Evaluation by Geochemistry of Geophysical Anomalies and Geological Targets Using Overburden Sampling at Depth

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ABSTRACT

As a result of some experimental work done early in the winter of 1967, a method of taking overburden geochemical samples at depth was developed. The technique proved to be an efficient, practical and economical means of obtaining basal till samples for geochemical analyses in the search for base metal deposits in areas covered by glacial lake sediments.

The method involves the use of a light, portable, gasoline-operated drill which drives a stainless steel sampler, attached to a series of steel rods, into the ground. When the desired sample depth is reached, the sampler is opened and then filled by driving it into the material to be sampled.

This system has been used in the Abitibi region of Quebec to evaluate EM geophysical anomalies that would not ordinarily warrant diamond drilling. Hole depths have varied from less than 10 feet to over 100 feet, but generally have averaged about 50 feet.

At one place, an EM anomaly was found to be due to a barren pyrite zone. However, geochemical analyses of the basal till several hundred feet away indicated abnormally high zinc values. The area in the vicinity of the geochemical anomaly was subsequently diamond-drilled, and a zinc deposit was found.

Orientation work over two known but buried copper deposits in the Val d'Or - Barraute region showed that geochemical analyses (Cu, Pb, Zn) of the minus-80-mesh fraction of the basal till normally gave positive results. However, much greater contrast was found when the plus-80-mesh heavy-mineral fraction was analyzed.

Microscopic examination of the heavy and light plus-80-mesh fraction from the basal till has also been helpful in detecting bedrock types, base-metal-bearing sulphides, graphite and barren sulphides. The latter two have been found to be the cause of many of the EM anomalies.

Geochemical anomalies found in the basal till have shown little horizontal displacement by glacial action; generally, the abnormal values occur over or in the immediate vicinity of the suboutcrop of the base metal deposits.

Another useful application of this drilling method has been the determination of depths of overburden either for engineering purposes or to correct for bedrock configuration in gravity surveys. More than 80 per cent of the gravity anomalies tested to date have been found to be caused by increases in the elevation of the bedrock surfaces.

The overburden sampling technique has also been successfully applied in delineating a niobium-bearing carbonatite about 15 miles west of Oka, Quebec. Because of weathering characteristics, it was possible to systematically sample the weathered carbonatite, which was covered by 0 to 70 feet of glacial overburden. Samples were visually examined for carbonatite fragments and then assayed for Nb_2O_5. Geochemical analyses for zinc and silver were also run.

After putting together the analytical information on the samples taken at depth, it was possible to show, in a very short time and at minimal cost, that instead of having two small separate carbonatite bodies, as was originally thought, actually there was one large body of niobium-bearing carbonatite.

Costs for these programs have varied from 50 cents to 2 dollars a foot.

INTRODUCTION

OVERBURDEN SAMPLING of glacial materials at depth for geochemical purposes began in Canada about 1956. At that time, S. V. Ermengen[2-3] did a study on the geochemical dispersion of base metals in the glacial tills over copper deposits in the Chibougamau area, Quebec. Samples at depth were taken using a hand-operated drill.

In 1957, C. F. Gleeson[6-7] began a study on the distribution of metals in bogs and glaciolacustrine deposits in northwestern Ontario and Quebec. To obtain samples at depth, he used a muskeg tractor fitted with a powered drill and conveyor-flight augers.

In 1962, geochemical sampling of overburden at depth was carried out successfully over the Poirier copper ore deposit using a Copco Cobra rock drill[1].

In the Yukon Territory, during the spring of 1963, United Keno Hill Mines instigated a geochemical program of sampling overburden at depth[10]. They used an Atlas Copco overburden drill powered by a diesel air compressor, and the unit was moved from site to site by a bulldozer. The program was successful in finding a new silver-bearing vein system which was covered by 20 to 40 feet of permanently frozen overburden.

In the summer of 1963, the Geological Survey of Canada began a study on the gold content of basal till from the Kirkland Lake area, Ontario[9]. To reach the basal till, pits were dug by hand and with the aid of dynamite. The results showed that glacial fans over the Kirkland Lake fault could be indicated by (1) grains of free gold, (2) silver-bearing magnetite grains, (3) chloritic rock fragments and (4) dark vein-quartz rock fragments in the basal till.

