

# SEMI-REGIONAL GEOCHEMICAL STUDIES DEMONSTRATING THE EFFECTIVENESS OF TILL SAMPLING AT DEPTH

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## ABSTRACT

In Canada till sampling has been carried out by different techniques for many years primarily to detect and define metal dispersion halos associated with metallic sources.

The technique described in this paper involves the sampling of till at or near bedrock by the use of a light percussion drill and piston sampler. Successful studies were carried out in areas underlain by ultramafic bodies and gold occurrences in the Timmins—Val d'Or region of Ontario and Quebec.

The results of the lake-sediment till sampling programme in the region show that lake sediment geochemistry will not detect underlying ultramafic rocks and gold occurrences where these targets are covered with glaciolacustrine sediments. However, geochemical results from till samples taken at the bedrock/till interface show that, in this environment, overburden sampling at depth is a useful detail and semi-reconnaissance exploration technique for outlining large geological targets such as ultramafic intrusives, as well as smaller targets such as gold-bearing structures.

Generally stronger contrast and better anomaly definition can be obtained from the geochemical analyses of the heavy-mineral concentrates, specific gravity greater than 2.96, from the till than with the minus 80-mesh ( $<177\mu$ ) or minus 230-mesh ( $<63\mu$ ) fractions from the till. By using nickel and copper as indicator elements the presence of ultramafic intrusives, overlain by up to 44.4 m (148 ft) of glacial sediments, were detected by sampling at 800-m ( $\frac{1}{2}$  mile) centres. Smaller targets, such as gold-bearing structures, were outlined using arsenic as a pathfinder element and by sampling at 400-m ( $\frac{1}{4}$  mile) centres.

## INTRODUCTION

From the conceptual and experimental stages at which geochemical overburden sampling at depth was in Canada when first studied by Ermengen (1957) in 1956, Gleeson (1960) in 1957 and later by such workers as Boniwell and Dujardin (1964), Lee (1963), Fortescue and Hornbrook (1969), Van Tassel (1969), Gleeson and Cormier (1971) and Garrett (1971), it has rapidly moved into an accepted geochemical exploration technique which is being used now throughout glacial terrains and in nearly all geological environments in Canada.

The major impetus which finally helped establish this geochemical approach in Canada came partially as a result of regional studies undertaken by the Geological Survey of Canada during the winter 1971–1972 in the Abitibi area of Quebec and Ontario, Canada. A programme of drift sampling at depth

in 11 localities of the region was carried out by Skinner (1972) involving 394 rotary drill holes and 140 percussion holes. In addition, a programme of regional lake sediment sampling and till sampling at depth under lakes was carried out by Hornbrook and Gleeson (1972, 1973) over some 20,000 km<sup>2</sup> (12,000 square miles) of the Precambrian shield. The till sampling at depth was done over four lakes in the Abitibi area; 30 sites were sampled on Pelletier Lake, 77 on Macamic Lake, 54 on Abitibi Lake and 60 on Nighthawk Lake (Fig.1).

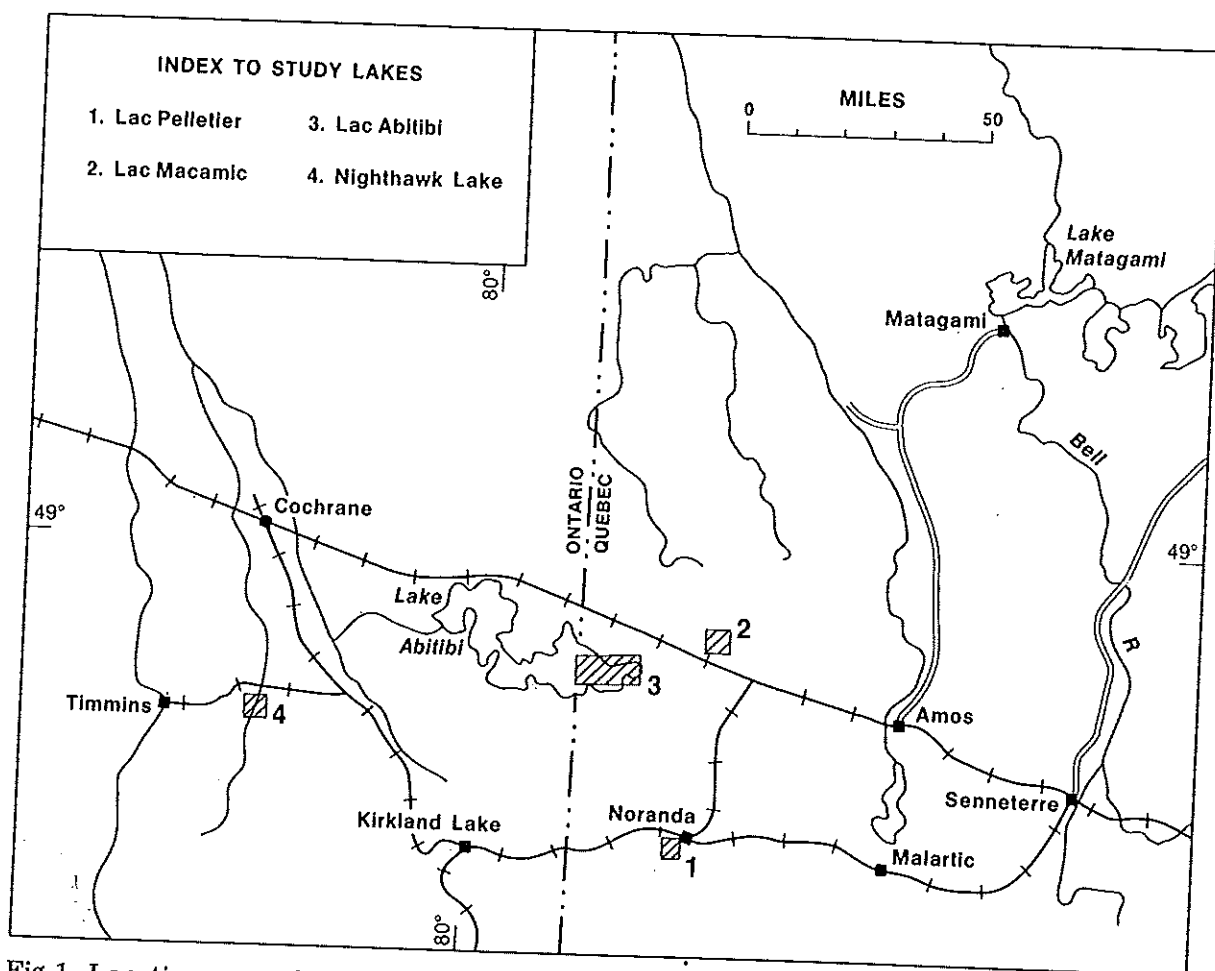


Fig.1. Location map of Abitibi area, Ontario/Quebec.

The purpose of the study by Hornbrook and Gleeson was to test the applicability of the semi-reconnaissance geochemical overburden sampling technique at depth in the Abitibi Clay belt. Prior to these studies the technique had proven useful to the mineral exploration companies in detailed surveys involving evaluation of geophysical and geological targets. This paper will discuss some of the pertinent highlights of the geochemical results from the vicinity of a gold-bearing structure on Pelletier Lake, Quebec and adjacent to gold-bearing structures and ultramafic rocks on Nighthawk Lake, Ontario.

### *Field methods*

Basically, the drilling and sampling equipment and the drilling techniques employed were the same as those originally outlined by Gleeson and Cormier (1971). The programme was carried out using two drill crews equipped with Pionjar-type portable percussion drills. In the Abitibi programme (4 lakes) a total of 221 sites were sampled and 3637 m (12,124 ft) of overburden were drilled at an average cost of \$6.30 a metre (\$2.10 a foot) or about \$10 per sample.

At each site, a lake sediment sample and an overburden sample from atop bedrock was taken. However, on Pelletier Lake duplicate till samples were taken at each site so that studies could be carried out on various size fractions.

