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DETAILED LAKE SEDIMENT SURVEYS FOR GOLD AND ASSOCIATED ELEMENTS IN WESTERN LABRADOR

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ABSTRACT

In 1986, detailed lake sediment geochemical surveys were conducted in three areas of potential gold mineralization in western Labrador. The areas were selected from reconnaissance lake sediment data collected by the Geological Survey of Canada several years earlier. The approximately 500 samples collected in this survey were analyzed by atomic absorption spectrophotometry and multi-element neutron activation methods. Analysis of the results from this survey outline anomalous sites in each of the survey areas.

INTRODUCTION

Detailed lake sediment geochemical surveys, with a sample density of 1 site per 3 km^2, were conducted in 1986 to follow up three areas of potential gold mineralization in western Labrador. Reconnaissance lake sediment surveys (Geological Survey of Canada, 1982a,b) had shown these areas to be enriched in potential gold-pathfinder elements, such as As, Hg, Ag, Cd, Co, Zn and Cu (Thomas and Butler, 1987). The three areas (Figure 1), referred to as 1) Sawbill Lake area, 2) Menihek Lakes area and 3) McPhadyen River area, are underlain by high-grade Archean rocks of the Ashuanipi Complex between Labrador City in the south and Schefferville, Quebec, in the north. Recent discoveries of significant gold prospects in rocks of similar age about 70 km northwest of Schefferville make the geochemically anomalous areas particularly attractive.

GENERAL GEOLOGY

The Sawbill Lake area was mapped by Rivers (1980). His mapping focused on rocks of the Labrador Trough and, therefore, the Archean Ashuanipi Complex is mapped in much less detail than in its northern areas. The geology of the sample area consists of granulite-grade, undifferentiated, banded, migmatitic and orthopyroxene-bearing, ferromagnesian and granitoid gneisses.

The northern part of the Ashuanipi Complex, which includes the Menihek Lakes and McPhadyen River areas was mapped by Percival (1987). The northern follow-up areas contain a series of granulite-grade metamorphic rocks, mainly migmatitic gneisses, consisting of metasedimentary mafic rocks and homogeneous granitoid rocks. Tonalite and garnet–orthopyroxene–biotite diatexite cut the migmatites. Later intrusions include orthopyroxene–biotite diatexite, granite and syenite.

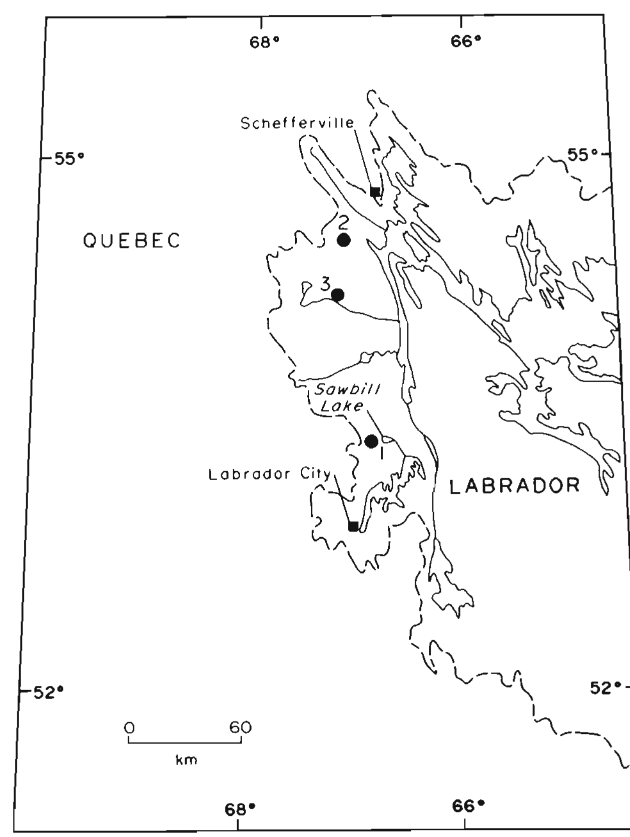


Figure 1. *Index map showing areas of detailed lake sediment surveys.*

The three surveyed areas are generally similar, and have approximately 300 m of topographic relief. The hilltops are usually barren and contain abundant outcrop. The valleys and low-lying areas are till covered and forested or contain bogs. Glacial features are abundant throughout the area. Klassen and Thompson (1987) have recorded five phases of glaciation and recognize a general east to southeast trend as the predominant glacial movement direction.

