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Mercury Gas Surveys over Base and Precious Metal Mineral Deposits in the Lynn Lake and Snow Lake Areas, Manitoba

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INTRODUCTION

The need to develop exploration techniques applicable to the search for mineral deposits that are "blind" or buried beneath a variety of surficial cover of variable thickness has been apparent to explorationists for many years. During the course of field studies in 1985 a technique designed to measure Hg-gas in overburden above mineral deposits was tested in both the Lynn Lake and Snow Lake areas. Hg-gas surveys were conducted over the Frances Lake Zn-Pb-Cu-Au-Ag massive sulphide deposit and the Rushed Au occurrence (Agassiz Metallotect) in the Lynn Lake area (Fig. 1); the Rod and Stall Cu-Zn massive sulphide deposits and the Kobar Pb-Ag massive sulphide occurrence in the Snow Lake area (Fig. 2). The surveys were undertaken to evaluate the usefulness of the AUREX DETECTION SYSTEM - a new and promising tool for locating Hg-gas anomalies associated with blind Hg-bearing mineral deposits. The evolution of any gas from a blind mineral deposit results in a potential "pathfinder" for the mineralization owing to the ability of the gas to migrate through overlying unconsolidated overburden and be systematically measured at surface.

The generation of the Hg vapour may be the result of absorbed free-state Hg on crystal faces of minerals that becomes separated from the solid phase as a result of a change in temperature or electrochemical potential. The Hg vapour may also be released as a result of the partial oxidation and reduction of ferric iron compounds with absorbed Hg due to intermittent water saturation of the substrate (Zonghua and Yangfen, 1981). The Aurex method has not been extensively tested under the highly variable surficial deposit conditions associated with mineral deposits of the Canadian Shield. Surficial deposits that overlie or mask many of the Shield deposits are variable in thickness and it is not uncommon to find a wide range of overburden types in the vicinity of a mineral deposit. The determination of the usefulness of integrative Hg-gas measurements using the AUREX DETECTION SYSTEM under conditions of permafrost, glaciolacustrine clay, thick till cover, wet swamp and any combination of these surficial deposit types will facilitate exploration for blind mineralization by providing a new and useful tool for explorationists or by preventing unnecessary expenditures on equipment that is incapable of "seeing" through particular overburden types.

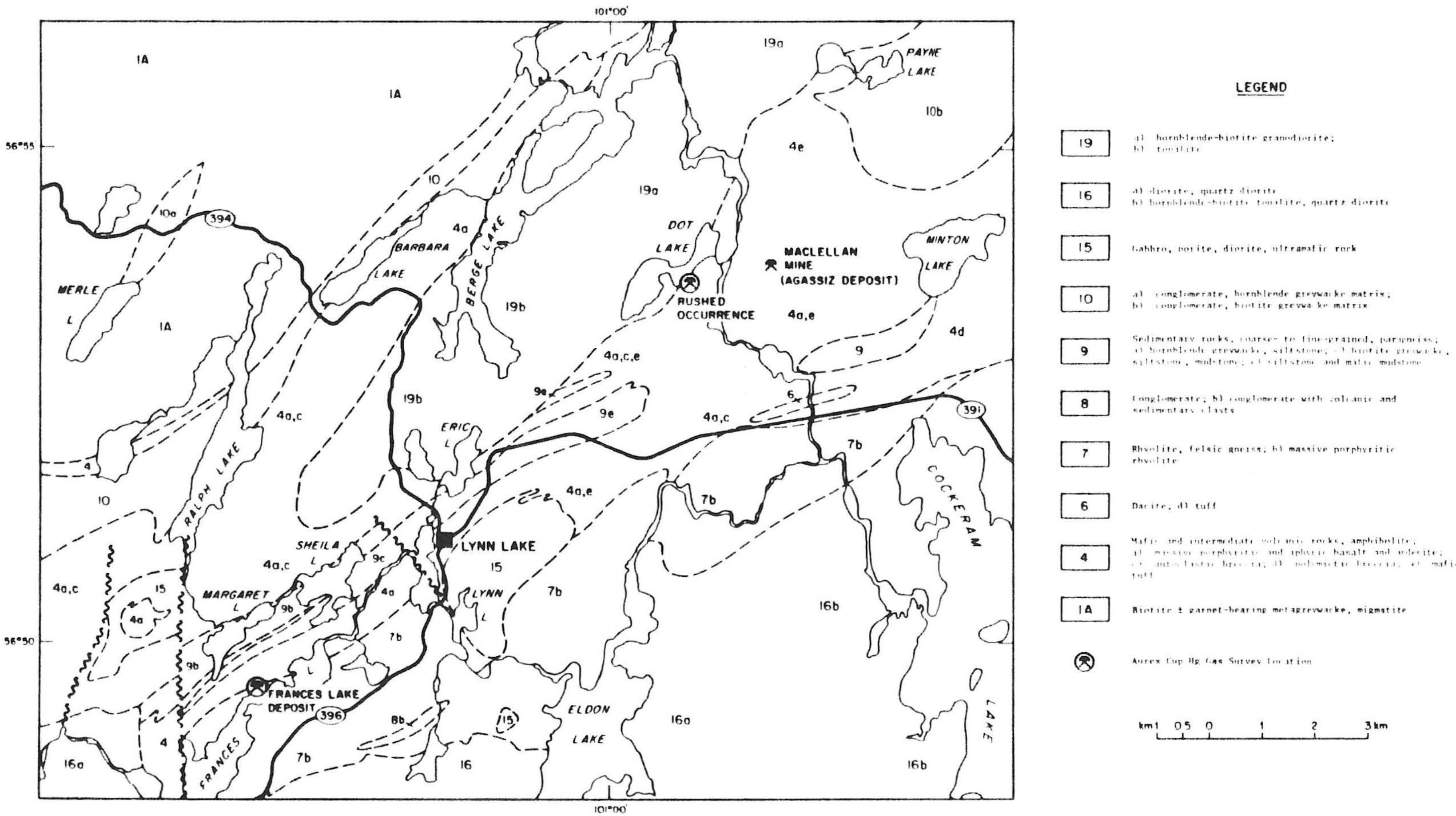


Figure 1. Mercury gas survey (Aurex Cup) sites, Lynn Lake area, 1985.
Geology modified after Gilbert et al., 1980.

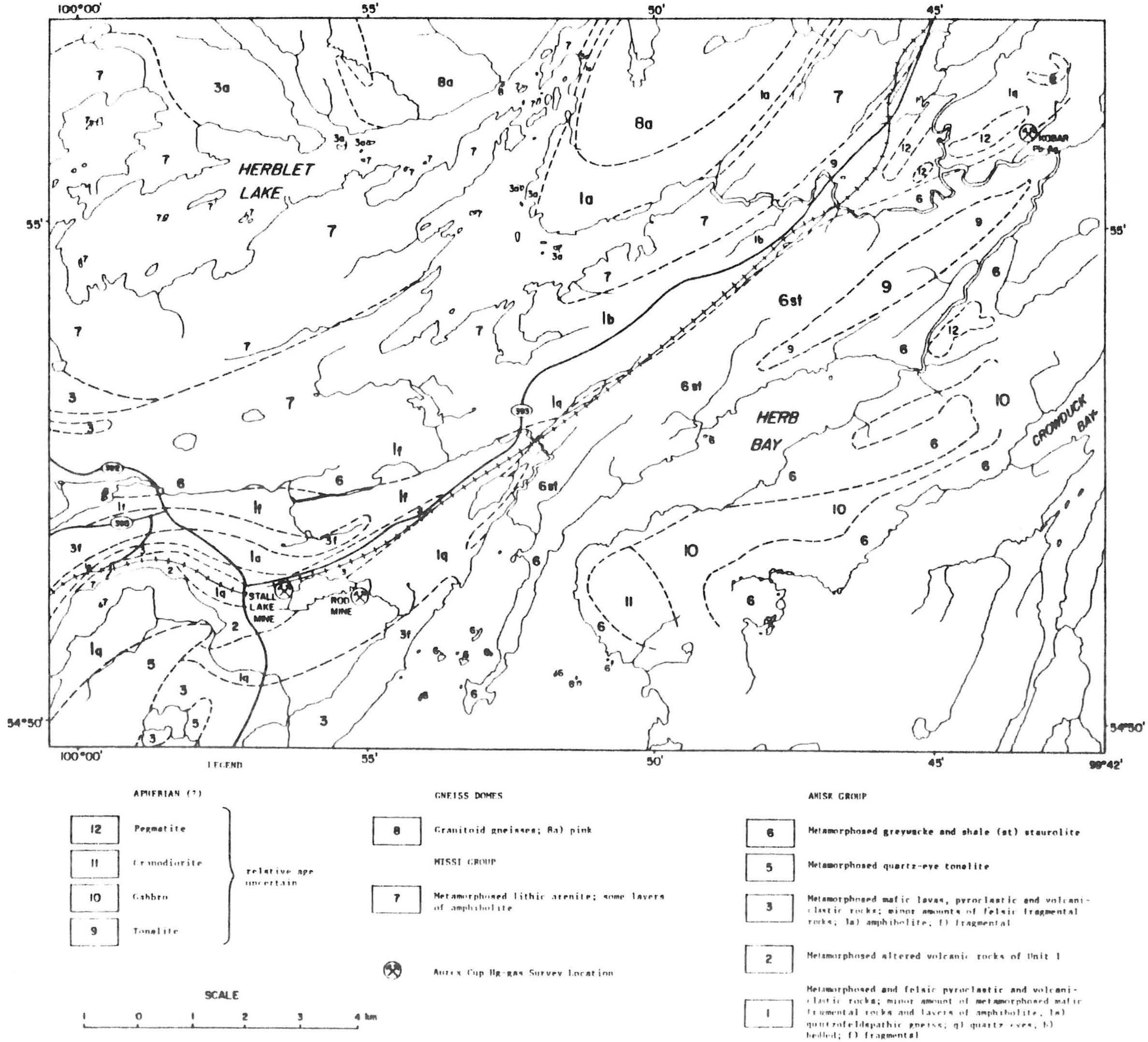


Figure 2: Mercury gas survey (Aurex Cup) sites, Snow Lake area, 1985.
Geology modified after Froese and Moore, 1980.

PREVIOUS WORK

In the past, explorationists have viewed Hg gas surveys with disfavour owing to numerous environmental and cultural effects on the gas measurements as well as the erratic and non-reproducible results. In a series of papers representing extensive research into the problems of Hg-gas measurements Klusman and Webster (1981) and others indicate that atmospheric conditions, including daily and seasonal variations, air and soil temperature, barometric pressure and humidity as well as soil geochemistry (comprising soil moisture, clay and organic content and Fe-Mn oxide and hydroxide content) are responsible for many of the difficulties encountered in the Hg-gas surveys. Ignoring the above factors can result in the presence of anomalies unrelated to mineralization and non-reproducible results. Klusman and Jaacks (1982) compared the techniques of instantaneous versus integrated or continual measurement of numerous gases and concluded that integrative methods were superior resulting in less noise and easily accountable variance. The Aurex System, developed by Earth Search Inc., Colorado, utilizes integrated Hg-gas measurements.

METHOD

The Hg-gas signal was measured continuously for 30 days in the Lynn Lake and Snow Lake surveys by inserting an activated noble metal detector, which is effectively a piece of noble metal wire fixed to the inner base of a plastic cup (Fig. 3), into a shallow 25 cm hole. Prior to planting, a protective glass vial is removed from the wire detector. The cup is covered with a thin sheet of plastic (1/4 of a green garbage bag was used for this purpose in these surveys) and the hole is then refilled. This scenario is depicted in Figure 4. A labelled flag is placed at the sample site to aid in recovering the cup at the end of the Hg gas collection period. Cups are placed at regularly spaced intervals along a test line or over an entire grid that covers the desired test area. Since the Aurex Cup is capable of amalgamating Hg with the detector wire while submerged in water (John Dunkhase, pers. comm.) the presence of water in some test holes was noted, along with the nature of the soil profile, but not considered a reason to relocate the sample site. During recovery of the cups the condition of the sample site is noted (disturbed or normal) as well as the presence or absence of water. The protective glass vial is replaced over the wire detector and then sealed by taping the vial and screw lid shut. The detectors were then shipped to Earth Search Inc. where they were analyzed for Hg.

ANALYTICAL TECHNIQUE

The analysis of mercury in the Aurex Cup surveys was accomplished using a Jerome Gold Film Mercury Analyser (Model 301). After removing the Aurex Cups from the field the noble metal wire is removed from its sealed protective glass vial. The wire is heated in a sealed vessel and the amalgamated mercury driven off the noble metal wire. The mercury vapour is collected and re-amalgamated with a silver wire. The resistivity of the silver wire before amalgamation and after mercury re-amalgamation is measured. By comparing the resistivity difference with standardized mercury-silver resistivities the concentration of mercury is determined and reported as nanograms of mercury (J. Dunkhase, pers. comm.).

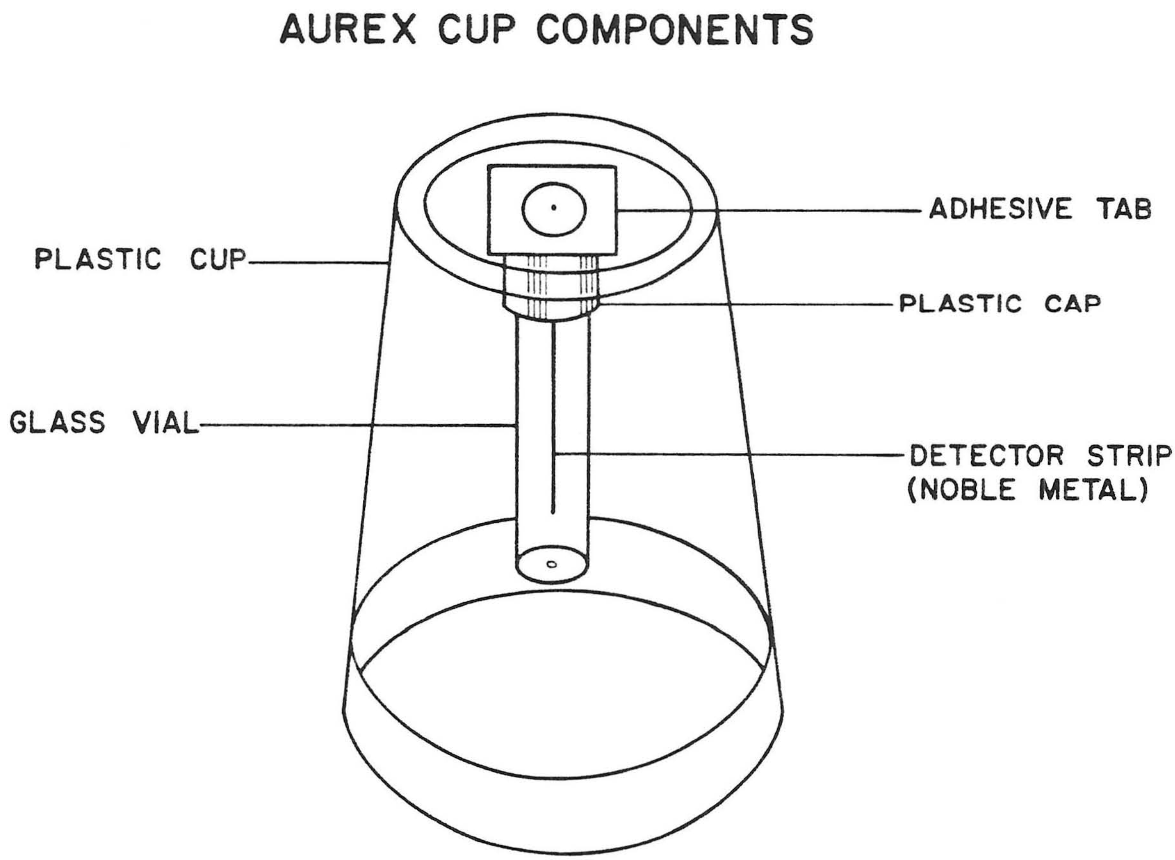


Figure 3: Components of an Aurex Cup. Diagram from Earth Search Inc., 1985.

