REGIONAL LAKE SEDIMENT GEOCHEMICAL SURVEY FOR ZINC MINERALIZATION IN WESTERN NEWFOUNDLAND

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ABSTRACT

Lake sediment samples were collected from a region of about 3000 square miles (7800 km^2) which is underlain by Lower Palaeozoic carbonate rocks containing several showings of zinc and lead mineralization. A total of 2494 sites were sampled, providing an average sample density of 1 sample per 1.2 square miles (3 km^2). Samples were collected from the central basins of lakes, and organic-rich material was the preferred sample type. An orientation study carried out in an area of significant zinc mineralization near Daniel's Harbour indicated that the zinc content of organic-rich, centre lake-bottom sediments was a reliable indicator of areas of mineralization within this terrain.

The samples were dried, sieved to minus 80 mesh (< 177 μ) and analysed for zinc, lead, manganese and iron by atomic absorption spectrophotometry. The loss on ignition (L.O.I.) of the samples was determined as an estimate of their organic content. Analysis of variance was carried out on 128 pairs of duplicate samples, and the combined sampling and analytical errors are significantly small at the 99% confidence level compared with the over-all variability of zinc, lead, manganese, iron and L.O.I.

Most of the areas containing the more significant zinc showings in the region are reflected in the zinc content of the lake sediments by anomalous or high background zinc values. The zinc distribution is, however, strongly correlated with the distributions of iron and loss on ignition, suggesting that zinc is coprecipitated with iron, and adsorbed or chelated by organic material. Stepwise multilinear regression was carried out with zinc as the dependent variable, and iron and L.O.I. as the independent variables. The regression equation accounted for 52.7% of the zinc variability.

The residual zinc distribution after regression better defines the areas of known zinc mineralization than does the actual zinc distribution. In addition, the lake sediments are anomalous in residual zinc scores in some areas where no zinc showings have been recorded, but where the geological setting is favourable for mineralization.

INTRODUCTION

Lake sediment as a low-density sample medium in regional geochemical exploration programmes has received increasing use over the last several years. Much of the early work was carried out by mining companies and remains unpublished, but recently, published results have become available (e.g. Allan, 1971; Allan et al., 1972, 1973). In common with other sample media used in geochemical exploration, the effectiveness of the trace element content of lake sediments to delineate areas of mineralization will vary from area to area, depending on the physical features of the area and the type of mineralization being sought.

A regional lake sediment sampling programme was carried out over about 3000 square miles (7800 km^2) of Lower Palaeozoic carbonate rocks in western Newfoundland in 1973 (Fig.1). The programme was carried out to

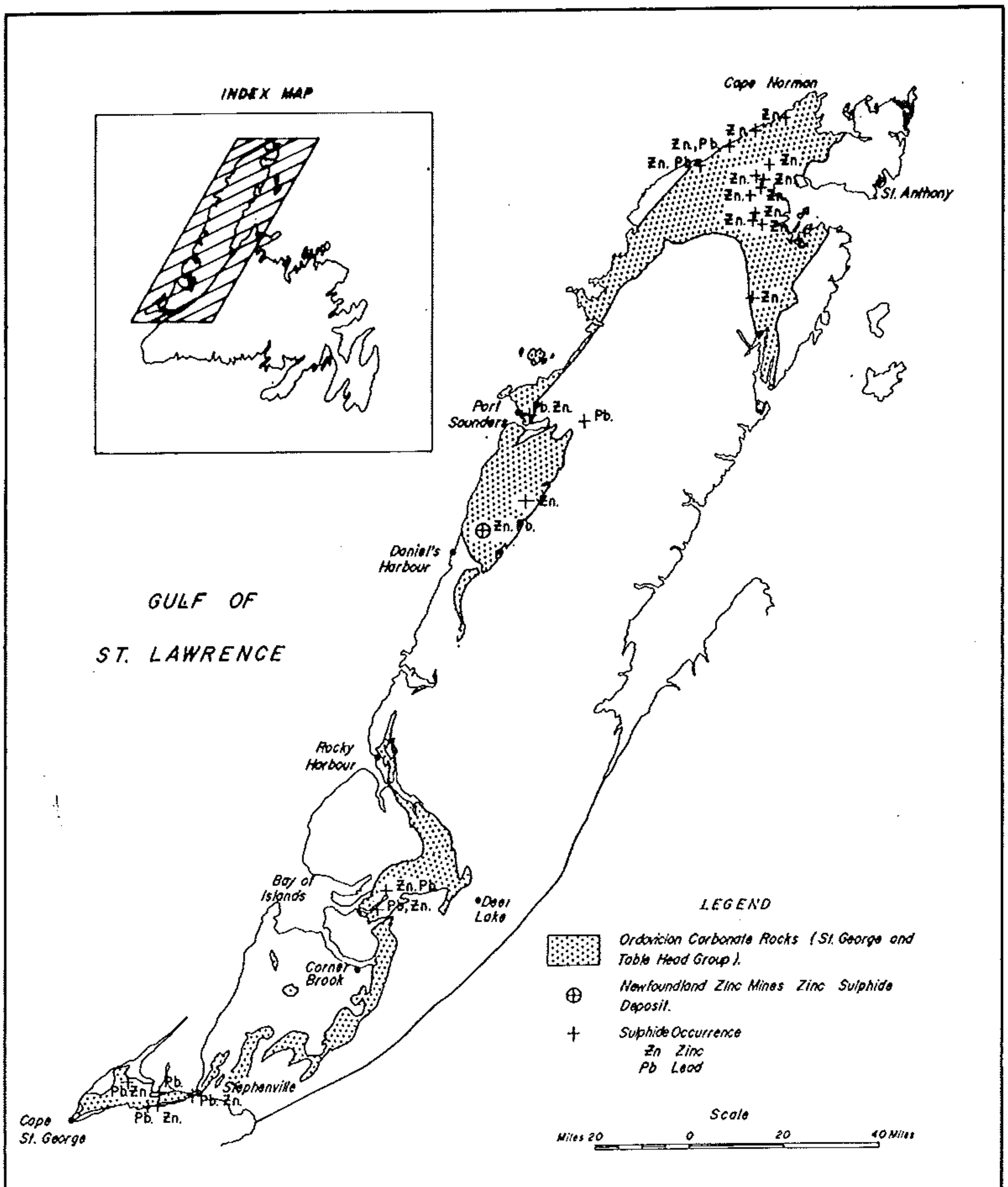

Fig.1. Distribution of Lower Palaeozoic carbonate rocks in western Newfoundland (from Williams, 1967) over which geochemical lake sediment survey was conducted.

delineate areas of potential zinc mineralization. The effectiveness of this type of survey in detecting zinc mineralization in this terrain was demonstrated in an orientation study carried out in an area containing significant zinc mineralization near Daniel's Harbour (Fig.1) (Hornbrook et al., 1974).

Whilst the interpretation of the data is not yet completed, the survey has been successful in detecting most of the significant known zinc showings in the belt, and has indicated new areas of probable mineralization, many of which are geologically favourable.

GEOLOGY OF STUDY AREA

The lake sediment sampling programme was confined almost exclusively to the area underlain by the St. George and Table Head Groups of carbonate rocks in western Newfoundland (Fig.1). These groups are comprised of limestone and dolomite, with very minor shale, and are of Middle or Upper Cambrian to Middle Ordovician age (Williams, 1967). They represent platformal carbonate deposition. The contact between the underlying St. George Group and the Table Head Group is disconformable over most, if not all, of its extent in the belt (Cumming, 1968).

Base-metal mineralization in the area may be subdivided conveniently into three main types. The first type is stratabound sphalerite mineralization occurring in the upper part of the St. George Group, a few hundred feet stratigraphically below the disconformity with the Table Head Group. This type is best exemplified by the Newfoundland Zinc Mines' deposit near Daniel's Harbour (Fig.1). Here sphalerite occurs in a number of pods, the largest of which contains 4.4 million tons of 8.8% Zn (Anonymous, 1974). The setting of these deposits is described by Collins and Smith (1972a, b). A second type of deposit contains both sphalerite and galena as ore minerals. Available details of this type of deposit are few, but they occur stratigraphically lower in the St. George Group. In general they are stratabound, but sulphide veinlets are associated in places. They are known to be present north of Corner Brook (Fig.1), and are described by Lilly (1963). A third type is the galena-sphalerite veins found in the Table Head Group rocks, particularly on the Port au Port Peninsula. Little data concerning these deposits are available.