LAKE SEDIMENT GEOCHEMISTRY

Sample Collection, Preparation and Analysis

The lake sediment samples were collected using the method described by Butler (1980). The samples were air dried in the field and on racks in the laboratory. To complete the drying, the samples were heated to 40 degrees C in drying ovens. They were then screened through 180 micrometre stainless-steel sieves. The less than 180 micrometre fraction (less than 80 mesh) was analyzed.

The elements Cu, Pb, Zn, Co, Ni, Ag, Cd, Mn, and Fe were determined by atomic absorption spectrophotometry following sample digestion in a 4M HNO_3–1M HCl acid mixture. Background correction was applied for Pb, Co, Ni, Ag and Cd determinations. Loss on ignition (LOI), an indication of the organic content of the sample, was determined by ashing the samples for three hours at 500 degrees C. Wagenbauer *et al.* (1983) describe these analytical methods in more detail.

Becquerel Laboratories Incorporated of Mississauga, Ontario, analyzed the samples for Sb, As, Ba, Br, Ce, Cs, Cr, Eu, Au, Hf, La, Lu, Mo, Rb, Sm, Sc, Se, Ag, Na, Ta, Tb, Th, W, U, Yb and Zr using a multi-element technique of analysis by neutron activation and delayed neutron counting. Davenport (1987) discusses the reliability of these data. The 27 site duplicates for Au (Figure 2) have a correlation coefficient of 0.075 and show a scattered plot.

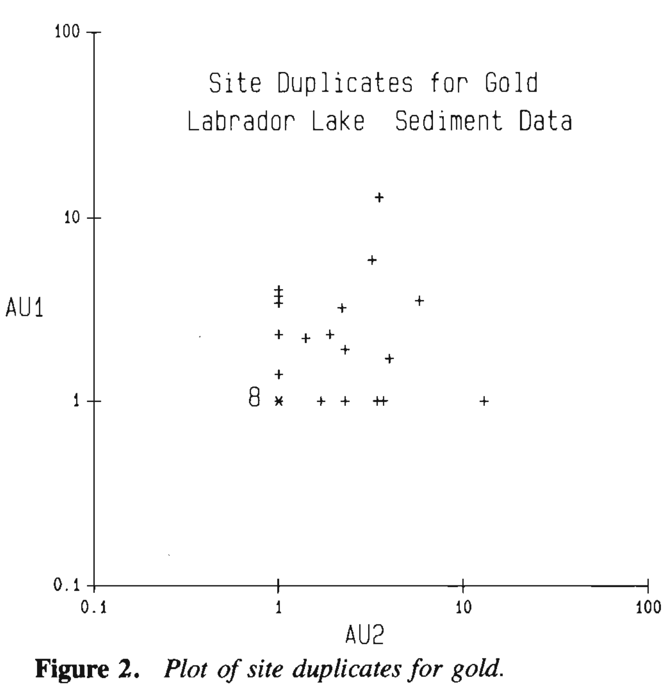


Figure 2. *Plot of site duplicates for gold.*

Data Presentation

Maps of the gold distribution for each of the three areas are present in Figures 3 to 5. The data have been subdivided into three classes, based on the percentiles obtained from the cumulative frequency plot (Figure 6). In Figures 3 to 5, a small plus sign indicates the sample site. The contour intervals are two primary intervals (solid lines with contour values added) and one secondary contour interval (broken or dashed lines). The plotting and contouring package used was the USGS Plotgen Program (supplied by Gerald Evenden).

