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METAL CONTENTS OF LAKE SEDIMENT CORES FROM ESTABLISHED MINING AREAS:
AN INTERFACE OF EXPLORATION AND ENVIRONMENTAL GEOCHEMISTRY

Project No. 730002

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INTRODUCTION

Exploration geochemistry is dependent on the detection of naturally occurring metal levels in various media. Areas of unusually high metal concentrations are often target areas for mineral deposit prospecting. Environmental geochemistry, in particular environmental protection, also requires knowledge of naturally occurring metal levels usually for comparison with higher concentrations suspected to be related to human activity. Both the exploration and environmental geochemist can be looking for the same type of areas, those with high metal concentrations, but obviously from a different motivation.

In the Canadian Shield, mining is one of the activities of man, often associated with increasing metal levels in the environment. However, mines are often to be

found in areas which have naturally occurring, higher metal concentrations in surficial materials, such as soils, waters, glacial overburden and drainage sediments. For the exploration geochemist working in such an area, high metal levels in certain easily collected materials may simply reflect mining activity. He must arrive at naturally occurring levels for genuine comparison with exploration geochemical anomalies located in virgin areas. For the environmental geochemist, the problem is the opposite. He asks, whether the higher levels are related to mining activity or (if he is aware of the possibility) just naturally high because the region is geochemically anomalous in certain metals.

In the southern Shield, mining towns have usually only the one industry, ore extraction, and have been established purely for this purpose. However, true

wilderness may be found only a few miles from even the largest centres such as Sudbury. Moreover, even the oldest mines such as at Sudbury, have only been in operation for about 80 years. The gold mines at Red Lake have been in operation for about 40 years and the copper mines at Chibougamau for about 20 years. Thus, human activity has been relatively recent compared with the several thousand years that have passed since the areas were deglaciated.

The Advantages of using Lake Sediment Cores as a Sample Medium

As outlined above, knowledge of two metal levels is required: (1) the natural level; and (2) the level since mining activity began. If there is contamination of the area, the difference between (1) and (2) will likely be an indicator of the degree of pollution.

Environment contamination by mining operations is likely to occur in four main ways: (1) tailings introduced as solids into drainage systems; (2) leachates from on-shore tailing piles; (3) effluents from mines or mining plants; and (4) airborne particulates from

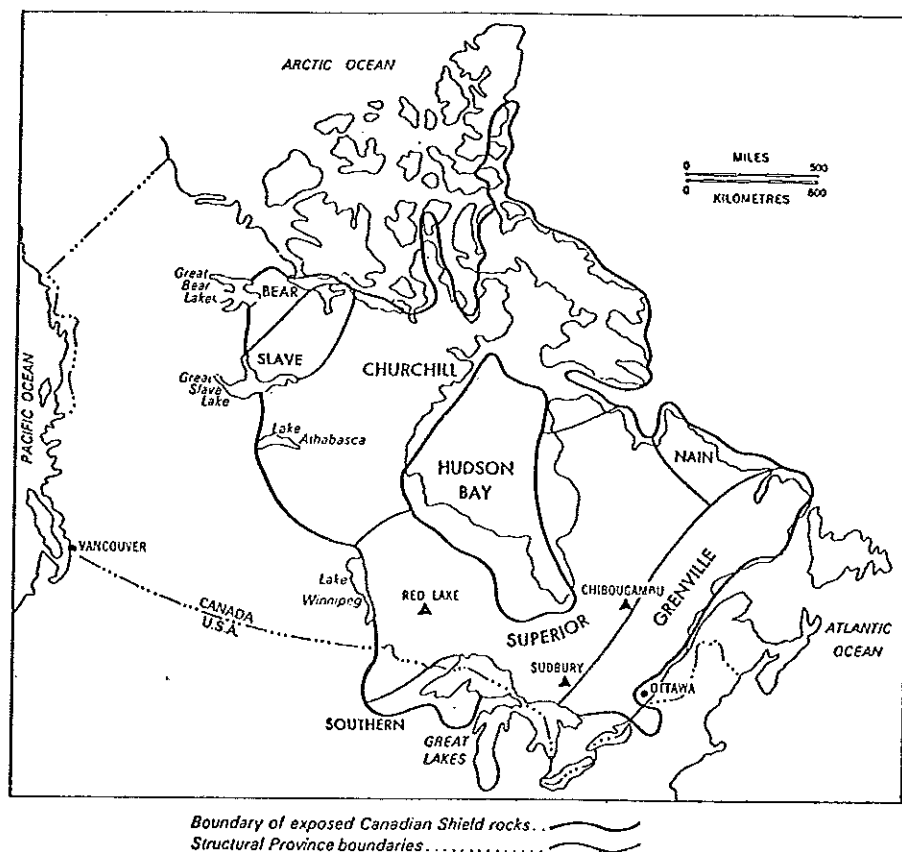


Figure 1. Location of study sites in the southern Canadian Shield

crushers and smelters. The area affected can vary considerably. If tailings are introduced into a lake with no obvious outflow, the effect is likely to be limited to the lake. In areas with tall smelter stacks, the effect may be very widespread. The examples discussed here are from areas where all of the above cases apply in varying degrees.

Bedrock cannot be significantly contaminated by mining operations and is thus not a sample material reflecting such operations. The types of geological materials available for exploration-environmental studies are thus limited to surficial media: (1) glacial deposits; (2) soils; (3) drainage sediments; and (4) waters. There are of course, biological media such as vegetation or fish. In normal cases, glacial deposits will be shielded from contamination by soils and vegetation. Stream and lake waters are likely to reflect only very recent pollution. Soils, although they may have accumulated the effects of contamination, cannot provide at the same location, two distinct samples, one representing pre-mining metal levels and one post-mining levels. Rivers in the Shield are either disorganized or are large sediment transport systems such as the Ottawa River. By collecting cores of sediment from lake bottoms, it is possible to select levels (samples) in the cores that have been deposited at different times in the past. Lake sediment cores are thus proposed to be an ideal sample media for environmental geochemical studies in the southern Canadian Shield. Also, in developed mining areas, the deeper levels of the cores can be used for exploration geochemical investigations.

In many lakes, large thicknesses of inorganic and organic sediments have accumulated since deglaciation. Most lakes, at least at the latitudes of the three study areas described here, have accumulated less than 10 cm of sediment in the last hundred years (R. Mott, pers. comm., Geol. Surv. Can.). Thus samples of sediment core taken from below this depth should reflect the natural levels which occurred in the sediments prior to mining activity. These are the concentrations that are relevant to the use of lake sediments as an exploration tool in developed mining regions. Samples taken above the 10 cm level reflect a change in concentrations which may be related to mining operations. At Chibougamau, the natural sediment accumulation in the last 20 years since mining began in the area, is probably in the range of 2 to 3 cms.

However, in using such cores, other factors must be considered: (1) diagenesis of the sediments with upward or downward metal movements; (2) biota effects in distributing sediments; (3) the ability of the sample device to collect a continuous core; and (4) bacterial activity which may remobilize metals within the sediments.

Sample Areas and Methods

To test the above basis for an exploration-environmental geochemistry overlap, about 150 cores of lake sediment were collected from sites in and around three widely separated, major mining areas of the Superior Province of the southern Shield. These were at Red

Lake, Sudbury and Chibougamau. Geology and mineralization is somewhat unique at each area. Red Lake is a classic Archean greenstone belt of volcanic-sedimentary rocks, surrounded by granites. It is presently a gold mining area, but has a potential for discovery of massive sulphides. The gold is associated with arsenopyrite. The Sudbury area consists of a Proterozoic, norite intrusion surrounded by Archean granites. The intrusion, referred to as the nickel-irruptive contains many Ni-Cu sulphide ore deposits. At Chibougamau, the deposits are mined for Cu. They occur around the periphery of Lac Dore, which is underlain by an anorthositic intrusion. A major fracture, the Lac Dore fault passes beneath the lake of the same name. Because of the different rock types and different ore metals, each area can be used with reservations, as a background area for the other two, at least in the case of the environmental aspect of this study.

The sample sites were reached by boat or small fixed-wing aircraft. The sample device used was an adapted Phleger Corer. The cores were taken from the centres of lakes as these most likely reflect the overall variation within the lake in relation to man's activities. The metal variations in deeper parts of these cores are discussed below in terms of geochemical exploration anomalies. At Red Lake, many of the samples were collected using an Ekman dredge. This sample device tends to collect only surface material. In effect the two jaws scrape the surface layer of sediment. Results for As using this device are compared with core samples from Red Lake itself.

Analyses

The cores were air-dried. All samples were silts, clays, or organic oozes and required no sieving. They were ball-milled to less than 200 mesh and analyzed for Ni, Cu, Co, Zn, Pb, Ag, Hg, Cd, As, Sb, Mo, Mn and Fe by spectrophotometric and colorimetric techniques. Loss on ignition, a measure of organic content was determined on each sample. Only examples for specific metals, As at Red Lake, Ni at Sudbury, and Cu at Chibougamau are given below. A report on the complete results is in progress. Some results for mercury in all three areas have been presented elsewhere (Allan *et al.*, 1974). For Ni and Cu, a weighed sample was digested at 90°C for 1.5 hours with 6 ml of 4N HNO₃ plus two drops of concentrated HCl. The extract was shaken, allowed to settle, then analyzed by atomic absorption spectrophotometry. For As, a weighed sample was leached with 6M HCl at 90°C for 1.5 hours. The test solution was centrifuged and an aliquot was then removed for As determination, wherein As is reduced to the trivalent state with KI and SnCl₂, and then evolved as AsH₃ upon reaction with nascent hydrogen generated by addition of granulated Zn metal to the test solution. The arsine was scrubbed from the hydrogen stream into a solution of silver diethyldithiocarbamate. The colour intensity of the arsenic complex so formed was determined at 520 μ using a colorimeter. The detection limit for As is about 1 ppm.