In 1964 and 1965, the Geological Survey of Canada carried out a geochemical survey using overburden drilling over the Kidd Creek orebody near Timmins, Ontario[4]. They used a Failing drill and demonstrated that the lower till material over and in the vicinity of the orebody was strongly anomalous in zinc and copper.

In the winter of 1967, the authors started on a program of developing an efficient low-cost method of obtaining overburden samples of glaciated material at depth. This paper will describe the equipment used, the geochemical results obtained and the applications of the method at four different localities. Three of these areas are in the Clay Belt of northwestern Quebec.

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FIELD METHODS AND TECHNIQUES

The drill used was a gasoline-operated Pionjar hammer drill similar to the type used by Boniwell and Dujardin. This equipment was selected because of its relatively low cost and light weight. It is easily transportable by Ski-doo in winter, and can be carried on a pack-frame in summer. The drill itself weighs about 60 pounds and, with 100 feet of rods, a jack, a sampler and two crowbars, the total weight of the unit is approximately 350 pounds (*Figures 1* and *2*).

The piston-type stainless steel sampler, with retractable point, is attached to the extension rods and driven into the overburden to the desired depth. The point is then retracted by turning the string of extension rods. This leaves the bottom of the sample tube open, and the open end of the sampler is driven into the material to be sampled. The tube measures about 6 inches in length and 1 inch in diameter. Once the open tube is driven as far as it will go, the rods and sampler are extracted from the hole using a 10-ton lift jack (*Figures 3* and *4*).

Generally in the Clay Belt, one sample of basal till in contact with bedrock was taken. The samples were dried, sieved to minus 80 mesh and analyzed geochemically. A heavy-mineral concentrate was obtained from the plus-80-mesh fraction by separation with tetrabromoethane. The heavy fraction was split and one part pulverized to minus 80 mesh for geochemical analysis. The mineral grains in the heavy and light fractions were examined using a binocular microscope.

Over the St-André carbonatite, the same field procedures prevailed. However, because the suboutcrop surface of the weathered carbonatite was soft, the material sampled usually contained a large amount of carbonatite. The minus-80-mesh material was analyzed geochemically for zinc and silver. The plus-80-mesh fraction was examined under a binocular microscope and pulverized to minus 80 mesh. Then, the latter was assayed for Nb_2O_5 using an X-ray fluorescence technique.

The results of five surveys carried out using this method will be described below.

FIGURE 1 — Overburden drilling operations under winter conditions.

BARVALLÉE PROPERTY

Setting

This property is located in Fiedmont township, Range X, Lot 28, approximately 2 miles west of Barraute and 30 miles north of the town of Val d'Or (*Figure 5*).

This site was chosen as a first test area because it contained a base metal deposit which is buried under 40 to 60 feet of glacial lake sediments. The deposit was found by systematically diamond drilling the assumed projection of a favorable geological horizon on the Vendome Mines property, 3,000 feet to the southeast. An earlier electromagnetic (vertical loop) survey over the Barvallée property gave negative results.

The sulphide zone occurs in a sequence of Precambrian tuffs and acidic volcanic rocks and is estimated to be 400 feet long and 6 to 25 feet wide. The lens is reported to contain 216,500 tons averaging 5.71 per cent zinc, 1.23 per cent copper and 1.42 oz. of silver per ton[8].

Results

On this property, it was found that the basal till, where present, was only a few inches thick and covered with 40 to 60 feet of silty glacial lake clay.

Samples were taken in holes 100 feet apart, and the minus-80-mesh material and plus-80-mesh heavy-mineral fraction were analyzed for copper, lead, zinc and silver.

FIGURE 2 — Overburden drilling operations under summer conditions.

FIGURE 3 — Pulling drill rods with the vertical lift jack.

FIGURE 4 — Sample tube retracted from drill hole and containing sample of till.