Statistics

Summaries of statistics of the data are presented for individual areas in Table 1. This table includes the geometric mean (GEO MEAN), $\log_{10}$ standard deviation (LOG10 STD DEV), range and the number of cases for the samples collected. Most elements have a coefficient of variation greater than 50 percent (Table 2), indicating that their distributions are not normal, and they are better represented by a log-normal distribution. Loss on ignition (LOI) and W has a coefficient of variation less than 50 percent, indicating that their distributions are approximately normal. Zinc has a coefficient of variation of 50 percent.

Table 3 presents the Pearson correlation matrix for all the data. All data have been $\log_{10}$ transformed into a normal distribution, except W and loss on ignition (LOI). Correlation of residual (R) values have also been calculated for As, Ba, Co, Cr, Cu, Ni and Sc and are included in Table 2. There are strong associations of Cu, Pb, Zn, Co, Ni, As with Fe and Mn and with each other. These correlations appear particularly strong in the Sawbill Lake area. These associations reflect the effect of coprecipitation of these metals with Fe and Mn oxides and hydroxides in the lakes. Antimony shows very little correlation with Au, As or indeed any other element. Gold has a weak association with W, U, Cr and Cu. There is also a strong association of Ba with Au, As, Co, Cr, Cu, Mo, Ni, Pb, Sc, Zn, Fe and Mn. The majority of these correlations is also shown in the residuals, particularly Au with residual As, Ba, Cr, Cu, Ni and Sc.

Interpretation

Sawbill Lake area. An area of high Au values is concurrent with high As values slightly to the east of Lac Boujonnier (Figure 3). The Au values of four samples in this area range from a low of 3.7 mg/t to a high of 10 mg/t. This area is also coincident with a topographic lineament.

A few one-point anomalies of Cu, Pb and Zn occur in the area but some anomalies coincide with more than one element. In particular, an area in the southwest near Lac Boujonnier, as well as an area to the northeast, near the top of the map area, is high in Cu and Zn. These areas are moderately high in Mn as well, indicating probable scavenging of base metals.

Menihek Lake area. One sample, about 1 km from the Quebec–Labrador border, is high in Au (13 mg/t); there are a number of samples in the 5 mg/t range, and one of 10 mg/t nearby (Figure 4). This area also correlates with As and Ba

Table 1. Summary statistics for the sample areas shown in Figures 3 to 5. Values are expressed as grams per tonne except where indicated.

	Sawbill Lake Data				Menihek Lakes				McPhadyen River			
ELEMENT	GEO MEAN	LOG 10 STD DEV	RANGE	CASES	GEO MEAN	LOG 10 STD DEV	RANGE	CASES	GEO MEAN	LOG 10 STD DEV	RANGE	CASES
Au (mg/t)	0.65	0.296	0.50– 10.00	92	2.07	0.426	0.05– 13.00	172	1.07	0.226	0.50– 12.00	233
As	0.54	0.282	0.10– 41.00	92	1.33	0.377	0.38– 135.00	172	0.85	0.335	0.27– 41.60	233
Ba	127.40	0.266	35.00– 1400.00	92	208.90	0.254	39.00–1200.00	172	0.06	0.283	0.02– 0.37	233
Cd	2.10	0.252	0.10– 1.90	93	0.38	0.239	0.10– 1.10	172	32.00	0.195	8.03– 153.00	234
Co	7.70	0.379	1.00– 67.00	93	12.70	0.351	2.00– 100.00	172	3.00	0.239	1.00– 18.00	234
Cr	53.10	0.248	11.00– 180.00	92	77.62	0.240	12.00– 264.00	172	61.23	0.210	28.00– 243.00	234
Cu	26.18	0.206	1.00– 163.00	93	36.31	0.161	15.00– 104.00	172	199.50	0.243	45.00– 1100.00	233
Mo	3.72	0.567	0.20– 28.00	92	4.19	0.277	0.20– 26.00	172	0.26	0.244	0.10– 1.50	234
Ni	25.90	0.263	1.00– 137.00	93	42.46	0.174	13.00– 153.00	172	10.90	0.348	1.00– 414.00	234
Pb	4.80	0.299	1.00– 27.00	93	3.94	0.268	1.00– 19.00	172	3.03	0.244	9.10– 170.00	233
Sb	0.06	0.426	0.02– 2.10	92	0.06	0.283	0.02– 0.89	172	6.81	0.193	0.20– 37.00	233
Sc	5.25	0.220	1.40– 18.10	92	7.29	0.214	1.80– 22.30	172	35.60	0.178	8.00– 193.00	234
Zn	94.40	0.341	1.00– 36.00	93	124.74	0.175	35.00– 251.00	172	98.17	0.166	1.90– 17.20	233
W	0.23	0.176	0.20– 1.20	92	0.67	0.425	0.20– 13.00	172	0.90	0.260	0.20– 8.80	233
U	0.60	0.390	0.20– 29.10	92	1.35	0.307	0.20– 22.00	172	0.58	0.425	0.20– 12.00	233
Fe (%)	1.04	0.430	0.01– 9.67	93	1.51	0.370	0.10– 16.96	172	127.90	0.495	14.00–107600.00	234
Mn	109.10	0.584	1.00–89300.00	93	129.70	0.417	17.00–5600.00	172	1.36	0.370	0.11– 15.58	234
LOI (%)	38.58*		7.20– 74.00	93	32.32*		3.80– 70.70	172	30.94*		4.80– 80.00	232