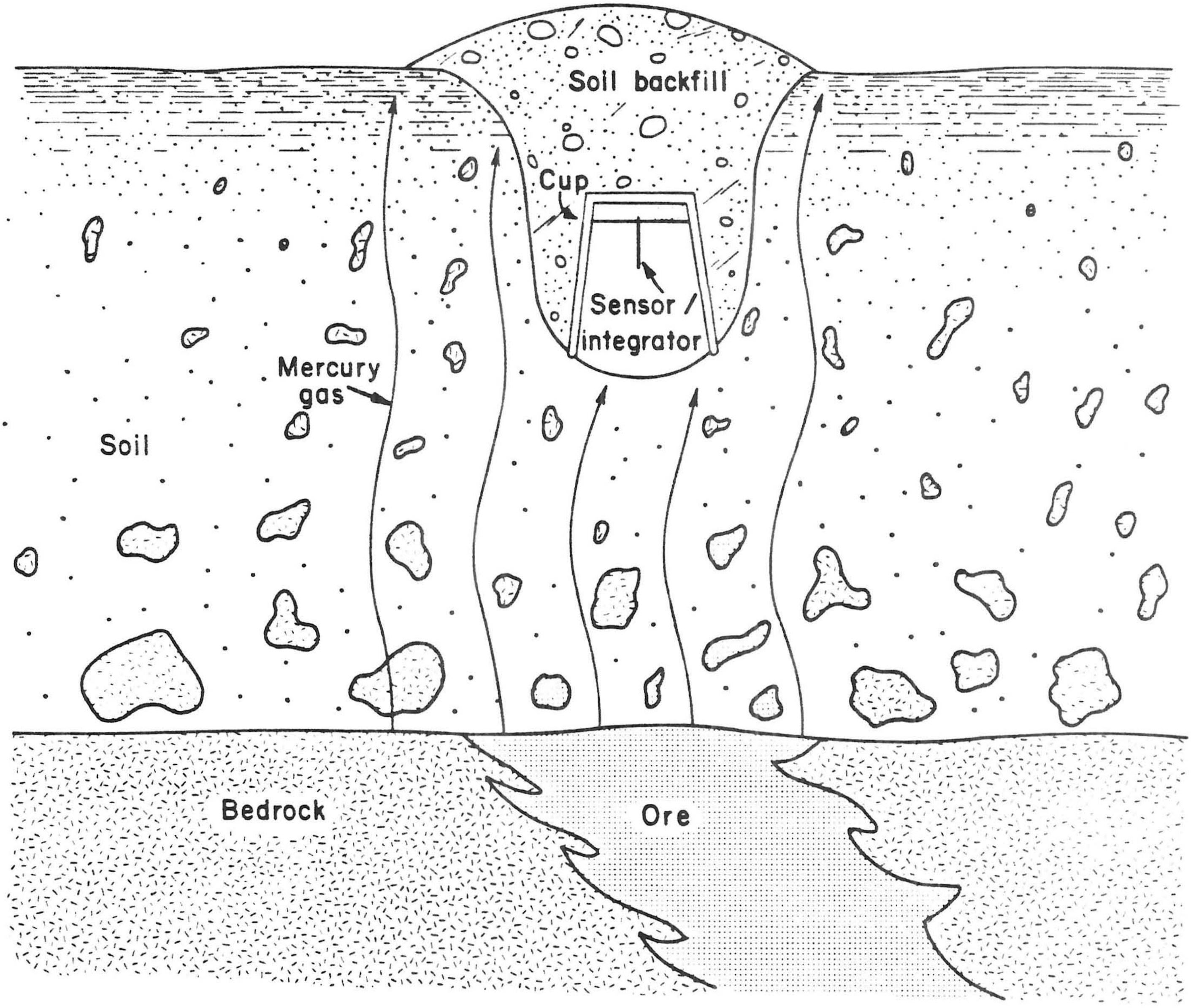


Figure 4: Schematic diagram illustrating the application of Aurex Cups in the measurement of mercury gas. Diagram from Earth Search Inc., 1985.

MERCURY IN BASE AND PRECIOUS METAL MINERAL DEPOSITS - CASE HISTORIES

A number of Hg-gas surveys have been conducted over known Hg-bearing mineral deposits in a variety of geological settings. The premise upon which this type of survey is undertaken is the occurrence of Hg with the mineralization. This association has been reported by a number of authors (Table 1) and the application of Hg-gas surveys to the search for volcanic and sedimentary rock hosted disseminated gold deposits have been described in the literature. Earth Search Inc. (1985) indicate a close and reproducible correlation was observed between Hg-gas measured using the AUREX system and the Hg and Au values in the host rocks to the gold deposits in the Cripple Creek and Victor mining districts in Colorado.

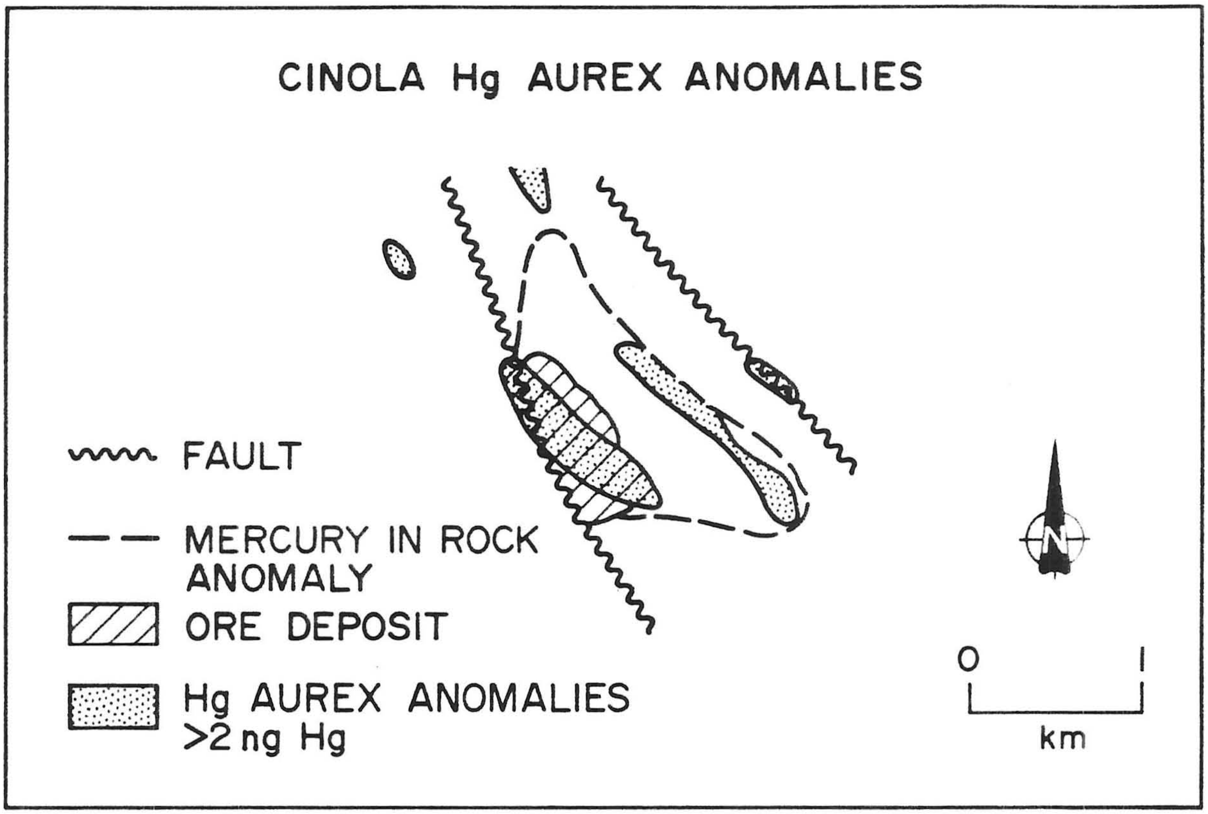
Table 1. Partial summary of mineral deposits with high concentrations of associated mercury (taken from Earth Search Inc., 1985)

DEPOSIT	REFERENCES
Precious Metals:	
1. Carlin-Cinola Disseminated Gold Deposit	Radke et al., 1972; Champigny and Sinclair, 1982
2. Archean Greenstone Gold Deposits	Weber and Stephenson, 1972
3. Silver/Lead/Zinc Vein Deposits	Lovering et al., 1966
Base Metal Sulphides:	
1. Massive Sulphide Deposits	Ryall, 1979; Wu and Mahaffey, 1978
2. Red Bed Copper Deposits	Boyle, 1974
3. Stratabound Sedimentary Sulphides	Ryall et al., 1981
4. Complex Pb-Zn-Ag Ores	Gustavson, 1976; Rose et al., 1979
5. Nickel/Cobalt Arsenide Deposits	Boyle, 1974
Exhalative Hot Springs Deposits:	
1. All Cinnabar Deposits	Koksoy and Bradshaw, 1969
2. Hot Springs Antimony Deposits	Koksoy and Bradshaw, 1969
3. Hydrothermal Fluorite Deposits	Rose et al., 1979
4. Barite Deposits	Friedrich and Pluger, 1971
Unconformity-Vein-type Precambrian Uranium Deposits	Ryall et al., 1981
Some Tin/Tungsten Contact Metasomatic Deposits	Levinson, 1980
Geothermal Areas	Matlick and Buseck, 1976; Phelps and Buseck, 1980

Other Hg-gas anomaly studies have been conducted at Hemlo in Ontario, a number of silver/base metal/gold-copper deposits in Wyoming, Montana and Colorado, and at the Cinola disseminated gold deposit in British Columbia (Earth Search Inc., 1985). The results from the Cinola and Hemlo studies are described in more detail below.

CINOLA: The Cinola disseminated gold deposit on the Queen Charlotte Islands in British Columbia occurs within conglomerate, siltstone and sandstone as free gold in quartz veins and as micron-sized particles associated with iron sulphides in a silicified altered zone. This epithermal system is also characterized by the association of arsenic, mercury and antimony with the gold. The deposit is overlain by a maximum of 35 m of glacial till topped by dense forest cover. Outcrop is scarce in the vicinity of the deposit. Champigny and Sinclair (1982) studied mercury contents in soil and rock at the deposit and indicate the Cinola ore is characterized by a 20 times enrichment in mercury (2.2 ppm) when compared to similar unmineralized rocks. The results of the mercury soil survey (both A and B horizons) indicate a significant mercury anomaly is present; however, the anomaly has been transported east of the deposit down the topographic gradient by groundwater action (Fig. 5; bottom). The results of an AUREX Hg-gas survey at Cinola (Earth Search, 1985) indicated a reproducible anomaly ranging from 2.2 to 4.3 nanograms against a background of less than 2 nanograms. This anomaly has not been displaced in the manner of the Hg soil anomaly and also provides a smaller and more accurate reflection of the location of mineralization (Fig. 5; top).

HEMLO: An orientation Hg-gas survey conducted over the Corona-Teck East and West ore zones in the Hemlo Gold deposit in Ontario indicated distinct Hg-gas anomalies associated with the mineralization (Fig. 6). A total of 150 Aurex Cups were planted using 25 m spacings on three lines 75 m apart. The three lines were perpendicular to the strike of the host rocks and mineralization. At the Hemlo East Zone a 3-6 nanogram Hg anomaly was delineated against a background of less than 2 nanograms Hg. The East Zone is overlain by approximately 50 m of glacial overburden. Similar results, in terms of anomaly:background contrast was identified over the West Zone except that this anomaly was, in, part, shifted to the south of mineralization. The shift was



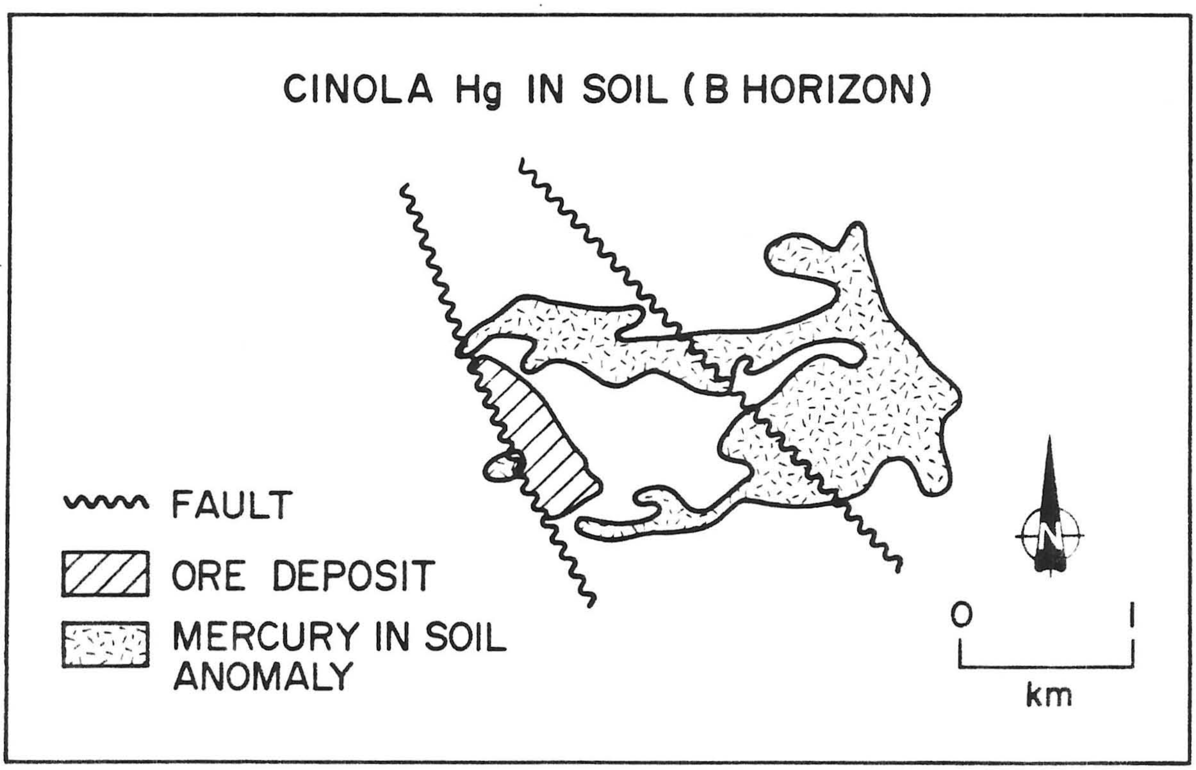


Figure 5: Top: Comparison between mercury anomalies in bedrock and those delineated with the Aurex Cup detection system, Cinola Au deposits, B.C.