The following brief description of the Quaternary geology is taken from Brookes (1972), Vanderveer (1973) and Grant (1974). During the glacial maximum Labrador ice affected only the northern tip of the Great Northern Peninsula, flowing generally southeastward to south-southeastward across the most northerly part of the area (Fig.2) and southwestward down the Strait of Belle Isle towards St. John Bay. As the glacial maximum passed, Labrador ice retreated and the area was affected only by the late Wisconsin ice cap that existed on the Long Range Mountains even during the Wisconsin glacial maximum. Flow from this cap was generally west over the area underlain by the St. George and Table Head Groups (Fig.2) and radially off the high lands

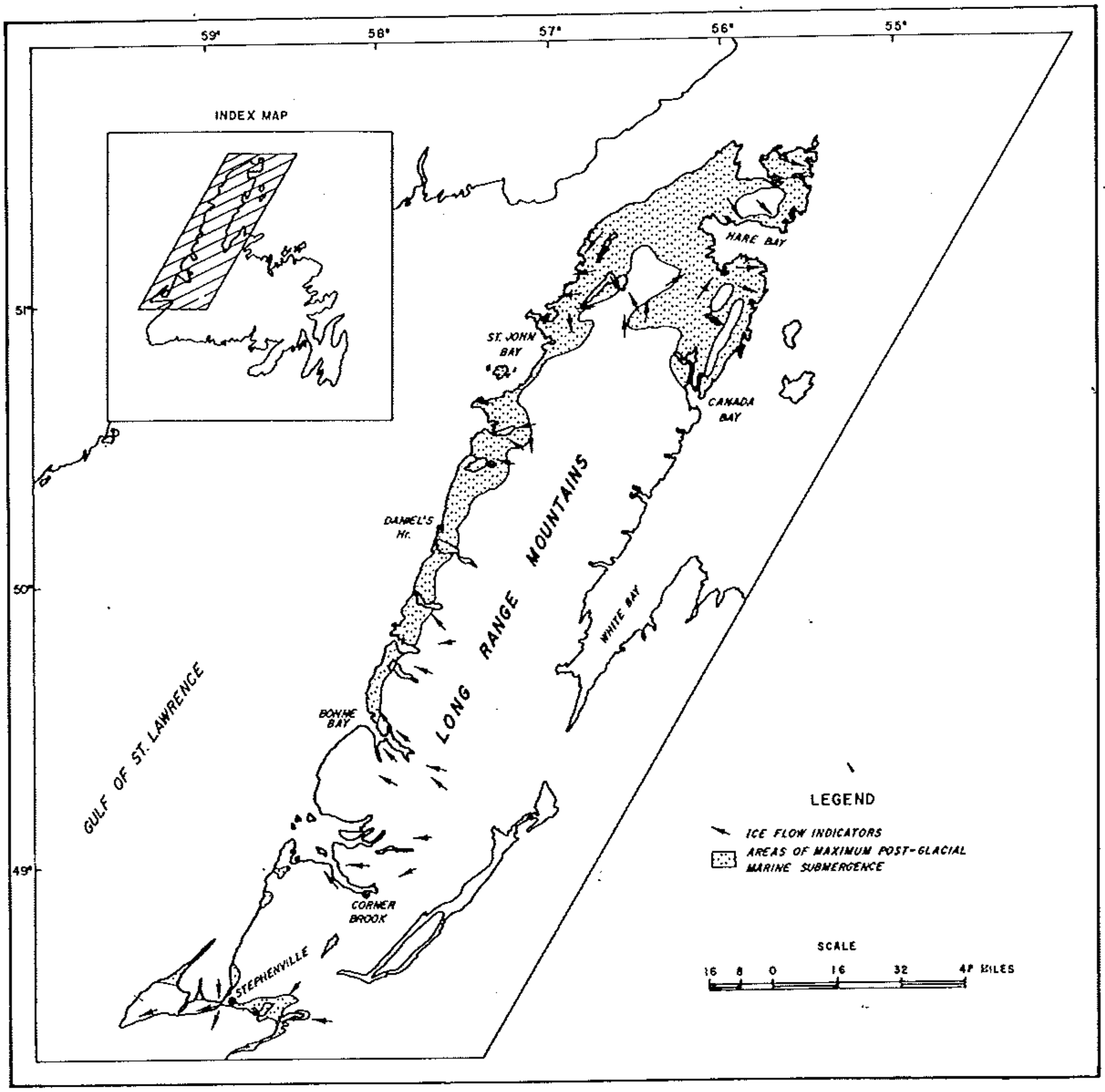

Fig.2. General ice flow directions and area of maximum marine overlap during Wisconsin Glaciation in western Newfoundland (compiled from Brookes, 1972; Vanderveer, 1973; and Grant, 1974).

and across the low-lying northern end of the Great Northern Peninsula. During this stage ground moraine was deposited over much of the area.

The sea advanced as this ice front retreated, and DeGeer moraines and marine deposits were laid down. In the late stages of glaciation the sea was held out from parts of the study area by glacial lobes fed from the Long Range Mountains. Marine deposits and shell fragments are found up to 450 ft above the present sea level in the north of the area and there is a general decrease in the maximum marine overlap from Hare Bay southwards to Stephenville. The maximum marine limit is shown on Fig.2, but in fact the areas actually inundated are much more restricted and were controlled by the position of the wasting ice front. Continued isostatic uplift and retreat of the sea led to some marine deposition along the coast (Grant, 1972) and deposition

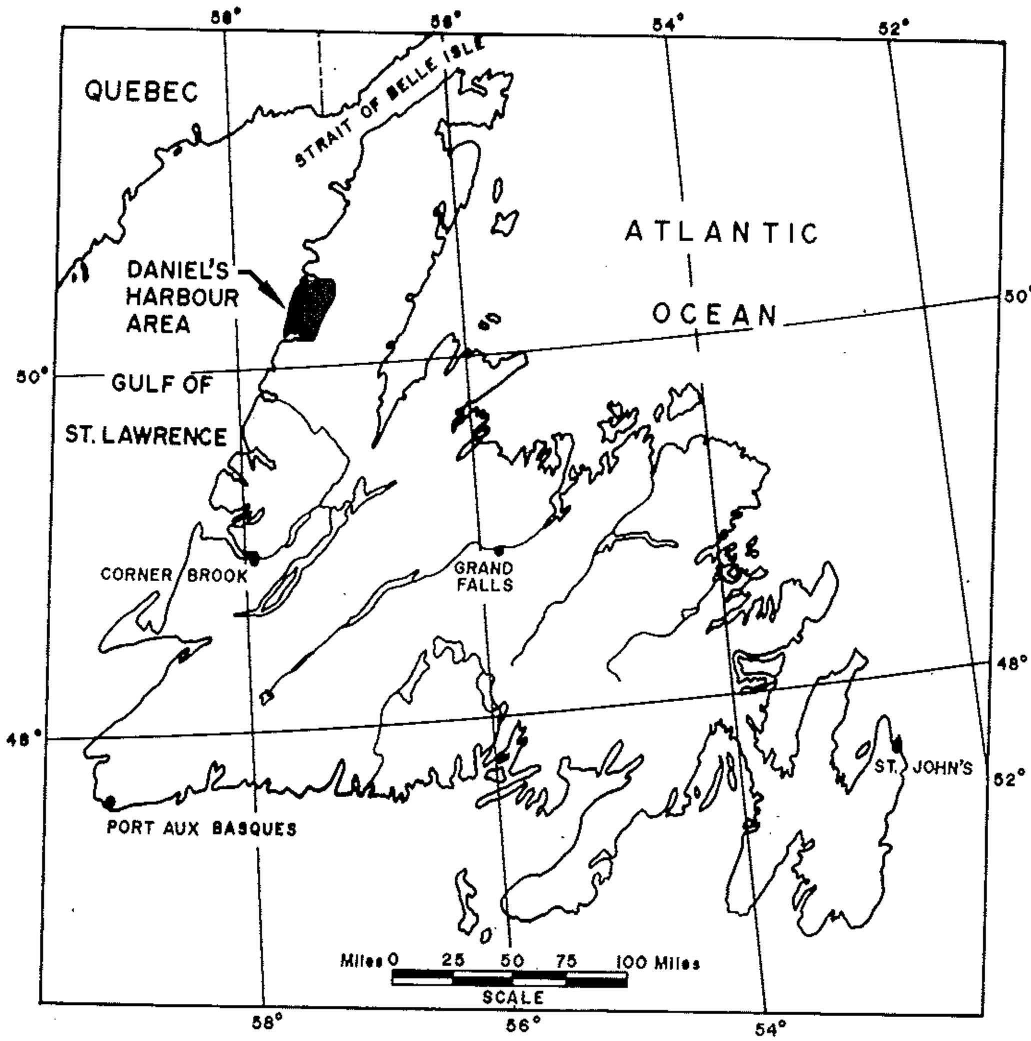

Fig.3. Location of Daniel's Harbour orientation study area.

of ablation moraine accompanied the wastage of the ice back into the highlands.

Marine deposition is rather minor, and marine clays are restricted to near the present coastline. Marine deltas and beach deposits are present in places, but more extensive areas are covered by lag-gravel deposits, the result of wave action on moraine. DeGeer moraines are most common in the northern part of the area.