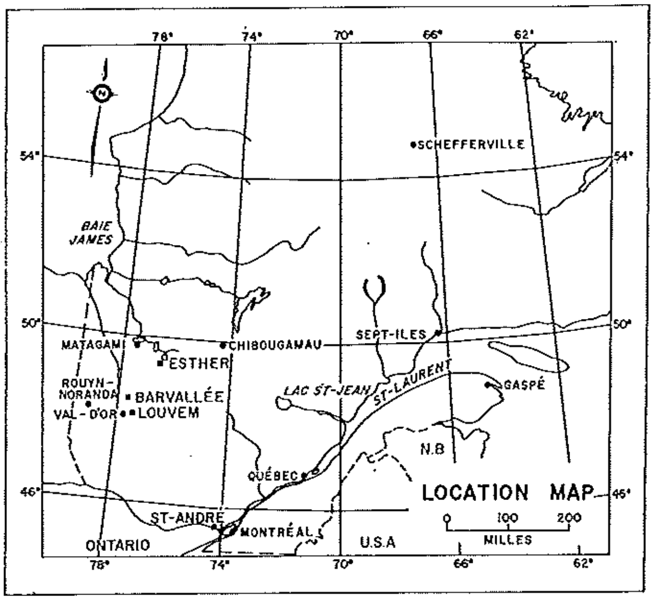
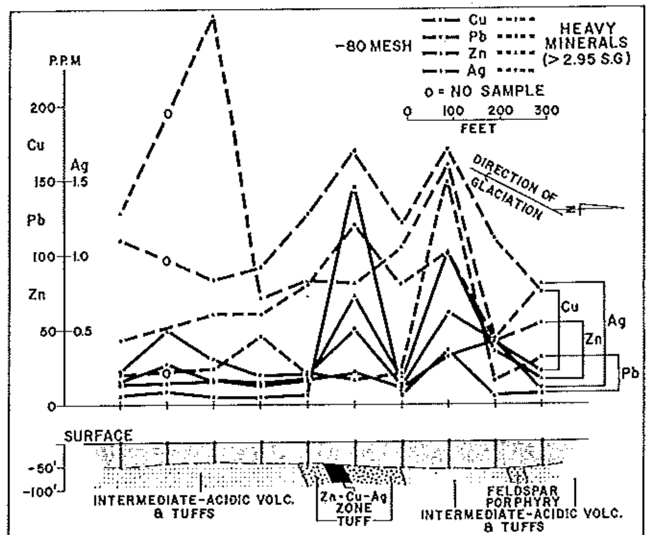


FIGURE 5.



Cu-Pb-Zn-Ag DISPERSION IN BASAL TILL
BARVALLEE PROPERTY

FIGURE 6.

Unfortunately, a hole wasn't drilled immediately over the projected suboutcrop of the sulphide zone. However, the samples of till nearest the copper-zinc-silver zone and over the pyritiferous tuff did indicate a copper and silver anomaly in the heavy-mineral fraction and zinc and lead anomalies in the minus-80-mesh material (*Figure 6*). An interesting copper, zinc and lead anomaly occurred in the heavy-mineral fraction of the till about 250 feet north of the known sulphide lens. This anomaly could be the reflection of another zone of base metals north of the original lens. Also, a zinc anomaly was found in the heavy-mineral fraction 250 feet south of the copper-zinc-silver deposit; another sample taken about 200 feet to the northwest of this station also contained abnormally high zinc values in both the minus-80-mesh fraction (400 ppm) and the heavy-mineral fraction (6,500 ppm). These zinc anomalies could be caused by glacially transported material from the main zone, or they could represent another zinc-bearing lens southwest of and parallel to the known one.

Results of this test were sufficiently encouraging so that it was decided to test some weak Turam geophysical anomalies outlined on a block of claims that SOQUEM had optioned in Louvicourt township near Val d'Or.

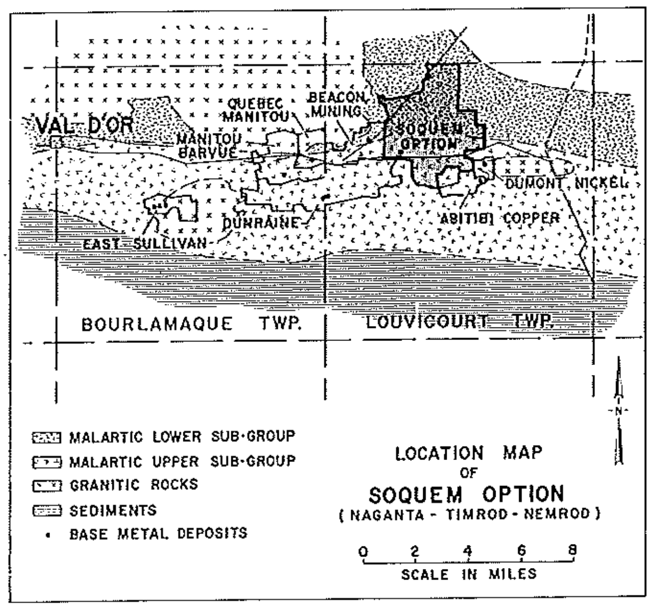


FIGURE 7.