Results

Analyses of the sediment cores show that in many cases there is a distinct increase in metal levels in the surface few centimetres as compared to the concentration found at depth. This effect is particularly noticeable for nickel in the Sudbury Basin (Table 1, Figs. 2 and 3), the oldest of the three mining areas. In many lakes, the difference in metal content between the surface layers and deeper samples can be used to assess recent metal input into the lakes. At Red Lake, the levels of arsenic in core samples (Fig. 4) show only minor variations with depth. However, much higher concentrations were obtained when the dredge sampler was used (Fig. 5) probably because this sample represented only the surface few centimetres of sediment. Copper changes with depth were minimal in cores from Lac Dore (Fig. 6) which is the most recently developed mining area of the three. Part of Lac Dore has been dammed off as a tailings pond but this does not appear to have affected copper levels in other parts of the lake.

Element concentrations of the levels found in the deeper parts of the cores from all three areas are often less than can be found in similar materials from wilderness areas of northern Canada. Comparison can only be made for silty sediments at this time. At other sites, especially at Sudbury, the metal concentrations of the surface few centimetres of sediment can rise to very high levels.

The deeper strata in the sediment cores could be used for exploration purposes. However, the results, at least in relation to absolute metal concentrations are inconclusive. The presence of major deposits of nickel, gold and copper had apparently little effect on lake sediment metal concentrations. Lake sediments from wilderness areas have been found with higher levels of all these metals than the majority of samples taken from these three mining areas. This could be partly due to the predominantly glacial origin of the

lake sediments. For example, Red Lake itself, the larger lakes in the Sudbury Basin, and Lac Dore may all be remnants of much larger glacial lakes. There are significantly large areas of glaciolacustrine deposits in the Sudbury Basin (Burwasser, 1972). If the silty bottom sediments found at the deeper levels in some of the cores are glaciolacustrine in origin, there is slight chance that they will reflect the metal contents of adjacent mineralized outcrops. Also, much of the glacial drift in the three areas is glaciofluvial in origin. Such material when transported to lakes, will bear little mineralogical relationship to the immediately surrounding bedrock. Another possibility, in this case for organic sediments, is that elements moved chemically into such sediment may be so diluted throughout the deep gyttja gels as to result in undetectable concentration changes relative to concentrations in non-mineralized areas. This discussion is limited to comparison of absolute metal concentrations and to the main ore deposit elements for the three areas. Combined element anomalies, element ratios, or specific extraction techniques could result in the detection of characteristic geochemical anomalies for the three areas. This aspect is being looked into further.

Nickel at Sudbury

The nickel distribution down sediment cores (Fig. 2) from one of the lakes sampled in detail in the Sudbury Basin, is given in Table 1. All samples were inorganic silts. No areas were sampled where the dredge brought up organic samples. The cores are most likely continuous. It appears that the Vermilion River has recently deposited sediment of high nickel content. However, the effect is usually limited to the surface two inches. Normal levels for this lake are close to 30 ppm Ni.

Figure 3 shows the distribution of nickel down lake sediment cores from lakes in and around the Sudbury Basin. These can be compared with nickel levels attributed to airborne pollution from smelters, in the surface two inches of soils around Coniston (Costescu and Hutchinson, 1972). In considering these soil values it should be remembered that natural concentration of metals in soil surface organic horizons is a well documented process and has been put to use in geochemical exploration (Boyle and Dass, 1967). Concentrations in the soils dropped rapidly with depth, for example from 2161 ppm in the 0-2 inch level, to 649 ppm at the 4-5 inch level, at a distance of 1.2 miles downwind from the Coniston smelter. These total analyses were made on extracts from the less than 2 mm fraction, following an HF digestion. The method of analyses used on the lake sediments gives close to a total analysis in most cases. At 5.5 miles from Coppercliff, the surface 2 inches of MacFarlane Lake and Raft Lake contain 871 and 625 ppm Ni respectively. Soils at 2.4 and 6.5 miles from Coniston contain 831 and 356 ppm Ni respectively. The surface 2 inches of a core from Whitefish Lake, about 8.5 miles from Coppercliff con-

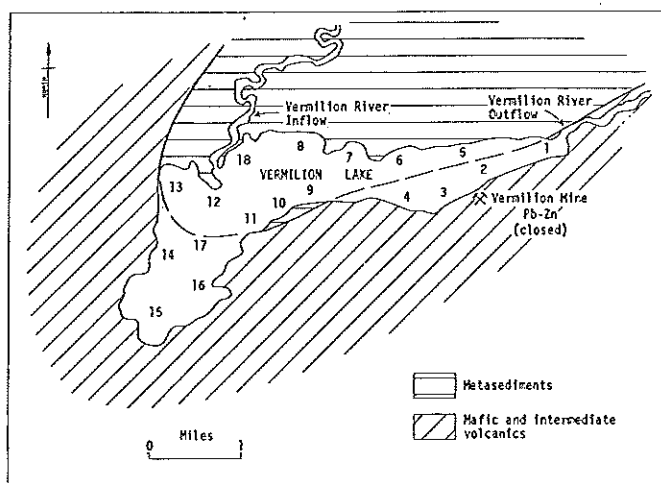


Figure 2. Location of sample sites and geology, Vermilion Lake, Sudbury Basin.

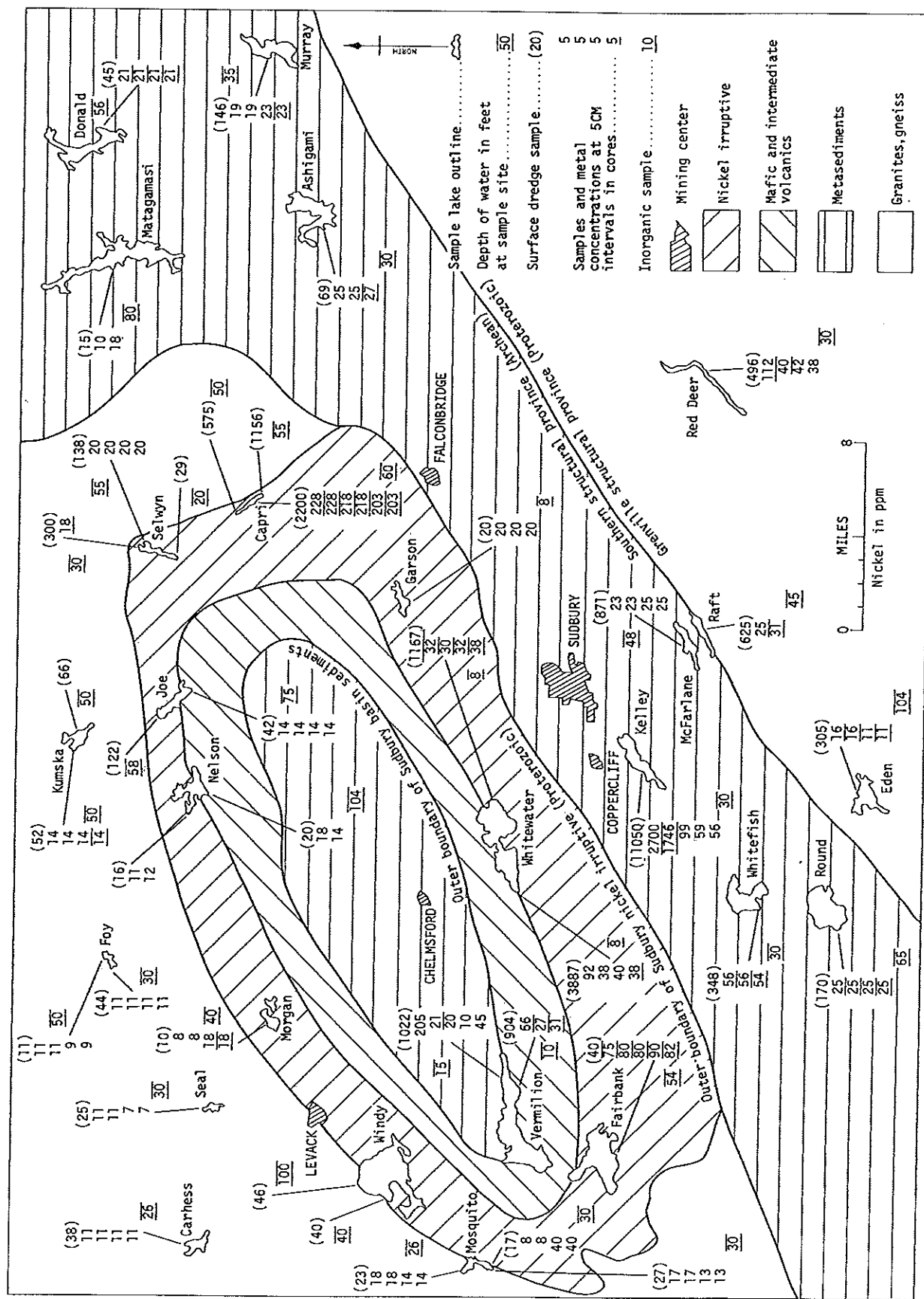
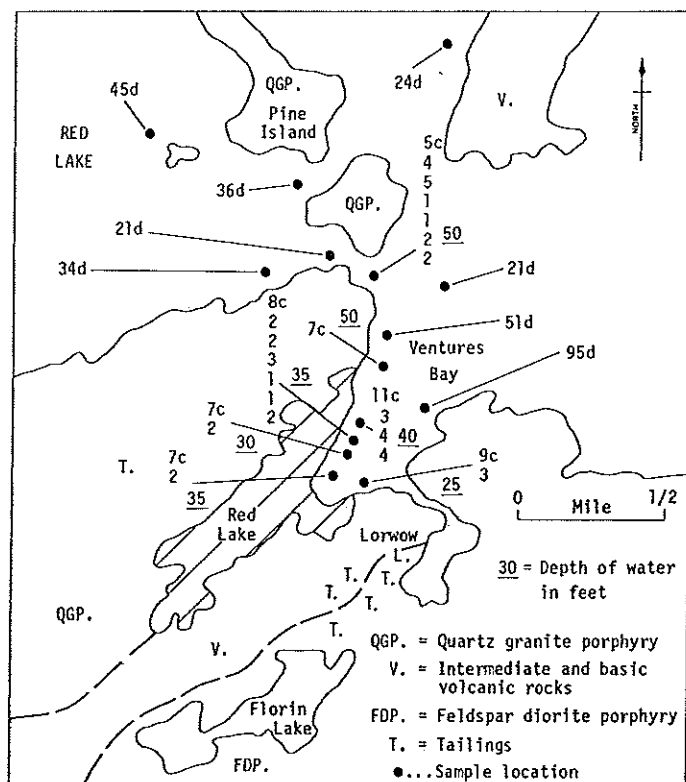


Figure 3. Nickel (ppm) in lake sediment core samples, Sudbury Basin area.