Bottom: Mercury in soil overlying the Cinola Au deposit, B.C. Diagram and results from Earth Search Inc., 1985.

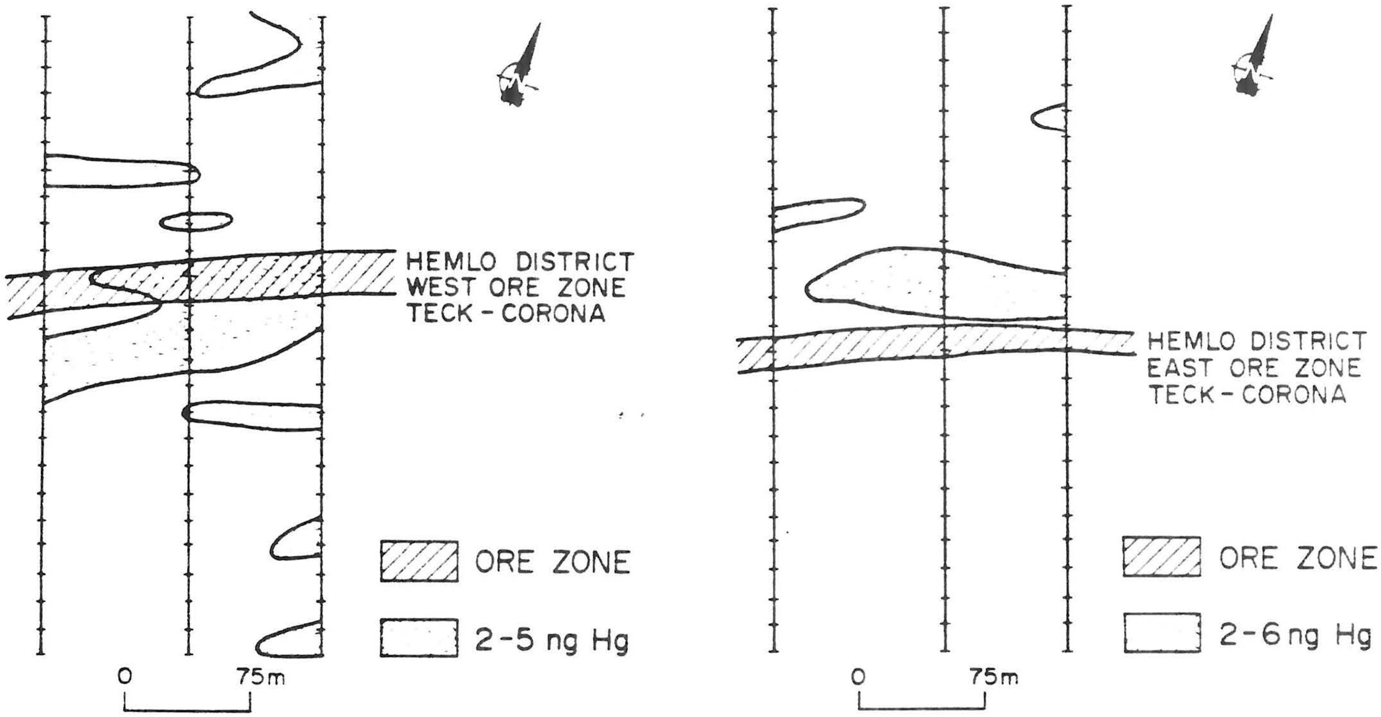


Figure 6: Results of an Aurex cup mercury gas survey at the Hemlo Au deposit, Ontario. Diagram and results from Earth Search Inc., 1985.

attributed to glacial dispersion and/or groundwater transport. This survey indicated that Hg-gas surveys utilizing the AUREX cup system can successfully define Hg-gas anomalies related to Hg-bearing gold mineralization.

It becomes apparent that mercury is associated with a wide range of mineral deposits and the evolution of Hg-gas from these deposits can be measured to give a "halo" effect. The results of 5 Hg-gas surveys designed to test this hypothesis with the Canadian Shield surficial environment are described in the following section.

RESULTS OF THE LYNN LAKE AND SNOW LAKE SURVEYS

The sample lines and grids with the locations of the Aurex Cups relative to the mineralized targets are presented with the discussion of results for each survey. Appendix I contains the raw analytical results of all five surveys. Table 2 summarizes the deposits surveyed, their host rocks and contained mineralization, the nature of the surficial deposits associated with each mineral deposit and survey specifications. The determination of Hg-gas threshold was accomplished using the cumulative frequency method of Tennant and White (1959). Table 3 provides a general statistical summary for each Hg-gas survey.

LYNN LAKE AREA

Rushed Au Showing Survey

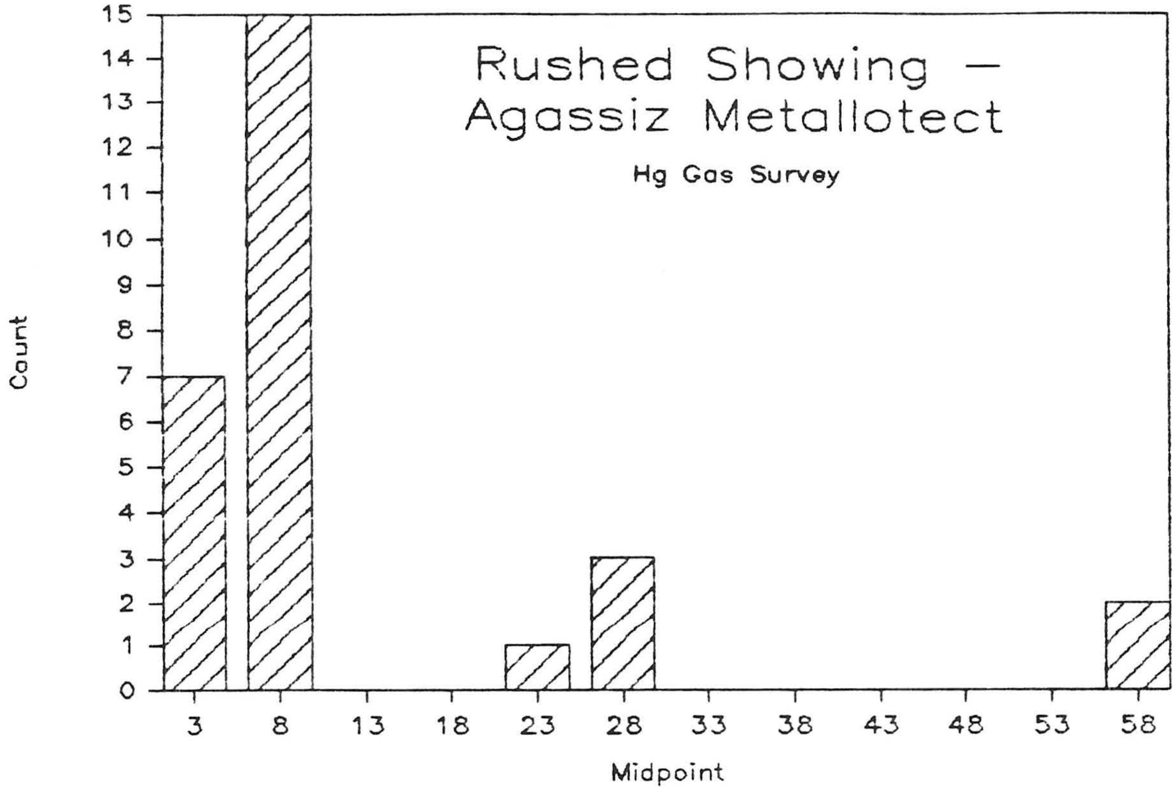
The analytical results from the Rushed Showing survey indicate a scattered, positively skewed (Fig. 7) data distribution with a range of 3-60 nanograms Hg, an arithmetic mean of 14 nanograms and a variance of 210. With proximity to the Rushed Au showing (Fig. 8; bottom) the variation of Hg concentration indicates that directly over the mineralized zone the Hg-gas analyses are generally at or below the graphically determined threshold of 10 nanograms (Fig. 9). On either side of this trough of low values are 1 (station 2460 - 30 nanograms) and 2 (stations 2467 and 2468 - 22 and 29 nanograms) sample Hg-gas anomalies that resemble a "rabbit's ear" anomaly configuration. Single sample anomalous Hg-gas analyses are present at station 2465 (57 nanograms), station 2472 (60 nanograms) and station 2477 (27 nanograms); however, none of these anomalies are associated with known mineralization. The rabbit's-ear configuration between stations 2461 and 2469 closely resembles the results for As in black spruce twigs reported in Fedikow (1984) from a preliminary biogeochemical survey over the Rushed Showing.

Table 2. Summary of the geology, mineralization, nature of the surficial deposits overlying the mineral deposits surveyed with the AUREX CUP DETECTION SYSTEM in 1985 and survey specifications.

Survey Area	Deposit and Description	Nature and Thickness of Surficial Deposit	Survey Specifications
1. Lynn Lake	Frances Lake Zn-Pb-Cu-Au-Ag Deposit near solid - solid sphalerite, galena, chalcopyrite, pyrite in felsic tuff and reworked pyroclastic volcanic rocks	oxidized and unoxidized sandy till topped by 1-2 cm of humus; wet, organic-rich mud; frozen silty grey clay overlain by 8-10 cm of black-brown humus; 1-10 m to bedrock	15 m (50') cup spacing; 17 cups planted along one line
	Rushed Au Occurrence (Agassiz Metallotect): near solid-solid arsenopyrite, pyrite, pyrrhotite in intermediate tuff and clastic sedimentary rocks	permafrost blonde sphagnum; black-reddish brown humus; unoxidized and oxidized sandy till topped by 2-3 cm of humus and 2-3 cm of sphagnum; granitic and basaltic pebbles and cobbles in the above deposits; less than 1 m to bedrock	5 m (16') to 50 m (165') cup spacing; 28 cups planted along one line
2. Snow Lake	Rod Cu-Zn Deposit: near solid-solid chalcopyrite, sphalerite, arsenopyrite, pyrite, pyrrhotite in quartz-phyric felsic pyroclastic and volcaniclastic rocks	red-black-brown humus; beige clay mixed with unoxidized white sand; black, organic-rich mud; red-yellow-brown sand topped by 5-7 cm humus, occasional basaltic pebbles and cobbles in the above profile; 1-6 m to bedrock	30 m (100') over the deposit and 61 m (200') cup spacing away from the deposit; 70 cups planted along six lines
	Stall Cu-Zn Deposit: near solid-solid chalcopyrite, sphalerite, pyrite pyrrhotite in quartz-phyric felsic rocks	blonde-black-brown permafrost and non-permafrost peat overlain by variable thickness of sphagnum; 7 m to bedrock	15 m (50') over the deposit and 30 m (100') cup spacing away from the deposit; 31 cups planted along two lines
	Kobar Pb-Ag Occurrence: near solid to solid galena, sphalerite, pyrite and chalcopyrite hosted by rusty weathered and silicified biotite-quartz-garnet gneiss (sedimentary rocks)	clay-rich overlain by 1-3 cm of humus; generally less than 1-2 m to bedrock	8 m (25') over the deposit and 15 m (50') cup spacing away from the deposit; 10 cups planted along one line

Table 3: Statistical summary of Hg-gas surveys in the Lynn Lake and Snow Lake areas. Units for Hg measurements are in nanograms.