In the northern area the drift is generally thin, ranging from 0 to 30 ft (9 m) in thickness. From Bonne Bay to Stephenville the drift is thin except in low-lying plains where thicknesses of the order of 200 ft (60 m) may be encountered, e.g. the area southeast of Stephenville.

ORIENTATION STUDY

To determine the optimum procedures for carrying out a regional geochemical exploration programme for zinc mineralization in the St. George and Table Head Group carbonate rocks, an orientation study was carried out in 1972. An area of approximately 350 square miles (900 km^2; see Fig.3), was selected which included the Newfoundland Zinc Mines Limited deposits which are currently being brought into production. The showings have been evaluated by drilling and one has been trenched but were otherwise undisturbed. Stream sediment, organic lake centre-bottom sediment and lake water samples were collected over this area, in addition to a detailed soil and basal till sampling study close to the zinc mineralization. The results of this study are discussed more fully by Hornbrook et al. (1974).

Briefly stated, the zinc distribution in the stream sediments, lake sediments and lake waters all reflect the presence of the major zinc mineralization. The potential of lake water samples was reduced because of the insufficiently sensitive analytical method employed, which allowed the reliable identification only of highly anomalous zinc concentrations. The distribution of streams in the orientation study area is erratic, owing to the development of underground drainage in places. Thus it is not possible to maintain a uniform sample density over the area, and this situation is also true in many places within the area underlain by the St. George and Table Head Groups outside the orientation study area.

Zinc distribution in lake sediments

The distribution of zinc in lake sediments is shown in Fig.4. The average sample density is 1 sample per 2 square miles (1 sample per 5.2 km^2), and the sample points have a fairly uniform distribution throughout the area. The frequency distribution of zinc is log-normal, and the contour intervals in Fig.4 are arbitrarily chosen at 0.5, 1.5, 2.5 and 3.5 standard deviations above the mean (150, 400, 1000, 2700 ppm Zn, respectively). The major zinc deposits and related showings are reflected by a multi-station anomaly, where the lake sediment samples contain zinc concentrations ranging from 6250 to 14,500 ppm. Only one of these sampled lakes may be contaminated by trenching over an adjacent showing. Other lower order anomalies occur on the east margin of the sampled area, where zinc showings are known.

The lake sediments were analysed for Cu, Pb, Ag, Co, Ni, Mn, Fe and L.O.I., in addition to zinc. Only very minor concentrations of copper, lead and silver are associated with the zinc mineralization, and the cobalt and nickel contents of the mineralization are very low. The distributions of these elements did not, therefore, reflect the presence of the zinc showings. Zinc is weakly correlated with iron and L.O.I. Despite the statistical significance of these correlations, however, the distribution of zinc residuals after linear regression with these parameters is essentially similar to the actual zinc distribution. There is no correlation between zinc and manganese in the orientation study data.

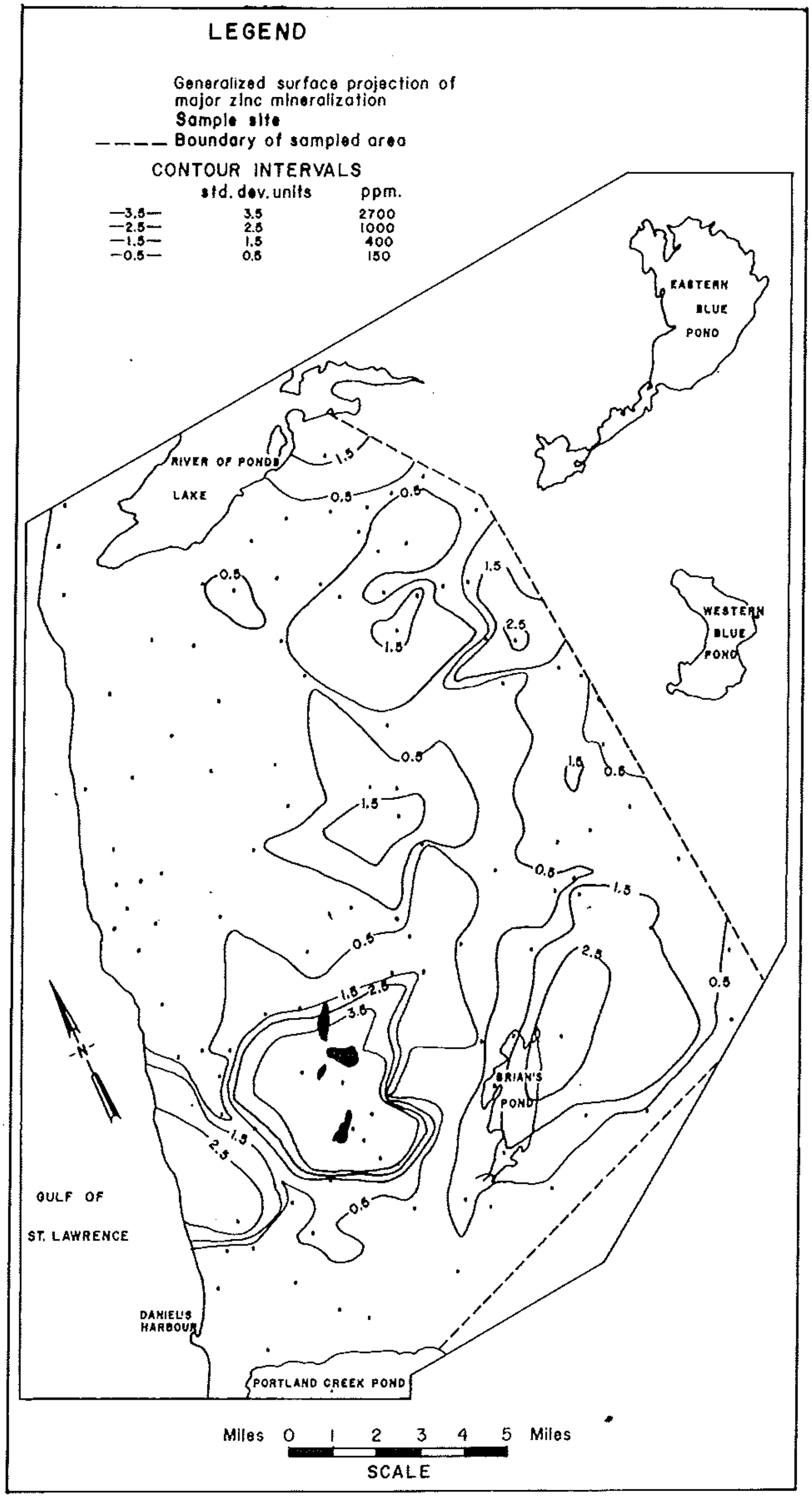

Fig.4. Distribution of zinc in lake sediments, orientation study area.

REGIONAL SURVEY

Design of survey

The results of the orientation study indicate that organic sediments from the central parts of lakes are the best sample medium for a regional reconnaissance survey for zinc mineralization in this terrain. Coker and Nichol (1975) have demonstrated that organic sediment samples from the central parts of lakes are more homogeneous in both major and minor element composition than near-shore samples. Organic gyttja-like material is the most common sediment in the regional study area, but in some areas, particularly in the northern part, no organic sediments are developed in the lakes.

A sample density of approximately 1 sample per square mile (2.6 km^2) was chosen for the regional survey. Over most of the area this density is easily achieved, but in places the sample interval is greater. The zinc and lead mineralization known in the belt occurs typically as clusters of pods or veins, which may occupy an area of several square miles. In general, however, significant dispersion of metals will occur only from mineralization which intersects the bedrock surface. Several of the zinc sulphide bodies on the Newfoundland Zinc Mines Limited property near Daniel's Harbour fortuitously suboutcrop in or close to lakes, thus readily supplying zinc to the drainage system. A fairly close sampling interval was adopted to minimize the possibility of failing to detect anomalies due to mineralization of which only a small proportion intersected the bedrock surface. Furthermore the host rocks of the mineralization, although commonly a particular stratigraphic unit, are not geochemically distinct in trace elements from other units in the succession (Sangster, 1968, J.A. Collins, personal communication, 1972).

The known base-metal mineralization in the belt of carbonate rocks contains the three important metal associations of zinc, zinc and lead, and lead. The only ore metals determined on the lake sediments were zinc and lead. The lead and zinc contents of carbonate rocks are generally low and show little variation between the two major rock types of dolomite and limestone; thus little background variation was anticipated owing to lithological variations. Although in the orientation study the correlation between zinc and iron and L.O.I. was weak, and there was no correlation between zinc and manganese, it was considered worthwhile to determine whether iron, manganese and L.O.I. are more significantly correlated with zinc over the whole belt. These parameters, therefore, were also determined. In this paper the lead distribution will not be discussed further, but the data are available (Davenport et al., 1974).

