> 0.1	r is not significant	NS
	0.1-0.05	possibly significant	PS
	0.05-0.01	significant	S
	0.01-0.001	highly significant	S^1
	< 0.001	very highly significant	S^2

CF - silt/clay fraction of C horizon
CS - coarse sand fraction of C horizon
MS - medium sand fraction of the C horizon
FS - fine sand fraction of the C horizon

TABLE 7 (A) shows the level of significance of the correlation coefficients (Brooks, et al. 1966)

(B) shows the change in the significance of a correlation imposed by using n = 11 as compared with n = 21. It was necessary to use the former in comparing all the horizons and fractions as only the A and B horizons and the CF (silt/clay) had 21 analyses performed on them. The difference is minimal, with the exception of CF†.

separate the fine sand/silt/clay fraction ($>2\phi$).

In areas were C horizon samples cannot be collected efficiently, the B horizon is suggested as an alternative sample medium. While its mean gold value is lower than that for the coarse sand fraction of the C horizon, its overall gold values are more consistent. The B horizon is preferred over the A horizon as a sampling medium because it gives higher gold values and is generally more uniform in its development and distribution.

It is expected that these techniques should be equally useful in soil geochemical surveys over any of the till covered gold deposits of the Meguma domain, since these gold deposits are very similar in their mineralogy and glaciation history.

Gold abundances in the $>2\phi$ fraction have a good direct relationship to arsenic abundances in all horizons and fractions analyzed, and therefore, arsenic would be a useful geochemical pathfinder element for gold. While lead abundances in the B horizon do have a relationship to gold abundances in the A horizon, the overall correlation with gold values in the C horizon is relatively poor. From geochemical and microprobe analyses (Chap. 4), it appears as though silver, at least at the Fifteen Mile Stream district, is not particularly promising as an effective pathfinder element. The presence of large amount of copper and zinc in the gold grains suggests that these two elements have a good potential as pathfinder elements. At Fifteen Mile Stream, gold itself is the best indicator of its own deposits.

CHAPTER 6

CONCLUSIONS

1. Geochemical analysis of gold from the A and B horizons, and 4 size fractions of the C horizon have shown that the highest gold abundances are found in the fine sand and silt/clay fractions of the C horizon ($>2\phi$).

2. The relatively high gold abundances obtained from the coarse fraction (1 to -1ϕ) of the C horizon, and the very high values obtained from the fine sand-silt/clay fractions ($>2\phi$) of the same horizon are thought to reflect the inherent nature of gold in the primary deposit, rather than the transport and abrasion of gold through glacial comminution.

3. Peaks of abundances along the lateral extent of the trenches may correspond to the location of auriferous quartz veins in the underlying bedrock or, alternatively, areas of gold concentration caused by precipitation from solution as a result of local perturbations in pH and/or Eh conditions.

4. The gold in the till occurs predominantly as foliated flakes which often exhibit delicate, dendritic-like extensions of grain edges. The grain surfaces are virtually unworn and without striations. This is considered as further evidence against the effects of glacial comminution being a major determining factor in the grain size distribution and character of gold in the till.

5. The composition of gold in the till differs significantly from the composition of gold from the primary deposit. Microanalysis of gold from the nearby mine tailings has given compositions averaging 91% gold and 9% silver. This contrasts sharply with values obtained for gold from the till which averages 70% copper, 9% zinc, 10% gold and 1% silver.

6. Gold grains from both the tailings and the till are heterogeneous in their elemental distribution. This irregular distribution is particularly evident in gold recovered from the till, which varied in one sample from 0% to 54% gold between two points analyzed on the grain surface. It was determined that the copper and zinc are not present as sulphide inclusions or coatings, but probably as oxides or some type of heterogeneous solid solution with gold.

7. The peculiar composition and extreme heterogeneity of gold grains from the till is considered to be a manifestation of a hydromorphic redistribution of the element.

8. The distribution of gold in the till is a culmination of both chemical and mechanical processes.

CHAPTER 7

RECOMMENDATIONS

1. Pedogeochemical surveys for gold near known occurrences and deposits hosted by rocks of the Meguma Group should utilize the C horizon lodgement till as a sample medium.

2. Where C horizon lodgement till is difficult or impossible to sample, the B horizon is suggested as an alternate sample medium.

3. A study of the overlying ablation till should be undertaken to determine the potential of this material as a sample medium in pedogeochemical prospecting for gold.

4. The $>2\phi$ fraction of the C horizon material is recommended as the optimum grain size range for analysis in gold exploration . The most essential elements for analysis are gold, arsenic, copper and zinc respectively.

5. Reconnaisance geochemical surveys for gold in the Meguma terrain should utilize the B horizon and the $>2\phi$ fraction of stream sediment material. Once anomalies are established, further delineation can be accomplished by a detailed sampling of the C horizon and analysis of the $>2\phi$ fraction.

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APPENDIX

Element	Detection Limit	Precision at DL	10 x DL	100 x DL
Pb	2 ppm	± 100%	± 15%	± 10%
As	2 ppm	± 100%	± 20%	± 10%
Au (10 g)	5 ppb	± 100%	± 20%	± 10%
Au (5 g)	10 ppb	± 100%	± 20%	± 10%

Table A. Precision in the Analyses

Table B

Precision in Duplicate Samples

Duplicate Samples	Corresponding Samples	Pb ppm DS	Pb ppm CS	As ppm DS	As ppm CS	Au ppb DS	Au ppb CS
DUP001H	FS022	17	17	666	678	4500	1275
DUP002H	FS024	15	12	267	248	1100	550
DUO003L	FS030	12	10	130	128	30	10
DUP004L	FS034	27	25	390	425	35	5
DUP005M	FS018	12	11	158	272	1550	405

Methods, Precision and Accuracy of the Geochemical Analyses

Pb, Ni - 0.5 grams of sample leached in hot HNO_3-HCl for 2 hours, diluted to 10 mls with deionized water, final measurement by AA.
Please note that this is not a total digestion; therefore, not all metal of interest may be liberated.

As - HNO_3-$HClO_4$ attack on 0.2 grams of sample. Arsenic is reduced with $SnCl_2$. Arsene gas is generated by adding Zn metal. This gas is passed through a mixture of silverdimethyldithiocarbamate in pyridine. The final measurement is spectrophotometric comparison against standards of known concentration.

Au - 10 grams of sample (unless otherwise noted) are preconcentrated using fire assay lead collection procedure. The resulting precious metals bead is dissolved in aqua regia and final measurement is by atomic absorption.

Cr,Ti - 5 grams of material are pressed to form a pellet which is passed through an X-ray beam. Resulting flourescence is measured, and counts are compared to known standards.

The overall accuracy was checked by analyzing standards of known concentration with each batch of samples processed. If the standards varied by more than the precision levels given in Table A, the whole batch was rejected.

Most of the standards used are internal (Bondar-Clegg Laboratories); however, they were established by comparison to certified materials from sources such as CANMET and USGS.