	NO. OF CUPS	$\bar{X}$	S.D.	Variance	Minimum	Maximum
1. LYNN LAKE AREA						
i) Rushed Showing, Agassiz Metallotect (Au)	28	14	15	210	3	60
ii) Frances Lake Deposit (Zn-Cu)	18	8	8	64	2	39
2. SNOW LAKE AREA						
i) Rod Deposit (Cu-Zn)	70	21	57	3231	2	445
ii) Stall Lake Deposit (Cu-Zn)	31	7	2	5	2	10
iii) Kobar (Pb-Ag)	10	6	2	5	2	10



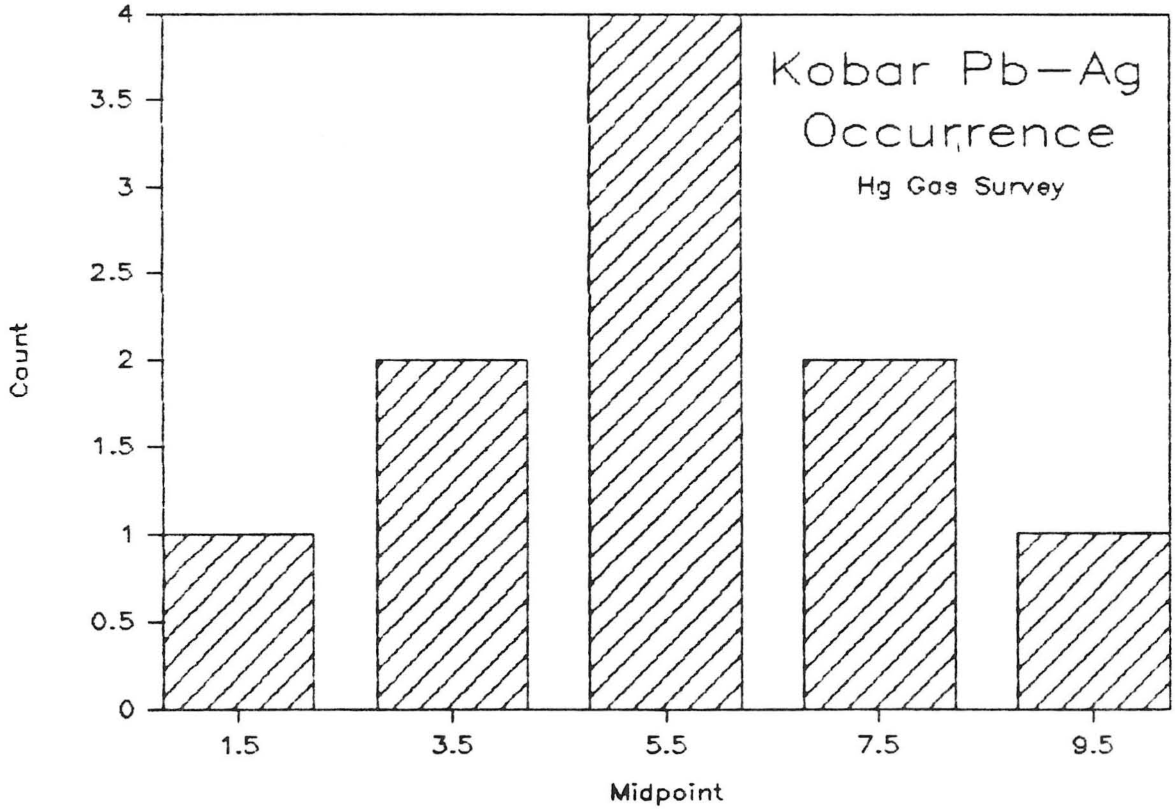
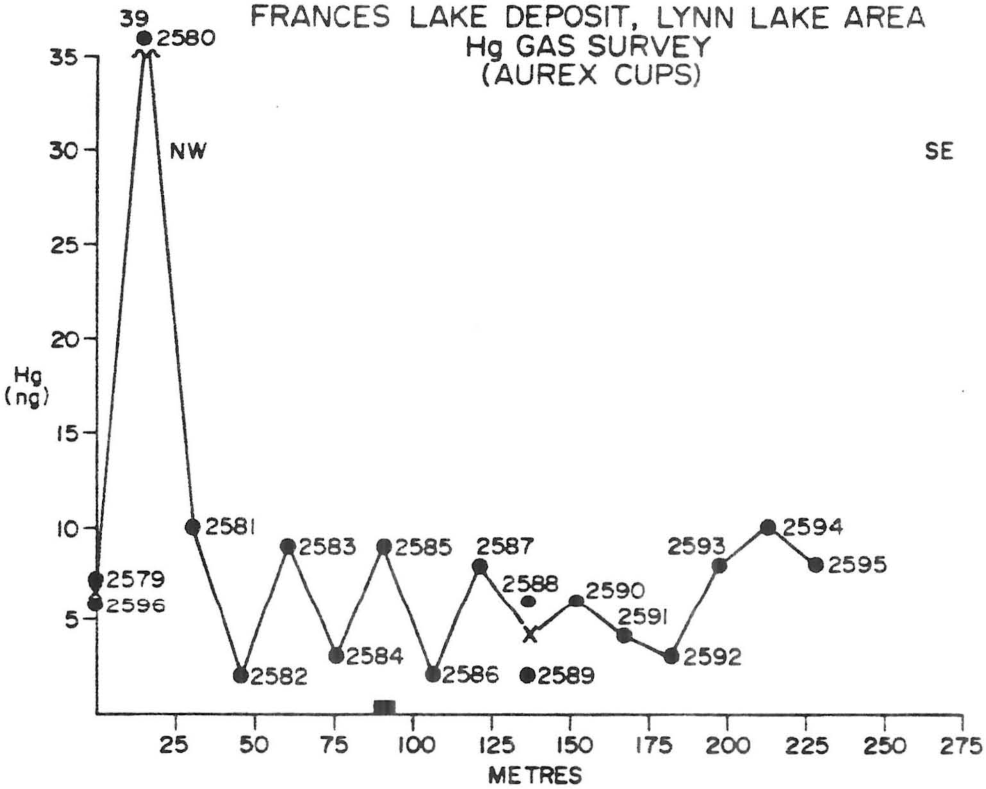


Figure 7: Top: Mercury gas data distribution for the Rushed Au showing, Lynn Lake area.
Bottom: Mercury gas data distribution for the Kobar Pb-Ag occurrences, Snow Lake area.



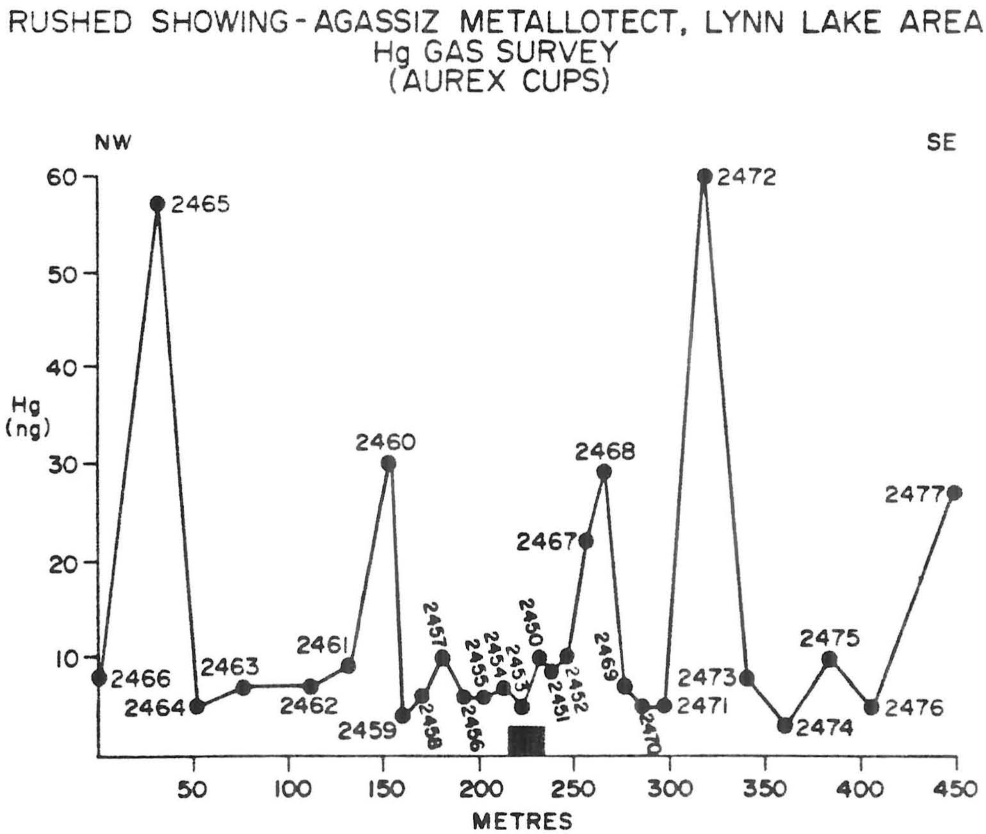
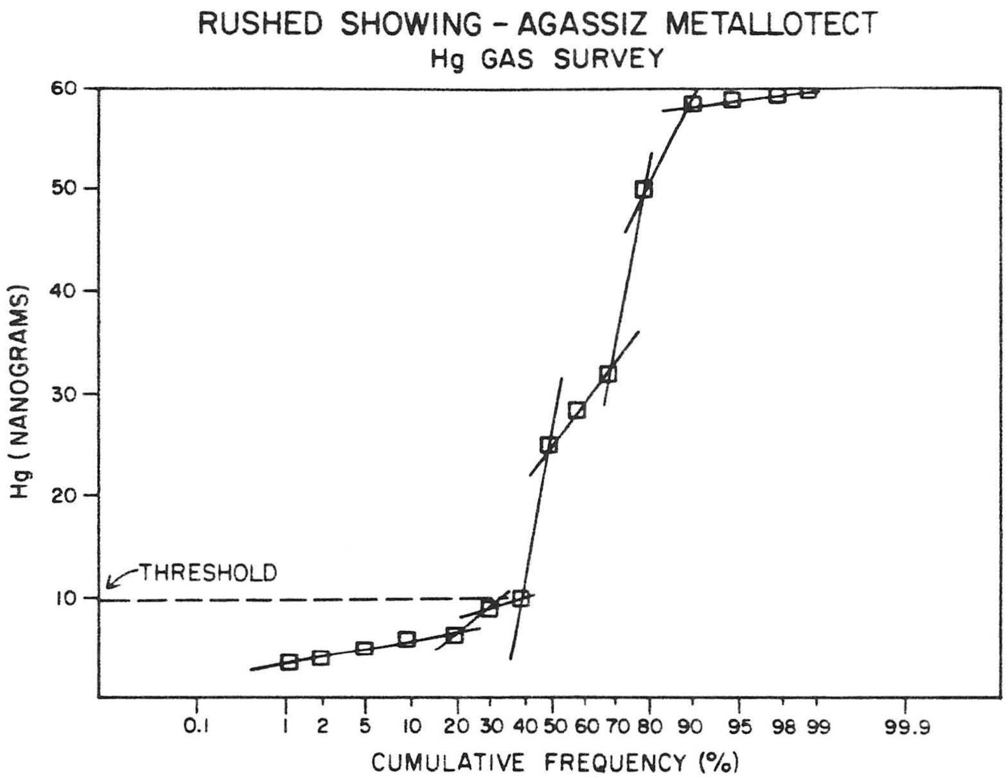


Figure 8: Top: Aurex cup survey results for the Frances Lake Zn-Cu deposit, Lynn Lake area.
Bottom: Aurex cup survey results for the Rushed Au showing, Lynn Lake area.



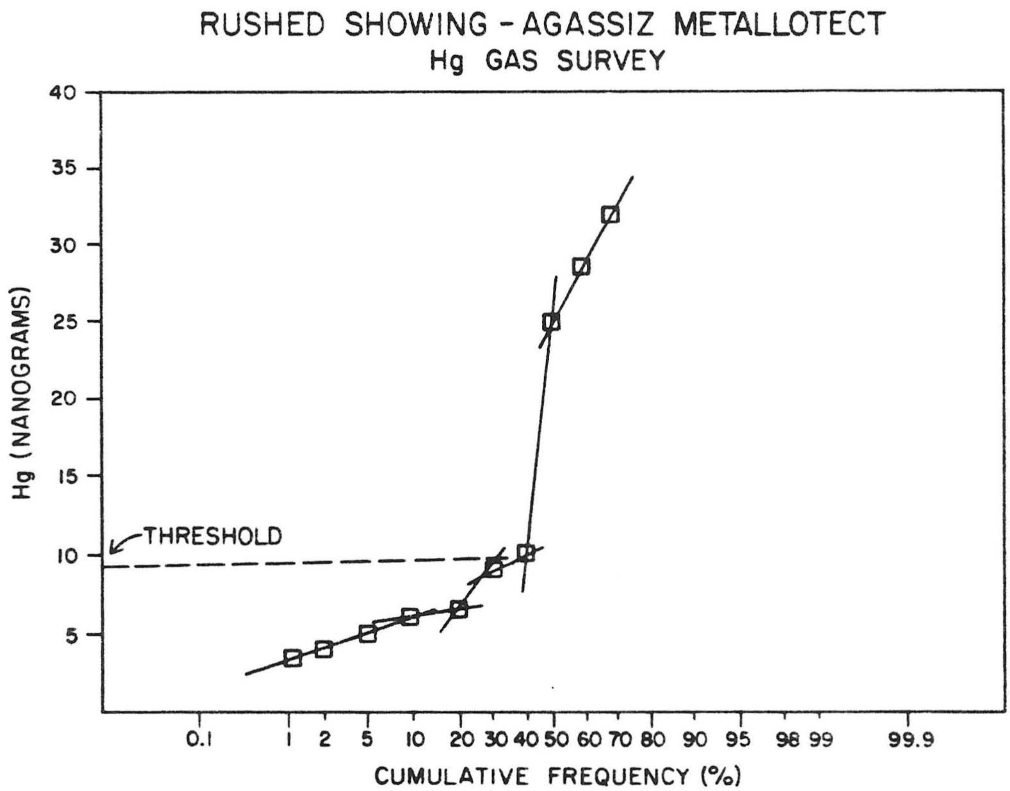


Figure 9: The cumulative frequency determination of mercury gas threshold in the Rushed Au showing survey.

Frances Lake Zn-Cu Deposit Survey

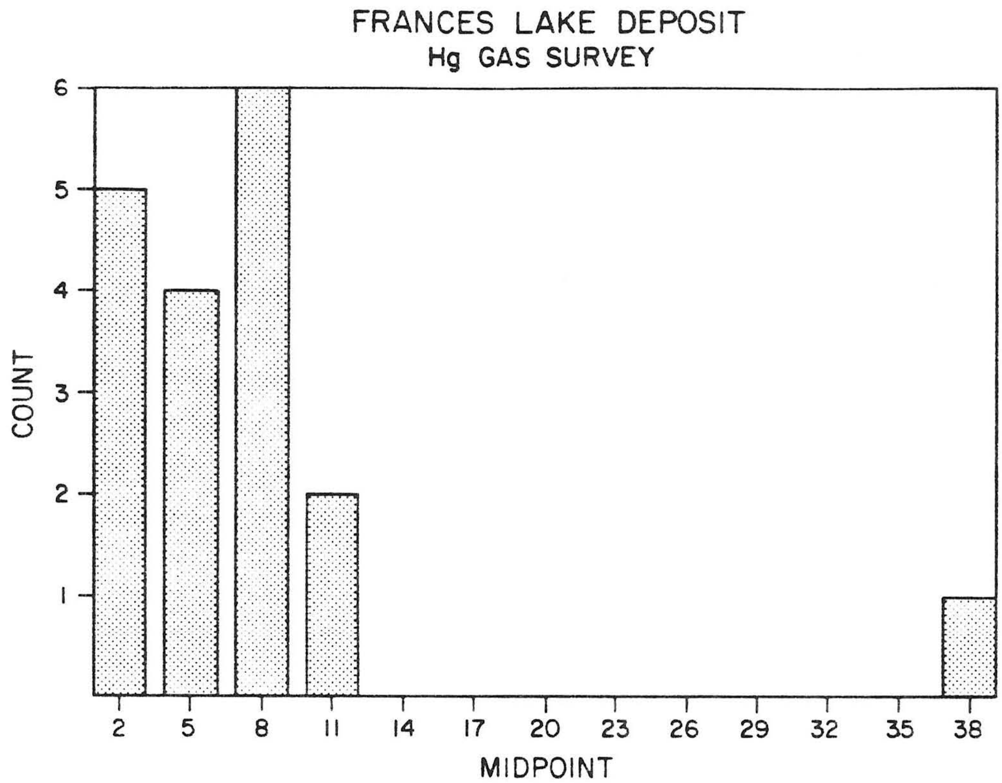
The results from the Frances Lake deposit survey range from 2-39 nanograms Hg with an arithmetic mean of 8 nanograms Hg. The distribution of the Hg-gas data indicates the clustering of a single discrete population characterized by 17 analyses at less than 10 nanograms Hg (Fig. 10; top). Only one analysis (Fig. 8; top, station 2580 - 39 nanograms Hg) is greater than the graphically determined threshold of 10 nanograms (Fig. 10; bottom). There is no deflection in the Hg-gas profile indicating proximity to the surface projection of the Frances Lake mineralization (Fig. 8; top). The single anomalous Hg analysis is obtained from a cup planted in oxidized sandy till 300 m northwest of the Frances Lake deposit.