LOUVEM MINES PROPERTY

This property is located about 15 miles west of Val d'Or (*Figure 7*) and is underlain by a Precambrian acidic to intermediate volcanic assemblage that has been intruded by granite and diorite.

A — EAST ZINC ZONE

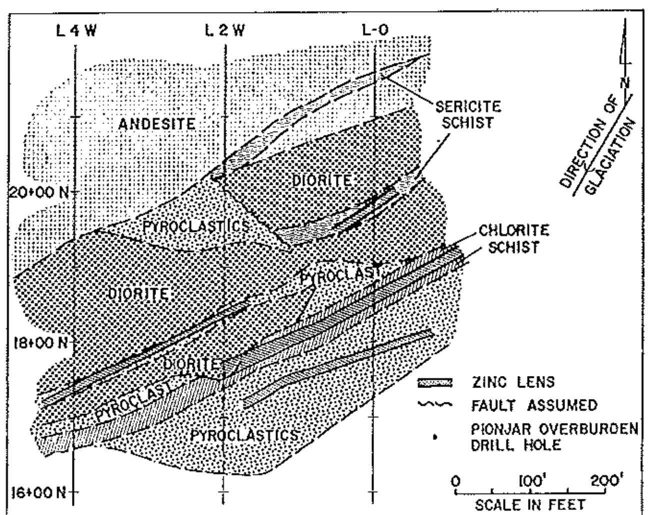
Setting

Geologically, this portion of the property is underlain by diorite which intrudes a pyroclastic assemblage that is in contact with andesites to the north (*Figure 8*).

Several zones rich in sphalerite appear to be associated with the diorite-pyroclastic contact. The main zinc-bearing lens is about 300 feet long; it varies in width from 10 to 20 feet and contains 4 to 10 per cent zinc and 0.5 to 1 oz. of silver per ton.

Results

A Turam electromagnetic survey had been completed on the property, and it was decided to test some of the weak anomalies by overburden drilling. The first anomaly selected for geochemical verification was on line 2W.



GEOLOGY OF LOUVEM MINES
EAST ZINC ZONE

FIGURE 8.

The thickness of the basal till varied from less than 1 foot to 3 feet and the overburden thickness was between 29 and 51 feet.

No geochemical anomaly was found over the electromagnetic conductor. However, two samples taken south of it contained 184 and 156 ppm zinc in the minus-80-mesh fraction and 2,925 and 1,900 ppm zinc in the plus-80-mesh heavy-mineral fraction (*Figure 9*). As was the case on the Barvallée property, the contrast between background and anomalous values shown by the analyses of the heavy-mineral fraction was much greater than that indicated by analyzing the minus-80-mesh fraction.

Recommendations were made to drill these geochemical anomalies, and subsequently four lenses of zinc mineralization were outlined. The suboutcrop of the two lenses on line 2W coincided with the geochemical anomalies found in basal till in contact with bedrock. The original EM conductor was found to be caused by a barren pyrite zone.

The lack of displacement of the geochemical anomaly in the down-ice direction tended to confirm the belief that the mineralogical composition of basal till taken directly on bedrock is representative of local bedrock.

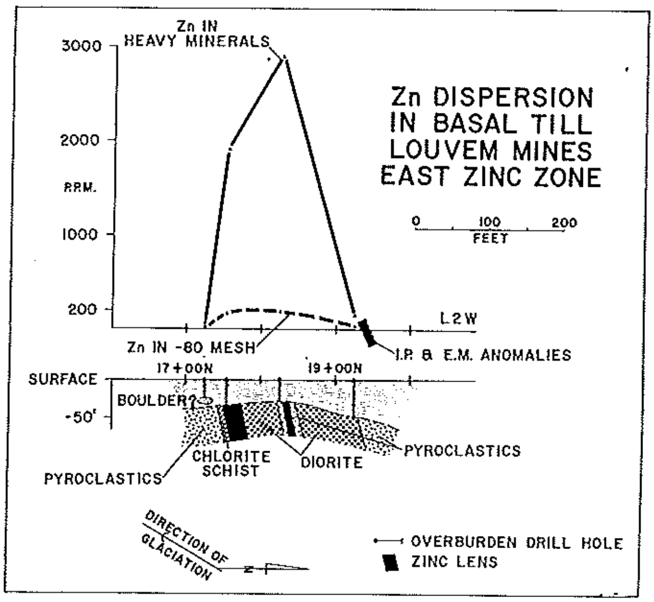


FIGURE 9.