On Pelletier Lake, stations were sampled every 150 m (500 ft) on lines 300 m (1000 ft) apart and on Nighthawk Lake samples were taken at 400- and 800-m ( $\frac{1}{4}$  and  $\frac{1}{2}$  mile) centres.

### *Sample preparation and analysis*

To test the metal dispersion patterns in the various size fractions, the lake sediment samples from Pelletier Lake were dried, split and one portion was passed through an 80-mesh ( $177\ \mu$ ) stainless steel screen and the other portion was put through a 230-mesh ( $63\ \mu$ ) stainless steel screen. The Nighthawk lake sediments were sieved through a 230-mesh ( $63\ \mu$ ) stainless steel screen. The minus 80-mesh ( $<177\ \mu$ ) and minus 230-mesh ( $<63\ \mu$ ) fractions were analysed geochemically.

To study metal dispersion in various size fractions of the till two samples were taken at each drill site over Pelletier Lake. One sample was sieved to obtain minus 10-mesh ( $<2\ \text{mm}$ ), plus 80-mesh ( $>177\ \mu$ ) and minus 80-mesh ( $<177\ \mu$ ) fractions and the second sample was sieved to obtain minus 50-mesh ( $<297\ \mu$ ), plus 230-mesh ( $>63\ \mu$ ) and minus 230-mesh ( $<63\ \mu$ ) fractions. In the Nighthawk Lake study only the latter separations were done.

Heavy-mineral concentrates from the tills were obtained from the minus 10-mesh ( $<2\ \text{mm}$ ), plus 80-mesh ( $>177\ \mu$ ) and minus 50-mesh ( $<297\ \mu$ ), plus 230-mesh ( $>63\ \mu$ ) fractions by separation with tetrabromoethane (specific gravity 2.96). The heavy-mineral fractions were split and one part pulverized to minus 100-mesh ( $<149\ \mu$ ) for geochemical analysis. The second portion was retained for mineralogical examination and the light fraction was stored for possible future studies. In addition, geochemical analyses were done on the minus 80-mesh ( $<177\ \mu$ ) and minus 230-mesh ( $<63\ \mu$ ) fractions of the tills from Pelletier Lake and on the minus 230-mesh ( $<63\ \mu$ ) fraction of the tills from Nighthawk Lake.

All samples were analysed geochemically for Cu, Pb, Zn, Mo, Ni, Mn, Ag, and As. The first seven elements were analysed using a Techtron AA-5 atomic absorption spectrophotometer after digesting 0.5 g of sample in hot aqua regia for 2 hours. Arsenic was determined colorimetrically utilizing silver diethyl-

TABLE I

Generalized stratigraphy and inferred events, Abitibi Clay Belt (after Skinner, 1972)

Units	Description	Events	Age ( $^{14}\text{C}$ yr B.P.)
Recent deposits	Peat, humus and alluvium Wind-blown sand, especially along eskers.		
Glacio-lacustrine silt and clay	Thin silt-clay varves; clay oxidized to chocolate brown. Not more than 5–10 ft thick.	Rapid dissipation of ice sheet; drainage of small post-Cochrane lakes.	by 7800 yr
Cochrane till	Clayey, silty till with few pebbles; essentially reworked Barlow-Ojibway sediments. Locally, a thin bed of sand and gravel at base of till. Southern limit shown on maps by Hughes (1960), Boissonneau (1965), and Prest et al. (1967). Unit < 1–35 ft thick. Difficult to recognize in drilling; essentially clay with a few pebbles.	Surge of lobe of ice sheet; affected only part of area.	8300 yr
Glacial Lake Barlow-Ojibway deposits	Grade from sand and gravel at bottom up through sand, then thick sandy silt varves, then into thin clayey varves at top of unit. Can be over 150 ft thick. Includes esker facies.	Glacier margin retreated perhaps as far north as James Bay lowlands; eskers formed during this retreat.	
Till	Bouldery, sandy to silty compact till, in places overlain by a relatively loose, sandy ablation facies. Locally has lenses of sand and gravel up to 10 or 20 ft thick. Unit can be as much as 75 ft thick.	Retreat Glaciation	10,000 yr
Bedrock			

dithiocarbamate (Vasak and Sedivec, 1952) after 0.5 g of sample was digested cold with a mixture of nitric and perchloric acids; then in a sand bath at 170°–200° C for 4 hours or until the nitric acid was expelled.

This report will deal only with the arsenic results from Pelletier Lake and the Cu–Ni–As results from Nighthawk Lake. The total data from all lakes sampled have been released as an open file report by the Geological Survey of Canada (Hornbrook and Gleeson, 1972).

### *Glacial stratigraphy*

A generalized glacial stratigraphic sequence for the Abitibi area has been drawn up by Skinner (1972) and it is presented here in Table I. The areas in the Abitibi region are underlain by deposits from glacial lake Barlow-Ojibway and till.

### PELLETIER LAKE

This lake is located in Rouyn Township about 3.2 km (2 miles) southwest of the towns of Rouyn-Noranda, Quebec, at latitude 48° 13' N and longitude 79° 03' W (Fig. 1). The depth of water in the area sampled varies from 0.9 to 5.4 m (3–18 ft) and the thickness of the glacial overburden varies from 2.9 to 34.8 m (9.5–116 ft). Thickness of the lodgement till varies from 0 to 3 m (0–10 ft) but generally it is less than 0.3 m (1 ft). Here and there, on top of the till, is a gravelly layer 0.3 to 7.2 m (1–24 ft) thick and this is overlain by a layer of fine sand 0.15–9 m (0.5–30 ft) thick and above the sand are glacio-lacustrine silts and clays which vary from 2.7 to 22.5 m (9–75 ft) in thickness. The direction of the last glacial advance in this area was approximately south 20° east.

In general there is a bedrock high along the easterly edge of the sampled area and from there the bedrock forms a ridge about 120 m (400 ft) wide which more or less follows the base line. North and south of this ridge the bedrock is at depths greater than 7.5 m (25 ft).

### *Geological setting of Lake Pelletier*

This lake was chosen as a test site because the east-northeast trending gold-bearing Pelletier Lake fault underlies the portion of the lake sampled. A former gold producer, Stadacona Mines Limited, is located at the east end of this fault where it joins with the main northeast-striking ore-bearing Stadacona fault. The faults cut Precambrian volcanic and dioritic rocks.

The Stadacona mine was in production from 1936 to 1958 and during that time some 3,053,420 tons grading 0.16 oz. Au per ton were mined. The ore zones comprise parallel and cross-cutting quartz-ankerite veins in the Stadacona fault. The maximum width of the ore zone was 6 m (20 ft) but rarely exceeded 2.4 m (8 ft). Besides quartz and ankerite the zone contained

tourmaline, pyrite, free gold, petzite, arsenopyrite, chalcopyrite, galena, talc and chrome-bearing mica (Wilson, 1962).

The rocks underlying Pelletier Lake are predominantly interbedded flows of Precambrian pillowed andesite, rhyolite agglomerate and tuff into which masses and dykes of diorite have been intruded. The volcanic and dioritic rocks are intersected by the Pelletier Lake fault and the southwestern extension of the Stadacona fault. Diamond drilling on the Pelletier Lake fault has revealed the presence of a gold-bearing pyritic, carbonatized (ankerite) shear zone veined with quartz. The zone appears to be 7.5–12 m (25–40 ft) wide.

### *Geochemical results*

The Pelletier Lake study was carried out to determine the effectiveness of till sampling at depth in outlining gold-bearing structures. Also to demonstrate the blanketing effect of impervious glacial lake clay sequences on the vertical migration of trace metals from underlying anomalous tills, the lake sediments were taken. Because of the presence of arsenopyrite in the gold-bearing zones, arsenic has been used as the pathfinder element.