Sampling method

Lake sediment samples were collected by means of a weighted, hollow, pipe-like sampler having a one-way valve in its lower section (see Fig.5). The valve prevents loss of the sample during retrieval of the loaded sampler from the lake bottom. Sampling was carried out from the pontoon of a helicopter by

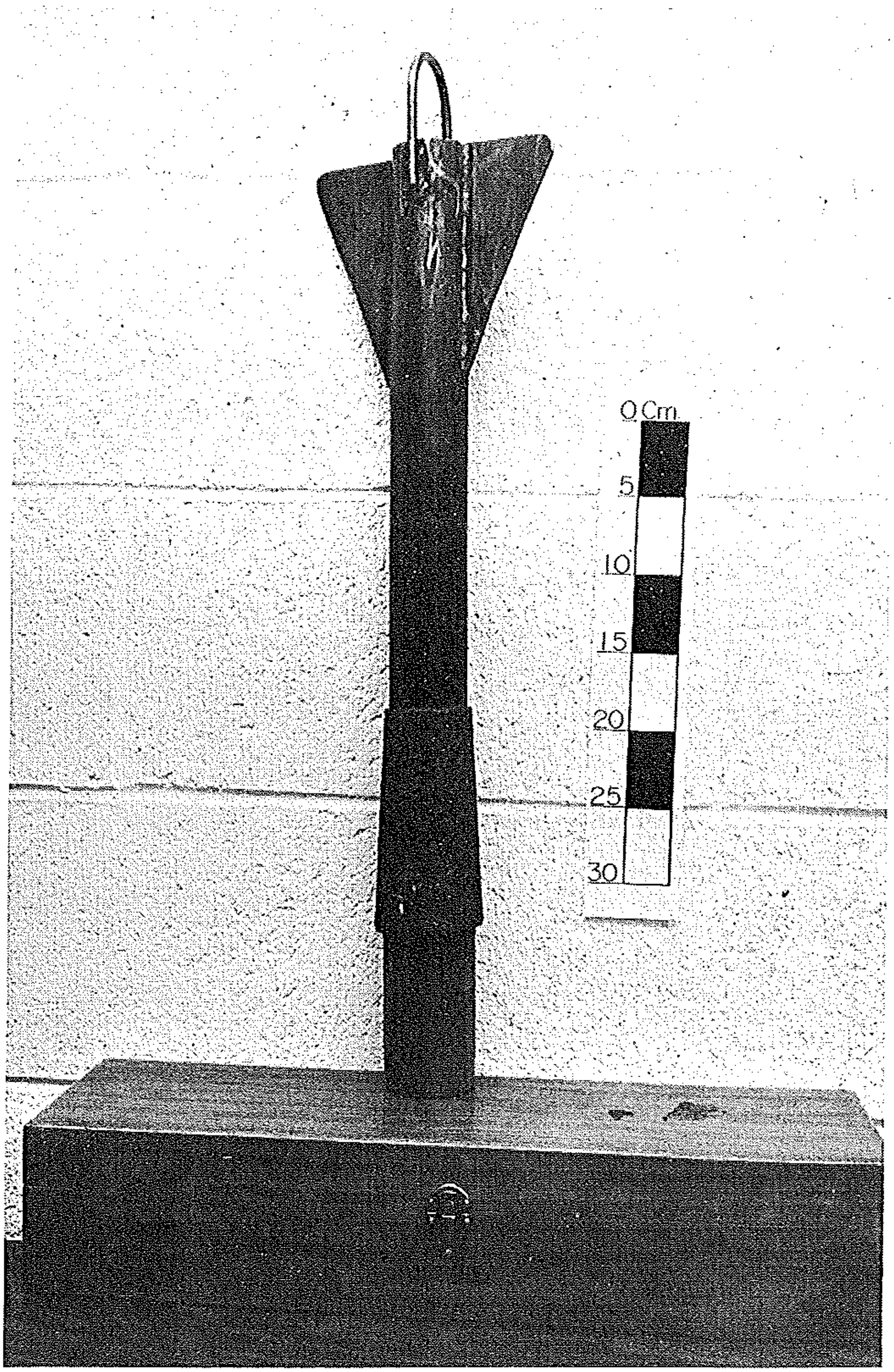

Fig.5. Lake sediment sampler.

allowing the sampler to free-fall through the water to penetrate the organic-mineral soil accumulation at the lake bottom. After retrieval of the sampler, the sample was shaken out of the lower section, examined, and transferred to paper sample bags. Features of the sample and sample site such as water depth, colour and composition of the sample and nature of the surrounding terrain were recorded.

Sample preparation

The samples were partially air dried in the field, and oven dried in the laboratory. During the orientation study, it was found that highly organic samples tend to form a hard, brittle cake when dry. Therefore, such samples collected during the regional survey were disaggregated in a food blender with stainless steel blades and glass jug. All samples from the regional study were sieved to minus 80 mesh ($<177\ \mu$), through stainless steel sieves.

Analytical methods

Both the samples from the orientation study and those from the regional survey were analysed by atomic absorption spectrophotometry for zinc, lead, manganese and iron. An aliquot of 0.2 g of the sample was digested in 3 ml of a $4M$ $HNO_3/0.1M$ HCl mixture at 100°C for 90 minutes and when cool the solution was made up to 10 ml with water. The analytical precision was determined by running a series of 10 control samples in each analytical batch. The precision of zinc, manganese and iron at the 95% confidence level were ±14%, ±12% and ±14%, respectively.

The percentage weight loss on ignition (L.O.I.) was determined on all samples as an estimate of their organic content. Approximately 0.2 g of sample was heated in an oven overnight at 110°C to drive off excess moisture, and weighed. The sample was then ignited in a muffle furnace on a 3 hour long, time-temperature controlled rise to 500°C, which temperature was maintained for 1 hour. The sample was then reweighed, and the weight loss calculated from the ratio of the difference in weight before and after ignition to the weight of the dried sample before ignition, expressed as a percentage. Timperley and Allan (1974) report that no carbonate decomposition occurs when ashing is carried out below 550°C.

Sample reproducibility

To determine the sample reproducibility and representativity, approximately 5% (128) of the 2494 sites were sampled in duplicate. These duplicate samples were collected throughout the study, and the means and standard deviations of the compositions of the subsets are similar to those of the whole data set. The method proposed by Garrett (1973) was used to determine whether the over-all variance of zinc, manganese, iron and L.O.I. in the data subsets is significantly greater than the variance due to sampling and analysis at each site. The F values of these variance ratios are given in Table I. It can be seen that the variance ratios for zinc, manganese, iron and L.O.I. all greatly exceed the critical F ratio (1.51) at the 99% confidence level.

TABLE I

Analysis of sampling and analytical variance for Zn, Mn, Fe and L.O.I. from 128 pairs of duplicate lake sediment samples

	F ratio*
Zn	13.01
Mn	8.59
Fe	17.05
L.O.I.	6.74

**F* ratio is the ratio of the variance of the distribution of each element in the data subset to the variance within the each sample pair (sampling and analytical variance). The critical *F* ratio with 128, and 127 degrees of freedom at the 99% confidence level is 1.51 (Garrett, 1973).

Zinc distribution

The distribution of zinc is shown in Figs.6, 7 and 8. The northern area (Fig.6) is arbitrarily separated from the central area to the south (Fig.7) for ease of presentation. The southern boundary of the central area is the approximate northern boundary of the Gros Morne National Park, and the northern boundary of the southern area (Fig.8) corresponds with the southern boundary of the park. All of the 2494 sample points are shown, and it can be seen that the sample site distribution in the northern and central areas are quite even, but in the southern portion of the southern area, especially on the Port au Port Peninsula, shown as an inset, the sample points are less evenly distributed, because of the uneven lake distribution. The zinc frequency distribution is log-normal, with a geometric mean of 55 ppm. Contour levels were arbitrarily chosen at 0.5, 1.5, 2.5, 3.5 standard deviations above the mean (107, 393, 1439, 5284 ppm Zn, respectively), based on the whole data set. Figs.6, 7 and 8 are hand contoured and represent the actual zinc distribution. In general the zinc distribution is quite smooth, with anomalous sites surrounded by sites containing high background zinc values. There are few high single point anomalies.

