UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Statistical summaries of elemental constituents in streambed sediments in the lower Kansas River basin; Nebraska, Kansas, and Missouri

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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Contents

Tables

Figures

INTRODUCTION

An investigation was undertaken in cooperation with the National Water Quality Assessment Program (NAWQA) to identify existing elemental data on streambed sediments in the lower Kansas River basin and to assess the usefulness of this data for water quality studies. Elemental concentrations in streambed sediments are orders of magnitude larger than those in the dissolved phase and may be used as indicators of potential concentrations in the overlying waters and thus as integrators of water quality. Elements in streambed sediments originate from two distinct sources: (1) a natural source derived from geologic formations found in the basin, as erosion and deposition of weathering products form the sediment matrix; and (2) an anthropogenic (manmade) component. In the lower Kansas River basin, the geologic formations consist chiefly of Quaternary glacial, alluvial, and eolian deposits, with some Permian and Cretaceous shales, carbonates, and sandstones whereas the anthropogenic source is primarily from diversified agriculture, ranching, and related enterprises. Data from the National Uranium Resource Evaluation (NURE) Program were used in this report to compile statistical summaries for elements in streambed-sediment samples for parts of the study area.

RETROSPECTIVE SEARCH

A search was conducted to identify sources of geochemical information concerning elemental concentrations of streambed-sediments in the lower Kansas River basin. The sources searched included literature and computer databases of the Geologic Division, U.S. Geological Survey, and Water Resource Division of Kansas and Nebraska Geological Surveys. The search revealed that the most extensive reconnaissance investigation of streambed sediments in the study area was conducted by the U.S.Department of Energy for the National Uranium Resource Evaluation Program (NURE) established in 1973 to assess uranium resources and to identify feasible areas for detailed uranium exploration throughout the United States. The streambed-sediment data presented here were retrieved from the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) portion of the NURE data located in computer databases of the U.S. Geological Survey . The data are also available in reports compiled and published by the Union Carbide Corporation, Nuclear Division (1979b, 1979c, 1980, 1981a, 1981b). Data are available for five of the seven National Topographic Map Series (NTMS) quadrangles (1:250,000 scale) which intersect the study area, comprising about 77 percent of the river basin. Quadrangles in which data are available include: Lincoln, Grand Island, and Fremont in

Nebraska; and Hutchinson and Manhattan in Kansas. The Kansas City and Lawrence quadrangles in Kansas also intersect the study area, however, there is no NURE data available for these quadrangles. Figure 1 shows a base map of the study area.

SAMPLE COLLECTION

Streambed-sediment samples were collected in 1978 by Environmental Systems Incorporated, under the direction of the NURE Program, during September and October in the Manhattan quadrangle; and during November and December in the Hutchinson quadrangle. Samples were collected in 1979 by BCI Geonetics, under the direction of the NURE Program, during September and October in the Fremont quadrangle; during October and November in the Grand Island quadrangle; and during November in the Lincoln quadrangle. A total of 3,180 streambed-sediment samples were collected from the five quadrangles, of which 1,067 samples fell within the boundaries of the lower Kansas River basin. The NURE sampling protocol called for collection of streambed-sediment samples from drainage basins that ranged in area from 5.2 to 52 square Km. This resulted in an average sampling density of approximately one sample per 26 square kilometers (10 square miles). Sample site density was relatively uniform throughout the basin.

ANALYTICAL PROCEDURE

Samples were submitted to the NURE project laboratory in Oak Ridge, Tennessee for preparation and analysis. They were dried overnight in an oven at 85 degrees Celsius, placed in a plastic envelope, and disaggregated by impact with a rubber mallet. The material was then sieved with a nylon sieve and the fraction less than 150 um (-100 mesh) was blended and retained for analysis. A 0.25-gram portion of the sample was digested with a 1-to-1 mixture of nitric and hydrofluoric acids and portions of the resulting solution were used for elemental determinations. Arsenic (As) and selenium (Se) were determined by hydride-generation atomic absorption. Uranium (U) was determined by two techniques to obtain a hot acid-soluble uranium concentration by fluorescence (U-FL) and a total uranium concentration by delayed neutron activation (U-NT) analysis. The remaining elements were determined by plasma source emission spectroscopy.

(Use of company names in this report is for informative purposes only and does not constitute endorsement by the U.S. Geological Survey.)

Table 1 lists the elements determined, the analytical techniques used and the lower limits of detection. More detailed information regarding NURE procedures involving sample collection, preparation, analysis, and quality control and assurance can be obtained from "Procedures Manual For Stream Sediment Reconnaissance Samples" (Union Carbide Corporation, Nuclear Division, 1978), and "Hydrogeochemical and Stream Sediment Reconnaissance Procedures of the Uranium Resource Evaluation Project" (Union Carbide Corporation, Nuclear Division, 1979).

STREAMBED-SEDIMENT DATA

Table 2 lists the minimum and maximum values along with the geometric means and the geometric standard deviations, by quadrangle, for the elements determined on the samples collected within the river basin. Geometric means and deviations were calculated because the log-transformed data approximates a normal distribution, (Ahrens, 1954). Only non-qualified data (data in which the measurements are reported as greater than the limit of determination), were used in the calculations of means and standard deviations. The number of observations used is shown in parentheses. More silver (Ag) was detected in Nebraska than in Kansas and none at all was found in the Grand Island or Hutchinson quadrangles. Molybdenum (Mo) was not detected in the Grand Island quadrangle. Hafnium (Hf), lanthanum (La), and lead (Pb) were not determined in the Manhattan and Hutchinson quadrangles.

Table 3 represents the results from Duncan's multiple range test (Duncan, 1955) which was run on a random population of 47 samples taken from each quadrangle. Forty-seven was used because it was the smallest total number of samples from any one of the five quadrangles. The table shows the mean of the 47 samples for each of the elements in each of the quadrangles. The underscores represent indistinguishable differences between quadrangle means. Ag, Hf, La, Mo, Pb, and Se were omitted from these calculations due to lack of data. Replacements were made in those remaining elements which contained qualified data. Eleven of the 27 elements tested showed variation between quadrangles. Of those eleven elements all showed overlap between quadrangles as well as between states except Ba and Nb. The differences pointed out here may be actual differences within the data or due to differences in the sampling and analytical protocols between quadrangles. Further interpretation on our part is difficult due to the limited information available concerning the accumulation of this data.

ANOMALOUS DATA

Geochemical distribution plots for selected elements are shown in figures 2-6 with figures 2a-6b showing corresponding log histograms, by quadrangle, for each of the plots. The geochemical distribution plots depict the areal distribution of samples enriched in specified elements within the study area. Elements were selected for these plots based on importance to water quality in the study area (targeted variables for the NAWQA Program), and the number and concentration of anomalous samples. This criteria resulted in the selection of silver (Ag), arsenic (As), chromium (Cr), copper (Cu), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn) for areal geochemical distribution plots. Threshold values (defined as the concentration at which a sample is considered anomalously high for a particular element) were established for these elements using some or all of the following information suggested by Rose et al. (1979), usually with emphasis on items 1 and 2: (1) cumulative frequency distributions of the data; (2) the average crustal abundance of an element; and (3) populations greater than two standard deviations above the mean. The dotted lines on the histograms represent these determined threshold limits.

Figure 2 shows the geochemical distribution of samples with anomalous Ag concentrations. Due to the large number of qualified values reported for Ag, the lower limit of detection of 2 ug/g was used as the threshold value. Figure 3 shows the geochemical distribution of samples with above threshold values of 5 ug/g for As and 1 ug/g for Se. The geochemical distribution of samples with anomalous Cu using 23 ug/g and Zn using 80 ug/g as threshold values is shown in figure 4. Figure 5 is the geochemical distribution plot of samples with anomalous concentrations of Cr, Mn, and Ni using 45, 1230, and 27 ug/g, respectively, as the threshold values. Figure 6 shows the geochemical distributions of Pb using a threshold of 36 ug/g and Mo with a threshold of 5 ug/g.

The lack of clustering of samples on the elemental geochemical distribution plots to form definitive patterns in specific areas suggests that the trace-element geochemistry of the streambed sediments in the river basin is relatively uniform. The very few samples containing elements with high concentrations and the small standard deviations for most elements are also a reflection of the homogeneity in the basin. Furthermore, the close agreement of means for most elements between each of the five NURE NTMS quadrangles (table 3) provides evidence for the uniformity of element concentrations in the streambed sediments of the study area.

DISCUSSION

The data from the NURE program provides information on concentrations of 33 elements in streambed sediments for most of the lower Kansas River Basin. The density of sampling gives reasonable coverage of the basin and the analytical protocol covers some of the elements useful for water-quality interpretation.

The focus of the NURE program was uranium exploration which resulted in a specific protocol that did not approach certain procedures in a manner which would produce the type of data important for assessment of streambed-sediment constituents as integrators of water quality. These include, but are not limited to, such procedures as: (1) seasonal sampling, (2) sample collection, (3) sample drying, (4) sample disaggregation, (5) sample sieving, (6) sample particle-size fraction, (7) sample decomposition techniques, (8) analytical techniques, and (9) constituents determined. Also, considering the fact that there is no NURE data for approximately 23 percent of the basin, it becomes apparent that the usefulness of the NURE data is limited with regard to water-quality interpretation of the Kansas River basin.