Figs. 2, 3 and 4 respectively show the results for arsenic in the lake sediments (minus 80 mesh and minus 230 mesh), tills (minus 80 mesh and minus 230 mesh) and heavy-mineral concentrates from the tills (minus 10-mesh, plus 80 mesh and minus 50-mesh, plus 230 mesh).

#### *Lake sediments (minus 80 and minus 230-mesh fractions)*

Arsenic in the minus 80-mesh fraction of the lake sediments varies from 3 to 18 ppm (Fig.2a). The Pelletier Lake fault zone has no anomaly associated with it. High values of 10 and 15 ppm in the southeast corner of the grid may be related to arsenic from the Stadacona fault zone which outcrops on the eastern shore of the bay. The 18-ppm value in the southwest part of the grid could also be related to sources of arsenic on shore as outcrops are abundant here. The high value (10 ppm) in the northeast part of the grid could be caused by contamination from mine tailings in the adjacent bay. A corresponding high value of 60 ppm also occurs here in the minus 230-mesh fraction (Fig.2b). Except for this value, arsenic in the minus 230-mesh lake sediment material varies from 3 to 9 ppm and no significant increase in arsenic is obvious over or near the gold-bearing structures.

Therefore, the distribution of arsenic in lake sediments from Pelletier Lake does not indicate the presence of the gold-bearing structures underlying the glaciolacustrine deposits.

#### *Till (minus 80 and minus 230-mesh fractions)*

The arsenic values in the minus 80-mesh fraction of the tills show a marked increase over and in the vicinity of the Pelletier Lake fault zone (Fig.3a). Arsenic in the minus 230-mesh fraction does not appear to increase immediately over the gold-bearing fault (Fig.3b). However, an increase does occur in the

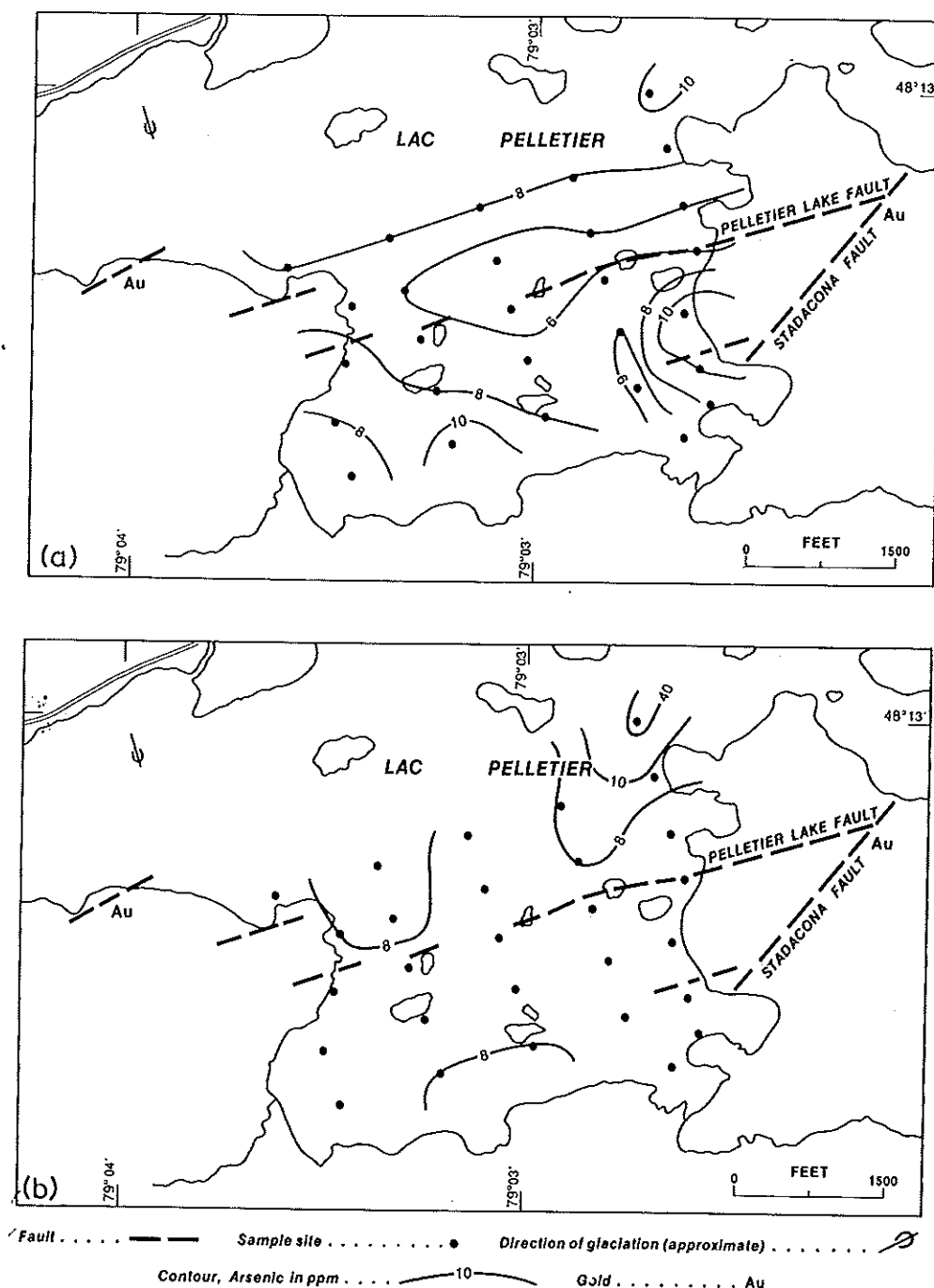


Fig.2. Arsenic distribution in lake sediments — Pelletier Lake, Quebec; (a) minus 80-mesh fraction, (b) minus 230-mesh fraction.

minus 230-mesh fraction of the till southeast of the Pelletier Lake fault. Overburden here is rather thin and this anomaly could be glacially transported from the northwest or it could represent hydromorphic dispersion, probably by groundwater, from the gold-bearing faults on shore. The latter is probably more likely because a southeasterly glacial dispersion fan from the fault is not evident from the results.