* Arithmatic mean

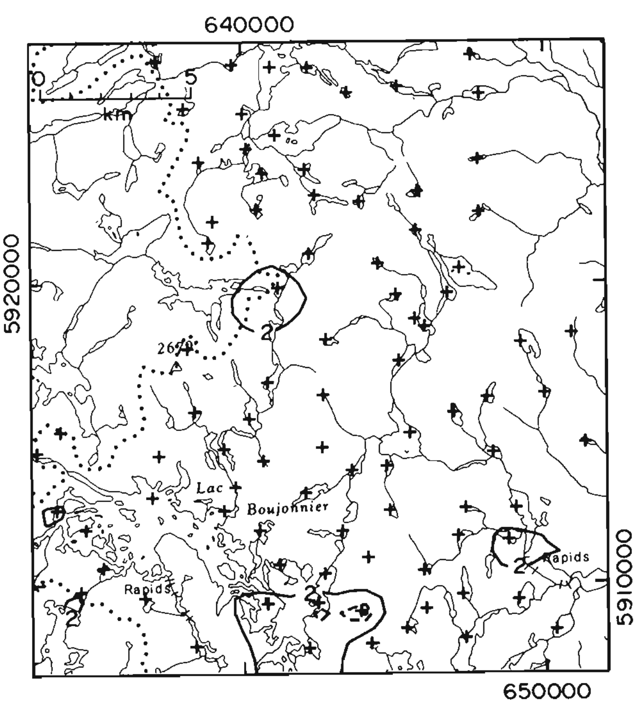
NOTE: mg/t = milligrams per tonne

Table 2. Summary statistics for combined areas of lake sediment survey in Labrador