Sample 1 Depth in cms.	Sample Site 2 Number (water depth in feet)															mean 4			
	1(15)	2(16)	3(20)	4(10)	9(10)	10(10)	11(18)	16(24)	15(20)	14(26)	13(36)	17(38)	12(36)	18(16)	8(16)		7(10)	6(18)	5(15)
0 - 5	-	42	941	66	423	397	208	139	146	153	252	170	172	337	610	118	146	205	252
5 - 10	-	29	-	27	45	149	279	27	29	25	20	31	23	103	262	17	23	21	68
10 - 15	-	-	-	31	-	141	46	33	31	27	20	-	21	23	21	-	21	30	37
15 - 20	-	-	-	-	-	-	-	31	-	25	12	-	-	-	-	-	25	10	21
20 - 25	-	-	-	-	-	-	-	-	-	21	-	-	-	-	-	-	25	45	30
25 - 30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	25

2. The sites compose two traverses in an east-west direction across the east-west elongated lake. From 1 to 15 is east to west and from 5 is west to east. Sites opposite the mouth of the Vermillion River are 10, 11, 17, 12, 18 and 8. Sites near the exit of the Vermillion River are 5, 3, 2 and 1.

⁴Means at 10 to 15 cm using 3 samples are: 27, 24, 29, 29, 23, 26, 30, 29.



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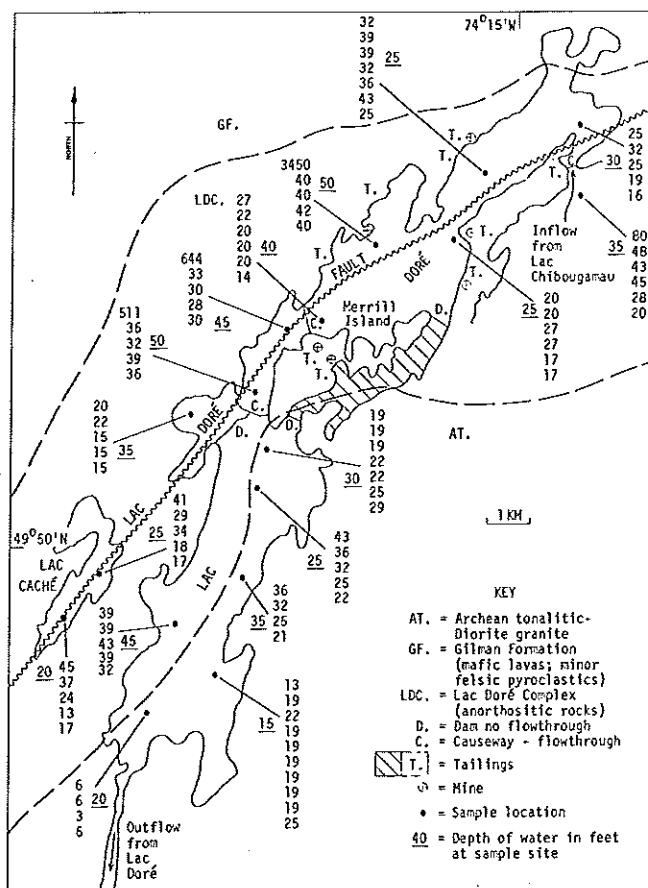


Figure 6. Copper distributions in lake sediment cores from Lac Dore, Chibougamau Area.

tains 348 ppm Ni. A soil at a similar distance downwind from Conistan contains 282 ppm Ni. It is interesting that the total concentrations are so similar. Study of Figure 2, quickly reveals the lakes with unusually high surface nickel concentrations. However, in many cases, it is only the sample collected by the surface dredge that is anomalous. An example is Whitewater Lake. Nickel levels in the cores of most lakes do not change significantly with depth. No distinct trend with depth is visible. Also, organic samples and inorganic samples from the same lake often have similar concentrations; for example, Kumska, Ashigami and Murray lakes. In most lakes, cores were either entirely organic or inorganic. The high contents in the dredge samples indicate that contamination is limited to only the surface few centimetres. The sediments are often thixotropic organic gyttjas, and the dredge settles into this gelatinous ooze. In organic lakes, the corer may well penetrate to some depth before taking a core (R. J. Mott, pers. comm., Geol. Surv. Can.). Thus the cores normally represent pre-mining activity.

A depth of 10 to 15 cm in the cores can be safely taken as representing natural levels. The nickel concentrations in lakes inside the Sudbury Basin are not consistently higher than those from lakes outside the

nickel irruptive. Most concentrations at 10-15 cm are between 10 and 40 ppm Ni, for example 40 ppm from Whitewater Lake which was the closest sample site to the Clarabelle open pit. Concentrations of nickel, much higher than these are found in inorganic, silty lake sediments from the Ungava ultramafic belt (Allan, 1971). The implication is that absolute nickel levels do not reflect the proximity of the Sudbury irruptive and nickel ores.

Arsenic at Red Lake

Red Lake is a major gold mining centre. The gold is associated with arsenopyrite in veins and fractures. There are numerous roasters in the area especially at Cochenour and Balmer at the southeast end of Red Lake. Because of the As-Au association, one would expect As levels in lake sediments to be naturally high. Cores (Fig. 4) from Ventures Bay show that this is not the case. At core depths greater than 2 inch, concentrations are typically in the 1 to 3 ppm range. Arsenic levels in lake sediments near similar gold deposits at Yellowknife are usually in the 15 to 60 ppm range (Nickerson, 1972). Higher concentrations in the surface 2 inches of some cores are possibly related to contamination from tailing piles; for example via Lorrwaw Lake.

It is of interest that, as for nickel at Sudbury, the dredge sampler collected samples of high As content. The reason has been proposed above. Five- to ten-fold differences can be seen between adjacent surface core and dredge sites (Fig. 4). Samples from other parts of Red Lake were collected by dredge. Considering the relationship shown in Figure 4, anomalous concentrations (Fig. 5) are probable effects contamination in the lake, rather than variations due to Au-As occurrences. Except for 3 sites near Cochenour, concentrations are low in comparison with those found in lake sediments from the Yellowknife area (Nickerson, 1972). In Figure 5, samples with very high manganese contents are underlined. The high arsenic levels in these samples are probably due to preferential accumulation of the element in ferromanganese nodules.

Copper at Chibougamau

The location of the copper mines around Lac Dore is shown in Figure 6. Copper concentrations in this lake are relatively low, considering the numerous copper mines around its shores. Lac Dore was found to have a predominantly silty bottom sediment in the section southwest of Merrill Island. Sediments to the north of the southern causeway to Merrill Island were mainly organic gels. Most concentration at depths of 10 to 15 cm are in the range of 20 to 40 ppm for both types of material. Concentrations are uniform with depth and no obvious trend is observed. The only samples which show evidence of Cu contamination come from the surface 2 inches at: (1) two sites between the causeways to Merrill Island, probably sediment deposited during causeway construction; and

(2) one site containing 3,450 ppm Cu in the northwest, probably related to slumping from an adjacent tailing pile. This lake is in the most recently developed of the three mining areas and on the basis of these results is largely unaffected by the Cu mines, at least in terms of Cu pollution. Even the levels of 511 and 644 ppm Cu near Merrill Island are less than found in several lakes from wilderness areas (Allan *et al.*, 1972) of northern Canada. There seems to be a slight correlation between copper concentrations and depth of water at sample sites but the pattern is not consistent.

Conclusions

Sediments from lakes in all three mining areas show the effects of pollution. Contaminated surface samples are more prevalent in the order Sudbury, Red Lake, Chibougamau, where mining operations began approximately 80, 40 and 10 years ago respectively.

Samples of cores generally show the variation between the original pre-mining metal concentrations and the present-day concentrations. At specific locations, the difference between concentrations in the surface 5 cm of core compared to those at 10-15 cm below the surface, show changes that may be partly attributable to mining activity.

However, even at Sudbury, where airborne particulate fallout has caused higher metal levels in the surface of soils (Costescu and Hutchinson, 1972) and presumably also in lake bottom sediments, the effect appears to be limited to the surface few centimetres. Kelley Lake, adjacent to the Coppercliff smelters is as expected, the most striking case. Even here however, concentrations of nickel reached acceptable levels at a depth of 15 cm in the one sediment core collected. Also, in view of the high metal content of this lake it may prove economically feasible to reclaim this or other lakes for their metal content.

The areas sampled represent three of Canada's major mining camps, for gold, nickel and copper. At each area there are numerous large deposits. Often, deposits were adjacent to lakes sampled. Yet, the absolute concentrations of As, Ni and Cu in the lake sediments from the three areas are low and do not reflect the ore occurrences. Various data treatments such as combinations of metals, or metal ratios may however show the areas to be geochemically distinct.

The variations in metal concentrations between samples collected by a dredging as opposed to a coring device is significant, and emphasizes the need for standardization of sampling devices and techniques when metal concentrations are to be compared between different areas. This is particularly important in environmental geochemical studies but also relevant to

exploration geochemical surveys.

Acknowledgments

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Project No. 700046

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Introduction

The purpose of this report is to provide information on (1) the concentrations of metals in various surficial materials in the vicinity of, and (2) the relative dispersion of various metals from, a Mississippi Valley type Pb-Zn deposit located in a cold-desert landscape.

The Arctic Desert zone of Canada lies north of the tundra zone. This desert landscape is found in most of the Arctic Islands excluding Baffin Island. Geochemical exploration methods using surface, frost boil soil samples for detailed geochemical prospecting and stream sediment surveys for reconnaissance geochemical mapping, has gone on here for several years. Most of the surveys were carried out in the late sixties by two organizations, Cominco Ltd., and J. C. Sproule and Associates. The areas surveyed included Cornwallis and Little Cornwallis islands, and the northern part of Somerset Island. The primary ore targets sought were Pb-Zn deposits of Mississippi Valley type.