FIGURE 10 — Exposed suboutcrop of the Louvem copper orebody. Note that the face of the suboutcrop has been scraped off by glacial action.

B — LOUVEM MINES COPPER DEPOSIT

Setting

At the same time that the overburden drilling was being done on the poorer Turam anomalies, diamond drilling was being carried out on several of the stronger ones. The first one to be tested was on line 16W.

The first hole cut a rich section of copper mineralization, and subsequent drilling outlined a deposit which, in the upper 500 feet, contains approximately 500,000 tons averaging 3 per cent copper. The deposit is now being readied for production (*Figure 10*).

The copper ore deposit is a steeply dipping, pipe-like mass, which suboutcrops over an area of about 300 by 80 feet (*Figure 11*). It occurs within a chlorite schist zone which is surrounded by pyritized sericite schist near an andesite-rhyolite contact.

Results

Overburden drilling along line 16 west (*Figure 12*) indicated that the glaciolacustrine cover in the vicinity of

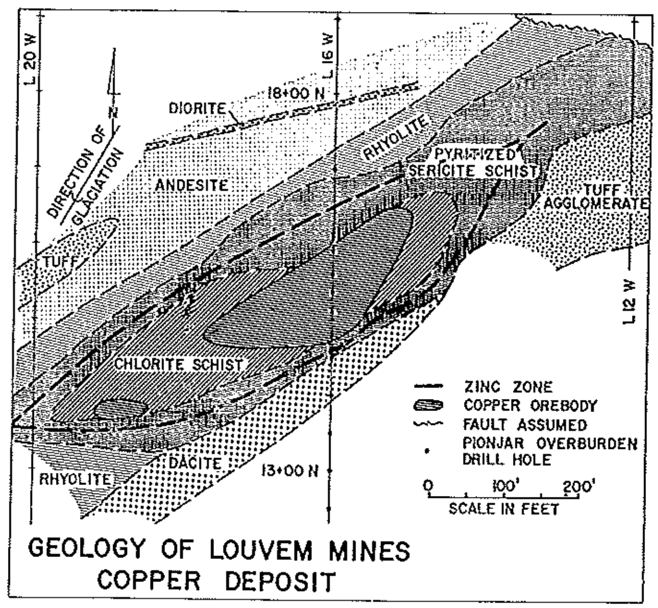


FIGURE 11.

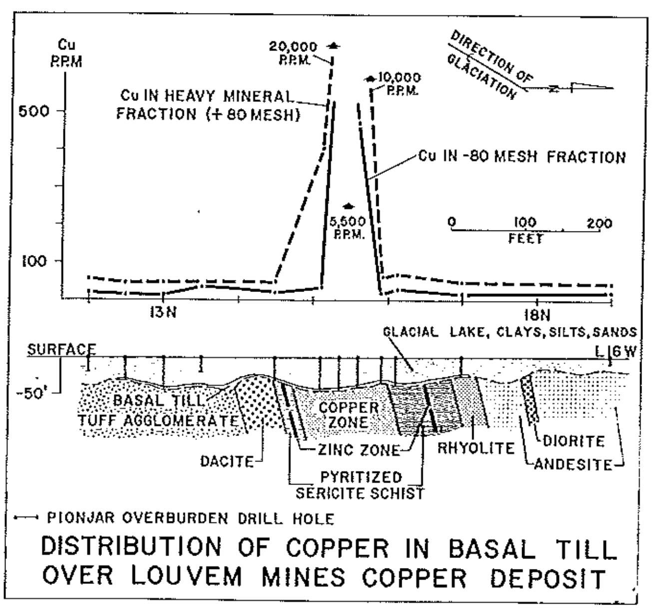


FIGURE 12.

the ore zone averaged about 40 feet. Of this, the lower 1 to 2 feet was composed of basal till. The basal till thickness over the rest of the property varied from less than 1 foot to 15 feet, but generally averaged 1 to 2 feet (*Figure 13*).

Samples of the minus-80-mesh fraction from the basal till at the bedrock surface contained up to 5,500 ppm Cu, and the plus-80-mesh heavy-mineral fraction contained up to 20,000 ppm Cu. The anomalous peaks were confined to the suboutcrop trace of the orebody.