	Mean	Median	Std Dev	Coeff Var	Geo Mean	Log 10 Std Dev	Range	Cases
Au	2.111	0.50	3.002	142.2	1.25	0.434	0.50 – 51.00	498
As	1.730	0.69	6.717	100.3	0.91	0.365	0.10 – 135.00	498
Ba	230.602	190.00	177.250	388.3	187.50	0.270	35.00 – 1400.00	498
Cd	0.393	0.30	0.252	76.9	0.33	0.265	0.10 – 1.90	500
Co	16.010	10.00	24.338	573.0	10.69	0.366	1.00 – 414.00	500
Cr	73.950	72.00	36.911	152.0	64.71	0.238	9.10 – 264.00	498
Cu	35.612	32.00	18.871	49.9	31.77	0.210	1.00 – 163.00	500
Mo	6.703	5.50	4.989	53.0	5.06	0.367	0.20 – 37.00	498
Ni	39.854	37.00	20.803	74.4	35.56	0.213	1.00 – 193.00	500
Pb	4.330	4.00	3.054	52.2	3.56	0.272	1.00 – 27.00	500
Sb	0.082	0.07	0.117	70.5	0.06	0.311	0.02 – 2.10	498
Sc	6.695	6.00	3.373	148.7	5.93	0.217	1.40 – 22.30	498
Zn	116.124	107.00	52.140	50.4	104.23	0.221	1.00 – 367.00	500
W	0.871	0.55	1.253	44.9	0.51	0.426	0.20 – 13.00	498
U	1.339	0.93	1.985	143.9	0.95	0.327	0.20 – 29.10	498
Fe	1.953	1.31	2.050	105.0	1.33	0.387	0.01 – 16.96	500
Mn	674.520	114.50	6313.334	936.0	124.45	0.488	1.00 – 107600.00	500
LOI	32.469	31.95	10.448	32.2			3.80 – 80.00	498

NOTE: Std Dev = standard deviation, Coeff Var = coefficent of variation, Geo Mean = geometric mean, Log 10 Std Dev = $\log_{10}$ standard deviation

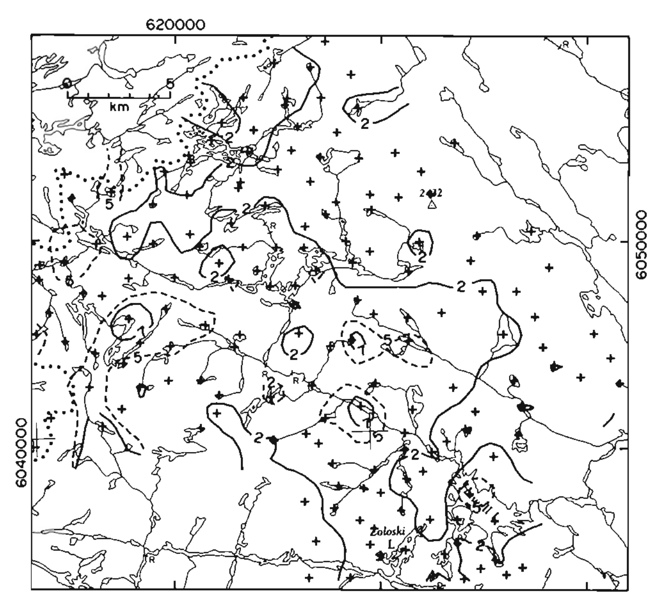
Data values are expressed as grams per tonne except where indicated



Contour Interval	Percentile
7 mg/t	97.0
5	91.0
2	60.0

\+ Sample sites

Figure 3. *Gold distribution in lake sediments, Sawbill Lake, Labrador (NTS 23G/7).*



Countour Interval	Percentile
7 mg/t	97.0
5	91.0
2	60.0

\+ Sample sites

Figure 4. *Gold distribution in lake sediments, Menihek Lakes, Labrador (NTS 23J/6,7,10 and 11).*

Table 3. Pearson correlation coefficients (x100) for all data from Labrador lake sediment survey. All elements, except W and loss on ignition, have been $\log_{10}$ transformed (n = 498).