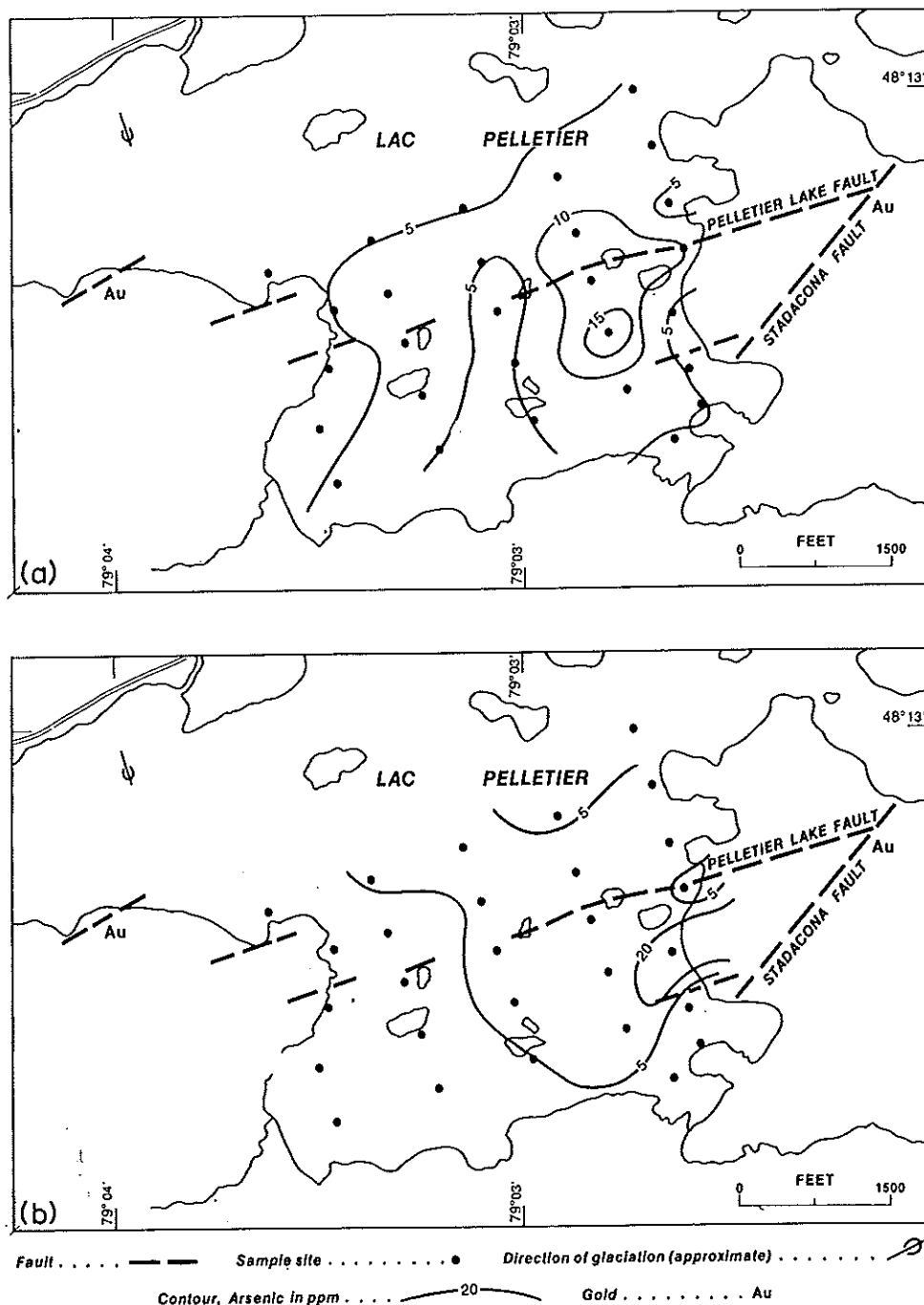


Fig. 3. Arsenic distribution in till — Pelletier Lake, Quebec; (a) minus 80-mesh fraction, (b) minus 230-mesh fraction.

#### *Till (heavy-mineral fractions)*

The minus 10-mesh, plus 80-mesh heavy-mineral fraction shows a good anomaly in excess of 20 ppm As over and down glacial ice-direction movement from the Pelletier Lake fault zone (Fig. 4a). Several unexplained anomalies occur in the northeast and southwest part of the sampled area.

The minus 50-mesh, plus 230-mesh heavy mineral fraction (Fig. 4b) is also

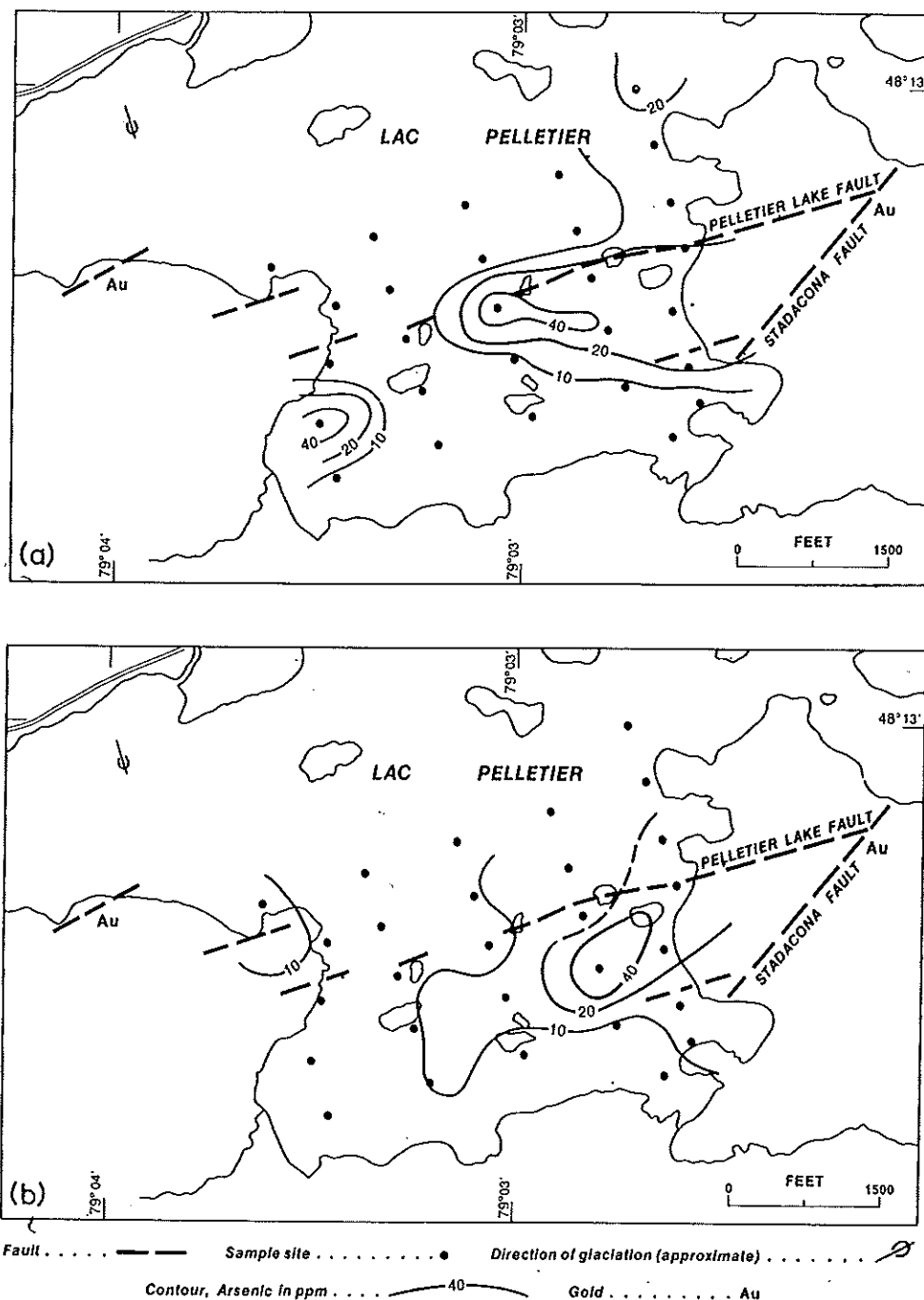


Fig.4. Arsenic distribution in heavy-mineral fraction of till — Pelletier Lake, Quebec; (a) minus 10-mesh, plus 80-mesh fraction, (b) minus 50-mesh, plus 230 mesh fraction.

anomalous over and down ice direction from the Pelletier Lake fault zone. However, the anomaly is less intense and more restricted than that found using the minus 10-mesh, plus 80-mesh material.

### Summary

The Pelletier Lake gold-bearing fault zone can be delineated by sampling

the tills atop bedrock on a 300 m × 150 m (1000 ft × 500 ft) grid. Using arsenic as the pathfinder element for the gold-bearing structure the minus 10-mesh, plus 80-mesh heavy-mineral material shows a more distinct anomalous pattern. However, more down-ice dispersion is evident with the minus 50-mesh, plus 230-mesh heavy-mineral fraction. The arsenic anomaly in the minus 80-mesh fraction of the till overlies Pelletier Lake fault. Its dispersion is more restricted than those from the heavy-mineral fractions. Arsenic in the minus 230-mesh till fraction does not seem to be effective in outlining the gold-bearing fault.

Lake sediments are ineffective in delineating the fault zones; however, there appears to be some hydromorphic dispersion of arsenic into the lake sediments possibly from the outcrops along the shore line and/or groundwaters from the fault zones. This creates single station anomalies in lake sediments taken near the shore.