ACKNOWLEDGEMENTS

The U.S. Geological Survey RASS-STATPAC System (Van Trump and Miesch, 1977) was used in compiling the statistics presented here. The geochemical maps were created using GSDRAW (Selner and Taylor, 1987). Special thanks to Wendy Speckman for modifications of the histogram plotting and drawing programs.

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Table 1

Detection limits of elements in streambed sediment samples[a]

Element	Lower limit of detection ppm
As	0.1
Se	0.1
Ag	2
Al	0.05(b)
B	10
Ba	2
Be	1
Ca	0.05(b)
Ce	10
Co	4
Cr	1
Cu	2
Fe	0.05(b)
Hf	3(c)
K	0.05(b)
La	2
Li	1
Mg	0.05(b)
Mn	4
Mo	4
Na	0.05(b)
Nb	4
Ni	2
P	5
Pb	10
Sc	1
Sr	1
Th	2
Ti	10
U-FL	.25
U-NT	.02
V	2
Y	1
Zn	2
Zr	2

(a) Union Carbide Corporation, Nuclear Division (1979b, 1979c, 1980, 1981a, 1981b)
(b) Detection limits expressed in percent.
(c) Except for the Fremont quadrangle, where the lower limit of detection is 15 ppm.

Table 2

Statistical summary by quadrangle for streambed sediments of the lower Kansas River basin

	Manhattan					Hutchinson				
	Min	Max	Geometric Mean	Geometric Deviation		Min	Max	Geometric Mean	Geometric Deviation	
Ag	2	4	---	---	(3)	---	---	---	---	(a)
Al%	1.44	5.38	4.0	1.2		2.37	5.67	3.8	1.1	
As	.8	13.5	3.3	1.5		1.1	5.4	3.2	1.3	
B	10	41	17	1.4	(330)	10	32	17	1.4	(42)
Ba	133	789	520	1.2		260	563	430	1.2	
Be	1	3	1	1.4	(378)	1	2	1	1.4	
Ca%	.14	10.49	1.6	2.3		.75	10.54	3.1	1.9	
Ce	20	141	51	1.3	(378)	41	93	65	1.2	
Co	5	40	12	1.4	(379)	8	21	12	1.2	
Cr	11	663	34	1.3		26	58	37	1.2	
Cu	5	102	15	1.3		11	31	15	1.2	
Fe%	.47	3.91	1.9	1.2		1.32	2.82	1.9	1.2	
Hf	---	---	---	---	(b)	---	---	---	---	(b)
K%	.46	2.25	1.4	1.2		.93	1.99	1.5	1.2	
La	---	---	---	---	(b)	---	---	---	---	(b)
Li	7	60	24	1.3		19	66	30	1.3	
Mg%	.10	2.17	.57	1.6		.51	2.04	.77	1.3	
Mn	151	3440	600	1.6		242	842	500	1.3	
Mo	4	35	---	---	(62)	4	8	---	---	(8)
Na%	.17	1.11	.63	1.2		.28	.69	.50	1.2	
Nb	7	28	13	1.2		9	17	13	1.1	
Ni	3	338	18	1.4		10	26	17	1.3	
P	76	820	410	1.3		256	520	360	1.2	
Pb	---	---	---	---	(b)	---	---	---	---	(b)
Sc	1	8	6	1.2		5	11	6	1.2	
Se	.1	2.9	.6	1.4		.2	3.5	.7	1.6	
Sr	44	3263	160	1.4		95	423	178	1.3	
Th	2	18	8	1.4	(378)	4	11	7	1.2	
Ti	948	3920	2250	1.1		1400	2440	2000	1.1	
U-FL	1.17	7.63	2.4	.5		1.19	3.90	2.5	.4	
U-NT	1.70	20.3	3.6	1.0		2.10	8.30	3.3	.4	
V	15	116	59	1.2		37	90	56	1.2	
Y	2	22	15	1.2		10	17	14	1.1	
Zn	23	137	47	1.2		29	67	46	1.2	
Zr	32	129	84	1.1		53	92	76	1.1	
Total samples analyzed:		380					47			

Note: The above statistics are computed on measured values only. The numbers in parentheses denote the number of measured values used in determining the statistics when qualified data were present. All samples are in parts per million unless otherwise noted.

(a) Element not detected.

(b) Element not determined.

Table 2 (cont.)

	GRAND ISLAND Min	Max	Geometric Mean	Geometric Deviation		FREMONT Min	Max	Geometric Mean	Geometric Deviation	
Ag	---	---	---	---	(a)	2	3	---	---	(3)
Al%	3.78	6.38	5.2	1.1		5.05	6.39	5.6	1.0	
As	.2	4.6	2.0	1.5		1.4	6.5	3.1	1.3	
B	10	34	2	1.2	(125)	15	33	24	1.2	
Ba	698	953	840	1.0		802	970	890	1.0	
Be	1	2	2	1.4		1	2	1	1.2	
Ca%	.66	1.45	.81	1.1		.58	1.04	.69	1.1	
Ce	33	120	58	1.2		57	78	65	1.1	
Co	4	10	5	1.2	(119)	4	11	7.6	1.2	
Cr	17	44	32	1.2		31	47	38	1.1	
Cu	4	100	12	1.4		12	37	16	1.2	
Fe%	1.00	3.03	1.9	1.2		1.47	2.69	2.0	1.1	
Hf	3	10	---	---	(18)	21	84	---	---	(13)
K%	1.34	1.85	1.6	1.0		1.39	1.76	1.6	1.0	
La	47	161	80	1.1		61	87	72	1.1	
Li	9	32	21	1.2		17	30	22	1.1	
Mg%	.26	.80	.51	1.2		.41	.74	.51	1.1	
Mn	215	712	360	1.2		297	1460	490	1.3	
Mo	---	---	---	---	(a)	4	7	---	---	(7)
Na%	.42	1.22	.97	1.1		.73	1.06	.90	1.1	
Nb	4	17	7	1.2	(125)	4	9	6	1.2	(50)
Ni	7	78	15	1.3		3	31	17	1.5	
P	248	2360	560	1.3		454	1090	620	1.2	
Pb	1	230	---	---	(79)	10	47	20	1.4	(52)
Sc	3	8	5	1.2		5	7	6	1.1	
Se	.1	2.1	.4	2.1	(102)	.1	1.0	---	---	(35)
Sr	124	242	180	1.1		146	197	170	1.1	
Th	2	22	9	1.4	(124)	2	15	6	1.7	(46)
Ti	1110	3680	2430	1.1		2180	2790	2420	1.0	
U-FL	.27	18.5	2.8	1.4		.45	6.47	2.1	.5	
U-NT	1.54	52.1	3.5	3.0		1.1	25.6	3.1	1.0	
V	31	103	65	1.2		55	93	70	1.1	
Y	10	27	17	1.1		12	17	15	1.1	
Zn	25	192	59	1.3		48	106	63	1.2	
Zr	52	157	97	1.1		74	109	86	1.1	
Total samples analyzed.	126					53				

Table 2 (cont.)

Lincoln					
	Min	Max	Geometric Mean	Geometric Deviation	
Ag	2	6	---	---	(34)
Al%	1.94	6.98	4.9	1.2	
As	.6	9.6	2.6	1.5	(459)
B	10	44	22	1.3	(457)
Ba	334	1220	820	1.1	
Be	1	2	1	1.2	
Ca%	.17	7.72	.68	1.4	(459)
Ce	44	157	72	1.2	
Co	4	43	9	1.5	(457)
Cr	15	144	35	1.2	
Cu	5	110	15	1.3	
Fe%	.87	4.15	1.9	1.2	
Hf	3	111	---	---	(136)
K%	.62	2.01	1.4	1.2	
La	49	179	80	1.1	
Li	9	31	19	1.2	
Mg%	.12	1.26	.44	1.3	
Mn	214	2480	500	1.5	
Mo	4	8	---	---	(55)
Na%	.30	1.59	.86	1.2	
Nb	4	33	7	1.3	(453)
Ni	3	94	18	1.6	
P	187	1760	520	1.3	
Pb	3	144	22	1.7	(427)
Sc	2	8	5	1.2	
Se	.1	5.0	---	---	(247)
Sr	54	358	160	1.2	
Th	2	32	7	1.7	(423)
Ti	1130	6600	2560	1.1	
U-FL	.53	6.55	2.2	.5	
U-NT	1.50	7.40	3.3	.5	
V	32	103	65	1.2	
Y	7	25	15	1.1	
Zn	21	750	58	1.4	
Zr	41	171	89	1.1	

Total samples analyzed: 460

Table 3

Comparison of log means from a random population of 47 samples from each quadrangle showing statistical similarities.

Al	H 3.80	M 3.95	L 4.72	G 5.25	F 5.58
As	G 1.98	L 2.55	F 3.12	H 3.23	M 3.56
B	M 14	H 15	G 21	L 21	F 24
Ba	H 432	M 524	L 824	G 836	F 893
Be	F 1.0	L 1.0	H 1.4	M 1.5	G 1.6
Ca%	L .68	F .69	G .81	M 1.21	H 3.14
Ce	M 54	G 58	H 65	F 65	L 73
Co	G 5	F 8	L 8	H 12	M 13
Cr	G 32	M 33	L 34	H 37	F 38
Cu	G 12	H 15	M 15	L 15	F 16
Fe%	L 1.85	H 1.87	G 1.90	F 1.95	M 1.96
K%	M 1.38	L 1.41	H 1.53	F 1.58	G 1.61
Li	L 19	G 21	F 22	M 23	H 30

Note: M=Manhattan; L=Lincoln; H=Hutchinson; F=Fremont; G=Grand Island. Underscores represent indistinguishible differences among means. All elements in parts per million unless otherwise noted.