	Au	As	RAs	Ba	RBa	Cd	Co	RCo	Cr	RCr	Cu	RCu	Mo	Ni	RNi	Pb	Sb	Sc	RSc	Zn	W	U	Fe	Mn
As	42																							
RAs	36	81																						
Ba	33	39	08^+																					
RBa	24	08^+	11	82																				
Cd	-01*	26	14	-17	-37																			
Co	29	58	05*	58	07*	26																		
RCo	19	13	16	17	21	05*	39																	
Cr	34	46	05*	70	34	14	74	20																
RCr	22	07*	10	44	54	02*	12	31	64															
Cu	32	51	23	18	-16	44	57	11	56	20														
RCu	22	25	29	-13	-17	42	13	16	17	25	84													
Mo	09^+	26	00*	08^+	-22	15	44	07*	24	-16	47	27												
Ni	36	58	21	59	24	26	79	32	75	38	71	42	35											
RNi	27	24	31	27	34	11	25	50	33	53	45	53	05*	73										
Pb	18	34	07*	25	-03*	50	51	12	51	25	46	26	24	45	16									
Sb	-01*	00*	04*	-16	-16	16	-06*	-02*	-07^+	-03*	08^+	15	13	00*	05*	13								
Sc	38	48	09^+	69	35	24	74	24	90	52	57	21	22	75	35	52	-02^+							
RSc	28	12	15	44	53	17	15	35	50	77	24	30	-15	39	53	27	05*	68						
Zn	30	51	13	36	-04*	51	71	14	68	24	72	42	43	80	45	58	14	69	29					
W	22	41	34	20	09	-01*	32	27	23	06	22	10	18	29	18	09	-07*	21	05*	23				
U	31	41	22	32	11	28	45	23	48	25	53	37	23	52	33	34	07^+	62	45	54	18			
Fe	25	54	-02*	53	-02*	18	86	-05*	75	-02*	58	05*	44	68	04*	46	-07*	72	-02*	69	24	41		
Mn	18	55	-01*	53	-02*	31	87	-04*	63	-01*	51	05^+	41	68	03*	48	-03*	62	02	65	19	33	83	
LOI	-12	-11	04*	-55	-49	37	-34	-19	-32	-17	12	34	03*	-23	-07*	-02^+	26	-28	-12	-07*	-05*	-09^+	-28	-24

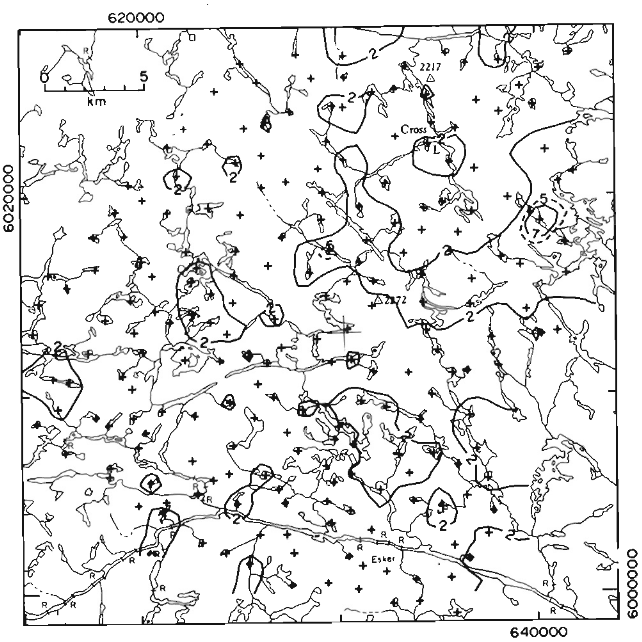
$^+$ not significant at the 98% confidence level
* not significant at the 95% confidence level

NOTE: n = number of samples

anomalies. Rock samples from the vicinity of the lake containing the 13 mg/t value show a range of values from 80 mg/t to 515 mg/t (McConnell *et al.*, 1987). Detailed soil sampling has also been completed in this area.

Numerous Cu, Pb and Zn anomalies occur throughout the area, but are usually associated with no more than one or two sample sites. A few of these anomalies are concurrent with each other. Only one sample has a value in Cu greater than 100 g/t. Mn and Fe are generally low and scattered.

McPhadyen River area. Gold values are more scattered than in other areas, but several sites of 7.5 mg/t and a high of 12 mg/t occur in the area (Figure 5). Most of these high Au values concur with As anomalies.



Contour Interval	Percentile
7 mg/t	97.0
5	91.0
2	60.0

\+ Sample sites

Figure 5. *Gold distribution in lake sediments, McPhadyen River, Labrador (NTS 23J/2,3,6, and 7).*

The central part of this area has Cu values between 60 and 150 g/t. These are concurrent with Zn anomalies in the same area, however, this central area also has moderate Mn and Fe values.