#### NIGHTHAWK LAKE

Nighthawk Lake is located 30.4 km (19 miles) east of the town of Timmins, Ontario (Fig.1) at latitude 48°30'N and longitude 80°55'W. In Northeast Bay of Nighthawk Lake the water varies in depth from 0.3 to 3 m (1–10 ft). The overburden is from 2.7 to 44.4 m (9–148 ft) thick and most of the north half of the bay and the extreme south part is covered by more than 24 m (80 ft) of glacial overburden.

Glacial striae measured by Leahy (1971) vary from 145° to 175°T. The glacial stratigraphy here consists generally of the following: an upper layer of glaciolacustrine clay and silt 0.3–18.6 m (1–62 ft) thick, which is underlain by fine sand and silt 1.5–30.6 m (5–102 ft) thick; underlying the sand and silt is 0.6–10.2 m (2–34 ft) thick layer of sand, gravel and boulders. In places the sand and/or gravel layer overlies 0.3 m (1 ft) or less of dense lodgement till. Some of the bouldery layers according to Hughes (1965) form part of the basal till. In most places samples were taken from the till on top of bedrock.

#### *Geological setting of Nighthawk Lake*

This lake was chosen to test the effectiveness of reconnaissance geochemical till sampling in outlining general geological targets of possible economic interest. The two targets of interest here are the ultramafic intrusions and gold occurrences.

Northeast Bay of Nighthawk Lake is underlain by several bodies of serpentinized peridotite (Fig.5). These ultramafics intrude volcanic rocks which in places have been altered to chlorite-carbonate schists. On the peninsulas to the south the rocks are mainly volcanic and these have been intruded also by peridotite.

In the south part of the bay, gold occurrences are known to be present in

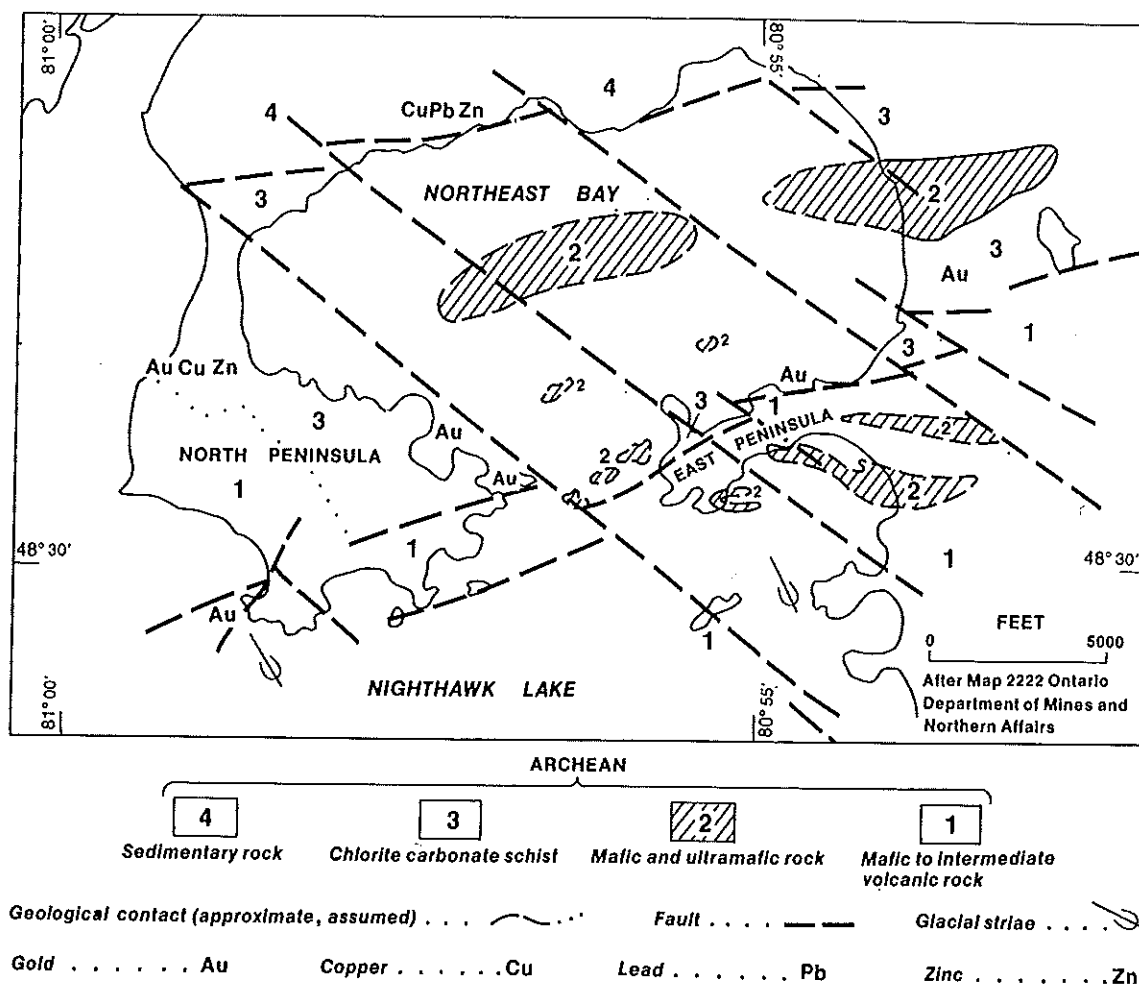


Fig.5. General geology of Northeast Bay, Nighthawk Lake, Ontario.

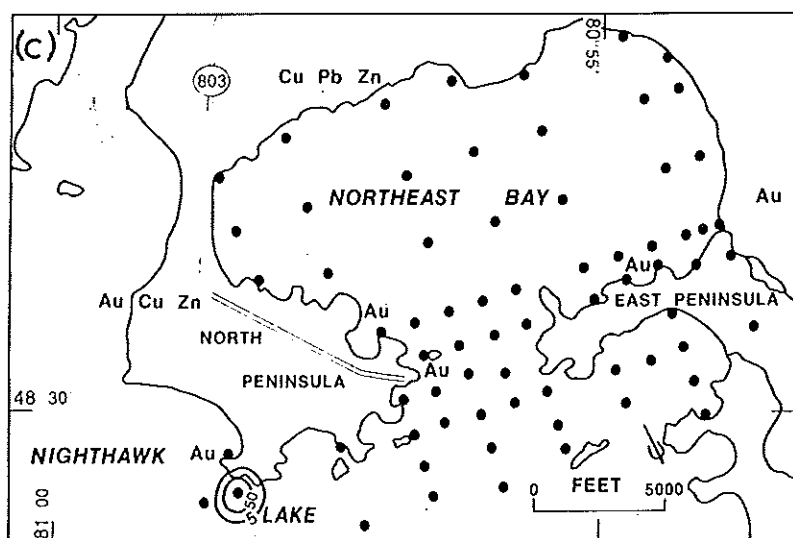
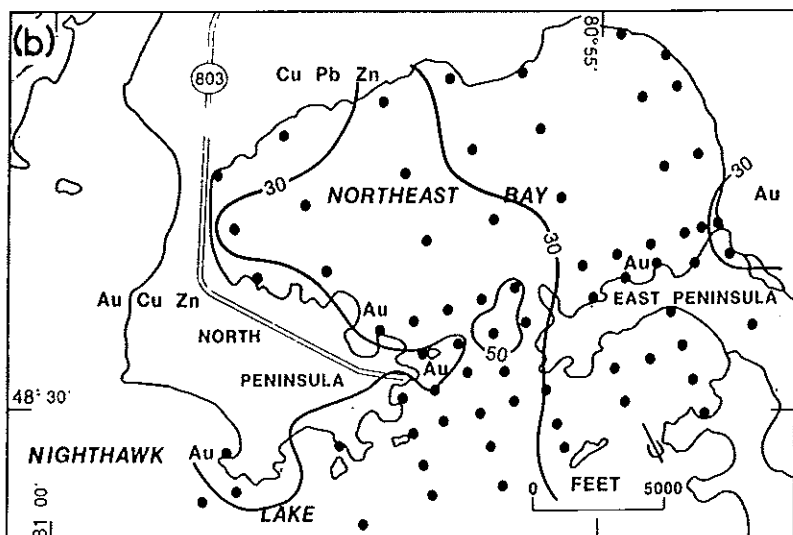
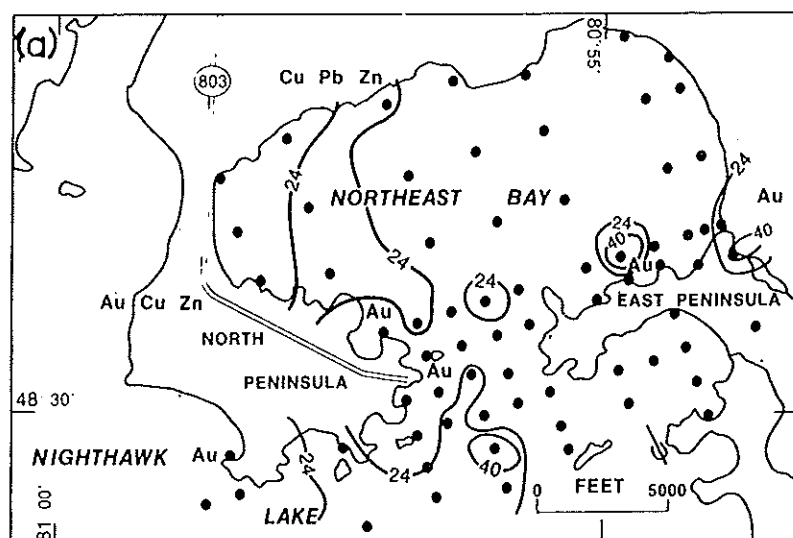
pink to grey felsite or porphyry dykes and quartz veins and stringers. These occur in strongly schistose volcanic rocks associated with grey and brown carbonates and green chrome-micas. The dykes and veins are frequently associated with fault zones which trend N70° E. The mineralized carbonate zones may contain about 5% pyrite and traces of chalcopyrite, sphalerite, pyrrhotite, galena, and free gold.