Table 3 (cont.)

Mg%	L .41	M .47	F .51	G .51	H .77
Mn	G 365	F 484	H 507	L 512	M 676
Na%	H .50	M .61	L .86	F .90	G .95
Nb	F 6	L 6	G 7	M 13	H 13
Ni	G 15	F 17	H 17	L 18	M 19
P	H 365	M 414	L 501	G 554	F 612
Sc	L 5	G 5	M 6	F 6	H 6
Sr	M 144	L 160	F 168	H 178	G 180
Th	F 5	L 6	H 7	G 8	M 8
Ti	H 2000	M 2290	F 2420	G 2430	L 2560
V	H 56	M 60	L 64	G 65	F 70
Y	H 14	L 15	M 15	F 15	G 17
Zn	M 46	H 46	L 58	G 58	F 63
Zr	H 76	M 84	F 86	L 89	G 98

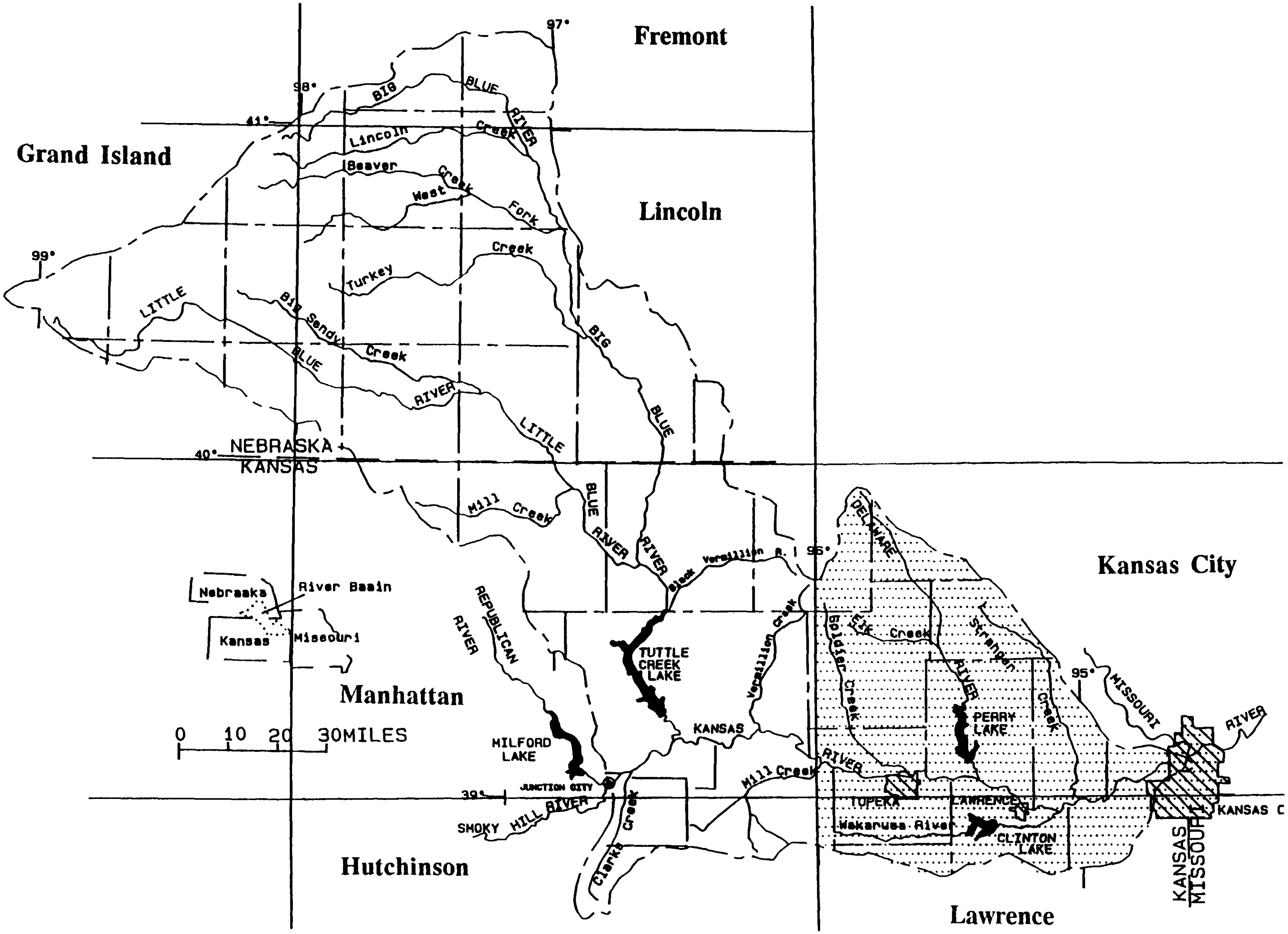

Figure 1.--Base map of the lower Kansas River basin study area. Shaded area is not covered by NURE data.

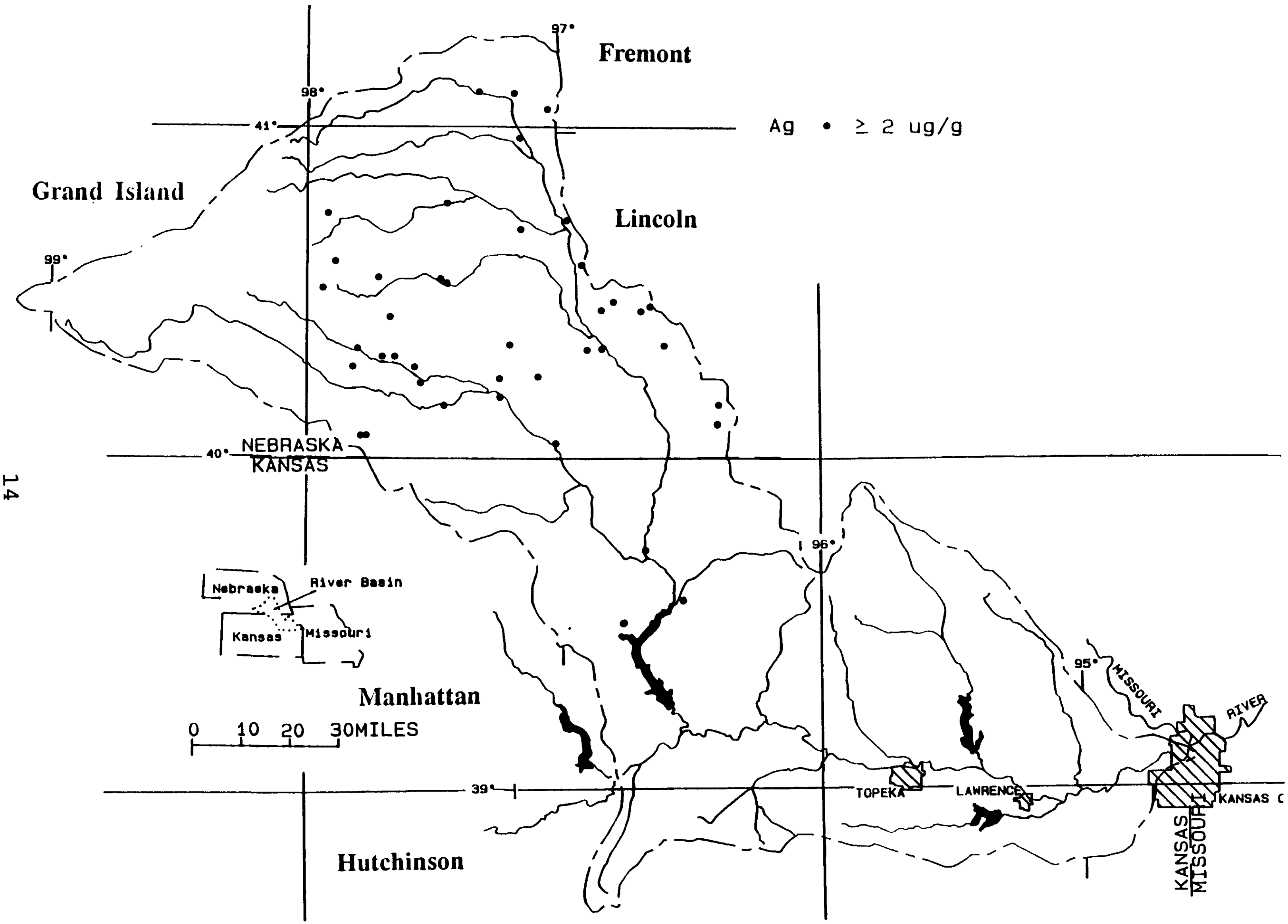

Figure 2.--Geochemical distribution of samples with anomalous Ag concentrations.