However, in spite of these extensive programs, generally available information on geochemical dispersion in this cold desert landscape is minimal. Nearly all of the information derived from these operations is held in confidential company assessment reports. In fact, many exploration geochemists outside Canada, may be unaware that conventional geochemical exploration techniques can be applied successfully in these far northern latitudes.

In terms of geochemical landscape, i.e., climate lack of vegetation, soil types, deep permafrost, lack of ice cap cover, the Canadian Arctic Archipelago is

somewhat unique. Only three land masses of equal area occur at these latitudes, Greenland and Antarctica covered by ice caps; and the Taimyr Peninsula, a tundra vegetated area of the U. S. S. R.

To date, the only major mineral deposit located in the archipelago is the Mississippi Valley type, Polaris Pb-Zn deposit on Little Cornwallis Island. The results described here are from a sampling program carried out in 1971 around the Eclipse ore zone on the same island (Fig. 1)

Since 1971, the mineral exploration situation in the High Arctic has changed. By extensive underground operations and drilling, it has become apparent that the Polaris deposit is one of the major Pb-Zn deposits of the world (Sangster, 1974). Its value is now estimated at \$1.5 billion. Plans for the extraction of this ore are now in progress. This would make it the farthest north operating mine in the world. Such a discovery has changed the "mineral potential" of this part of the Arctic Islands. Also, case histories on geochemical prospecting in the High Arctic have not appeared in print. An exception was the sampling of waters and sediments from the mouths of seven rivers flowing into Lancaster Sound from southern Devon Island (Dyck, 1973). This was part of a wider program to promote the use of icebreakers as a base for sampling river estuaries. Thus, the presentation of the complete data from the 1971 Eclipse ore zone study area, is considered pertinent.

Geology and Ore Deposits of Little Cornwallis Island

The geology of the island has been described in detail by Thorsteinsson and Kerr (1968). This geology has been generalized as a base for Figure 2.

The geology of Little Cornwallis Island consists of a succession of shales and dolomitic limestones. The mineralization at the Eclipse zone is approximately 1M tons, 12% Zn, 2.18% Pb. This smaller ore zone is at the east end of Little Cornwallis Island. The much larger Polaris ore zone (now called Arvik Mines) is at the western edge of the island. The ore mineralogy of the two deposits has been described by Sangster (1971; 1974). The Eclipse deposit occurs in the dolomite of the late to middle Ordovician Thumb Mountain Formation. The Polaris deposit occurs at the top of the Thumb Mountain Formation, below a disconformity separating the Thumb Mountain-Irene Bay shale and the overlying Silurian-Devonian Cape Phillips shale. Sangster (1971, 1974) considers both deposits to be Mississippi Valley type, controlled by karst solution caves. Low grade mineralization is in the form of veins, high grade as massive to botryoidal sphalerite and crystalline galena.

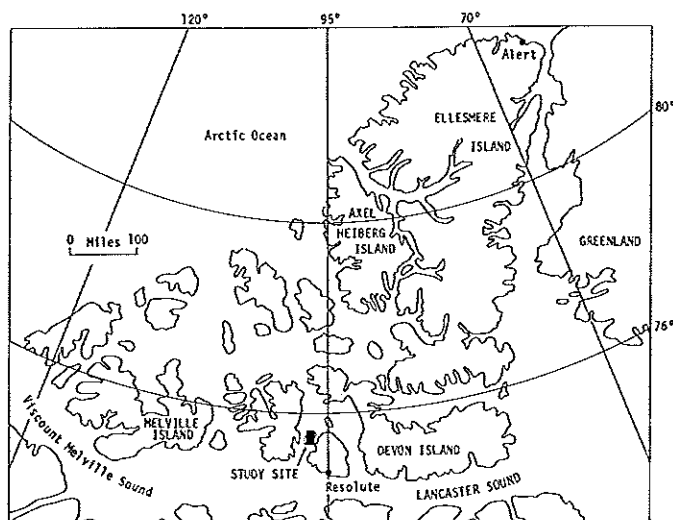


Figure 1. Location of Little Cornwallis study site: Canadian Arctic Archipelago.

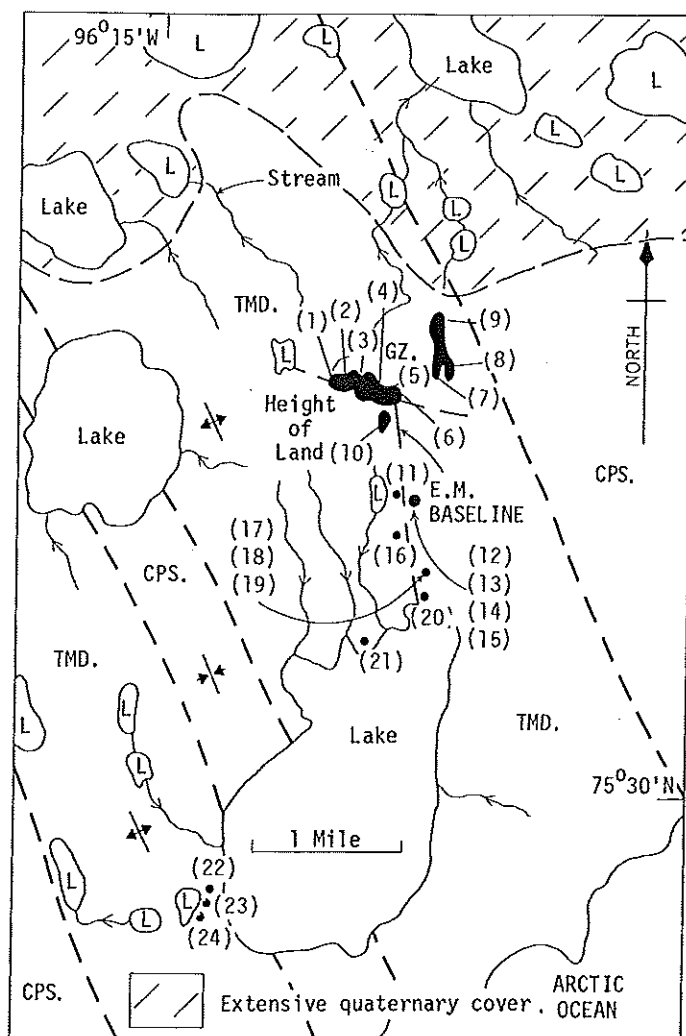
Sampling and Analytical Procedures

The eastern part of Little Cornwallis Island is separated from the western part by a narrow neck of land. This eastern part is divided into north and south sections by a broad valley filled with glacial debris, mainly of marine origin, and large lakes. The southern section rises on all sides to a plateau-like area, underlain by the Thumb Mountain dolomite and with the Eclipse ore zone near the height of land (Fig. 2). Several streams drain this higher point. Other than the completely barren, desert landscape of the island, the most distinctive physiographic features are the omnipresent, gravelly, beach ridges formed during isostatic readjustment of the area. The Polaris ore zone outcrops on the coastline at the western edge of the island. Because of this geomorphic setting, the Eclipse ore zone which is located in the centre of the island, was considered to be the more favourable for a metal dispersion study. Samples were collected of gossan soils, frost boils, stream and lake sediments, and stream and lake waters. The sampling was conducted in early August. There were occasional snowfalls which rapidly melted. Water flow in streams is related to this early winter snowfall. The lake sediments were taken, where feasible, from the estuaries of inflowing streams. Sample sites were reached by a two-wheel, oversized-tire, motorcycle.

Samples of gossan soils, frost boils, stream and lake sediments were sieved to minus 80 mesh and the metals extracted by digesting 200 mg of sample at 90°C for 1.5 hours with 6 ml of 4N HNO₃ plus two drops of concentrated HCl. The extract was shaken, allowed to settle, then analyzed by atomic absorption spectrophotometry.

Gossan Soils at the Ore Zone

The Eclipse ore zone is marked by an extensive red-brown gossan zone, visible from the air for many miles. However, many rocks in this part of the Arctic Islands weather to similar colours and the presence of the red-brown area is by no means diagnostic as representing an underlying deposit. The metal contents (Table 1) of soil samples (Fig. 2) from gossans in this area are, however, very diagnostic. Concentrations of 4% Zn were found in 56% of the samples collected from depths of up to 45 cm directly over the ore zone. Lead concentrations exceeded 1% in 61% of the samples. Silver concentrations were not particularly high, seldom exceeding 10 ppm. Copper, nickel and cobalt levels were monotonously low and in most samples were close to background values (Table 2) obtained in frost boils located (Fig. 2) over dolomitic limestone some distance from the ore zone. Weathering is intense and soils developed on the shales and limestones are often a water-saturated, thixotropic mud. Although the island was ice-covered and much of the present topography is related to beach ridges, the geological boundaries as shown by colour changes of frost boils appear to be in situ. Glacial transport as affecting geochemical anomalies does not seem to be significant. There was



TMD. = Thumb Mountain dolomite and limestone

CPS. = Cape Phillips shale

GZ. = Gossan zone

(10) = Frost boil sample location

Figure 2. Drainage pattern, geology, and frost boil sample locations and numbers.

no consistent variation with depth in metal concentrations of the soils.

Levels of zinc and lead were much lower (Table 1) in samples from a transported gossan to the northeast of the main gossan zone (Fig. 2). This gossan material was probably moved downslope by solifuction processes or by wave action during isostatic readjustment. This latter mode of displacement implies that a gossan was developed prior to the last glaciation, perhaps during an interglacial period. Relatively low zinc and lead concentrations were also found at a gossan site south of the main ore zone.