SNOW LAKE AREA

Stall Lake Cu-Zn Deposit Survey

Two lines of Aurex Cups were run over the surface projection of the Stall Lake Cu-Zn mineralization. The cups were planted on 15 m centres with 30 m line spacing. Raw data, Aurex Cup station numbers and the geophysical expression of the deposit are illustrated in Figure 11.

The entire survey area is overlain by wet and permafrost peat bog so that the results of this survey are effectively standardized in terms of the nature of the overburden. The results (Fig. 11) range from 2-10 nanograms Hg with an arithmetic mean of 7 nanograms Hg. The data are negatively skewed without suggestion of two or more discrete populations (Fig. 12). There is no suggestion of Hg-gas enrichment or depletion with proximity to mineralization and there is also an absence of any kind of recognizable trend in this survey. The graphically determined threshold of 3 nanograms Hg (Fig. 13) indicates that 88% of the analytical results are above threshold. The absence of any recognizable trend, however, must preclude the implications of the graphically determined threshold. Otherwise, the alternative explanation must be that the entire survey area is anomalous in Hg-gas and the Aurex Cups were not sited far enough from the target in order to approximate



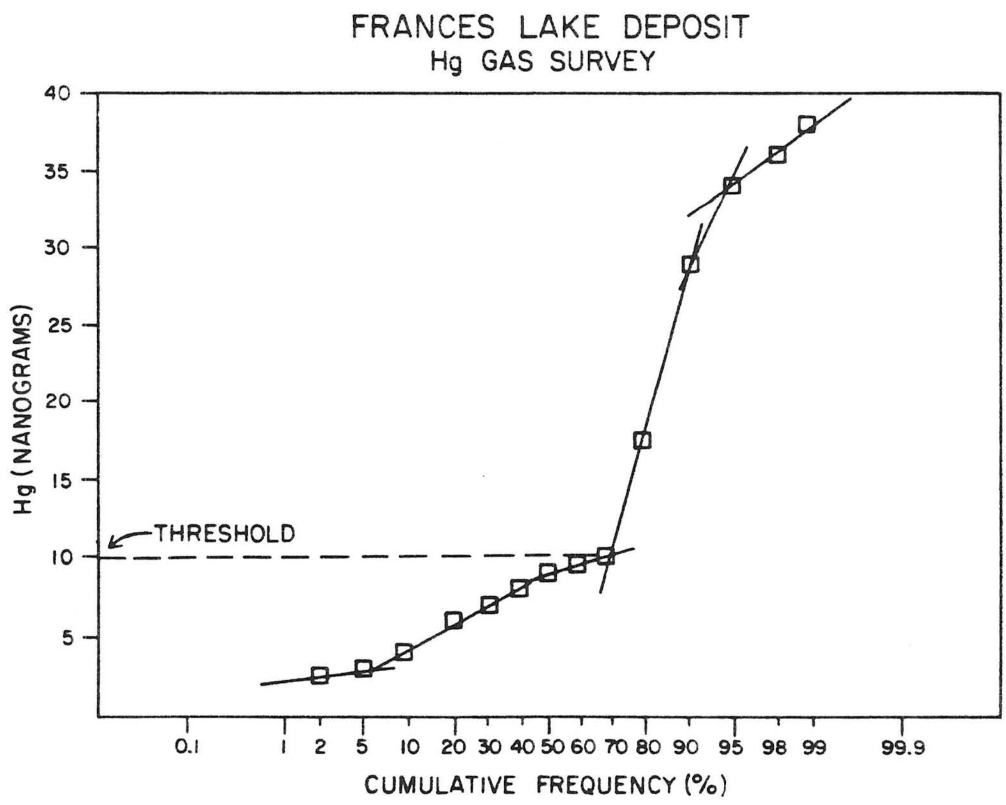


Figure 10: Top: Mercury gas data distribution for the Frances Lake Zn-Cu deposit, Lynn Lake area.

Bottom: The cumulative frequency determination of mercury gas threshold in the Frances Lake Zn-Cu deposit, Lynn Lake area.

the background Hg-gas contents. The latter explanation is probably spurious since, historically, Hg-gas anomalies are restricted to the immediate vicinity of the mineralized target (cf. Hemlo survey, Earth Search Inc., 1985; Zonghua and Yangfen, 1981). The results for the Aurex Cup survey must therefore be considered to be negative.

Kobar Pb-Ag Occurrence Survey

A total of 10 Aurex Cups were inserted along a single line over the Kobar Pb-Ag occurrence in Snow Lake. The results of the Hg analyses indicate that despite an overburden depth of less than 1 m there is no apparent response to the Hg-gas survey. The Hg analyses range from 2-10 nanograms Hg with an arithmetic mean of 6 nanograms. The Hg-gas is normally distributed (Fig. 7; bottom). There is a poorly defined 4 nanogram threshold determined in Figure 14. There appears to be no response of the Kobar mineralization to the Aurex Cup Hg-gas survey (Fig. 15); apparently the clay-rich nature of the overburden has effectively sealed any Hg-gas evolving from this mineralization.

Rod Cu-Zn Deposit

The Hg-gas analyses for the Rod deposit survey range from 2-445 nanograms Hg with an arithmetic mean of 21 nanograms, a standard deviation of 57 nanograms and a variance of 3231 indicating a highly variable data distribution. This variability is reflected in Figure 16 as a positively skewed lognormal distribution with 12 samples having Hg-gas analyses greater than the graphically determined threshold of 10 nanograms (Fig. 17). The mean Hg-gas content of 21 nanograms represents the highest average content in any of the 5 surveys undertaken. In addition, the Rod Mine data are also the most variable with the greatest calculated variance. The variability is related to a second population of Hg-gas values that range from 24-445 nanograms Hg (12 samples) representing a marked departure from the main population of 58 samples with 10 nanograms or less. The value of 445 nanograms Hg represents the highest Hg-gas measurement obtained in the 5 surveys.

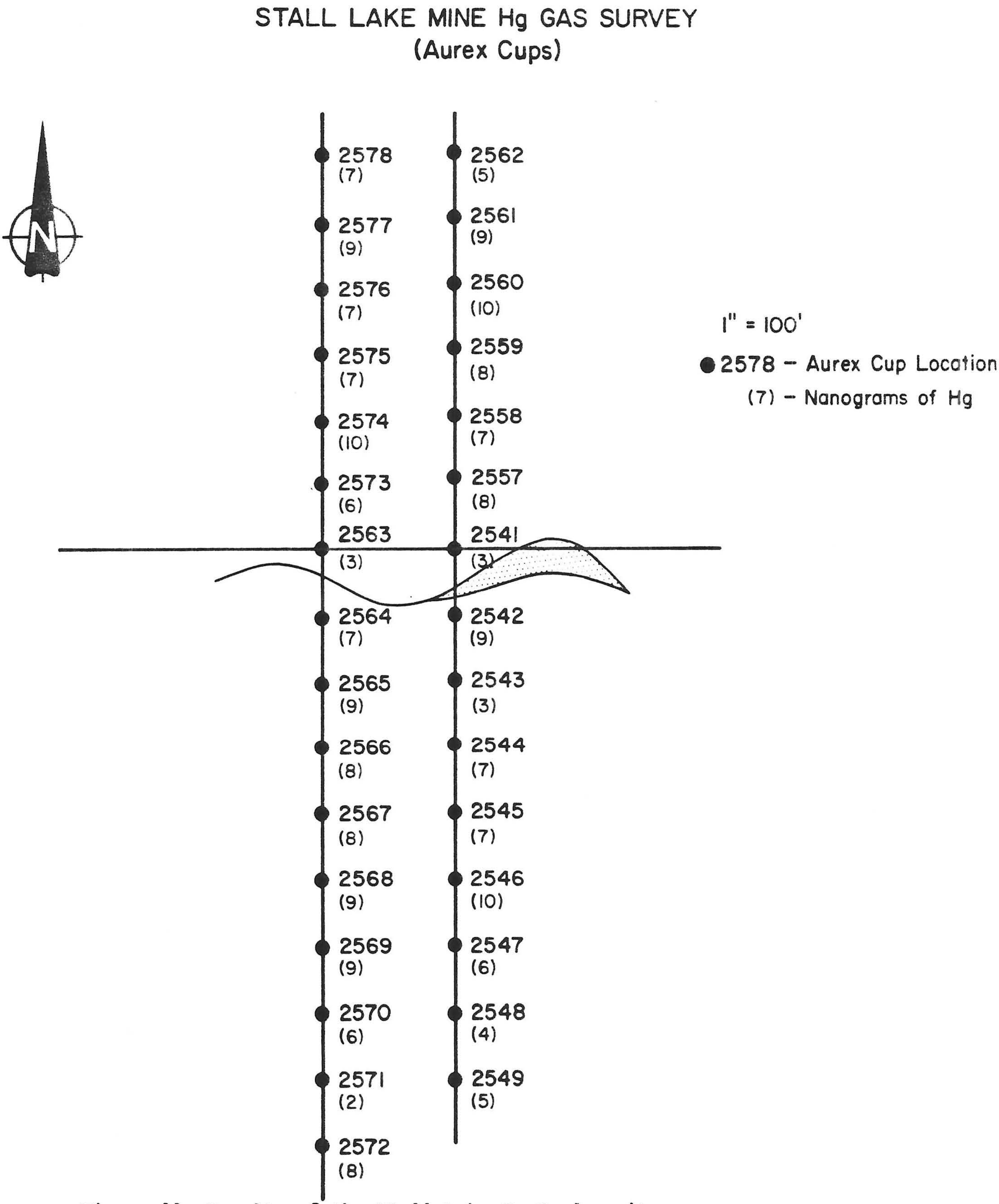


Figure 11: Results of the Stall Lake Cu-Zn deposit mercury gas survey. Scale 1:1200

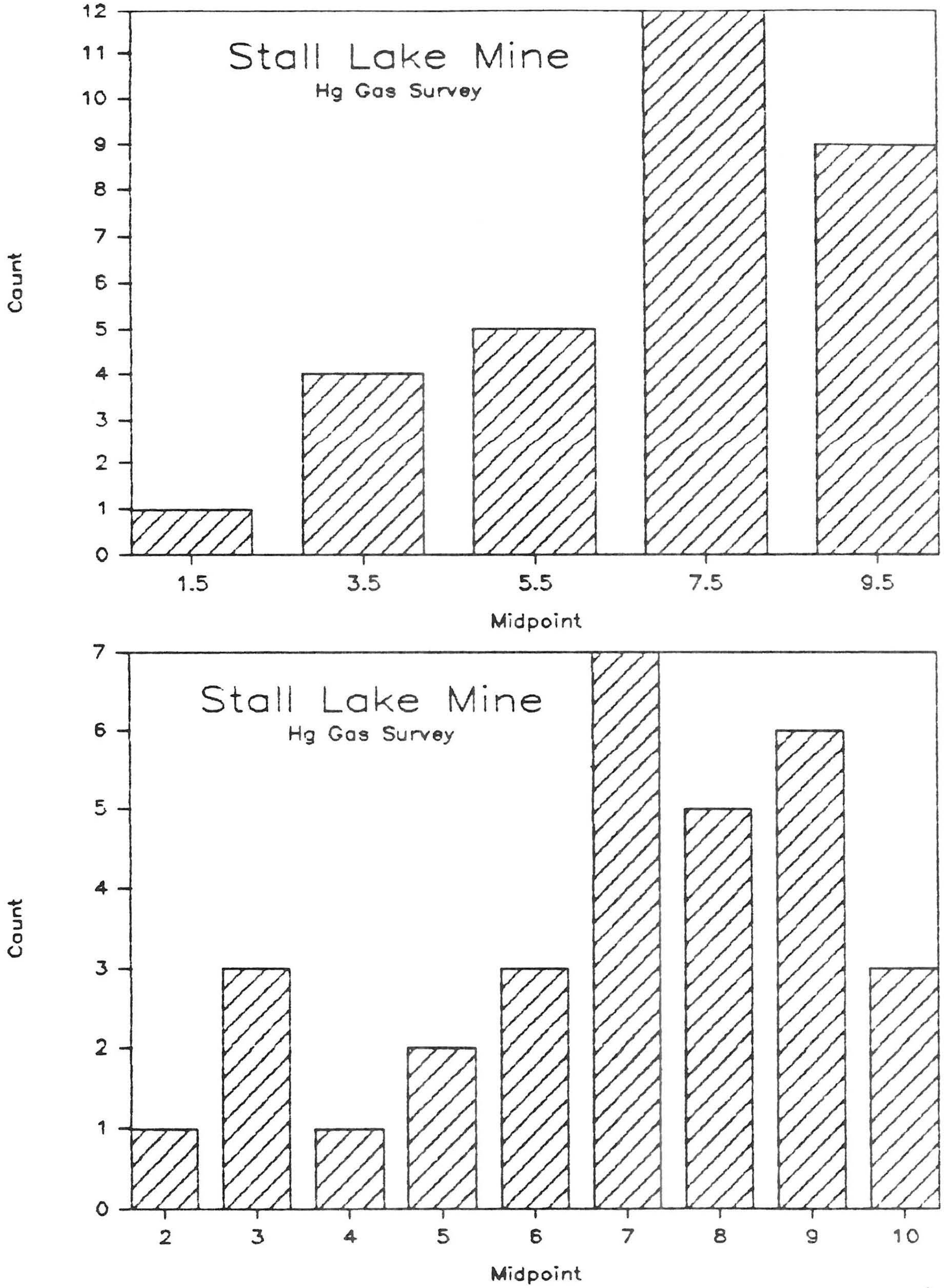
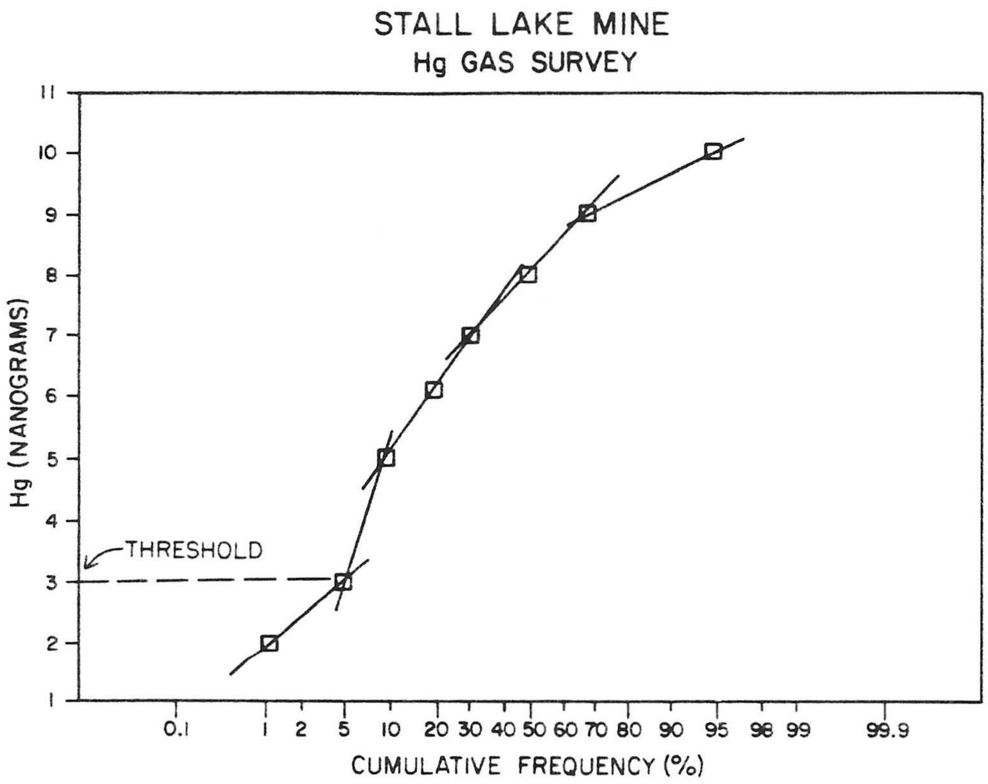


Figure 12: Mercury gas data distribution for the Stall Lake Cu-Zn deposit.