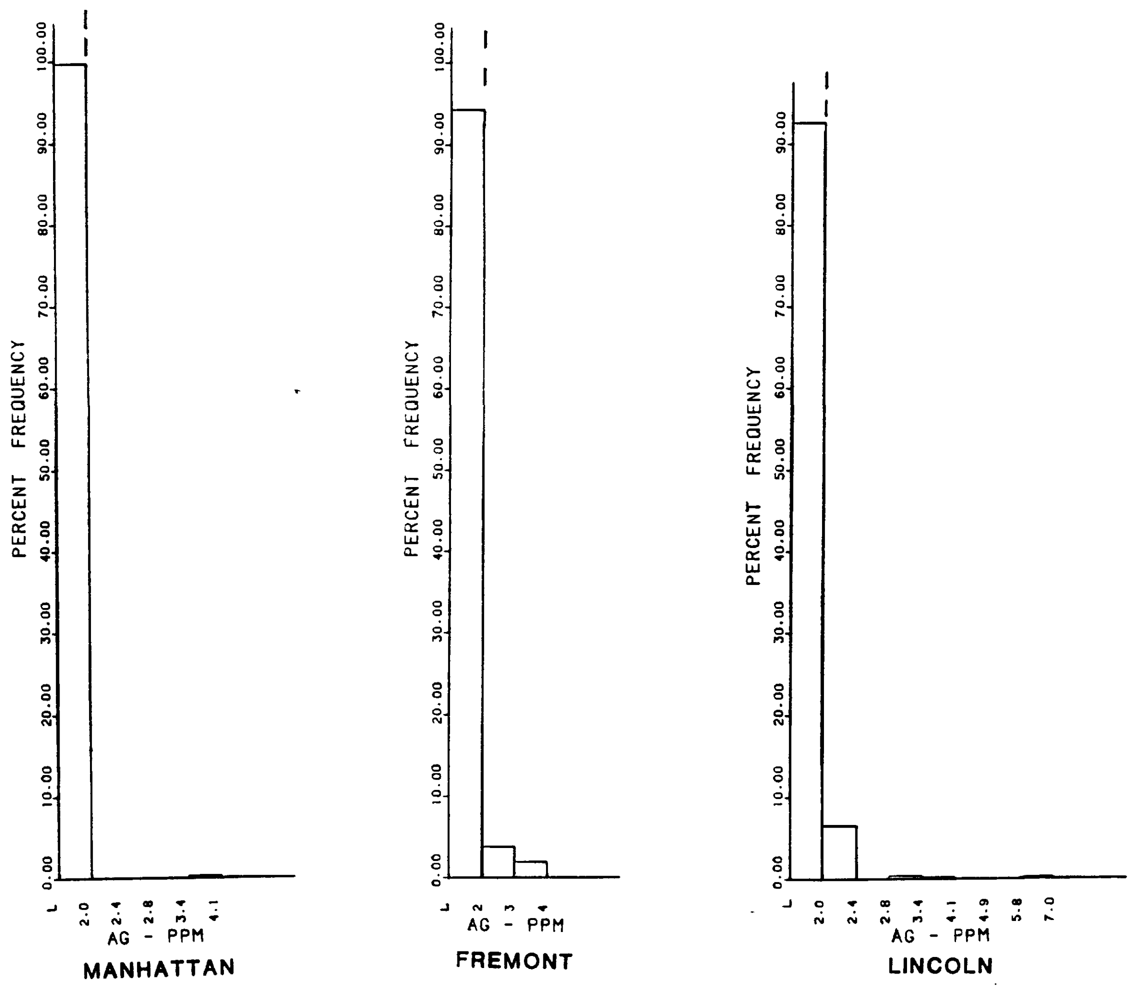

Figure 2a. Log histograms by quadrangle for Ag in the lower Kansas River Basin.

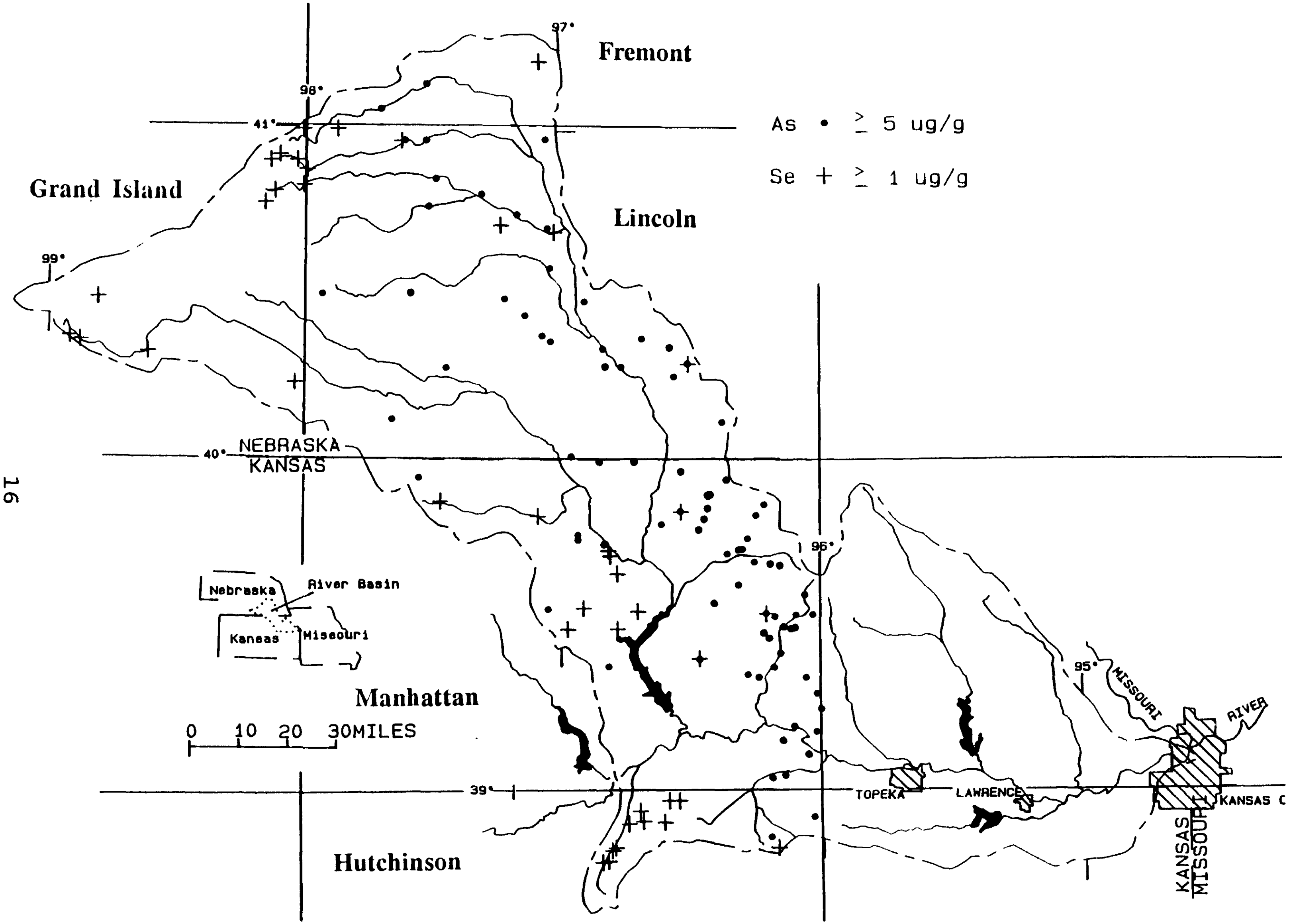

Figure 3.--Geochemical distribution of samples with anomalous As and Se concentrations.