Surface Frost Boil Samples

Soil samples from the surface of frost boils were taken at two other (Fig. 2) locations: (1) along a geographical baseline and mineralized zone extending south

Table 1

Element concentration in the Gossan Frost Boils (Soils):
Eclipse Ore Zone, Little Cornwallis Island

DEPTH	SAMPLE SITE									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
cms	----- % ZINC -----									
0-15	0.7	3.4	5.2	3.7	7.7	3.6	0.4	0.5	0.2	0.5
15-30	0.9	4.0	5.4	4.0	7.2	5.1	0.4	0.6	0.2	1.0
30-45	0.7	4.8	4.9	4.2	6.8	6.0	0.4	0.6	0.2	1.0
	----- % LEAD -----									
0-15	2.0	0.1	0.8	2.5	1.8	1.2	0.02	0.06	0.03	0.02
15-30	0.7	0.1	0.8	2.5	1.7	2.1	0.02	0.07	0.02	0.03
30-45	2.4	0.1	0.8	2.7	1.8	2.3	0.02	0.06	0.02	0.03
	----- ppm SILVER -----									
0-15	11.9	3.0	6.1	4.1	5.2	11.6	2.1	2.5	3.1	1.8
15-30	2.2	3.3	5.7	3.7	5.7	15.1	2.1	2.5	3.0	2.5
30-45	5.5	3.2	5.1	3.6	5.9	17.1	2.1	2.5	3.0	2.5
	----- ppm COPPER -----									
0-15	55	13	37	40	30	18	18	24	15	15
15-30	33	13	32	29	27	21	21	29	15	14
30-45	79	13	68	22	31	19	18	31	17	15
	----- ppm NICKEL -----									
0-15	13	19	16	18	20	15	41	29	19	36
15-30	13	18	16	16	18	11	47	34	19	23
30-45	14	16	18	20	19	12	42	38	20	24
	----- ppm COBALT -----									
0-15	5	7	8	9	12	11	11	16	16	13
15-30	10	9	6	9	12	15	11	19	15	8
30-45	6	8	10	12	12	13	10	21	14	10

1. Samples 1 to 6 from above main ore zone; 7 to 9 from transported gossan anomaly; 10 from possible extension of main ore zone.

2. Locations of sample sites shown on Figure 2.
Interval between sites is 185 m.

of the ore zone and; (2) a background location in the southwest of the study area. The results (Table 2) show that high concentrations of zinc and lead only occur at locations where sphalerite and galena are visible. The three background samples show consistent, low metal levels. One unique sample (Table 2, No. 21) comes from a frost boil located purely by chance but with evidence of malachite staining. Copper occurrences are not unknown in the Devonian bedrock of this part of the Arctic Islands.

Table 2

Element concentration in Surface Frost Boil Samples,
Little Cornwallis Island

Sample ¹ Number	Element					
	ZINC	LEAD	SILVER	COPPER	NICKEL	COBALT
(11)	220	75	2.4	7	7	8
(12) ²	94,538	25,417	9.8	60	10	8
(13) ²	88,655	57,111	11.8	66	8	4
(14) ²	5,065	2,679	3.2	12	9	10
(15) ²	3,247	1,719	3.2	12	8	8
(16)	97	63	2.8	7	8	7
(17) ³	165	43	2.8	8	18	7
(18) ³	113	32	2.8	7	16	10
(19) ³	142	41	2.6	6	16	11
(20)	513	77	2.5	13	20	8
(21) ⁴	14,828	1,563	5.9	2,778	406	68
(22) ⁵	75	29	3.0	12	21	10
(23) ⁵	75	32	2.7	11	17	10
(24) ⁵	79	38	2.4	14	17	10

¹Sample site location shown on Figure 2.

²Four samples taken at a galena showing.

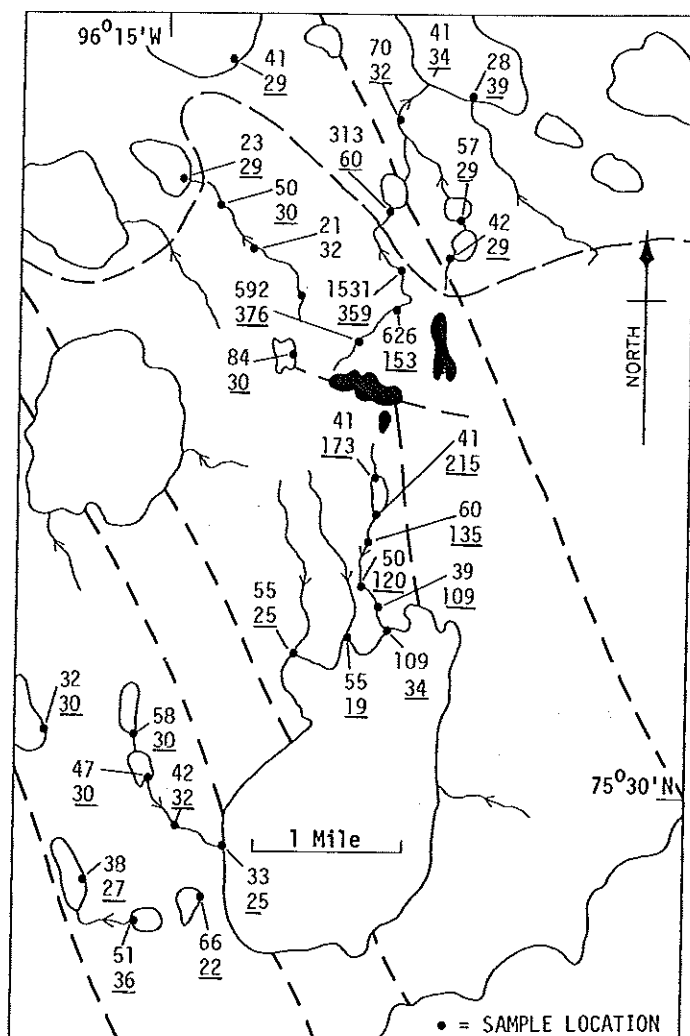
³Three samples near a supposed galena showing.

⁴Sample of a boil in an area of Devonian bedrock. Boil was partly stained with malachite.

⁵Three background samples.

Stream and Lake Sediments

Active stream sediments were collected from three streams (Fig. 2) which appeared to drain the area containing the gossans. Only that draining to the north could unambiguously be said to drain the ore zone. Lake sediments come from the estuaries of these streams or others draining the height of land formed by this

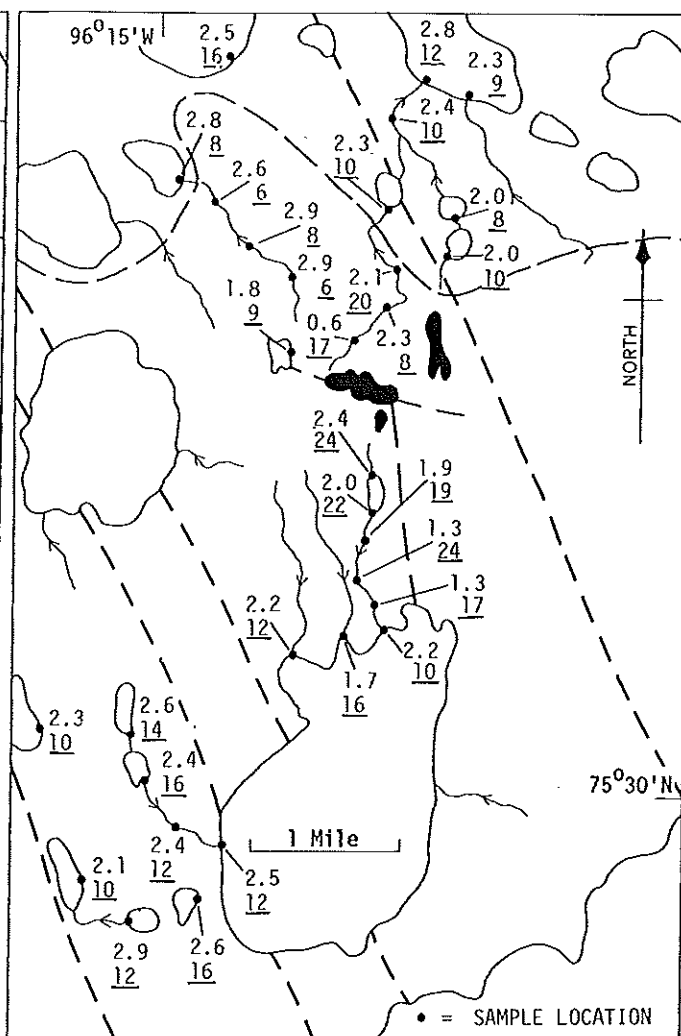


52 = Zinc concentration in ppm
10 = Lead concentration in ppm

Figure 3. Zinc (ppm) and lead (ppm) in stream and lake sediments.

anticline in the Thumb Mountain Formation. Samples of background stream and lake sediments were taken from sites located on a second height of land to the southwest (Fig. 2). As for the Eclipse ore zone site, this area is an anticline formed by the dolomitic-limestone of the Thumb Mountain Formation. At the background sites, concentrations of zinc and perhaps lead appear to be higher in the axis of the anticline (Fig. 3). Levels of zinc increase from 32, 33 and 38 ppm at the edge of the outcrop, through 42 and 47 ppm, to 51, 58 and 66 ppm at sites near the axis of the anticline. This change may be significant when considering the karst, solution cave genesis of Pb-Zn deposits in this area. The variation for zinc is also evident in the water results (Fig. 6).