Three of the five heavy-mineral samples from the basal till in contact with the suboutcrop of the ore zone were abnormally high in copper, and two samples from the minus-80-mesh fraction were anomalous. Anomaly contrast was considerably heightened in the heavy-mineral fraction, and anomaly width was increased over that of the minus-80-mesh fraction. Subsequent work by Garrett[5] using more sophisticated sampling equipment confirmed these preliminary findings.

Also, an examination of the heavy-mineral fraction of the basal till (using a binocular microscope) showed that all anomalous samples contained grains of chalcopyrite, bornite and chlorite.

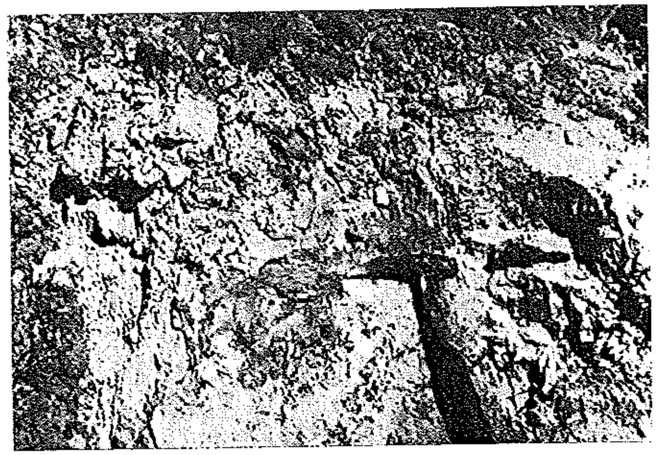


FIGURE 13 — Section showing basal till in contact with the suboutcrop of the Louvem copper orebody; the contact is along the top of the hammer.

ESTHER PROJECT

Setting

This project area is located about 95 miles northeast of Val d'Or (*Figure 5*). The geology, as inferred from geophysical data, is shown in *Figure 14*. The area is apparently underlain by Precambrian volcanics of intermediate composition containing interlayers of rhyolitic and tuffaceous rocks.

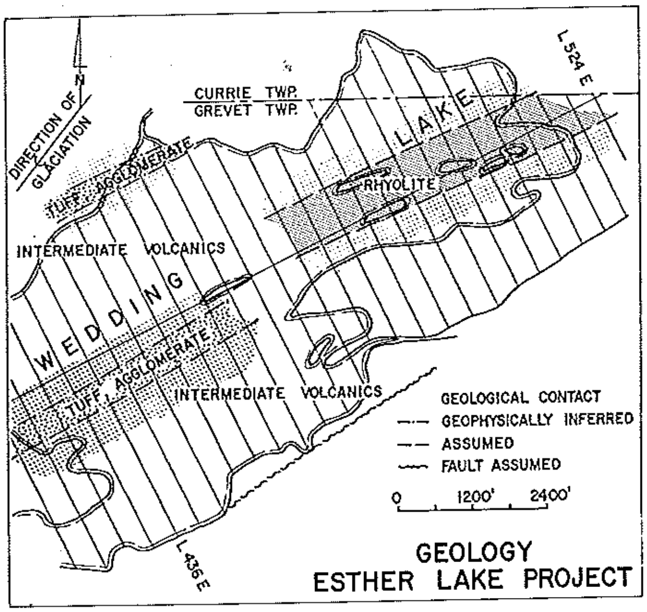


FIGURE 14.

Results

A previous electromagnetic survey (horizontal loop) over Wedding lake revealed a large number of conductors. Therefore, to help evaluate these anomalies, overburden sampling using the Pionjar equipment was done from the ice during the winter months. Thirty-four holes, varying in depth from 12 to 73 feet, were drilled and a sample of basal till on top of the bedrock was taken (*Figure 15*) at each site.

Analyses of the minus-80-mesh fraction and the plus-80-mesh heavy-mineral fraction yielded only one sample with copper and zinc values (sample 32). The minus-80-mesh material from sample 32 contained 220 ppm Cu and 310 ppm Zn; the heavy-mineral fraction contained 550 ppm Cu and 1,920 ppm Zn.