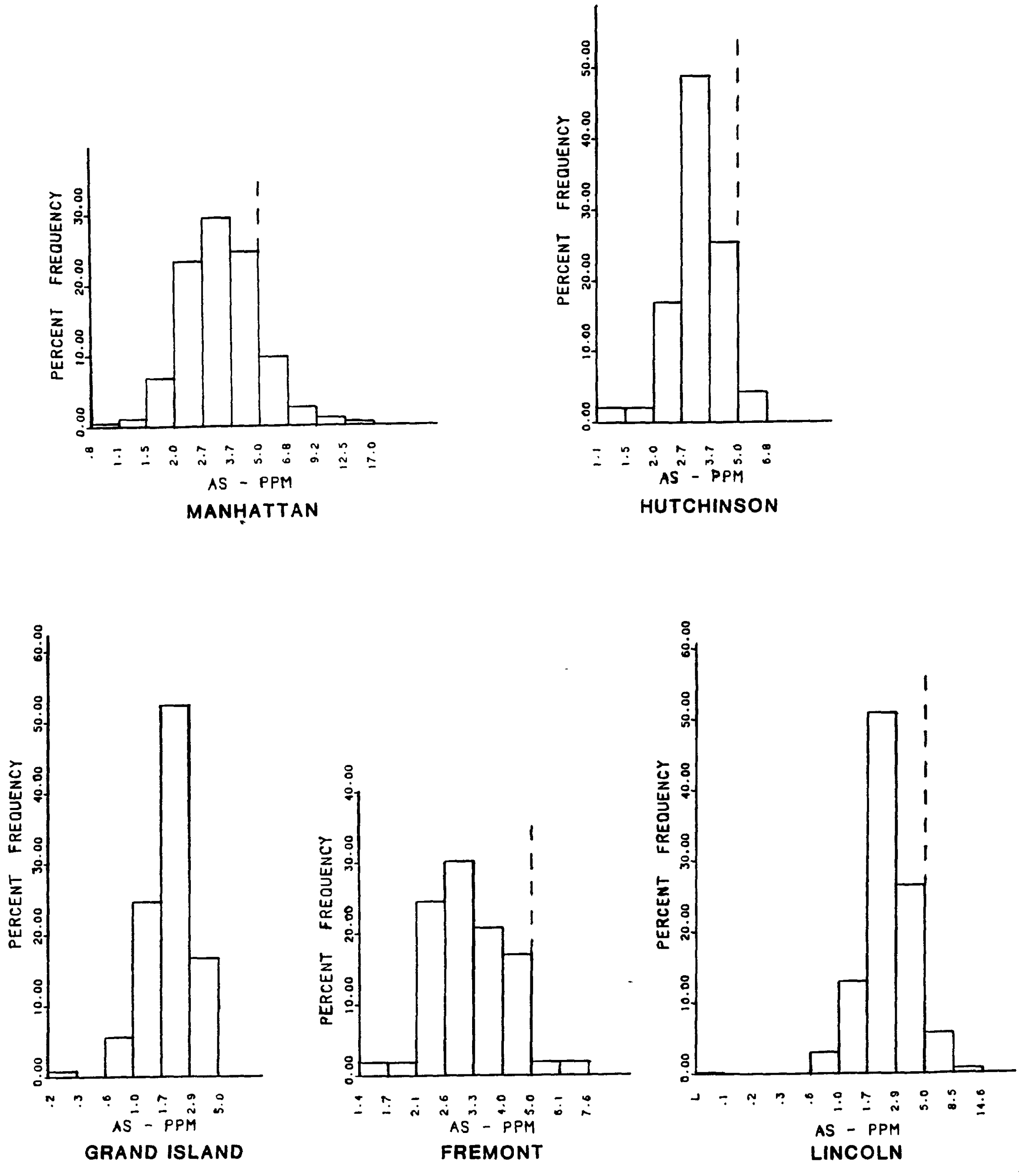

Figure 3a. Log histograms by quadrangle for As in the lower Kansas River Basin.

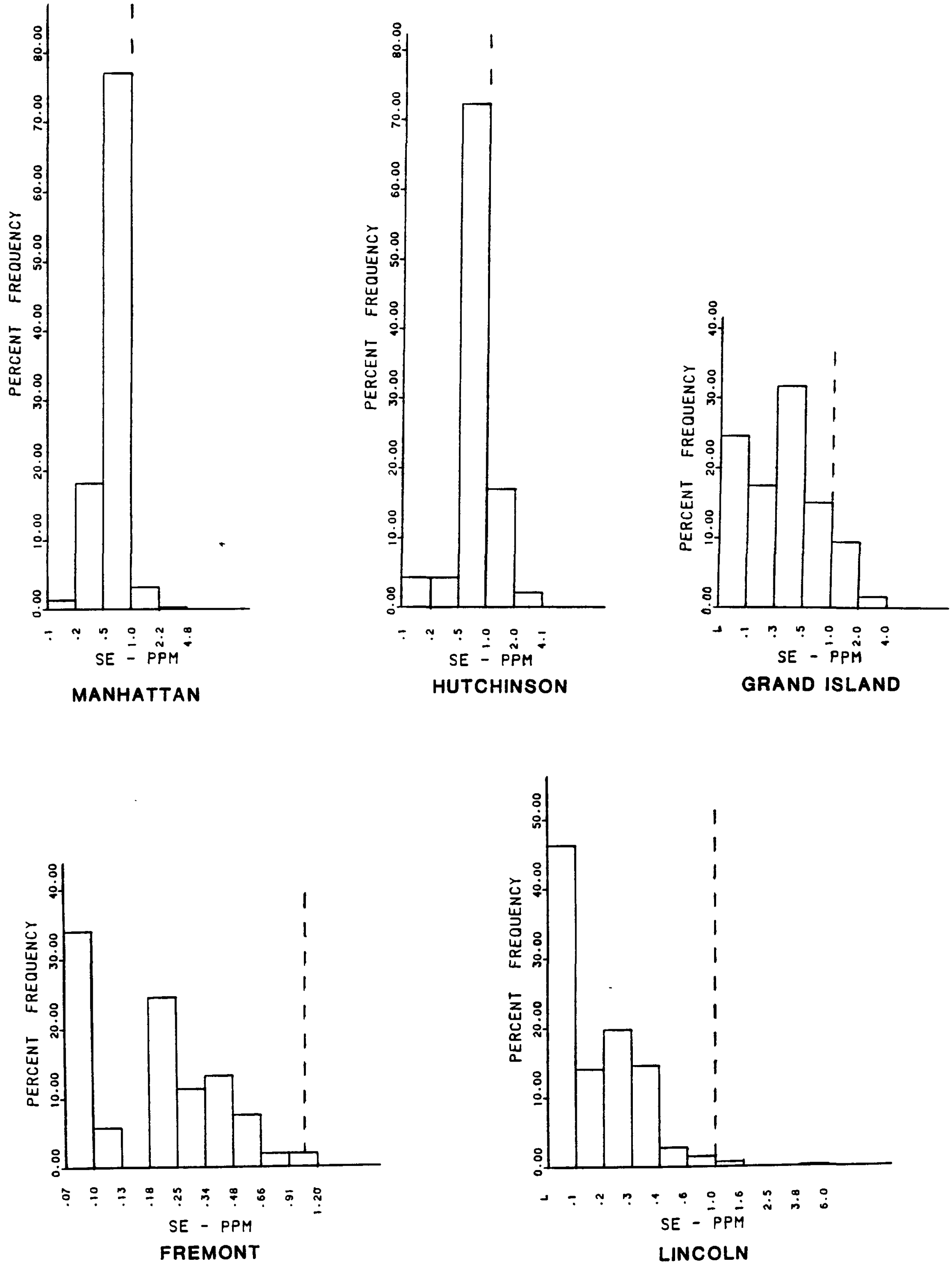

Figure 3b. Log histograms by quadrangle for Se in the lower Kansas River Basin.

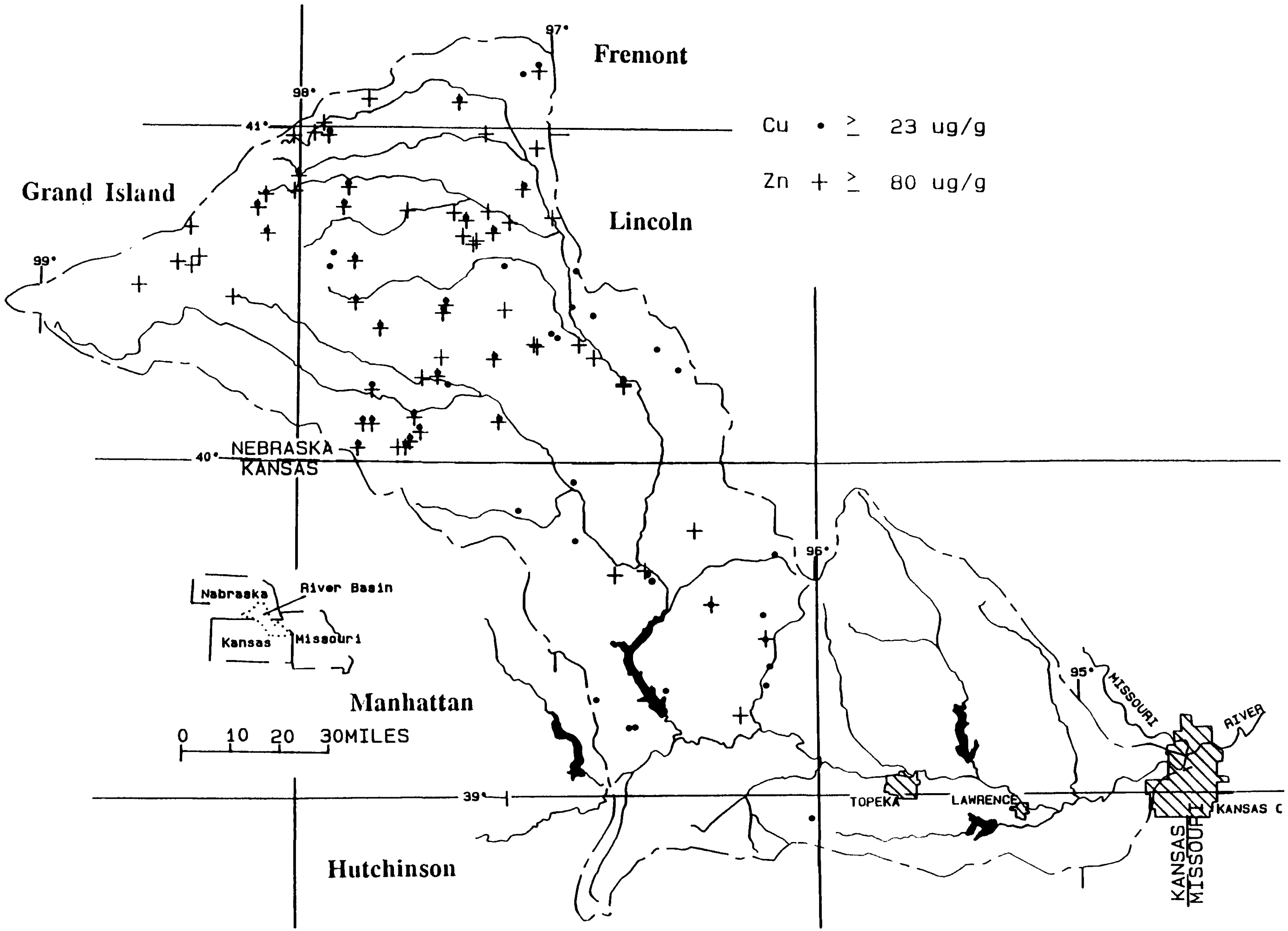

Figure 4.--Geochemical distribution of samples with anomalous Cu, and Zn concentrations.