The northern area

From Fig.6 it is apparent that the eastern portion, east of lines joining A to C and C to E contains higher zinc values than the area to the west. The zinc showings (Fig.1) to the west and southeast of B (Fig.6) are reflected only by high background zinc values in the lake sediments. The high background zinc values from A to the area east of C approximately follow the upper part of the St. George Group near its contact with the overlying Table Head Group, and may indicate that the zinc mineralization is more extensive than shown in Fig.1. The highest values of zinc in the lake sediments occur immediately to the north of D, and southwards to the area south of E. Two anomalous samples

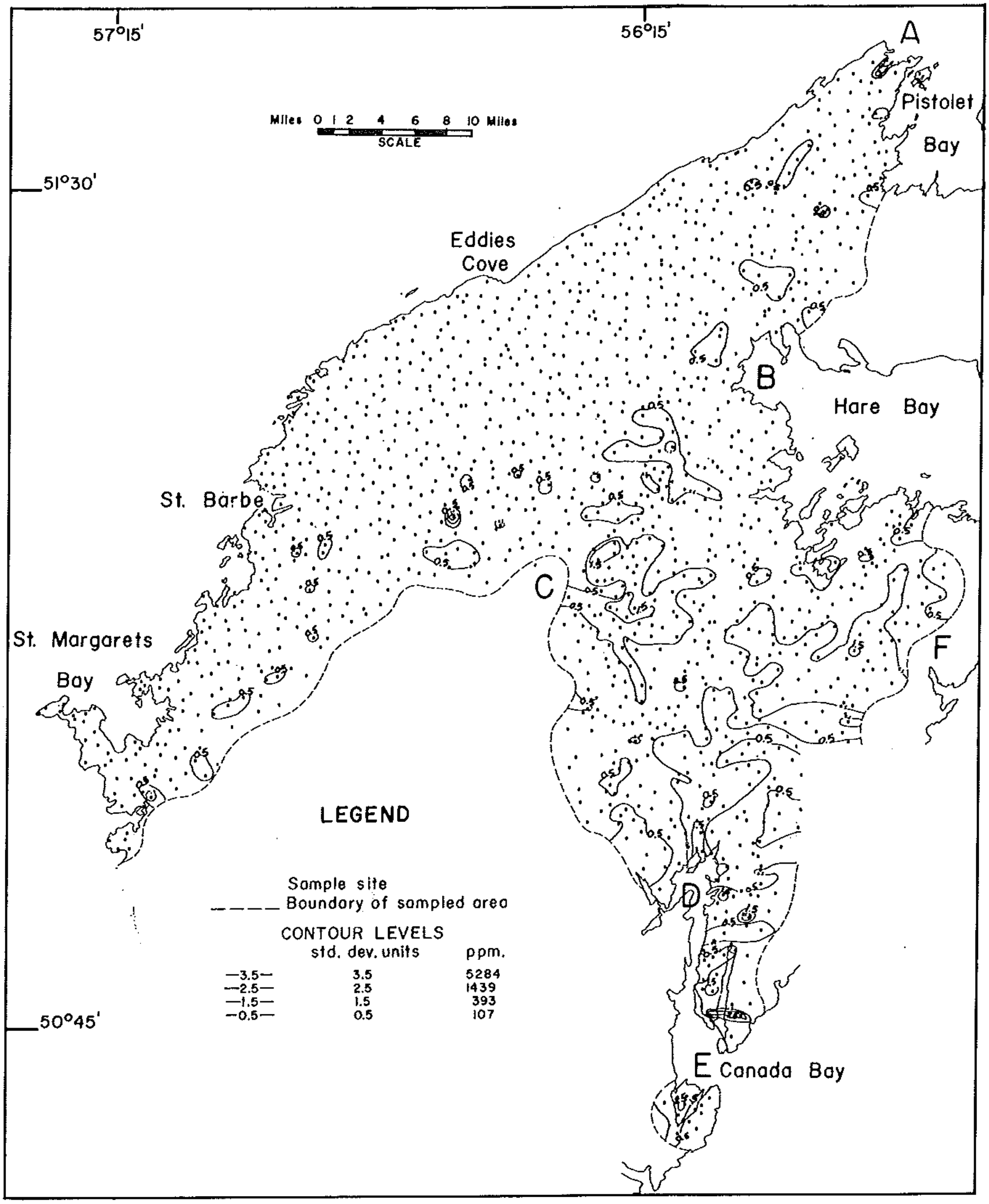

Fig.6. Zinc distribution, northern area.

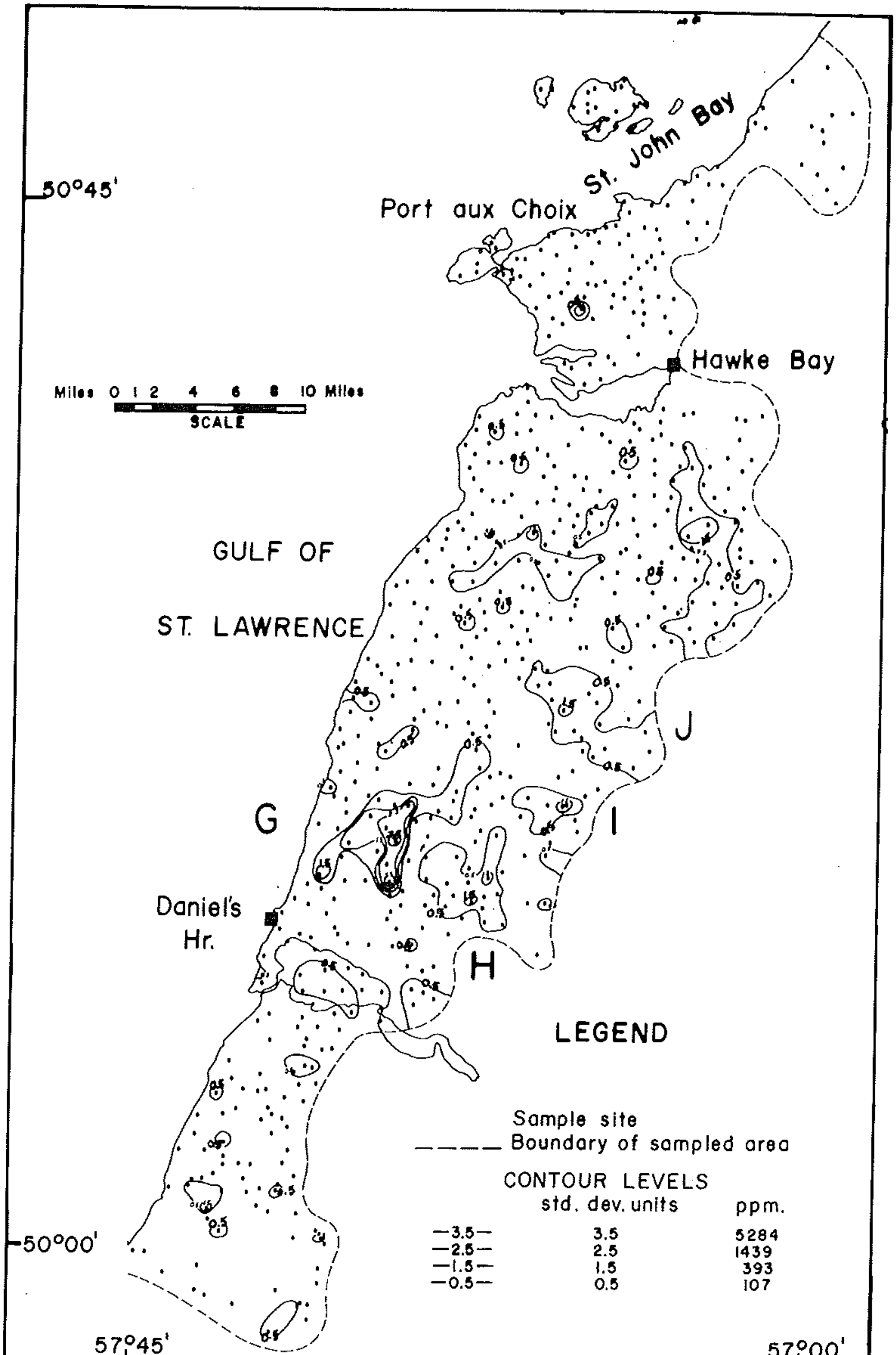

Fig.7. Zinc distribution, central area.