Gold occurrences have been described also as occurring in quartz veins cutting serpentine-chlorite-carbonate schist which contain abundant pyrite (Leahy, 1971).

Between 1924 and 1944 Porcupine Peninsula mine, which is located at the southwestern tip of North Peninsula, produced about 100,000 tons of ore from which 27,416 oz. of gold was recovered (Leahy, 1971).

#### *Geochemical results*

The Nighthawk Lake study was done to determine the effectiveness of systematic semi-reconnaissance till sampling at depth in outlining large geo-



Sample site . . . • Contour, metal in ppm . . . —40— Glacial striae . . . ↗  
 Copper . . . . . Cu Gold . . . . . Au Lead . . . . . Pb Zinc . . . . . Zn

Fig.6. Metal distributions in minus 230-mesh lake sediments — Nighthawk Lake, Ontario; (a) copper, (b) nickel, and (c) arsenic.

logical targets of economic interest (ultramafic intrusions) and gold-bearing structures. Also lake sediments were sampled to demonstrate the ineffectiveness of this technique in areas underlain by thick glaciolacustrine deposits.

The distribution of copper, nickel, and arsenic in the lake sediments, tills and heavy-mineral concentrates from the tills are shown in Figs.6, 7 and 8, respectively.

*Lake sediments (minus 230-mesh fraction)*

The lake sediment values for copper (Fig.6a) vary from 4 to 63 ppm and average 15 ppm, for nickel (Fig.6b) they vary from 8 to 105 ppm and average 25 ppm, for arsenic (Fig.6c) they range from 0.5 to 100 ppm and average 2 ppm.

All arsenic values but one are less than 5 ppm. The one high result (100 ppm) occurs near a small island (Pine Island) in the southwest part of the grid. This single high value may be due to contamination from the mine tailings of Porcupine Peninsula mine.

There is no apparent relationship between the distribution of nickel, copper and arsenic in the lake sediments and the geology of the area.

*Till (minus 230-mesh fraction)*

The distribution of copper, nickel and arsenic in the minus 230-mesh fraction of the tills are shown in Fig.7a, b and c, respectively.

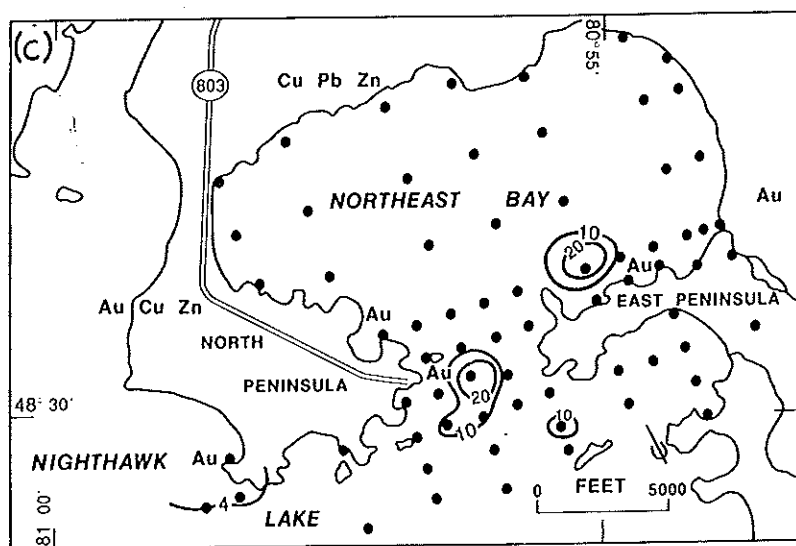
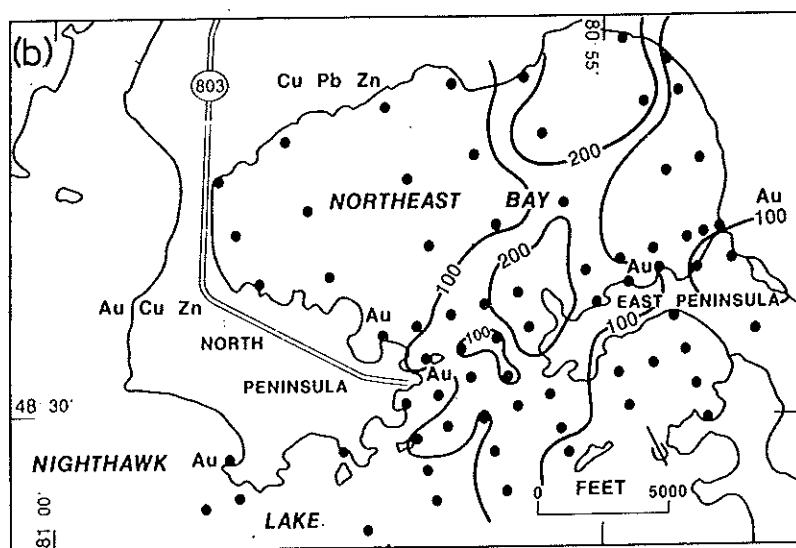
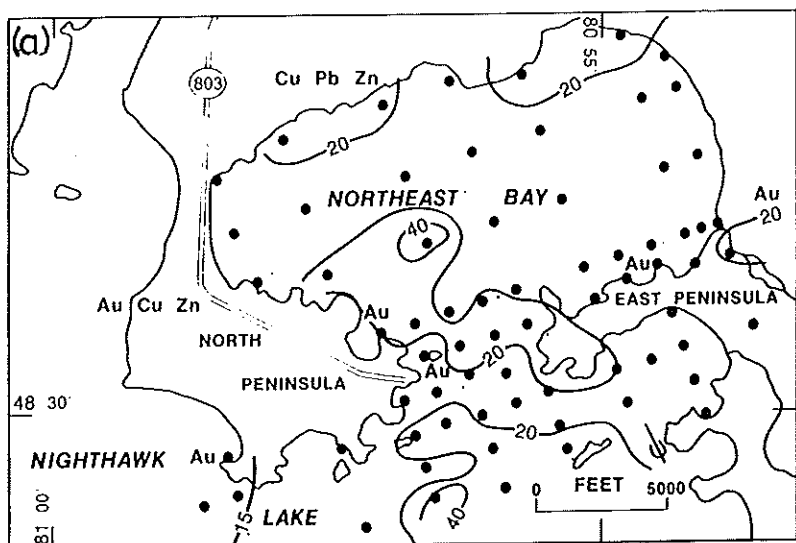
Copper values vary from 8 to 50 ppm and average 15 ppm. There is little apparent correlation between the known geology and copper in the fine fraction of the tills.