Metal dispersion from the ore zone seems to be mostly via the stream draining to the north, and to a lesser degree, that to the south. The latter is possibly influenced more by the galena showings to the east, along the geophysical baseline. Levels of zinc in the

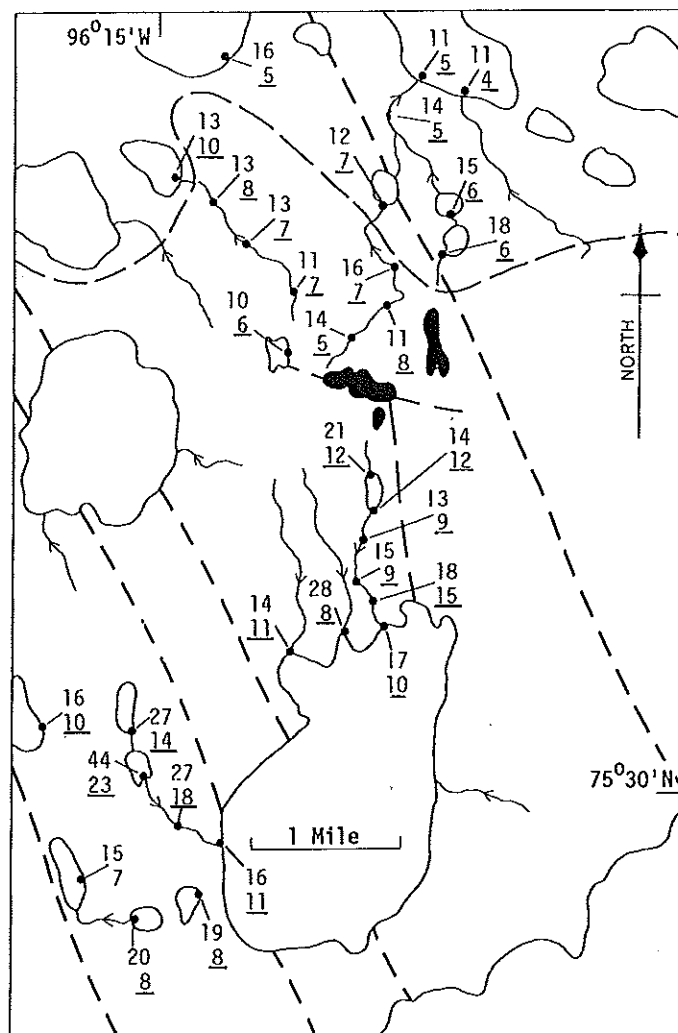


1.5 = silver concentration in ppm
50 = copper concentration in ppm

Figure 4. Silver (ppm) and copper (ppm) in stream and lake sediments.

southern stream sediments are 2 to 3 times background and in the northern stream, 6 to 30 times background concentrations noted for streams in the southwest area. For the southern stream, a concentration of about twice the background level is found in the lake about 1.5 miles south of the ore zone. To the north, concentrations of zinc drop drastically as the stream leaves the dominantly residual soil area on the anticline, and enters the low-lying valley area of marine sediment cover. In areas of nonmarine overlap, dispersion of zinc should reflect mineralization for over 1.5 miles from its source. The stream draining to the northwest appears to be unaffected by the nearby presence of the ore zone. This stream is in fact separated from the ore zone gossan by a slight ridge. Because of the low metal tenor of this stream, dispersion from the ore zone is apparently a surface rather than a groundwater (talik zone) phenomenon.

Dispersion of Pb, as would be expected with a less mobile element, is considerably less. Background

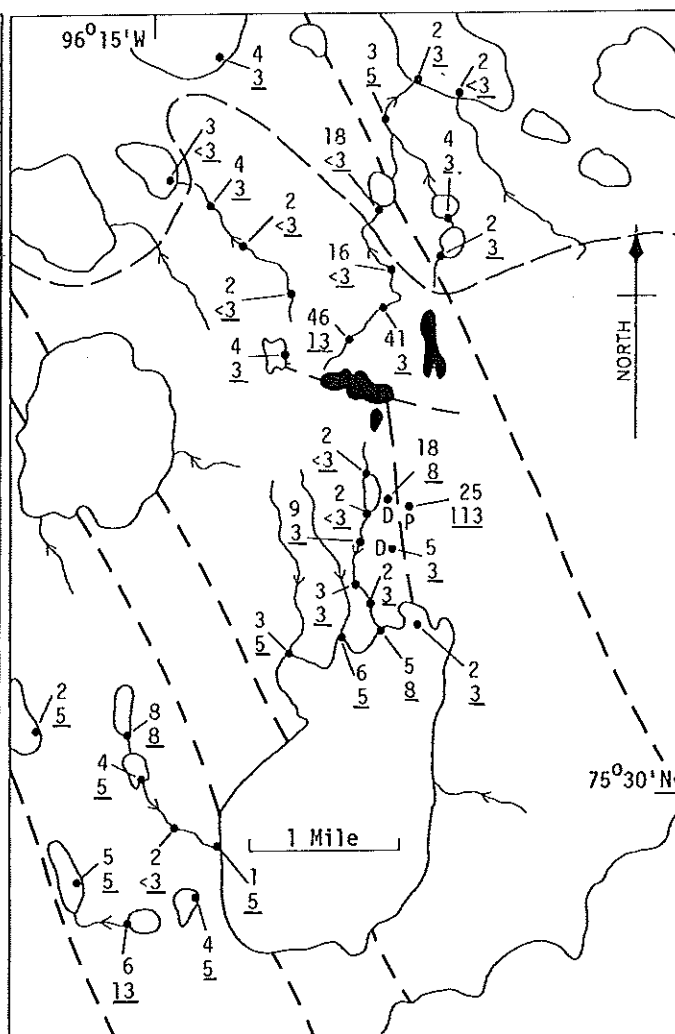


- = Sample Location
- 20 = Nickel concentration in ppm
- 10 = Cobalt concentration in ppm

Figure 5. Nickel (ppm) and cobalt (ppm) in stream and lake sediments.

levels are reached in the southern stream only 1 mile from the ore zone and in the northern stream are again cut off by marine sediment overlap.

Diagrams are also presented to show the levels of Ag-Cu (Fig. 4) and Ni-Co (Fig. 5) at the stream and lake sediment sample sites. Silver levels are consistently in the range of 2 to 3 ppm. Such levels are similar to those found in the gossan soils (Table 1) and also the background frost boil samples (Table 2). These occur over an area of 20 square miles and are high relative to those found in lake sediments sampled in the tundra zone of the northern Canadian Shield (Allan et al., 1972). This may indicate the presence of the ore zone as part of a regional geochemical silver anomaly. Little Cornwallis Island may have been detected by reconnaissance geochemical mapping, using low sample

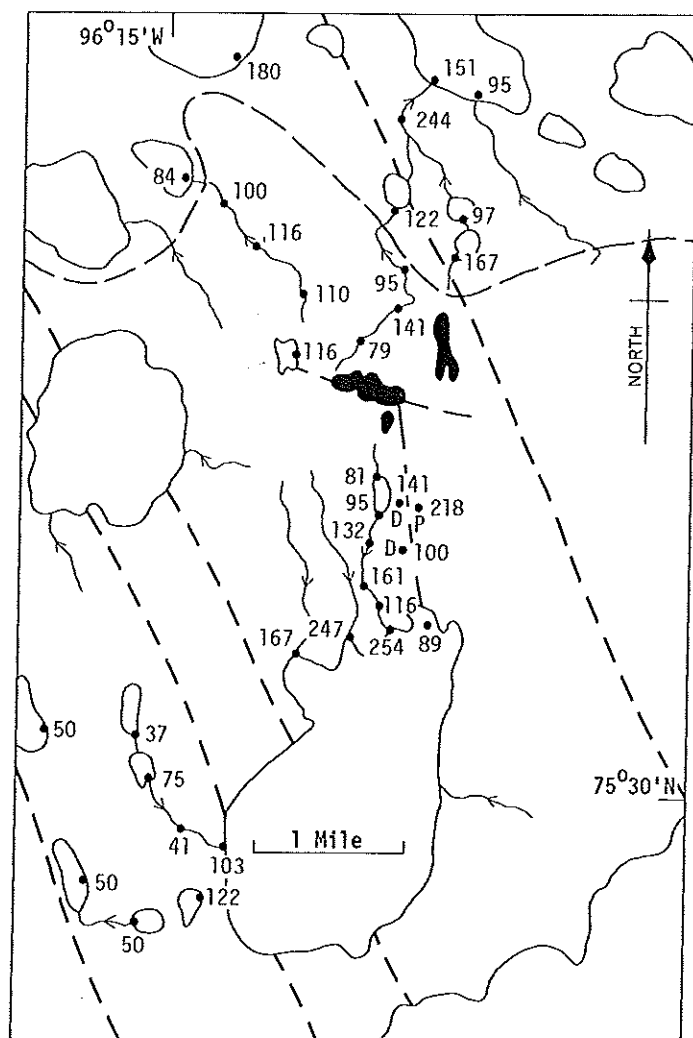


- = Sample Location
- 5 = Zinc concentration in ppb
- 3 = Lead Concentration in ppb
- D = Small Depression
- P = Pit in Galena Showing

Figure 6. Zinc (ppb) and lead (ppb) in stream and lake waters.

site densities, as a silver anomaly. The only exceptions to the 2 to 3 ppm Ag range are the samples closest to the ore zone (0.6 and 1.8 ppm Ag respectively). Again, this may be significant in relation to the solution cavity origin of the ore deposit.

Copper, cobalt and nickel concentrations are monotonously low and are presented: (1) as a contrast to the Zn and Pb dispersion; and (2) as evidence of consistent background levels of such metals both adjacent to the ore zone and in other anomalous samples for zinc and lead. However, it should be noted that the only concentrations of copper greater than 20 ppm are to be found in the stream south of the ore zone. This stream is in the same general area as the Cu-rich (Table 2) frost boil located in Figure 2.



• Sample Location
84: Mercury Concentration in ppt

Figure 7. Mercury (ppt) in stream and lake waters.

Stream and Lake Waters

Stream waters were possibly related to freshly fallen snow, which melted quickly, oversaturating the already poorly drained soils of the area, and thus replenishing the streams with mineralized soil waters. Lake waters were collected from nearshore sites.

Zinc and lead concentrations (Fig. 6) were only above background levels in the stream draining to the north of the ore zone. Again, concentrations dropped drastically (18 to 3 ppb Zn) as the stream entered the area of marine sediment overlap. A concentration of 13 ppb Pb was detected in the background area to the southwest. This was equal to the highest lead value obtained near the ore zone. Lead does not appear to be moved into the drainage system in solution. However, the element does get into solution in this environment, as 113 ppb Pb was found in the water filling a pit in a galena showing.

Mercury is a metal that can often be used as a pathfinder for sphalerite-rich ore bodies. Mercury in

drainage water (Fig. 7) shows that concentrations are higher in the Thumb Mountain dolomite area associated with the deposit. Levels here are normally greater than 100 ppt Hg and often over 150 ppt, whereas in the background Thumb Mountain dolomite to the southwest, they are usually less than 100 ppt Hg. A dispersion pattern of Hg from the ore zone itself is not apparent.

Conclusions

The basic conclusion from the company work in the area and from the above results, is that weathering and dispersion of trace metals from anomalous sources, does occur in the Arctic Desert landscape. Exploration geochemistry is a valid tool for mineral prospecting in this somewhat unique area of Canada.