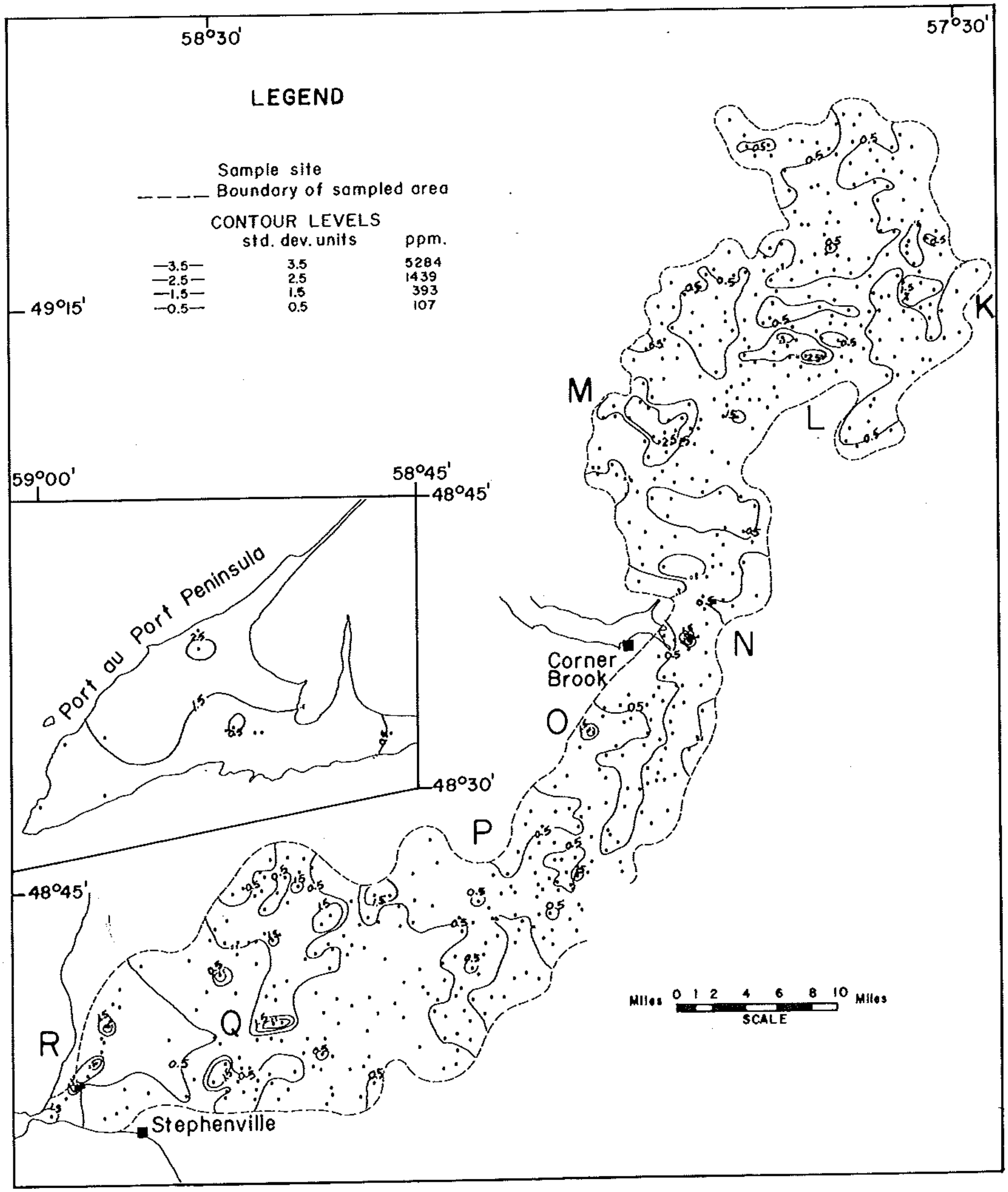

Fig.8. Zinc distribution, southern area.

between D and E occur to the east of the area underlain by carbonates, and are in lakes overlying predominantly clastic rocks of the Hare Bay Allochthon (Smyth, 1973). The area generally to the west of F is predominantly underlain by allochthonous clastic rocks which contain black shale units (Smyth, 1973). This area was sampled because windows of Table Head Group carbonates are present within the allochthon. This area is also characterized by high background zinc levels in lake sediments which may be attributable to high zinc concentrations in the shale units rather than to zinc mineralization. The showings indicated in Fig.1 on the northwest coast of the northern area are all minor, and the lack of any high background or anomalous zinc values in this area suggests that no significant showings of zinc occur inland.

The central area

The zinc distribution in this area (Fig.7) reflects the presence of the zinc deposit and related showings of Newfoundland Zinc Mines Ltd., east of G. As in the results of the orientation study (Fig.4) a multi-station anomaly is developed in the lake sediments from the area containing these deposits. The high background values north of H and west of I and J (Fig.7) also correspond to high background or anomalous values in Fig.4. It should be noted that the contour levels of zinc in ppm differ between the orientation study and the regional study.

The southern area

The zinc distribution is shown in Fig.8. High background to anomalous zinc values occur to the west of K and north of L. There are no published data on showings in this area, but it is believed to be favourable from past geochemical surveys carried out by mining companies in the general area. The area to the east of M contains lead and zinc showings (Lilly, 1963) although there is little published information as to their grade or extent. The other significant anomalies occur to the east of Q and to the east of R. To the writers' knowledge no mineralization has been recorded from these areas. The northwestern part of the Port au Port Peninsula (inset, Fig.8) also contains high background to anomalous zinc contents. Some minor Pb—Zn mineralization is known to occur in the Table Head Group in this area.

Coprecipitation and adsorption of zinc

The actual zinc distribution identifies most of the more economically significant zinc showings, and identifies areas of high zinc where there is no known mineralization. To determine whether the distribution of zinc was correlated with those of manganese, iron and L.O.I. a correlation matrix was calculated (Table II). The distributions of manganese, iron and L.O.I. are all approximately log-normal, so that all the data are log-transformed. All these coefficients are significant at the 99% confidence level. Thus the zinc distribution is correlated significantly with iron, L.O.I. and manganese. Manganese

TABLE II

Correlation matrix of Zn, Mn, Fe and L.O.I. from lake sediments

	Zn	Mn	Fe	L.O.I.
Zn	1.0			
Mn	0.35	1.0		
Fe	0.60	0.71	1.0	
L.O.I.	0.47	−0.06	0.12	1.0

All the data have been transformed into logarithms. Number of samples is 2494.

and iron are themselves very closely correlated. Thus it appears that on a regional scale that zinc is subject to coprecipitation with both iron and manganese oxides and hydroxides, and adsorption or chelation by organic material. Stepwise multilinear regression was carried out with zinc as the dependent variable, and iron, L.O.I. and manganese successively as the independent variables. It was found that iron accounted for 36%, L.O.I. for 16% and manganese for only 0.1% of the variance of zinc. Thus the regression was carried out again with only iron and L.O.I. as the dependent variables.

Residual zinc distribution

The normalized zinc residuals are plotted in Figs.9, 10 and 11. The data are again hand contoured from the residual scores plotted at the sample sites. The contour intervals of +0.5, +1.5, +2.5 and +3.5 standard-deviation units are chosen to correspond with those of the actual zinc distribution, shown in Figs.6, 7 and 8.

The northern area

Areas of high background or anomalous zinc residual values (Fig.9) are better defined than is the case with actual zinc values (Fig.6). Three well-defined anomalous areas are present between A and C, and the known zinc showings (Fig.1) west of B (Fig.9) are fairly well defined. In a similar way the residual zinc anomalies immediately north of D, and extending discontinuously to the south of E over rocks stratigraphically favourable for zinc mineralization are enhanced relative to the actual zinc values. The residual zinc values to the west of F over allochthonous rocks are background, suggesting that the high background actual zinc values are not related to mineralization. The two high actual zinc anomalies furthest to the east from D and E are also anomalous in residual zinc. The cause of these anomalies occurring outside the St. George and Table Head Groups is unknown. The area to the west of a line joining A and C is rather featureless in residual zinc, as it was in actual zinc. Two anomalous clusters of residual zinc scores are present immediately to the north and northwest of C, which were not well defined in the actual zinc data (Fig.6).