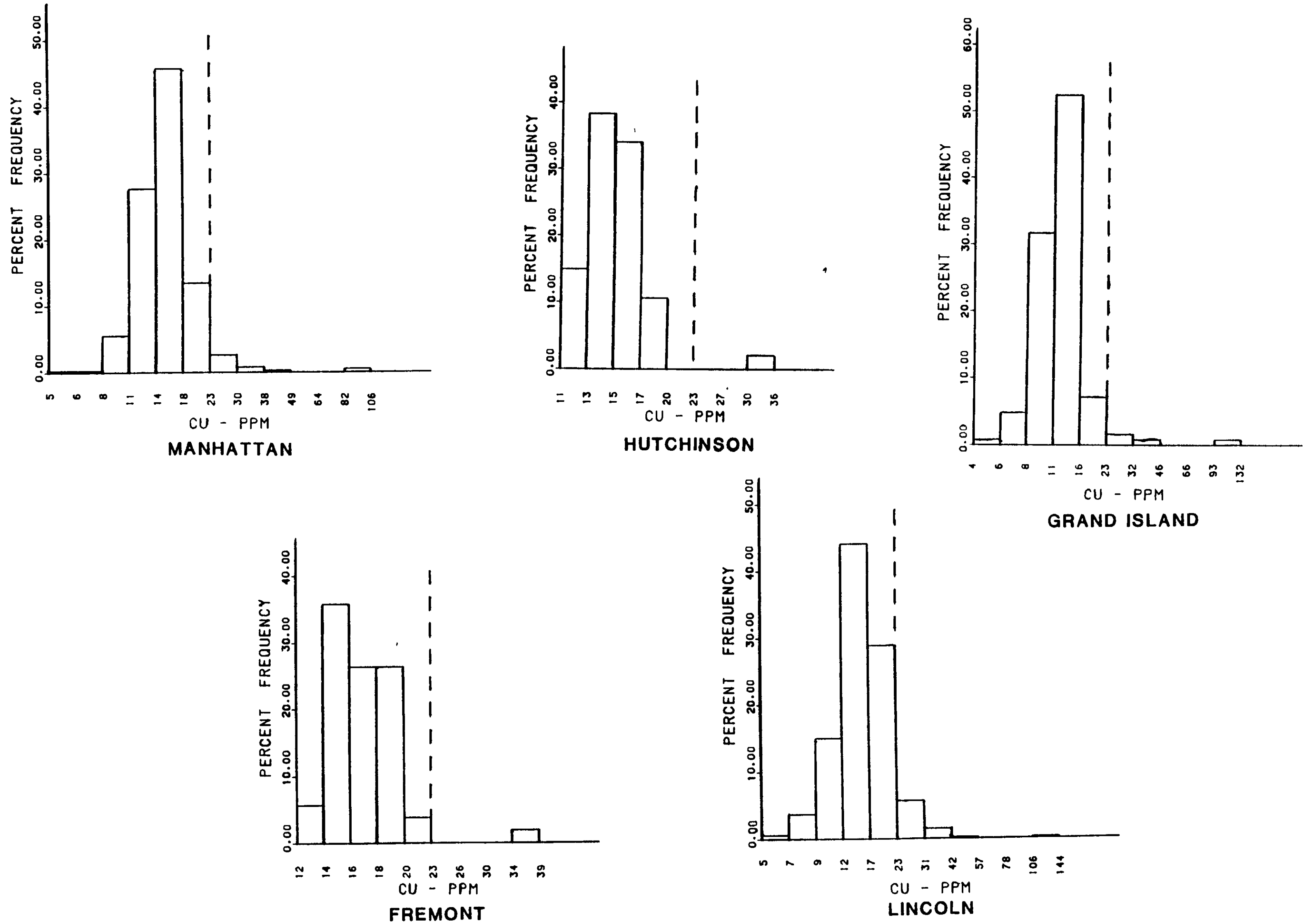

Figure 4a. Log histograms by quadrangle for Cu in the lower Kansas River Basin.

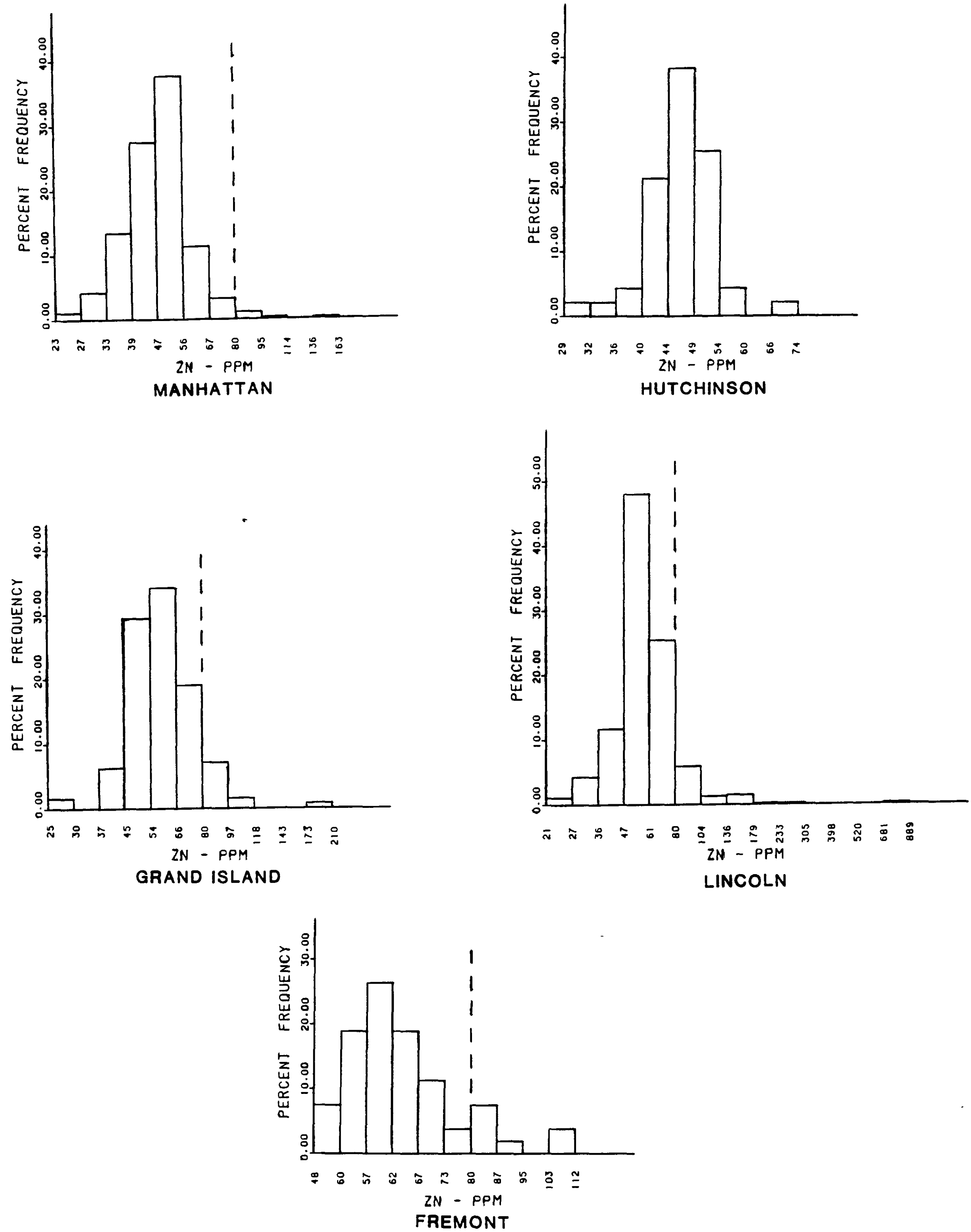

Figure 4b. Log histograms by quadrangle for Zn in the lower Kansas River Basin.