More specifically, if the major targets are Mississippi Valley type, Pb-Zn ores, the following seems to apply. Based on the results given above, and using reconnaissance sample densities, analysis of waters for zinc and mercury, and of drainage sediments for zinc and silver may locate anomalous zones several square miles in area. At more detailed sample densities, zinc and lead in stream sediments is more diagnostic. Gossan samples and drainage sediment samples suspected to be derived from a very close source, should be analyzed for lead and zinc. Anomalous lead levels are more likely to reflect underlying mineralization.

Acknowledgments

The samples were collected during a two-week stay on Little Cornwallis Island. Mr. N.G. Lund assisted with the sample collection.

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Project 720067

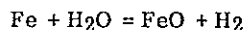
Willy Dyck

Resource Geophysics and Geochemistry Division

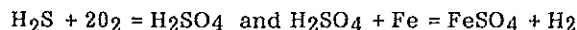
In an effort to determine the source of H_2 in the drillhole water samples near the air-water interface, several drillholes at the New Inco copper sulphide deposit near Duparquet, Quebec were resampled in greater detail before freeze-up. Samples were taken in such a way that at least three came from within the steel casing, the overburden interval between surface and bedrock, and at least three from below the casing in bedrock, alteration zone or ore. The main purpose of this test was to determine whether the H_2 had entered the drillholes at the overburden-bedrock interface and hence could be the result of decay of organic matter in soils. Means of analytical results of the two samplings are given in Table 1. Of the total number of holes, ten were sampled on both occasions. The concentrations of H_2 , H_2S , CH_4 , O_2 , CO_2 , and He are expressed as volume fractions of the total dissolved gas content of the water samples. The Rn content is given in picocuries per cubic centimetre of dissolved gas, and the total amount of dissolved gas is expressed in cc(STP) per litre of water. From the results it is clear that CO_2 and N_2 make-up the bulk of the total dissolved gas, but in order to conserve space N_2 along with Ne and Ar are not tabled. A rather marked decrease in the total amount of dissolved gas content due largely to a decrease in the amount of CO_2 is evident in the October samples but the reason for this is not obvious.

Two typical drillhole profiles of dissolved gases from the second sampling are shown in Figure 1. These results show clearly that H_2 does not enter the casing at the overburden-bedrock interface and hence is not due to the decay of organic matter in soils, but rather that it is being generated at a rapid rate in some holes within the first few metres of the water table inside the steel casing. The grouping of results in Table 1 was meant to accentuate the presence of H_2 and the absence of H_2S and CO_2 in the topmost samples compared to lower samples. However, since not all holes had H_2 in the topmost sample and one hole from the October suite contained large amounts of H_2 in the top two samples (47% and 56%, respectively) and another 2.7% H_2S and very little H_2 in the topmost sample, the 'normal' profile illustrated by holes 9 and 27 in Figure 1 is not so clearly evident when averaged over a large number of holes.

Considering all the evidence collected to date the following mechanism is postulated as the one most likely responsible for the production of H_2 ; it is simply the reaction of the iron in the casing with water thus,



The fact that it occurs only near the air-water interface suggests that the reaction



also play an important part in this process. Hence the lack of H_2S when H_2 is present. The presence of small amounts of O_2 in all the samples is most likely due to contamination during the handling of the samples in atmospheric air. Tests suggest that on the average close to 1% O_2 in O_2 -free samples is picked up during handling. So that in fact the true O_2 level is closer to 0.0% or 0.1% in subsurface samples and about 0.5% to 2% in the topmost samples. By comparison, air dissolved in water in equilibrium with atmospheric air contains about 35% O_2 .

A pH of close to 9 in the H_2 -rich samples is difficult to explain on the basis of the above mechanism. However, the H_2 -rich samples contained virtually no CO_2 (<1%) which appears to be instrumental in lowering the pH in the other water samples in the drillholes. Presumably the CO_2 in the topmost samples is being

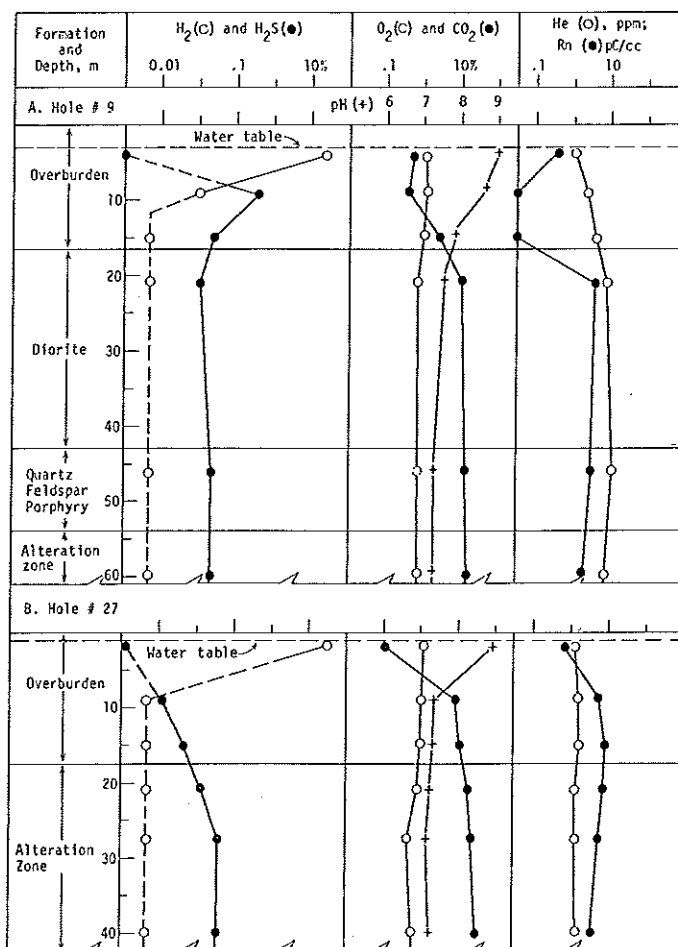


Figure 1. Dissolved gas composition profiles in two drillholes at the New Inco copper sulphide deposit near Duparquet, Que.

Table 1. Arithmetic means, standard deviations, and ranges of dissolved gas constituents from drill hole waters at the New Insko copper deposit in Duparquet, Quebec

Constituent	All but topmost samples				Topmost samples only			
	No. An.*	Mean	S.D.	Range	No. An.*	Mean	S.D.	Range
A. 57 samples from 12 holes collected June, 1973								
H ₂ , %	18	.44	.75	.01 - 3.09	8	10.17	10.11	.02 - 28.66
H ₂ S, %	22	.21	.42	.001 - 1.94	8	.01	.02	.001 - .06
CH ₄ , %	7	.01	.01	.01 - .03	6	.03	.02	.01 - .07
O ₂ , %	44	1.7	2.1	.1 - 8.7	12	1.2	1.1	.06 - 4.3
CO ₂ , %	45	48.0	17.4	14.7 - 80.6	12	22.4	18.5	.3 - 51.4
He, ppm	42	2.9	2.6	1.0 - 11.0	11	2.2	.8	1.0 - 3.0
Rn, pC/cc	43	5.4	3.4	1.0 - 16.1	8	3.3	3.3	.5 - 8.6
Gas, cc/l	45	77.3	39.7	32.3 - 193.3	12	52.6	43.0	22.8 - 177.3
pH	45	6.91	.44	5.11 - 7.35	12	6.88	1.07	4.58 - 8.68
B. 68 samples from 14 holes collected October, 1973								
H ₂ , %	8	7.0	19.7	.01 - 55.7	10	14.5	15.4	.01 - 46.6
H ₂ S, %	50	.13	.35	.001 - 1.6	6	.49	1.10	.001 - 2.7
CH ₄ , %	13	.02	.02	.01 - .06	7	.03	.03	.01 - .07
O ₂ , %	52	1.0	.5	.2 - 3.1	14	1.6	1.8	.1 - 7.7
CO ₂ , %	52	24.4	14.8	.3 - 69.8	14	10.1	14.3	.1 - 36.7
He, ppm	52	4.8	6.6	1.0 - 36.0	14	2.1	.8	1.0 - 3.0
Rn, pC/cc	49	6.1	4.9	.1 - 19.5	14	1.8	1.5	.3 - 4.9
Gas cc/l	54	47.4	18.0	14.7 - 116.0	14	32.4	12.8	22.7 - 67.3
pH	54	7.34	.43	6.45 - 8.72	14	8.18	.89	6.40 - 9.26

* No. An. - Number of analyses above the detection limit.

displaced or expelled by the H₂. While the mere absence of CO₂ still does not explain the high pH, the presence of basic minerals such as dacite and sericite and carbonate materials in the alteration zone could account for the basic character of the water in the absence of CO₂.

A second mechanism, electrolysis of water, could also explain the high pH and H₂ if one can envisage a galvanic cell in which the water-air interface acts as the cathode. Self-potentials of several hundred millivolts, and in one case 1300 mv have indeed been observed over sulphide deposits. Researchers in the field of self-potentials invoke oxidation-reduction reactions to explain self-potentials. However, no self-potential measurements were carried out over the New Insko deposit. While it is difficult to envisage an electrolytic cell in this particular situation, self-potential measurements are needed to help identify the mechanism of production of H₂ in the drillholes.

Aerobic H₂ and NH₃ producing bacteria could also account for the observed H₂ and pH in the water samples. But it is difficult to conceive of a source of nutrients to sustain active colonies of bacteria in more or less stagnant columns of water unless these bacteria can live on CO₂, H₂O and N₂.

The He and Rn values given in Table 1 and Figure 1 were included for comparison with He and Rn values observed in a radioactive drillhole near Gooderham, Ontario and listed in Table 2. Although the U in the Gooderham core did not exceed 200 ppm, the Rn levels in the water were the highest detected to date by the author anywhere, including water from an Elliot Lake uranium mine. A very rough comparison between the Gooderham and Duparquet values gives a U ratio in the rocks of about 100, and He and Rn ratios in the waters of 10 and 3000, respectively. Actually most of the dissolved gas samples from Duparquet contained about 2 ppm He, the normal background level in surface and

Table 2. Concentration of dissolved gases based on the total amount of dissolved gas from a drill hole in radioactive rock near Gooderham, Ontario.