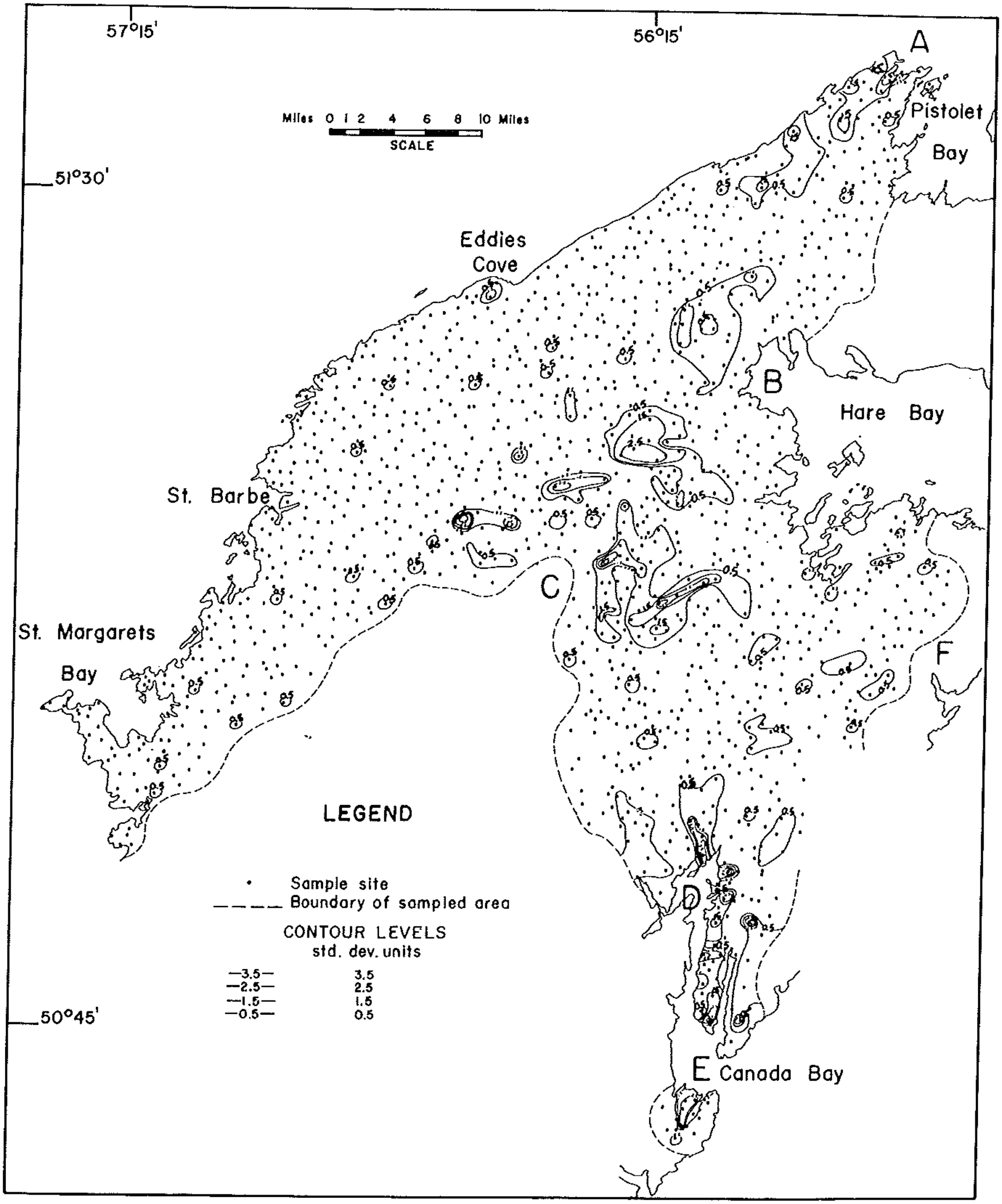

Fig.9. Residual zinc distribution after multilinear regression against iron and loss on ignition, northern area.

The central area

The most striking feature of the residual zinc distribution in this area (Fig.10) is the multi-station anomaly east of G, over the zinc deposits of Newfoundland Zinc Mines Ltd. (Fig.1). The anomaly is more clearly defined by the residual zinc distribution than by the actual zinc distribution (Fig.7). Elsewhere in this area the residual zinc pattern differs from the actual zinc distribution pattern, with generally a better clustering of anomalous and high background areas. The discontinuous strip of high background and anomalous residual zinc values describing the arcuate pattern from H to H′ (Fig.10) includes two known showings of zinc mineralization and follows the favourable upper part of the St. George formation. This pattern was scarcely apparent in the actual zinc distribution (Fig.7). This area may contain substantially more zinc mineralization than has been found to date.

The southern area

The high background and anomalous residual zinc values (Fig.11) cluster better than in the case of the actual zinc values. The anomalies west of K, north of L, west of N, east of O, south of P and west of Q are all better defined by the residual zinc distribution than by the actual zinc distribution (Fig.8). The anomaly east of M, associated with known Zn Pb showings (Fig.1) is considerably enhanced in the residual zinc data (Fig.11), as is the anomaly east of R. The anomalous zinc values in the northwestern part of the Port au Port Peninsula are even more striking in the residual zinc distribution (Fig.11) than in the actual zinc distribution (Fig.8).

SUMMARY AND CONCLUSION

The data presented in this paper demonstrate the effectiveness in this terrain of using the zinc content of organic-rich, lake centre-bottom sediments, collected at a density of approximately 1 sample per 1 square mile (2.6 km^2), in delineating areas of zinc mineralization. An orientation study provided the basis for the over-all design of the programme indicating the optimum approach for the regional survey. An analysis of variance of replicate samples was used to determine the reliability of the data in terms of sample representativity. The data being acceptable on this basis, a limited amount of data processing has been carried out in an attempt to improve the delineation of areas of zinc mineralization. Stepwise multilinear regression was carried out with zinc as the dependent variable and iron and L.O.I. as the independent variables. The distributions of residual zinc values resulting from this regression improves the delineation of zones of known zinc mineralization, and hence the residual zinc distribution is believed to be a more reliable indicator of new areas of potential zinc mineralization.

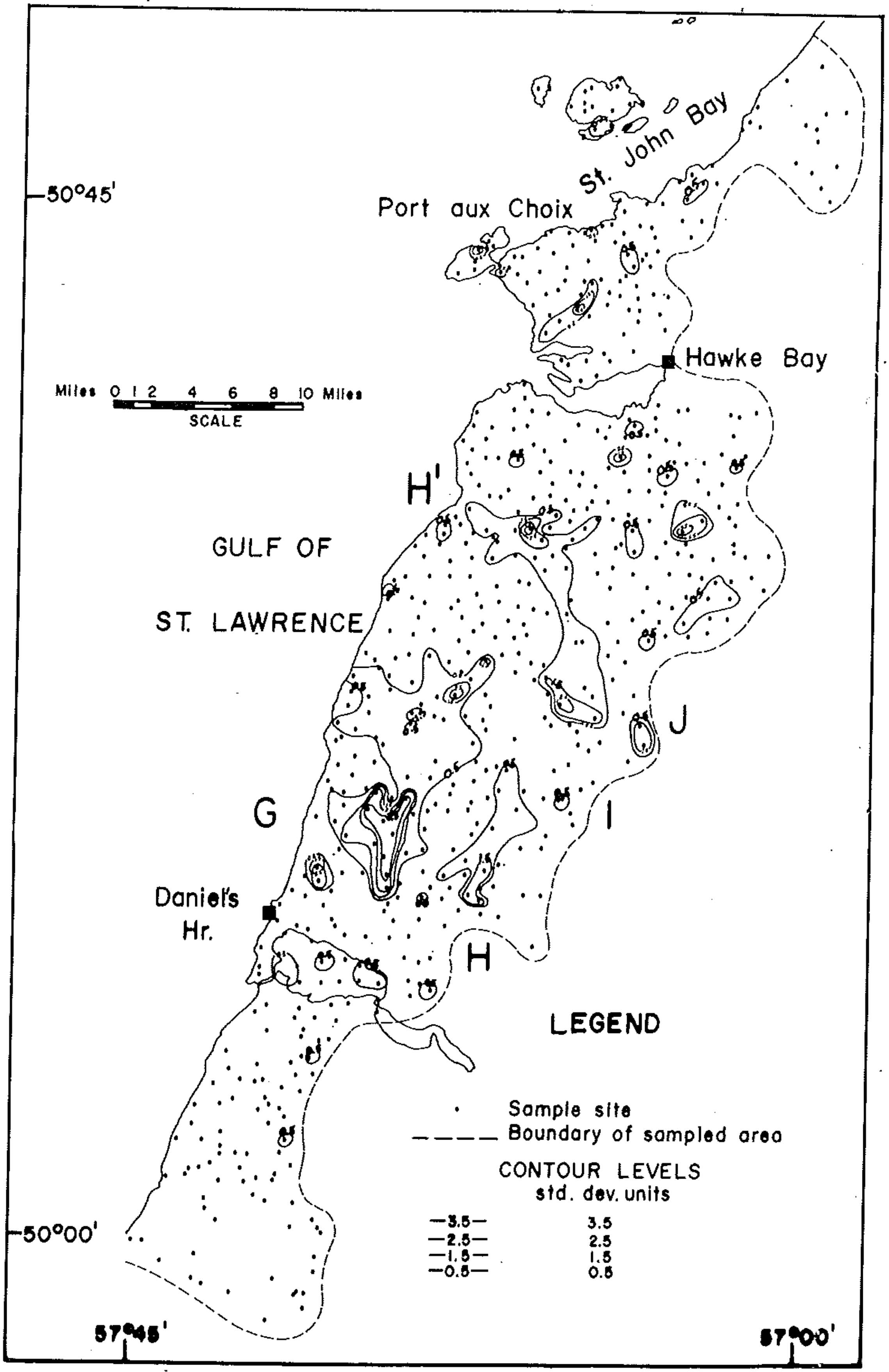

Fig.10. Residual zinc distribution after multilinear regression against iron and loss on ignition, central area.