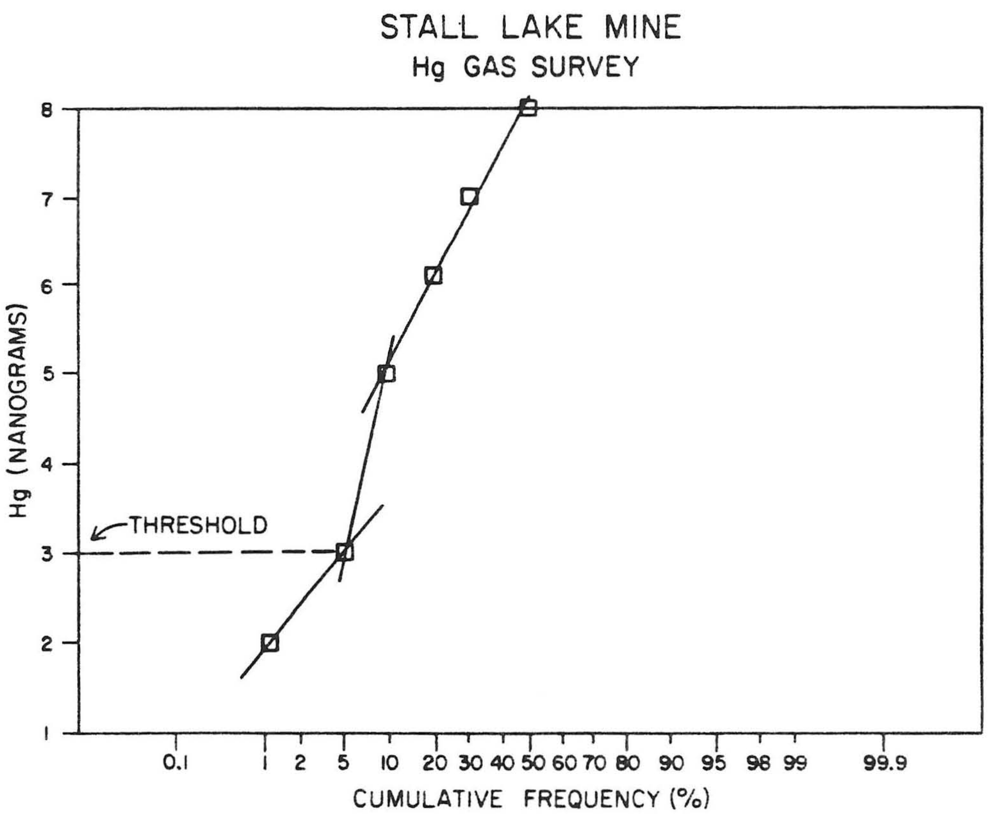
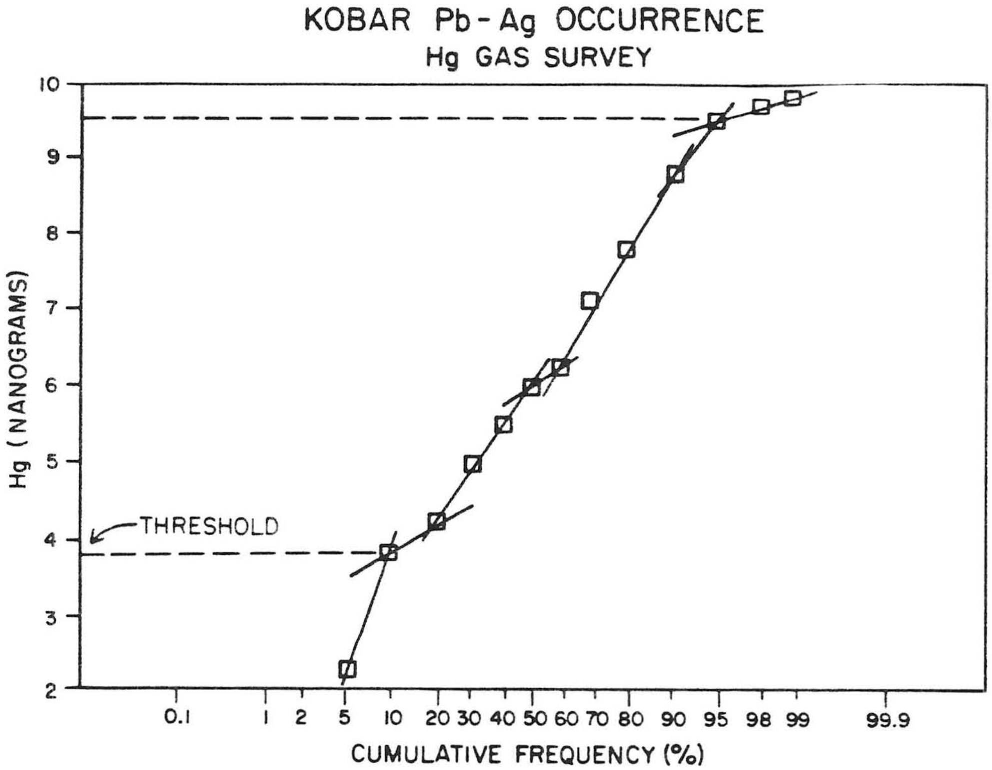


Figure 13: The cumulative frequency determination of mercury gas threshold in the Stall Lake Cu-Zn deposit survey.

Figures 18 and 19 represent plots of the analytical results obtained from the Rod Mine survey. In general, the highest Hg-gas measurements do not correspond to the surface projection of the orebody; however, there is a predominance of samples with analyses greater than 10 nanograms Hg over the orebody and from the northwest portion of the grid (8 samples on the northwest, 4 on the southeast). Also there are more anomalous samples from the southwest portion of the grid (7 Sa) than from the northeast portion of the grid (5 Sa) including the 445 nanograms Hg analysis. This may be explained in terms of the depth to mineralization. The southwest portion of the orebody is 183 m below surface whereas the northeast portion is 732 m below surface. The predominance of anomalous Hg-gas analyses, albeit small (7 Sa), is a reflection of the fact that the southwest portion of the orebody is closer to surface than the northeast portion. There is, however, no consistent pattern of Hg-gas response to the orebody.



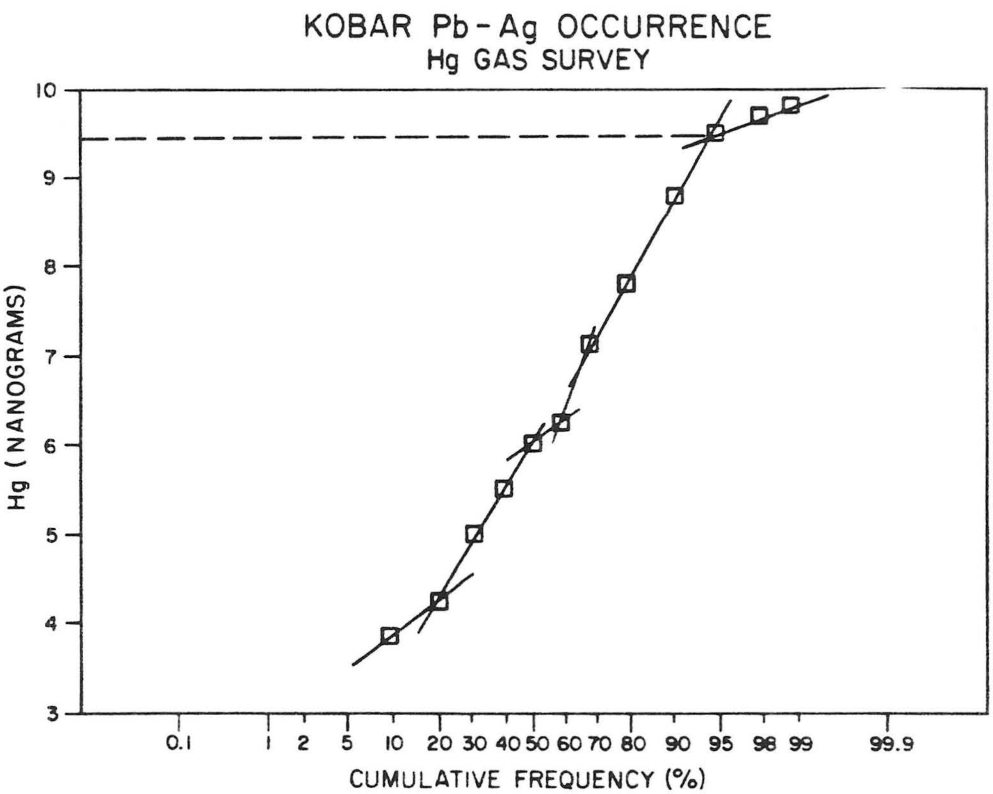


Figure 14: The cumulative frequency determination of mercury gas threshold in the Kobar Pb-Ag occurrence survey.

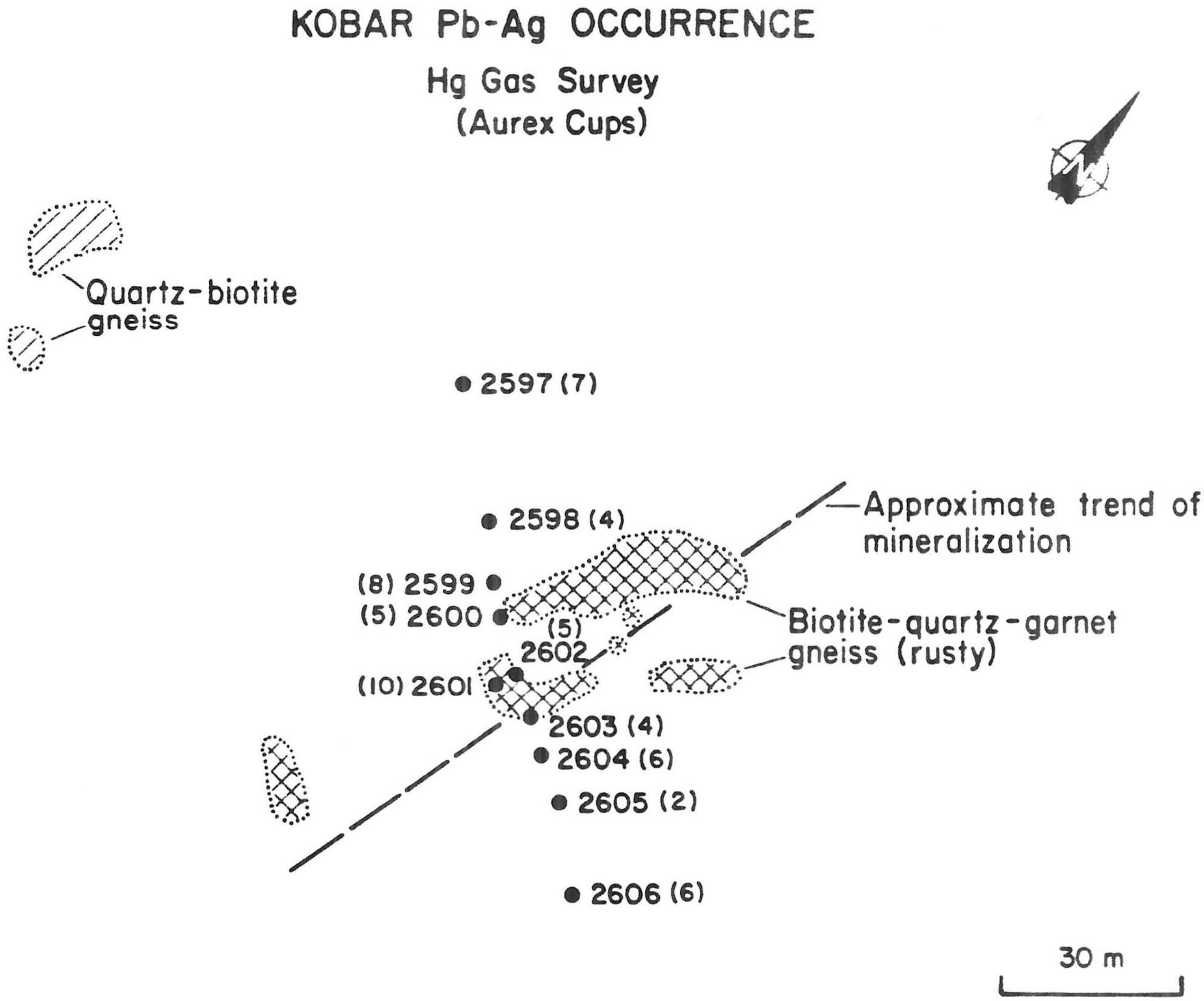


Figure 15: Results of the Kobar Pb-Ag occurrence mercury gas survey. Bracketed figure represents nanograms of Hg; 4 digit number adjacent to sample location represents the Aurex Cup number.