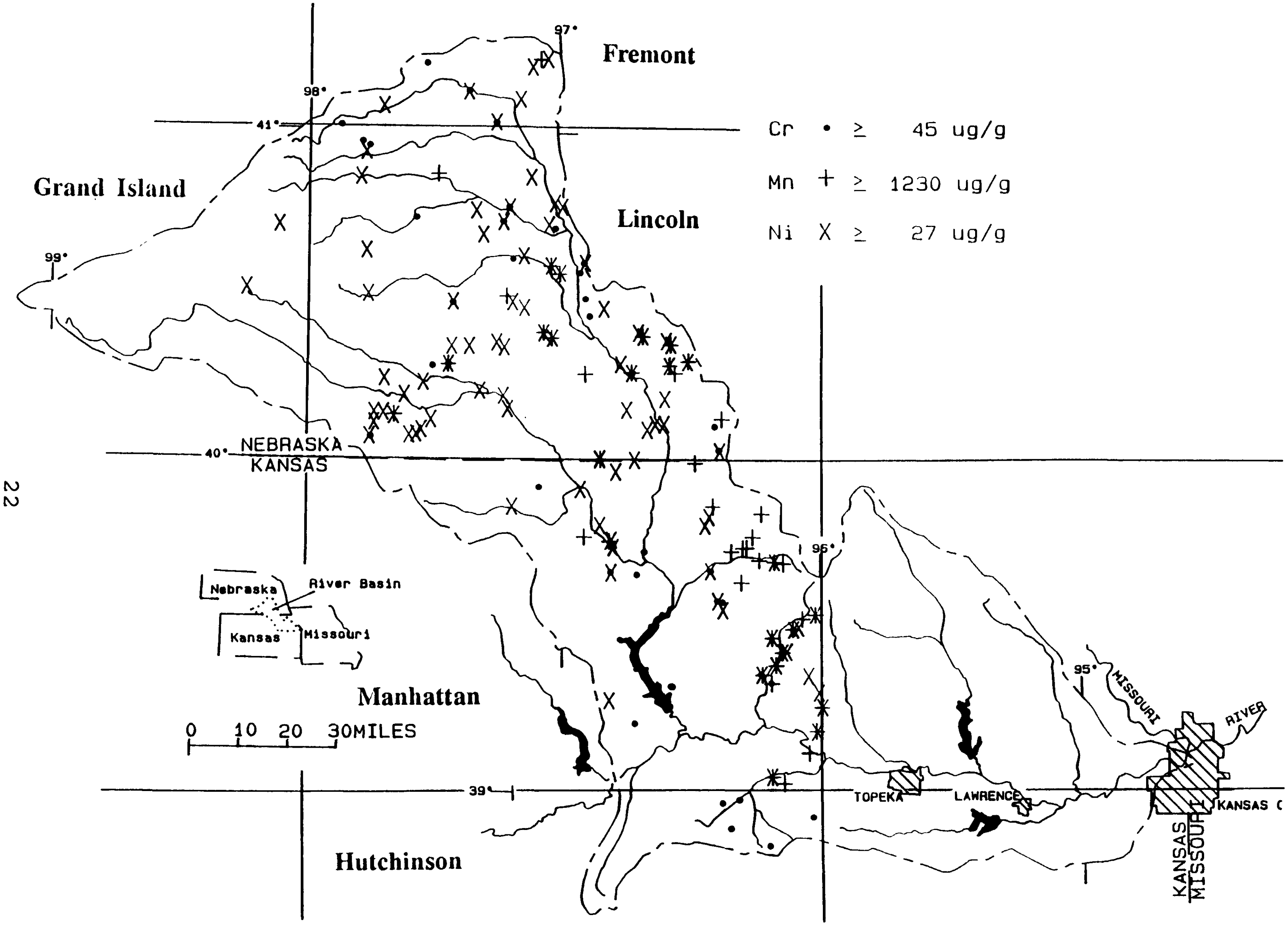

Figure 5.--Geochemical distribution of samples with anomalous Cr, Mn   Ni concentrations.

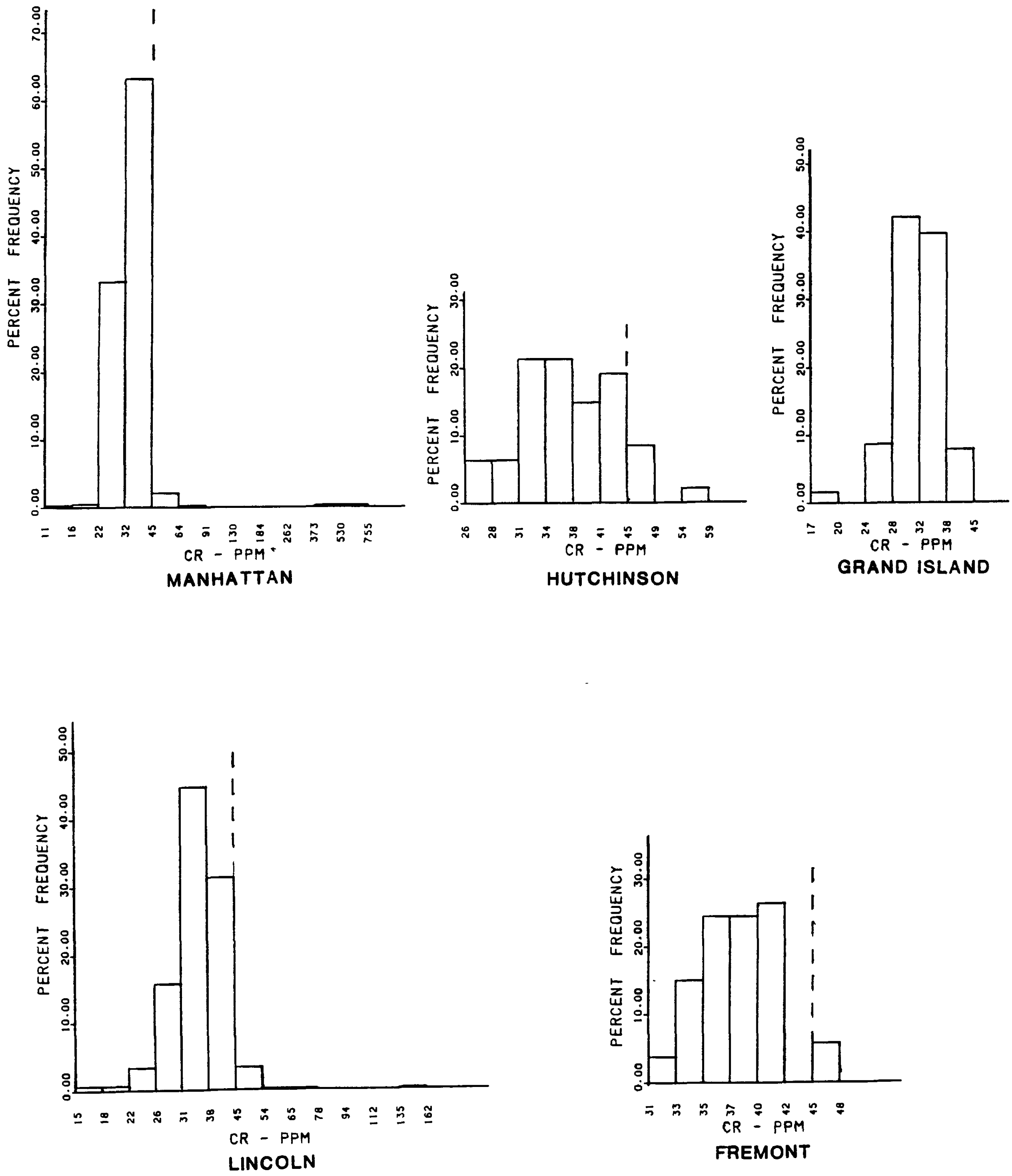

Figure 5a. Log histograms by quadrangle for Cr in the lower Kansas River Basin.