Subsequently, a microscopic examination was made of both the heavy and light fraction of the plus-80-mesh material. This mineralogical study revealed that the basal till over all the anomalies contained one or more of the following minerals: graphite, pyrite and pyrrhotite (*Figure 15*). Again, the only exception was sample 32 at the east end of the lake. In this sample, pyrite, graphite and one fragment containing chalcopyrite were noted; this piece analyzed 1,370 ppm Cu and 670 ppm Zn.

Hence, it was concluded that all but one of the EM conductors were caused by barren pyrite or pyrite-pyrrhotite-graphite zones in the bedrock.

Information to evaluate these anomalies was obtained at a considerably lower cost (average $2.00 per foot drilled) than that of a comparable diamond drill program.

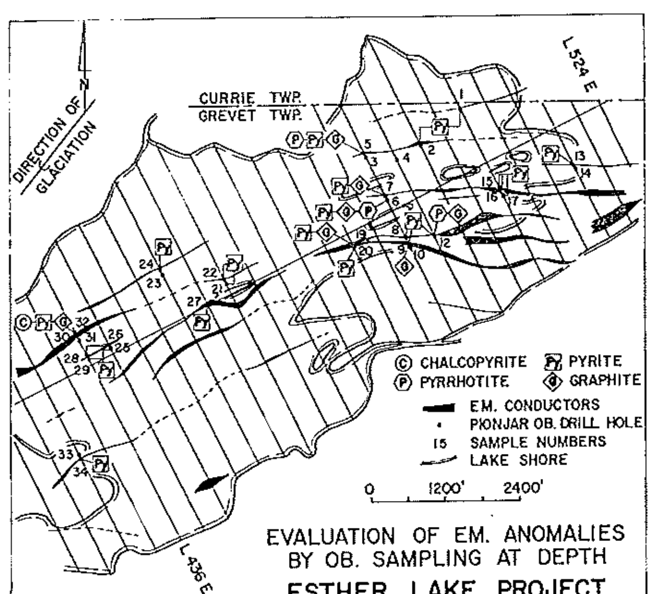


FIGURE 15.

ST-ANDRÉ CARBONATITE

Setting

Another area where this method of overburden sampling at depth found an application was over a niobium-bearing carbonatite near the town of St-André (St. Andrews), about 35 miles west of Montreal and 15 miles west of the St. Lawrence Columbium mine at Oka, Quebec (*Figure 5*).

The St-André carbonatite was originally detected by an airborne radiometric survey. Subsequent radiometric ground surveys indicated two main anomalies that were interpreted as being caused by two separate masses of carbonatite (*Figure 16*). Diamond drilling on the west portion of the radiometric anomaly has outlined several interesting niobium-bearing zones similar in grade to that mined at Oka.

Techniques

To attempt to establish the full extent of the carbonatite by diamond drilling would have been very costly. Hence, it was decided to sample the area using the Pionjar drill. The procedure followed was to drill through the overburden and sample the soft weathered carbonatite suboutcrop surface. Some ninety such holes were drilled to depths varying from 2 to 78 feet.

Earlier work on diamond drill core had shown that the carbonatite was geochemically high in zinc (180 to 1,040 ppm) and silver (2 to 4.5 ppm). Hence, the minus-80-mesh fraction of the overburden samples was analyzed geochemically for zinc and silver. The plus-80-mesh fraction was assayed for Nb_2O_5 after it was visually checked for carbonatite fragments.

This program involved about 2,000 feet of overburden drilling, at an average cost of $2.00 a foot.

Results

The distributions of Nb_2O_5 and zinc are shown in *Figure 16*. By using the 0.01 per cent contour for Nb_2O_5 and the 200-ppm contour for zinc, the probable extent of the carbonatite was outlined. The geochemical results showed that there was definitely one mass of carbonatite, approximately 7,200 feet long and 3,000 feet wide. Also, the northern contact, instead of closing, as was indicated in the radiometric work, is continuous to the northeast.

Additional analyses of the overburden samples also indicated zones abnormally high in fluorine, barium and molybdenum.

In *Figure 17*, it can be seen how the radiometry and the zinc distribution in the "B" horizon of the soil were controlled by topography and overburden thickness. The radiometric profile and zinc in the "B" horizon correspond remarkably well. The trough between the two peaks was caused by a layer of glacial clay 11 feet thick. However, the results for zinc and Nb_2O_5 in the overburden samples at depth showed that the carbonatite was continuous; this fact was also confirmed by diamond drilling.