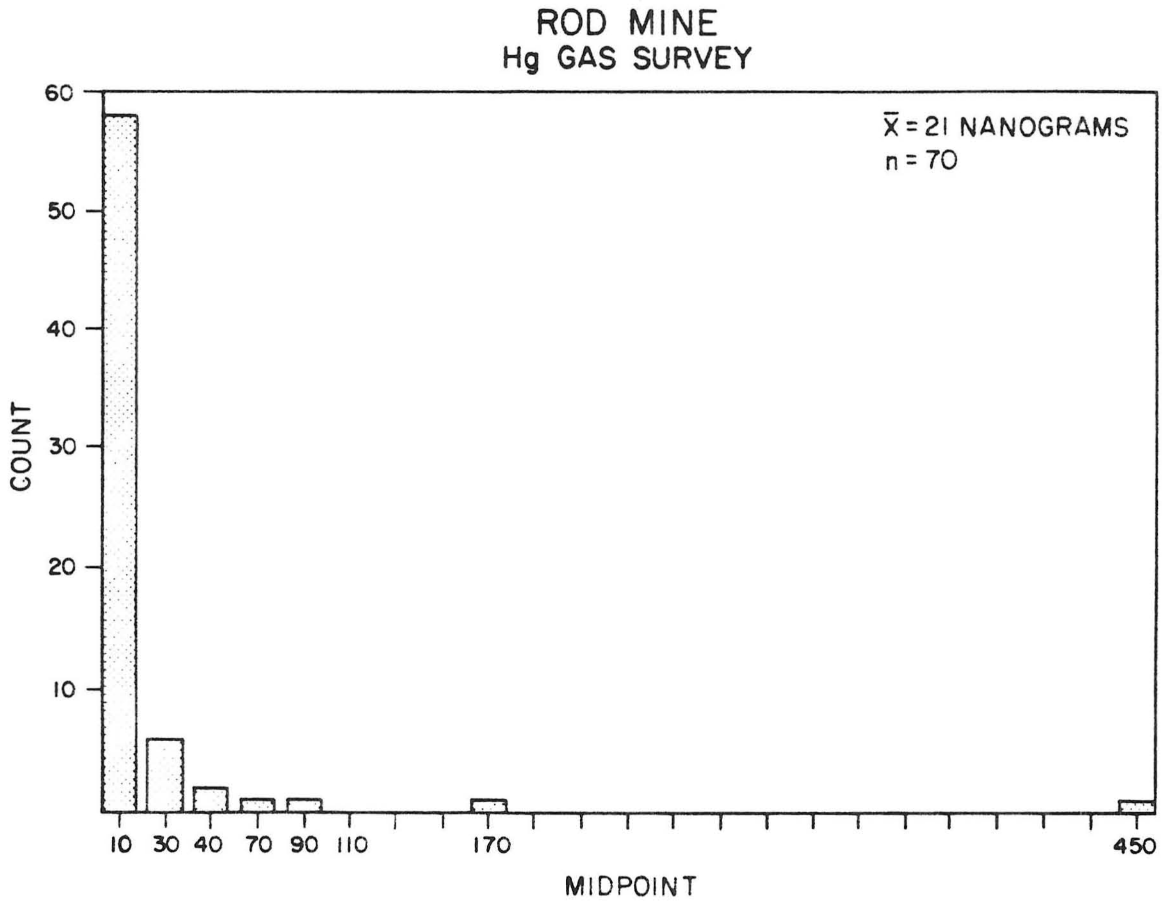
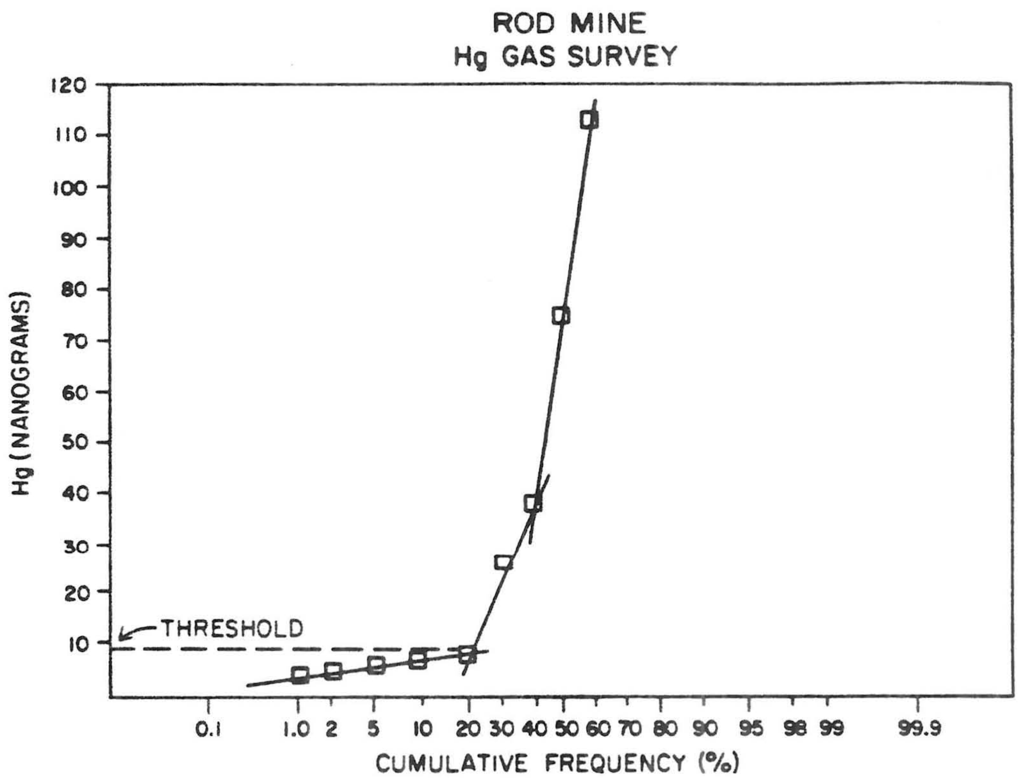


Figure 16: Mercury gas data distribution for the Rod Cu-Zn deposit, Snow Lake.



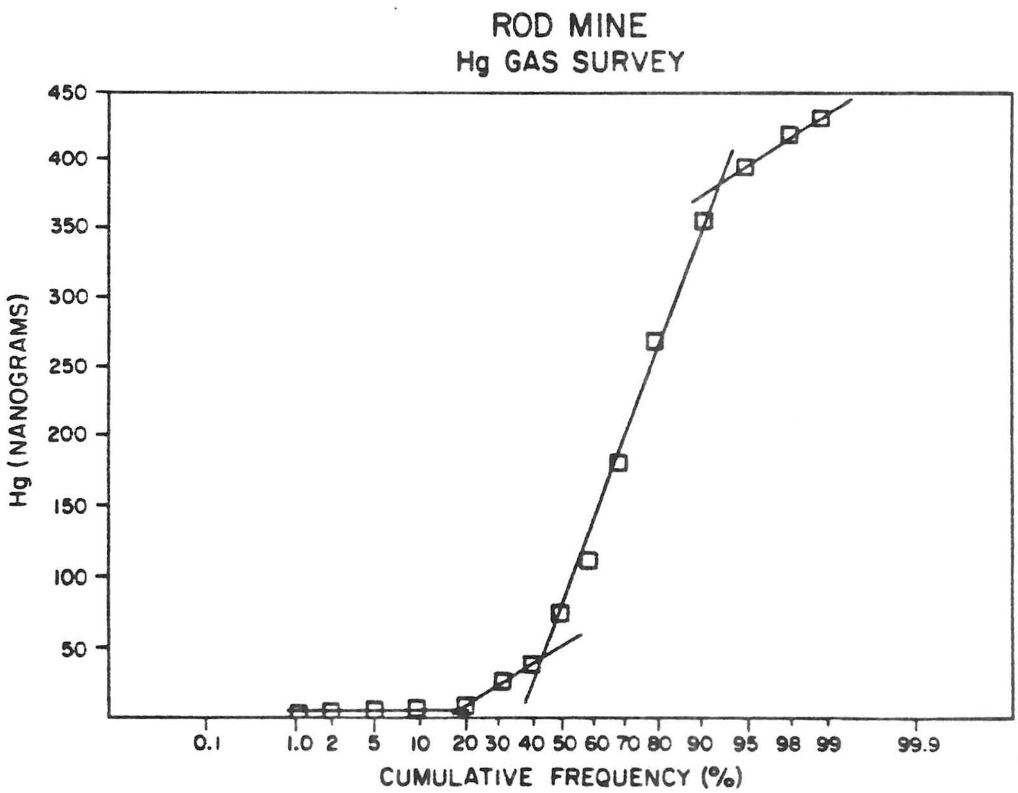


Figure 17: The cumulative frequency determination of mercury gas threshold in the Rod Cu-Zn deposit survey.

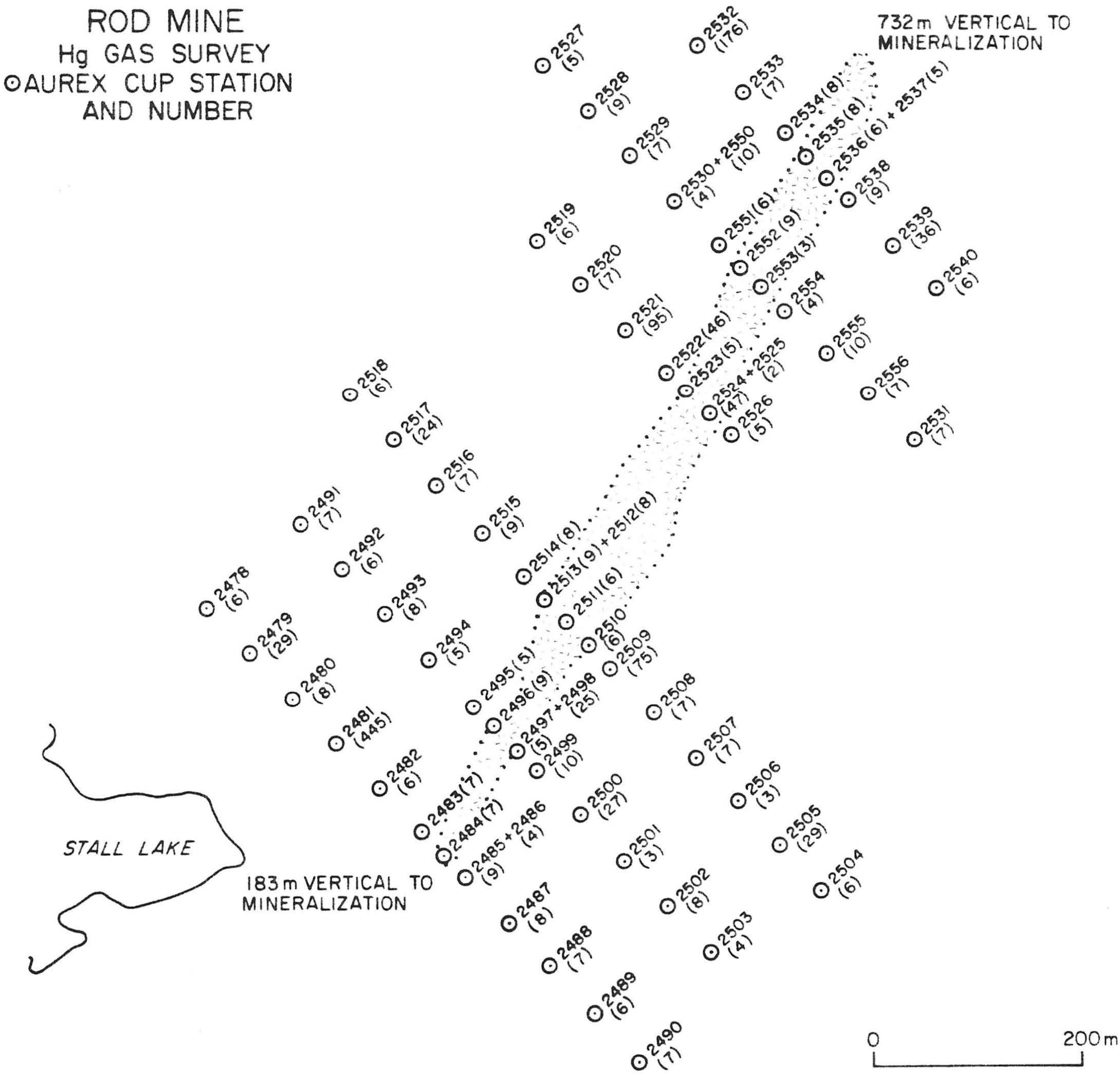


Figure 18: Location of Aurex Cups over the Rod Cu-Zn deposit, Snow Lake area. Bracketed figures represent nanograms of Hg at that station.

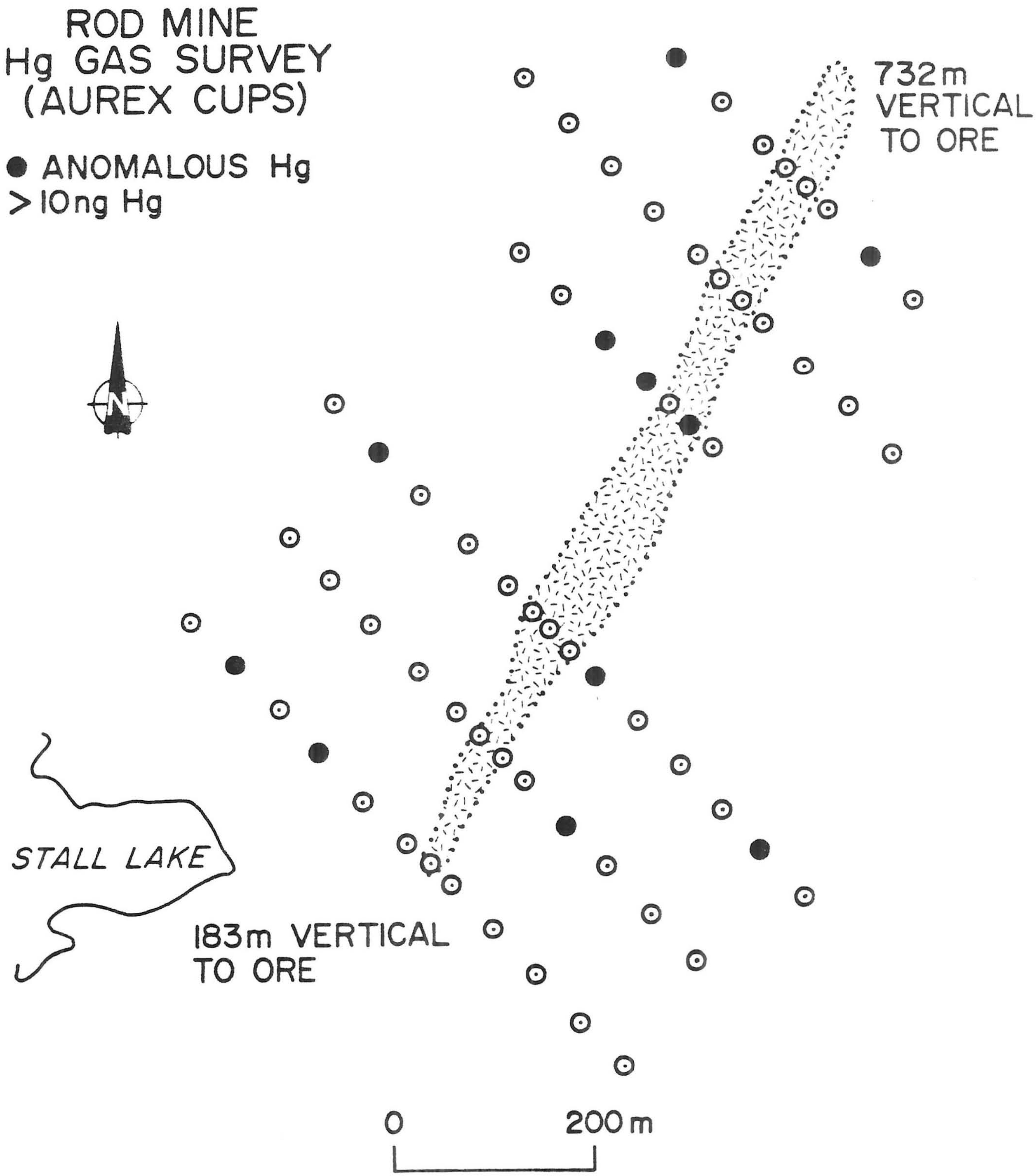


Figure 19: Results of the Rod Cu-Zn deposit mercury gas survey.