Depth, m	H ₂ % ²	H ₂ S ppm	O ₂ % ²	CO ₂ % ²	He ppm	Rn pC/cc	cc gas 1 H ₂ O (STP)
A. Samples collected September 25, 1973							
30	<.01	470	1.1	10.9	39	16,100	27.9
60	.5	<10	2.9	8.3	38	19,100	29.9
90	.4	<10	1.2	11.7	31	15,500	26.7
120	<.01	110	3.1	10.7	39	20,600	24.0
150	<.01	<10	1.1	10.8	42	16,000	25.6
B. Samples collected November 16, 1973							
29	.5	<10	1.1	29.0	12	10,100	29.6
40	.3	<10	1.0	18.1	26	15,700	28.4
52	.2	<10	1.2	15.6	29	14,400	28.4
61	.2	<10	1.8	12.0	32	15,300	29.3
92	.1	<10	2.8	14.9	30	13,200	31.9
107	.1	<10	0.9	14.0	34	15,200	27.2
122	.2	<10	1.1	12.4	34	14,600	26.4
137	.3	<10	0.8	19.3	18	12,500	28.9
157	.1	<10	4.1	14.3	30	15,900	26.8

near surface groundwaters. In one hole the He level rose smoothly with depth to about 36 ppm at a depth of 30 m with a similar weak increase in Rn, suggesting some form of communication with U-bearing strata. The relationship between U, He, and Rn in rocks and groundwaters is obviously not a simple one. Factors such as rock porosity, chemical potentials and rate of flow of

groundwaters, type of U-mineral structure and dispersion all influence the concentration of He and Rn in groundwaters.

Although the study of dissolved gases in groundwaters gives meaningful results in terms of geochemical processes, a great deal of research is indicated to determine the usefulness of gases for mineral exploration.

Project 720036

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The purpose of the program was to outline areas in Newfoundland with good potential in metallic mineral resources, in order to facilitate discovery by exploration companies and thus contribute to the economic and social development.

The 1972 pilot studies in the Daniel's Harbour area of the Northern Peninsula where zinc mineralization is associated with the St. George and Table Head Group carbonate rocks have been briefly discussed in Hornbrook (1973) and Hornbrook and Davenport (1973). Essentially, regional organic lake sediment exploration has effectively defined known areas of mineralization and indicated others, some of which were associated with the St. George-Table Head disconformity. A complete discussion of the pilot studies will be published soon in Hornbrook *et al.* (1974).

Thus, in 1973 a regional organic lake sediment survey was carried out of the total belt of lower Paleozoic carbonate rocks in western Newfoundland. The data are briefly described in Hornbrook and Davenport (1974) and Davenport *et al.* (1974a). The single element contour maps for Zn, Pb, Mn and Fe and the weight loss on ignition contour maps have been released on open file (Davenport *et al.*, 1974b). The data have outlined several areas throughout the belt of anomalous zinc values comparable to those associated with the zinc deposits at Daniel's Harbour. However, the data have also poorly outlined other areas, whose significance in relation to their zinc potential is difficult to assess. For example, high background zinc values were found south of Hare Bay, in an area predominantly underlain by allochthonous clastic rocks which contain black shale units, Smyth (1973).

All of the data are undergoing statistical analysis to determine primarily the correlation of zinc with features of the surficial environment such as: coprecipitation with iron and manganese oxides and hydroxides; sorption by organic matter; topographic relief and sample lake area and depth. Findings to date have revealed that zinc correlated significantly with iron and loss on ignition (estimate of organic content). Thus, multilinear regression analysis was carried out in order to remove the influence of iron and loss on ignition and obtain the residual zinc values. Further computer processing of the data is in progress and present findings were described in Davenport *et al.* (1974c). The distribution of residual zinc values resulting from the regression analysis has improved the delineation of zones of known zinc mineralization relative to the distribution of untreated zinc values. Further, referring to the example given above, the high background zinc values in the area of marginal

interest south of Hare Bay has been reduced to background residual zinc values through regression suggesting the high background, untreated zinc values are not related to mineralization.

Thus, the residual zinc distribution is believed to be a more reliable indicator than the untreated zinc distribution of new areas of potential zinc mineralization. In the vicinity of known zinc mineralization, residual zinc distribution has also indicated adjacent target areas for further development work.

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Introduction

A preliminary study of the geochemical dispersion of uranium, radon, zinc, copper, lead, nickel and molybdenum has been made over a small area of March Township, eastern Ontario.

The specific location of a uranium occurrence in the study area is described by Grasty *et al.* (1973) who first discovered it as an anomaly in a series of gamma-ray spectrometer profiles flown over the area in 1972. Steacy *et al.* (1973) have described the mineralogy of the occurrence which consists largely of discrete radioactive grains associated with hydrocarbon material, a little chalcopyrite and some pyrite in dolomite-sandstone host rock of the Ordovician March Formation.

A series of hydrogeochemical surveys covering 45 square miles (115 km²) in the vicinity of the occurrence were undertaken to establish the extent of geochemical dispersion of uranium, and to ascertain the effectiveness of various geochemical indicators in locating this and perhaps other similar occurrences.

Results

Table 1 presents summary information on the abundance of several metals in samples from the occurrence (X) and from a pegmatite vein in some nearby Precambrian rocks (Y). It is interesting to note that whilst both locations show a uranium enrichment, the relative abundances of some ancillary metals, viz, Zn, Cu, Mo change markedly between occurrences, an observation which suggests that the material at (X) is probably not derived from occurrences similar to (Y).

Table 2 presents information on the contents of some trace metals in soils near (X) and from soils some distance from (X). The soils clearly reflect the presence of U and Cu in the mineralization beneath, but Mo is not particularly impressive as an indicator element. Contrary to expectations Zn seems to be slightly enriched in the mineralized zone.

Table 3 data indicate that of the elements tested only Pb shows an enrichment in snow cover above the mineralization. U and Cu are notable by their absence. In other areas where snow has been used as a prospecting aid, Cu is usually quite useful in defining zones of mineralization (Jonasson, unpublished data), but to date U has not been found in any significant quantity in snow cover over mineralization. The reasons for this are not yet fully understood.

Figure 1 is a map of radon distribution in stream waters over the whole map-area studied. It can be seen quite readily that the mineralization at (X) is clearly defined as a high Rn anomaly and that the anomalous zone covers about 4 square miles (10 km²). Two other lesser anomalous zones also appear; the significance of which remains uninvestigated.

Figure 2 presents data for the uranium distribution in stream sediments at the same sample sites from which waters were collected for Rn determination. The mineralization at (X) is again clearly defined although the U contents measured are quite low over most of the area. Nevertheless the U and Rn anomalies are reasonably superimposable.

The lesser anomalies detected by Rn measurement do not reproduce in Figure 2. Rather, several different locations appear to be slightly anomalous. One in particular at the east end of the study area shows a clear dispersion train down a single stream from a point source. This one should be checked further. All of the U anomalous zones are also anomalous in Zn (≥ 85 ppm, b.g., 45 ppm) and perhaps in Cu (≥ 25 ppm, b.g., 12 ppm). Zn is by far the best indicator

Table 1

Analyses of some U-bearing materials (ppm)

a) Interbedded dolomite-sandstone: March Formation (X)						
U	Zn	Cu	Ni	Mo	Pb	Se
60	6	1500	21	100	30	<0.1
b) Biotite from a pegmatite vein: Precambrian (Y)						
575	531	6	<3	0.5	41	-

Table 2

Some trace metals in soils near the uranium occurrence (X) and distant from it (ppm)

a) near (X)				
U	Zn	Cu	Ni	Mo
8.5	133	90	6	2
12.0	76	143	19	3
0.5	47	22	9	3
1.6	80	98	19	3
0.0	82	26	13	1
7.6	37	269	16	-
7.2	35	217	15	-
11.2	43	145	24	-
15.0	52	110	19	-
b) distant				
0.0	61	15	19	1
0.1	71	13	16	3
0.0	61	8	13	2
0.0	62	7	5	2
0.0	37	7	13	2
0.0	44	2	13	1

Table 4
Nature of dissolved gases in stream and run-off waters

Location	total dissolved gas (cc/l) (d.g.)	Rn pc/cc dissolved gas	H ₂ % d.g.	CH ₄ % d.g.	O ₂ % d.g.
Snow-melt at (X)	40 41	2.8 2.0	0 0	0 0	12.8 21.7
Snow-melt downstream from (X)	39 39	55.1 21.2	0 0	0 0	25.8 16.7
Stream water at B (Fig. 3)	52	3.3	0	2.47	5.5

water temp: 0°C; air temp: 4°C; H₂S detected by odour only at Site B.

element for U in stream sediments in the streams which drain the (X) zone as defined in Figures 1 and 2, where some values reach 250 ppm in sediments and 400 ppm in soils. Further work is required to ascertain the reasons for this strong correlation.

Figure 3 represents an expanded section of a soil traverse, A-B, noted on Figure 2. Traverse distance is about 2 miles (3.2 km). Humic-rich A horizon soils only were collected. The uranium occurrence at (X) is again clearly defined (Table 2) relative to the surrounding area.

Preliminary studies have begun (Spring, 1974) on detailed studies of dissolved gases in stream and snow-melt waters at selected sites across the study area. Table 4 displays some early data. Elevated levels of Rn are found downstream from the occurrence at (X) whereas little is detectable in water overlying the mineralization.

The stream water at B is unusual for its methane (CH₄) content which is matched by a depleted oxygen content and an odour of H₂S. The interpretation at present is that stagnant groundwater is moving into this stream as the water-table in the area rises.

Fuller details of this work and of the movement of dissolved metals in run-off waters will be presented at a later date.

Discussion

The results of this work indicate that the occurrence of uranium mineralization is perhaps more widespread than was apparent from the work of Grasty *et al.* (1973).

Hydrogeochemical studies of U dispersion and Rn dispersion probably are effective in outlining areas of interest where follow-up soil traverses may be deployed usefully. Analyses of uranium enriched rocks allow a realistic choice of geochemical indicator elements to be made and which can also be sought in soil, sediment and water samples. In this case, Cu and Zn may prove effective as prospecting aids; Mo may yet prove to be useful.

At present the usefulness of snow samples is very limited, but preliminary data indicate that snow-melt-waters may be sampled advantageously for Rn which is flushed from soils and groundwaters of mineralized zones.

References

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