DISCUSSION

The geometric mean value for Au, in the areas sampled in this survey, vary from 2.07 mg/t in the Menihek Lakes area to 0.65 mg/t in the Sawbill Lake area. The overall mean for the areas is 1.25 mg/t, which compares well with mean values for Au from the Port aux Basques and White Bay areas of insular Newfoundland. These areas have shown mean values for Au to be 1.21 and 1.38 mg/t respectively (Davenport and Nolan, 1987). Arsenic, however, has a much lower mean value in the Labrador data (0.91 g/t) than in the island data (3.73 and 1.98 g/t), but is highest in the Menihek Lakes area at 1.33 g/t. Barium, which also correlates well with Au, has an overall mean of 187.5 g/t and is highest in the Menihek Lakes area. Only Pb, Cd and LOI are higher than the overall mean in the Sawbill Lake area. Gold, along with As, Pb, Zn and Cu are higher than the overall mean in the Menihek Lakes area. The mean for almost all elements, except Cu, Ni and Mo, in the McPhadyen River area, rank between the other two area.

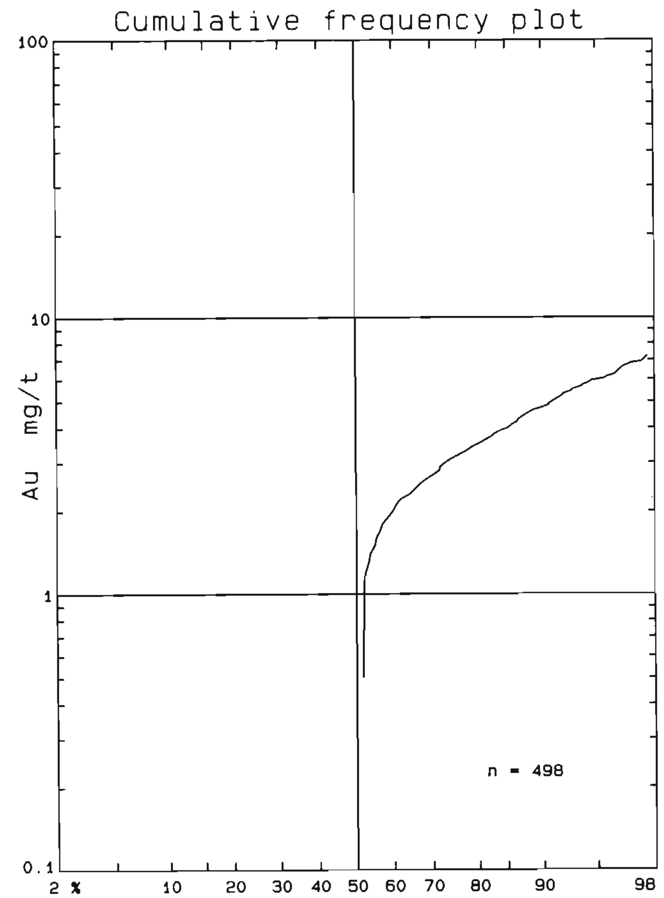


Figure 6. *Cumulative frequency distribution plot of Au for the sample areas.*

CONCLUSIONS

Based on this survey, and on the results of detailed soil and rock sampling in this area by McConnell *et al.* (1987), the Menihek Lakes area (Figure 3) is the most favourable target for detailed exploration for gold. The McPhadyen River area also has several anomalies and has produced several high values in rock samples (Thomas and Butler, 1987). The statistics are similar to, but lower than, the Menihek Lakes area. The Sawbill Lake area has one anomaly, near Lac Boujonnier, which coincides with a topographic lineament and has a value of 10 mg/t. The chemistry of the Sawbill Lake area is different from the other two areas and may indicate a difference in the geology. The anomalous area near Lac Boujonnier should be explored in more detail.

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