OTHER USES

This equipment has also been used on gravity surveys in the Abitibi region of Quebec to determine depths to bedrock and hence correct for bedrock configuration. More than 80 per cent of the gravity anomalies tested in some places have been found to be caused by an increase in the elevation of the buried bedrock surfaces.

The technique has also been useful in tracing boulder fans by the vertical systematic sampling of till, and analyzing the till geochemically. This approach enables one to determine the inclination of boulder fans and hence facilitates tracing the boulders to their source.

In a situation in which wider-spaced sampling might be desirable, it would be advisable to sample the full section of basal till instead of taking one sample near bedrock. This would apply if, for example, one was working on a more general geological target instead of on well-defined geophysical anomalies.

As dispersion is mainly mechanical, much information can be gleaned on local geology and metal mineralization by microscopic examination of the rock fragments and heavy-mineral grains from the basal till.

SUMMARY AND CONCLUSIONS

Several examples of the application of overburden geochemical sampling at depth in glaciated terrains have been presented. The equipment used in this work was a lightweight Pionjar drill equipped with a piston-type sampler. Although the equipment has its limitations, in that it cannot penetrate bouldery material or sample bedrock unless

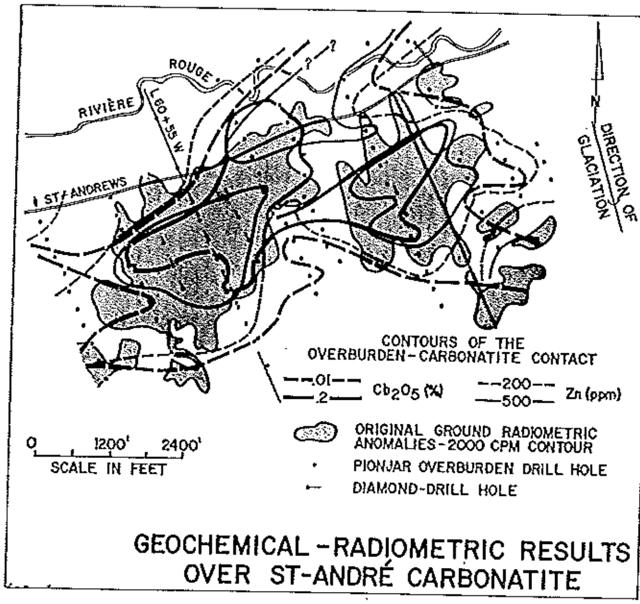


FIGURE 16.

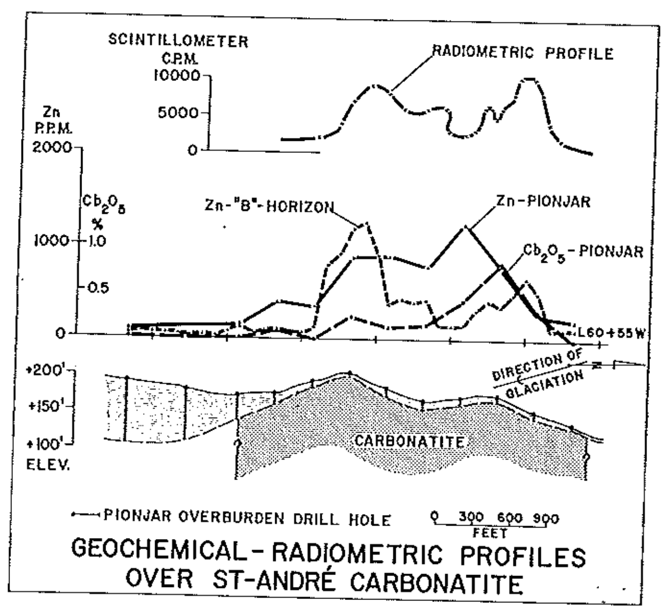


FIGURE 17.

the suboutcrop is rather soft, it has proved to be a useful and economical method in helping to evaluate geophysical anomalies covered by up to 100 feet of glacial lake sediments. It has effectively led to the discovery of a zinc occurrence on the Louvem property, near Val d'Or, Quebec, and assisted greatly in delineating a carbonatite mass near St-André, Quebec.

Orientation work over two known base metal deposits (the Barvallée copper-zinc-silver zone and the Louvem Mine copper deposit) in the Clay Belt indicates that the method is capable of pinpointing such buried deposits.

Analyses and microscopic examination of heavy-mineral concentrates from the basal till can aid greatly in obtaining better anomaly definition.

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