MERCURY CONTENT OF MINERALIZATION AT AUREX CUP SURVEY SITES

The results of inductively-coupled argon plasma geochemical analysis of 6 sulphide samples collected from muck at the Kobar Pb-Ag occurrence (Snow Lake) are presented in Table 4. The extraordinary contents of many of the elements in the samples presented in this table is not unexpected in a base-metal rich deposit. Of particular interest are the very high Hg contents which range from 4800 to 9000 ppb in near solid to solid sulphides, greater than those presented for the Cinola deposit (Champigny and Sinclair, 1982a). It is distressing to compare the Aurex Cup Hg-gas results of 2-10 nanograms from the Kobar survey with the Hg content of the mineralization, particularly when this mineralization is covered by an average of 0.3 m of overburden with numerous outcroppings of host rock in the area. The soaking of both the mineralization and the thin overburden at Kobar with meteoric and groundwaters should have resulted in oxidation of the mineralization, generation of Hg vapour and the subsequent measurement of this vapour at surface. Unfortunately this is not the case and the failure to detect Hg-gas anomalies might be explained by the clay-rich nature of the overburden at Kobar. This particular kind of overburden effectively seals the mineralization and/or absorbs Hg-gas thereby preventing its migration.

Table 4. Geochemical inductively coupled argon plasma analysis of 6 sulphide samples collected from the muck at the Kobar Pb-Ag deposit. Sample 00623 represents a sulphidic quartz vein.

Element	Sample Nos.					
	00621	00622	00623	00624	00625	0141
Mo (ppm)	40	46	4	75	49	42
Cu (ppm)	1010	984	272	924	372	1034
Pb (%)	1.40	1.33	0.40	1.41	1.36	1.11
Zn (%)	5.92	7.13	0.09	8.60	8.03	6.67
Ag (ppm)	250	280	19	302	88	286
Ni (ppm)	11	65	44	75	76	47
Co (ppm)	22	25	17	23	34	23
Mn (ppm)	2233	2774	6687	3064	2895	2558
Fe (%)	12.1	13.0	6.4	11.1	13.3	12.3
As (ppm)	65	90	11	62	72	83
U (ppm)	5	5	5	5	5	5
Th (ppm)	1	1	1	1	1	1
Au (ppb)	60	95	1	105	22	110
Cd (ppm)	141	181	1	216	205	162
Sb (ppm)	627	692	19	821	230	681
Bi (ppm)	20	28	12	33	11	32
Hg (ppb)	4800	5200	50	6000	9000	5400

REPRODUCIBILITY OF AUREX CUP Hg ANALYSES

As a check on Hg-gas collection and analytical reproducibility for Hg analyses a total of 9 duplicate pairs of Aurex Cups were implanted during the Hg-gas surveys in Lynn Lake and Snow Lake. Care was taken to ensure that each cup of the duplicate pair was sited in exactly the same type of surficial deposit, i.e., both cups were at the same depth in permafrost peat bog or oxidized till and both cups were sited in overburden with the same apparent moisture content. Proximity to outcrop, ponded waters, vegetation and exposure to direct or indirect sunlight were standardized. Both Aurex Cups used for the assessment of reproducibility were planted and later, following the 30-day Hg-gas collection period, retrieved at the same time.

The analyses from the duplicate Aurex Cup pairs are summarized in Table 5 for the Rod Mine, Kobar and Frances Lake deposit surveys. A brief inspection of these tabled data indicates there is questionable reproducibility of the Hg analyses in the duplicate pairs particularly at Hg levels exceeding 10 nanograms. Below 10 nanograms Hg there also appears to be a wide range in the duplicate analyses but at least with some suggestion of reproducibility. Of the 5 duplicate pairs with Hg analyses less than 10 nanograms Hg the reproducibility of the analyses ranges from 10% (station numbers 2512 and 2513) to 300% (stations 2588 - 2589). Duplicate pair analyses above 10 nanograms Hg are effectively non-reproducible with analyses ranging between 2-47 nanograms Hg and 5-15 nanograms Hg. The fact that high-Hg analyses are non-reproducible is disturbing in light of the magnitude of some of the responses obtained in these surveys. The validity of Hg analyses of 445 nanograms (stations 2481, Rod Mine Survey) and 60 nanograms Hg (station 2472, Rushed Showing Survey) is therefore questionable. The non-reproducible results may be related to instrumental analytical variance or to the simple fact that the seepage of Hg-gas from Hg-bearing sulphide mineralization is not uniform over a 1 m^2 area.

Table 5: Analytical results for duplicate pairs of Aurex Cups for the assessment of analytical and Hg-gas collection reproducibility.

Survey Site	Cup No.	Duplicate Results (nanograms Hg)
Rod Cu-Zn	2485	9
	2486	4
	2497	5
	2498	25
	2512	8
	2513	9
	2524	47
	2525	2
	2530	4
	2550	10
	2536	6
	2537	5
Kobar Pb-Ag	2601	10
	2602	5
Frances Lake Zn-Cu	2588	6
	2589	2
	2579	7
	2596	6

DISCUSSION

Of the five Hg-gas surveys undertaken in the 1985 field season the results for the Stall Lake Cu-Zn deposit and the Kobar Pb-Ag occurrence in Snow Lake and the Frances Lake Zn-Cu deposit in the Lynn Lake area are considered to be negative. The reasons for the failure of the Aurex Cup technique to detect Hg-gas must be directly related to the nature of the overburden at each of these occurrences. The permafrost peat bog overlying the Stall Lake deposit and the organic and clay-rich surficial deposits overlying the Kobar and Frances Lake deposits represent impermeable "caps" to the Hg-gas evolving from the mineralization. The strong absorption of Hg by clay minerals and dispersed colloidal Fe and Mn oxides has been well documented (Saukov, 1946). Although the Aurex Cup Hg-gas collection is based on an integrative or continuous measurement technique the clay and organic-rich overburden at these deposits has effectively sealed the system in the immediate area of the survey. This observation is critical in that Hg vapour anomalies measured at surface would appear to lie directly above primary Hg sources at depth (Zonghua and Yangfen, 1981).

The Rushed Showing near the town of Lynn Lake represents one of the two apparently successful surveys which outlined Hg-gas responses to known mineralized targets. The response obtained from the Rushed Showing survey indicates a trough of low values directly over the mineralization with peaks at either end of the trough. The similarity between these results and those for As in black spruce twigs (Fedikow, 1984) can be compared to Hg soil gas results presented by Zonghua and Yangfen (1981) in a survey of a skarn copper deposit in Shanghai. These results indicate a peak of greater than 180 nanograms Hg per m^3 that corresponds to the updip portion of the mineralized zone. There is a trough of low Hg-gas values, however, over the mineralization (cf. Fig.2, p. 79 and Fig. 4, p. 82) bracketed by another peak on the north side of the trough. This trend is reversed, however, in their Fig. 11 (cf. p. 89). Peaks in the Hg soil gas responses appear to be related to bedding and/or contact planes between the mineralization and the host rock. At the Rushed Showing the "rabbit's-ear" anomaly configuration may suggest mineral zonation in the occurrence rather than any structural pathway for the escape of Hg-gas if, in fact, the "rabbit's ear" configuration is real. This must be questioned, however, since Hg analyses of two samples of near solid to solid pyrrhotite, pyrite and arsenopyrite collected from the Rushed Showing contained only 20 and 15 ppb Hg (ICP analysis). Another consideration pertaining to the results of this particular survey is the relatively thin (less than 1 m) sandy, clay-poor overburden that tops the mineralization. This kind of surficial deposit represents the optimum in porosity and permeability for the migration of soil gases to the surface while at the same time minimizing the absorption reaction between clay minerals, Fe-Mn oxides and Hg-gases.

The results of the Rod Cu-Zn deposit survey provide the highest number of clearly anomalous Hg-gas analyses of any of the five surveys undertaken. It is difficult to relate the anomalous responses to the Rod mineralization that is overlain by a relatively thin, but variable surficial cover.

The anomalous responses in the Rushed Showing and the Rod deposit surveys must be considered in light of the apparent non-reproducibility of the Hg-gas results. Anomalous responses may represent spurious results due to unequal rates of Hg-gas evolution and migration, analytical variance and/or the widely variable surficial cover (i.e., Fe-Mn oxides and clay minerals).

CONCLUSIONS

The conclusions that can be drawn on the basis of these five surveys are as follows:

1. The presence of permafrost surficial cover (peat bog, clay) clay or organic-rich muds effectively inhibits the migration of the Hg-gas in such a manner as to render the Aurex Cup technique questionable;

2. If surficial cover is characterized by a high porosity-permeability medium, such as a low clay till, then evolving Hg-gas can migrate to surface and apparently be measured there using the Aurex Cup technique.

3. The Hg-gas responses may be scattered as in the Rod deposit survey with structural controls on the location of Hg-gas anomalies. Under these circumstances more than a single transect of Aurex Cups may be required to adequately assess the viability of measuring Hg-gas evolving from a mineral deposit. If only the results of stations 2527 to 2531 from the Rod survey (cf. Fig. 19) were assessed then no Hg-gas response to the Rod orebody would have been recognized.

4. The most serious drawback to the Aurex Cup survey is the apparent non-reproducibility of the Hg-gas analysis. Serious consideration must be given to the validity of a high Hg-gas analysis when the results of reproducibility tests in these surveys indicate non-reproducibility of Hg-gas analyses greater than 10 nanograms (i.e. background).

5. The non-reproducibility of the Aurex Cup duplicate pairs spaced 1 m apart indicates the results from Aurex Cups spaced 5 to 50 m apart are questionable. The survey is therefore not cost effective.

6. The background concentration of Hg-gas in the Lynn Lake and Snow Lake areas measured with the Aurex Cup Detection System is 10 nanograms Hg.

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APPENDIX I

Raw Data

SURVEY SITE	STATION NUMBER	MERCURY (nanograms-ng)
Rushed Au Showing--	2450	10
Agassiz Metallotect	2451	9
Lynn Lake Area	2452	10
	2453	5
	2454	7
	2455	6
	2456	6
	2457	10
	2458	6
	2459	4
	2460	30
	2461	9
	2462	7
	2463	7
	2464	5
	2465	57
	2466	8
	2467	22
	2468	29
	2469	7
	2470	5
	2471	5
	2472	60
	2473	8
	2474	3
	2475	10
	2476	5
	2477	27
Frances Lake Zn-Cu	2579	7
Deposit, Lynn	2580	39
Lake Area	2581	10
	2582	2
	2583	9
	2584	3
	2585	9
	2586	2
	2587	8
	2588	6
	2589	2
	2590	6
	2591	4
	2592	3
	2593	8
	2594	10
	2595	8
	2596	6

SURVEY SITE	STATION NUMBER	MERCURY (nanograms-ng)
Kobar Pb-Ag Occurrence, Snow Lake Area	2597	7
	2598	4
	2599	8
	2600	5
	2601	10
	2602	5
	2603	4
	2604	6
	2605	2
	2606	6
Rod Cu-Zn Deposit, Snow Lake Area	2478	6
	2479	29
	2480	8
	2481	445
	2482	6
	2483	7
	2484	7
	2485	9
	2486	4
	2487	8
	2488	7
	2489	6
	2490	7
	2491	7
	2492	6
	2493	8
	2494	5
	2495	5
	2496	9
	2497	5
	2498	25
	2499	10
	2500	27
	2501	3
	2502	8
	2503	4
	2504	6
	2505	29
	2506	3
	2507	7
	2508	7
	2509	75
	2510	6
	2511	6

SURVEY SITE	STATION NUMBER	MERCURY (nanograms-ng)
Rod Cu-Zn Deposit, Snow Lake Area (cont'd)	2512	8
	2513	9
	2514	8
	2515	9
	2516	7
	2517	24
	2518	6
	2519	6
	2520	7
	2521	95
	2522	46
	2523	5
	2524	47
	2525	2
	2526	5
	2527	5
	2528	9
	2529	7
	2530	4
	2531	7
	2532	176
	2533	7
	2534	8
	2535	8
	2536	6
	2537	5
	2538	9
	2539	36
	2540	6
	2550	10
	2551	6
	2552	9
	2553	3
	2554	4
	2555	10
	2556	7
Stall Cu-Zn Deposit, Snow Lake Area	2541	3
	2542	9
	2543	3
	2544	7
	2545	7
	2546	10
	2547	6

SURVEY SITE	STATION NUMBER	MERCURY (nanograms-ng)
Stall Cu-Zn Deposit, Snow Lake Area (cont'd)	2548	4
	2549	5
	2557	8
	2558	7
	2559	8
	2560	10
	2561	9
	2562	5
	2563	3
	2564	7
	2565	9
	2566	8
	2567	8
	2568	9
	2569	9
	2570	6
	2571	2
	2572	8
	2573	6
	2574	10
	2575	7
	2576	7
	2577	9
	2578	7