Nickel values vary from 12 to 370 ppm and average 52 ppm. Anomalous values in nickel are common in areas underlain by ultramafic rocks. The northeasterly trend of the nickel anomalies (Fig.7b) between the two peninsulas coincides with the attitude of some of the ultramafic bodies (Fig.5). Similarly the easterly nickel trend on the north side of East Peninsula corresponds with the strike of the serpentized ultrabasic rocks there. Ultrabasic rocks or their altered equivalents are in close proximity to the gold-bearing structures. The northeast part of the bay is underlain by an anomalous nickel zone which coincides with the location of a peridotite intrusion. The anomaly is open to the north and probably represents dispersion of the fine fraction of the till from a source to the north.

Arsenic in the minus 230-mesh fraction of the till (Fig.7c) varies from 1 to 33 ppm and averages 2 ppm. There does not seem to be any regional trend for arsenic in this fraction. Local circular anomalies coincide with anomalous nickel on the north side of East Peninsula and at two locations in the narrows between and south of East and North Peninsulas.

*Till (heavy-mineral fraction)*

The distribution of copper, nickel and arsenic in the minus 50- plus 230-mesh heavy-mineral fraction (specific gravity > 2.96) is shown in Fig.8a, b and c, respectively.



Sample site . . . • Contour, metal in ppm . . . — 20 — Glacial striae . . . ↗  
 Copper . . . . . Cu Gold . . . . . Au Lead . . . . . Pb Zinc . . . . . Zn

Fig. 7. Metal distribution in minus 230-mesh till — Nighthawk Lake, Ontario; (a) copper, (b) nickel, and (c) arsenic.

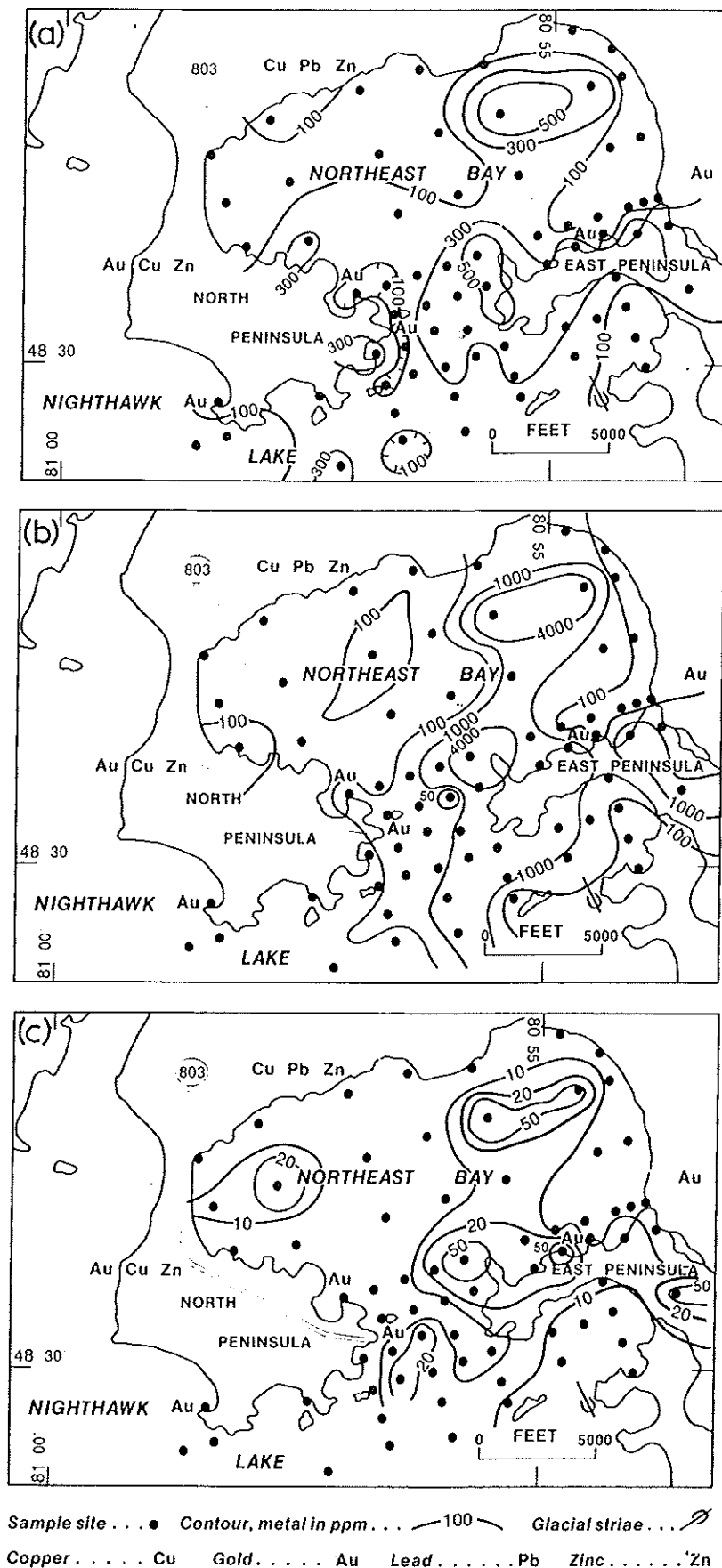


Fig.8. Metal distribution in minus 50-mesh, plus 230-mesh heavy-mineral fraction of till — Nighthawk Lake, Ontario; (a) copper, (b) nickel, and (c) arsenic.

*Copper.* Copper values vary from 14 ppm to 2200 ppm and the average is 88 ppm.

Strong easterly trending copper anomalies underlie the north half of the bay, these are related to ultramafic rocks and talc-chlorite-carbonate schists. Traces of chalcopyrite were identified in the heavy-mineral concentrates from here.

On East Peninsula strong copper anomalies are present. Gold deposits occur here in carbonated and schistose volcanic and ultramafic rocks. Also copper anomalies underlie a large portion of the area between the two peninsulas and south of them. This regional increase in copper probably is related to ultramafic rocks and to an area of intense hydrothermal alteration that has produced large bodies of carbonatized rocks. Carbonatization occurs in areas intruded by albite-syenite and albite-syenite porphyry dykes. According to Leahy (1971) the carbonates are ankerite, calcite, dolomite and magnesite. Other common minerals in these rocks are sericite, fuchsite, pyrite, quartz, albite and leucosene. Trace amounts of chalcopyrite have been identified in the heavy-mineral concentrates from the area between and south of the two peninsulas and carbonate minerals such as ankerite and magnesite are common.

Another source of the copper in the area sampled could be minor amounts of chalcopyrite which are known to occur in gold veins.

An increase of copper to 164 ppm in the northwest part of the sampled area could be part of a dispersion train from a minor Cu—Pb—Zn occurrence immediately north in the sedimentary rocks.

Hence, it appears that the large anomalous dispersion pattern for copper found in the heavy-mineral concentrates from the tills in this part of Night-hawk Lake are related probably to multiple sources such as ultramafic rocks, altered carbonated zones and gold deposits. Minor base-metal mineralization in the sedimentary rocks north of the lake also probably contributes copper to the tills.