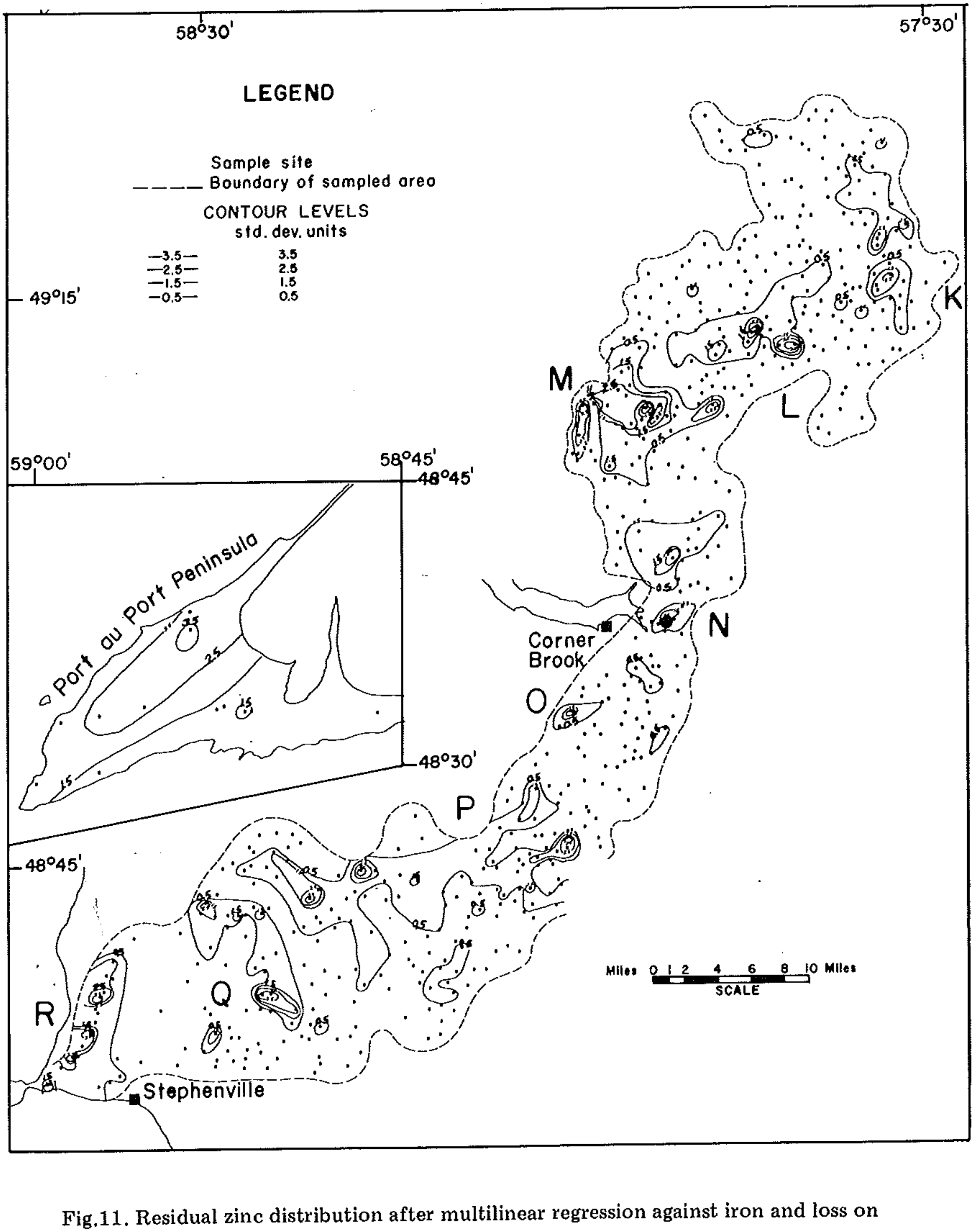

Fig.11. Residual zinc distribution after multilinear regression against iron and loss on ignition, southern area.

Regional background variation

From Figs.6, 7 and 8, a general increase in the average zinc content is apparent progressively from the northern area to the central area, and from the central area to the southern area. This regional effect is also apparent, although less noticeable, in the normalized residual zinc scores (Figs.9, 10 and 11). Furthermore, iron and L.O.I. also show this same trend, and manganese to a lesser extent, being roughly equivalent in mean level in the northern and central areas, but substantially higher in the southern area. These regional variations are summarized in Table III.

Table IV compares the means of the actual zinc and normalized residual zinc scores expressed in terms of standard deviation units from the means of each variable in the whole data set. Thus it can be seen that although the means of the residual zinc scores in the three areas are more similar than the means of the actual zinc values, the residual zinc score means are significantly different.

For each sample site, the lake area, lake water depth at the sample site, and the topographic relief — in a circular 1 square mile (2.6 km^2) search area centred on the sample site — were measured. The correlation coefficients between the lake area, lake depth (at sample site), topographic relief, zinc, manganese, iron and L.O.I. are given in Table V. Zinc is quite strongly correlated with both lake depth and topographic relief, in addition to iron, L.O.I. and manganese. It is also noteworthy that manganese and iron are correlated

TABLE III

The means and standard deviations of Zn, Mn, Fe, L.O.I. and normalized residual Zn score (after stepwise multilinear regression against Fe and L.O.I.) distributions in lake sediments from all the data and from the northern, central and southern areas

		All data (N* = 2494)	Northern area (N=1420)	Central area (N=493)	Southern area (N=581)
Zn	geometric mean (ppm)	55	39	61	115
	standard deviation	0.524	0.505	0.447	0.481
Mn	geometric mean (ppm)	170	142	133	325
	standard deviation	0.561	0.437	0.510	0.748
Fe	geometric mean (%)	0.924	0.782	0.955	1.353
	standard deviation	0.472	0.414	0.511	0.523
L.O.I.	geometric mean (%)	15.1	11.5	18.5	24.8
	standard deviation	0.600	0.644	0.551	0.436
Zn	mean	0	−0.165	0.020	0.387
scores	standard deviation	1.000	0.899	1.006	1.115

Data have been transformed into logarithms.
*N = number of samples in each data set.

TABLE IV

Comparison of the means of actual Zn and residual Zn scores (after stepwise multilinear regression with Fe and L.O.I.) in the northern, central and southern areas, expressed as standard-deviation units from the mean of the whole data set

	Northern area	Central area	Southern area
Actual Zn means	−0.285	0.086	0.611
Residual Zn means	−0.165	0.020	0.387

TABLE V

Correlation matrix between lake area, lake depth, topographic relief, Zn, Mn, Fe and L.O.I. for 2494 lake sediment samples

	Lake area	Lake depth	Topo-graphic relief	Zn	Mn	Fe	L.O.I.
Lake area	1.00						
Lake depth	0.53	1.00					
Topographic relief	0.00	0.36	1.00				
Zn	0.11	0.38	0.38	1.00			
Mn	0.37	0.48	0.26	0.35	1.00		
Fe	0.33	0.44	0.23	0.60	0.71	1.00	
L.O.I.	−0.28	0.09	0.28	0.47	−0.06	0.12	1.00

All data have been transformed into logarithms.

quite strongly with lake depth. This tends to suggest that in the deeper lakes, chemical precipitation of manganese and iron, possibly with the coprecipitation of zinc is an important process. The addition of these three parameters to the regression equation in addition to iron and L.O.I. accounted for only a further 2% of the variation of zinc. Thus the significant differences between the mean zinc residual scores between the three areas cannot be accounted for by the parameters measured.

There is no apparent reason to expect the background zinc content of the carbonate rocks to change significantly from north to south along the belt, nor is there any reason considering the present level of knowledge, to suggest that the mineral potential increases in this direction. The belt of Cambro-Ordovician carbonate rocks in western Newfoundland does extend, however, between the latitudes of 51°30′ north and 48°30′ north. Thus climatic conditions are rather different at the two extremes of the belt, with consequent differences in such factors as weathering and erosion processes and vegetation type. The vegetation surrounding each sample site was noted as being either predominantly forest, mixed forest and swamp, swamp or barren rock. The proportion of samples collected in forested areas increases from 51% in the northern area, to 65% in the central area, to 91% in the southern area. In each of the three areas, the mean zinc content of the sample from forest areas is higher than the mean zinc contents of samples from the other three categories. Thus one major component of the background variation is caused by the increase in forest cover from north to south within the area. Whilst this is partly a function of climate, the nature of the drift and topography are important factors in controlling vegetation type. In the northwest part of the northern area, the drift cover is thin or absent, the topography very flat, and forest coverage minimal.

A final interpretation of these lake sediment data must take into account all the relevant parameters that have been recorded. The use of stepwise multilinear regression is helpful in removing local variations in the environment of sedimentation, and to some extent in reducing the background variation in zinc content on a regional scale The correspondence between the loci of known zinc mineralization and residual zinc anomalies in the lake sediments is good, and the residual zinc distribution is a considerably more reliable guide to areas of known and potential zinc mineralization than the actual zinc distribution. A still more reliable picture will emerge when the data are subdivided into more homogeneous subsets on the basis of the available and relevant qualitative parameters, such as vegetation and physiography, before carrying out stepwise multilinear regression and other data processing as appropriate on each subset.

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