*Nickel.* Nickel in the minus 50- plus 230-mesh heavy-mineral concentrates varies from 20 to 11500 ppm and averages 163 ppm.

The strongest nickel anomaly (7000 and 11,500 ppm) occurs in the northeast part of the bay. Minor amounts of pyrrhotite, chalcopyrite and pyrite in the heavy-mineral concentrates indicate that some of the nickel found in the tills here is related to sulphide occurrences. Other significant nickel anomalies are present on East Peninsula and north and south of East Peninsula. All these nickel anomalies are closely associated with ultramafic intrusions and/or their altered equivalents. Many of the nickel highs are associated with anomalies in copper, which indicates that most of the copper anomalies discussed previously are derived probably from ultramafic rocks.

*Arsenic.* The minus 50- plus 230-mesh heavy-mineral concentrates contain 0.5 to 160 ppm arsenic and average 5 ppm.

High arsenic values are coincident with zones high in nickel. In the vicinity

of the gold-bearing structures on East Peninsula high arsenic values occur. The broad distribution of arsenic anomalies suggests that gold mineralization could be wider spread than previously known. The coincidence with nickel probably results where gold-bearing structures intersect ultramafic rocks such as on East Peninsula.

Although no arsenopyrite was seen in the heavy-mineral concentrates many of the samples contain from a trace amount to 7% pyrite. Pyrite is commonly associated with the gold deposits and the arsenic in the heavy-minerals is probably derived from pyrite.

### *Summary*

Lake sediment sampling in this area is ineffective in outlining broad geological targets such as ultramafic intrusions or more restricted targets such as gold-bearing structures underlain by up to 44.4 m (148 ft) of glacial sediments.

However, till sampling at depth on 400- and 800-km ( $\frac{1}{4}$  and  $\frac{1}{2}$  mile) centres has proven effective in outlining both of the above types of targets. The most definitive results have been obtained from the minus 50- plus 230-mesh heavy-mineral concentrates. Coincident anomalies in copper, nickel and arsenic have been obtained over the ultramafic intrusions and over the gold structures where they cut the ultrabasic rocks. The results suggest that the gold mineralization could be wider spread than previously known, this is particularly true north and southwest of East Peninsula.

### GENERAL DISCUSSION

Although Cu, Pb, Zn, Mo, Ni, Mn, As and Ag content were determined in all samples from four different lakes in the Abitibi area, only selected elements over two lakes have been discussed here. To compare the type of results obtained in lakes that are apparently devoid of mineral deposits (Abitibi and Macamic Lakes) with those obtained from lakes underlain by mineral occurrences and/or ultramafic rocks (Nighthawk and Pelletier Lakes) a summary of background values obtained from all four lakes is presented in Table II.

This table shows that, except for arsenic and manganese, slight increases in element background values are apparent in the minus 230-mesh fraction of the lake sediments from Pelletier Lake as compared to the minus 80-mesh fraction. All metals, except arsenic in the tills from Pelletier Lake, have lower average metal values in the minus 80-mesh fraction than in the minus 230-mesh fraction. Also, except for arsenic and manganese, the averages of the metal values in the minus 10- plus 80-mesh heavy-mineral fraction of the till from Pelletier Lake generally are lower than the metal averages in the minus 50- plus 230-mesh heavy-mineral fraction.

The mode of element dispersion in the till is by particulate transport and this increase in arsenic in the coarser fractions of the till may be a reflection

TABLE II

Geometric means of trace elements from lake sediments and tills, Abitibi region

Lake	Fraction and material	Geometric mean (ppm)							
		Cu	Pb	Zn	Mo	Ni	Mn	As	Ag
Pelletier	-80 mesh lake sediments	50	18	93	2.1	42	576	7.1	1.2
	-230 mesh lake sediments	52	25	96	2.5	44	552	6.2	1.2
Pelletier	-80 mesh tills	35	11	44	1.3	27	330	4.5	1.0
	-230 mesh tills	52	18	65	1.8	34	409	3.7	0.7
Pelletier	-10+80 mesh hvs tills	115	20	76	2.4	57	597	9.2	1.4
	-50+230 mesh hvs. tills	173	29	84	2.4	58	430	7.9	1.5
Nighthawk	-230 mesh lake sediments	15	13	38	1.5	25	362	1.6	1.3
	-230 mesh tills	15	13	27	1.8	52	263	2.0	1.3
	-50+230 mesh hvs tills	88	21	45	6.9	163	396	4.7	1.0
Macamic	-230 mesh lake sediments	25	19	66	2.6	39	596	2.5	1.2
	-230 mesh tills	10	9	26	2.0	18	145	1.2	0.7
	-50+230 mesh hvs tills	22	16	33	2.2	36	254	2.3	1.0
Abitibi	-230 mesh lake sediments	15	15	64	1.5	24	360	2.8	0.9
	-230 mesh tills	14	10	28	1.4	20	190	1.2	0.6
	-50+230 mesh hvs tills	33	10	31	1.7	32	295	2.1	0.7

Note: hvs = heavy-mineral concentrate, specific gravity &gt; 2.96

of the proximity of the source of arsenic (i.e. Lake Pelletier fault). The increase of arsenic in the coarser fraction on the lake sediments also suggests that some of the dispersion of arsenic in the lake sediments may be in the form of minute particles. One possible source of such dispersion would be contamination from mine tailings.

Background values in Table II for most elements in the heavy fraction of the tills show marked increases over the lakes containing gold mineralization and ultramafic rocks, (Pelletier and Nighthawk Lakes) as compared to those under which no ultramafic rocks or gold deposits are known (Abitibi and Macamic Lakes).

From the Pelletier Lake study it is concluded that analyses of the coarser heavy minerals (i.e. minus 10-mesh, plus 80 mesh) is as effective in outlining gold-bearing structures as the heavy concentrates from finer fractions. When sampling close to the source of the metals the minus 10-mesh, plus 80-mesh fraction is preferable.

In future studies of this type it would be interesting to compare the element contents of whole till samples with the element contents of the heavy-mineral fractions from the till. The whole till samples would be prepared for analysis by pulverizing them to minus 100 mesh much in the same manner as one would prepare a rock sample for geochemical analysis. It is suggested that where lodgement till is sampled, meaningful results possibly could be obtained by analyzing the whole till sample. Such an approach is economically justified because expensive heavy-mineral separations would be avoided.

To establish optimum sample densities for detailed and semi-reconnaissance work additional investigations involving till sampling are required over and near various types of mineral deposits and geological targets.

Recent work by Gunton and Nichol (1974) has demonstrated that overburden sampling at depth can be effective in evaluating surface geochemical anomalies that are suspect of being transported to a position remote from their bedrock sources.

Also in Finland (Wennevirta, 1973) sampling of the bedrock/till interface not only has been used as an effective geochemical exploration technique, but by examining the rock fragments in the coarse fraction of the till they have been able to estimate the nature of the underlying geology. This aspect of the technique has not been stressed in Canada but it could prove to be a valuable geological mapping technique in extensively overburdened areas such as the Abitibi Clay Belt.

#### GENERAL CONCLUSIONS

In Canada sampling of till at the bedrock/till interface by means of light portable percussion drills is rapidly becoming one of the most frequently used geochemical exploration techniques for evaluating geophysical and geological targets in glacial terranes. Although, in the past, the technique has been restricted to detailed studies of specific anomalies, it is now apparent that the method is applicable on a semi-reconnaissance basis. The results presented have clearly demonstrated that larger geological targets such as ultramafic intrusions can be outlined by sampling at 800-m (½ mile) centres, and analysing the heavy-mineral fraction for such elements as copper and nickel. Smaller targets, such as gold-bearing structures, have been delineated by sampling at 400-m (¼ mile) centres and analysing the heavy-mineral fraction for arsenic. The technique has been proven effective in areas underlain by up to 44.4 m (148 ft) of glaciolacustrine deposits and where surficial geochemistry does not work.

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