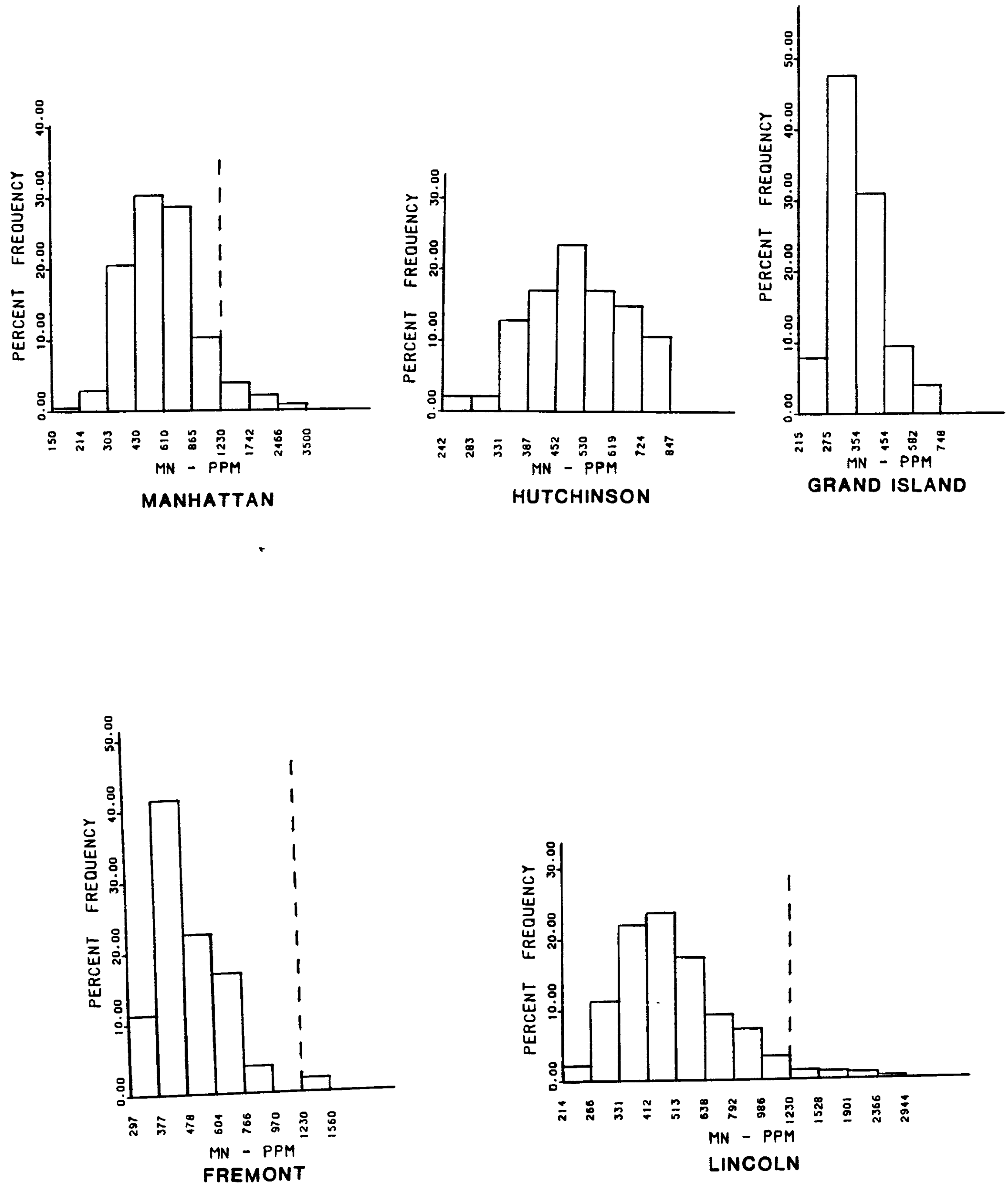

Figure 5b. Log histograms by quadrangle for Mn in the lower Kansas River Basin.

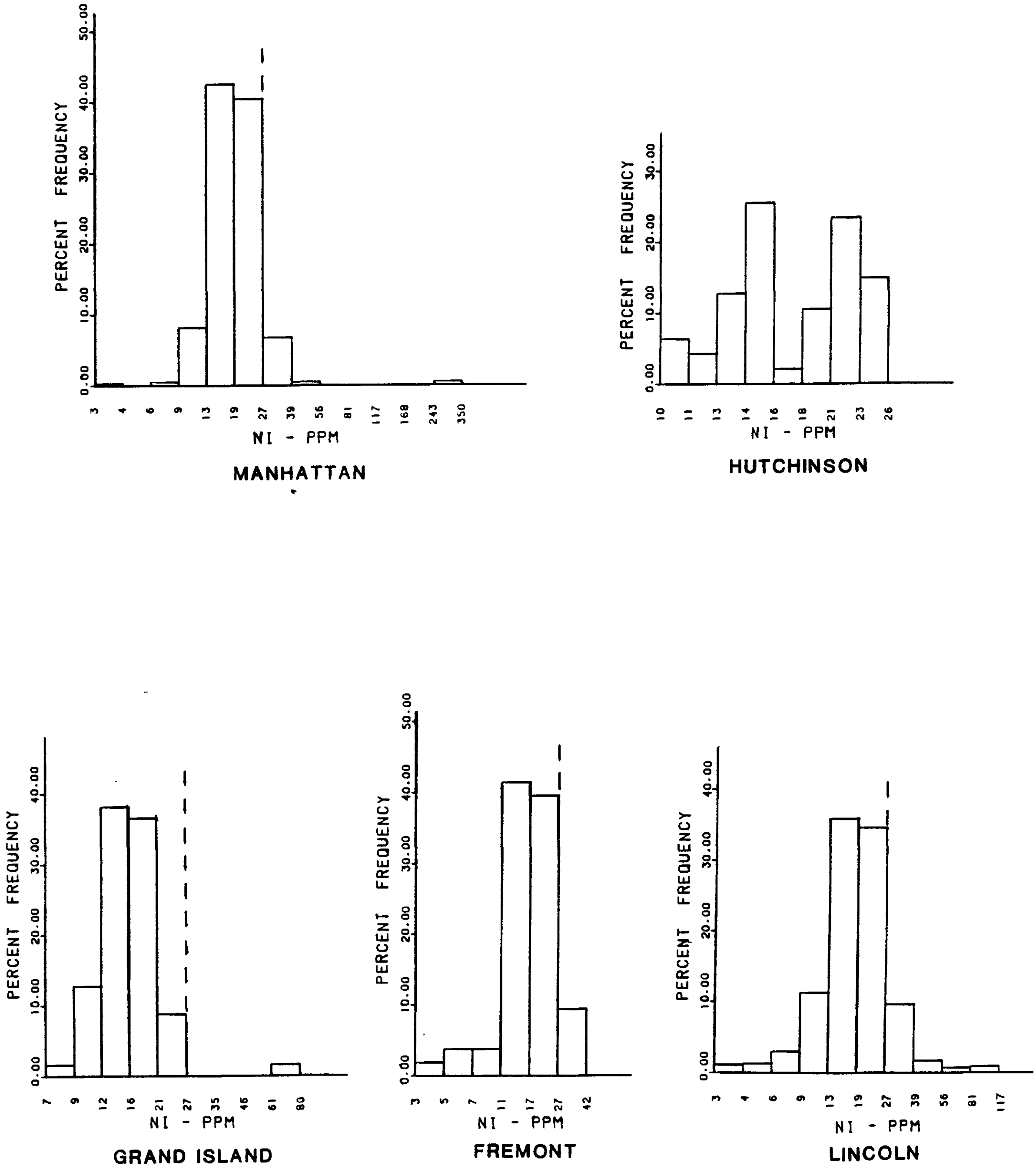

Figure 5c. Log histograms by quadrangle for Ni in the lower Kansas River Basin.

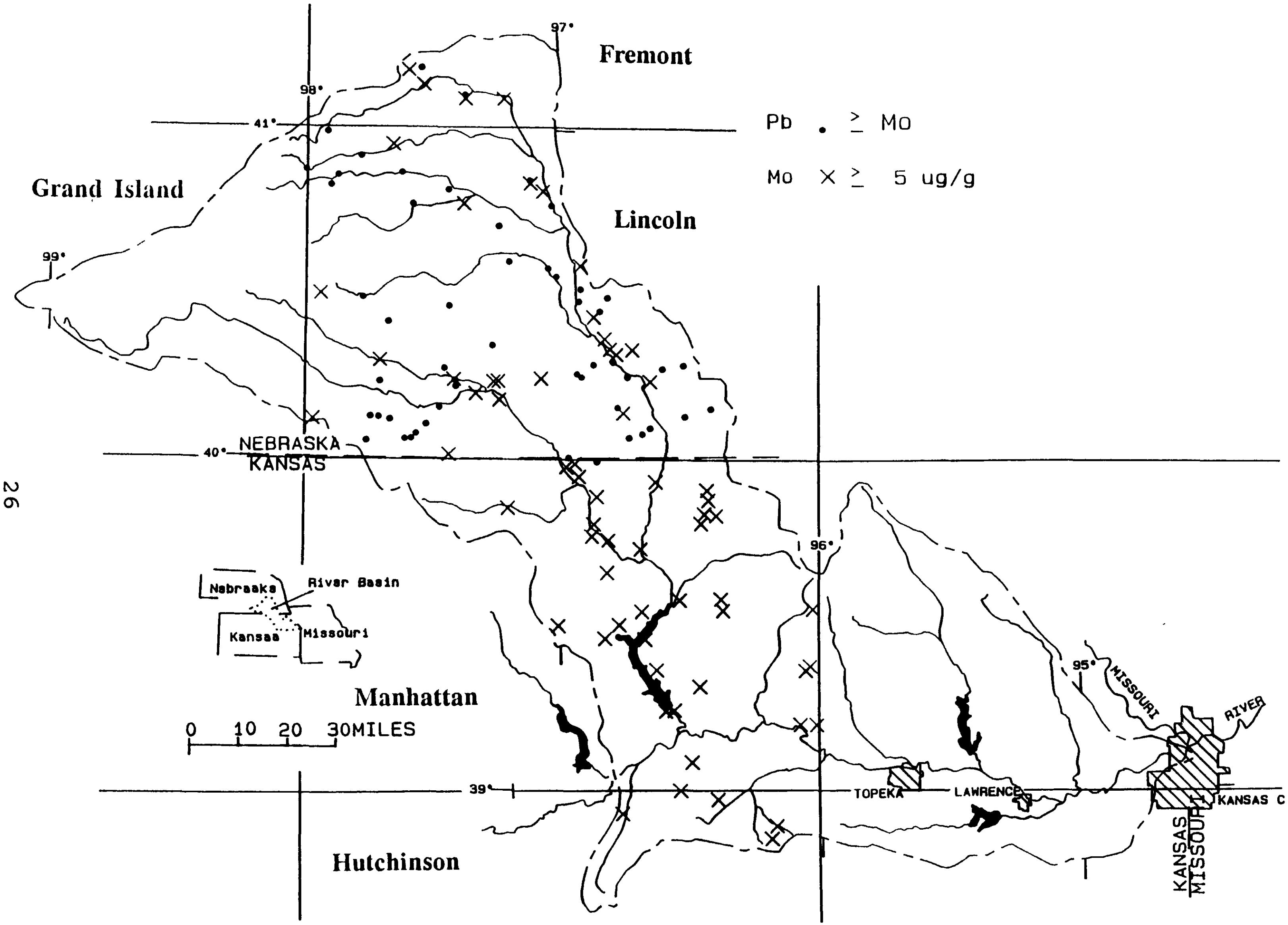

Figure 6.--Geochemical distribution of samples with anomalous Pb and Mo concentrations.

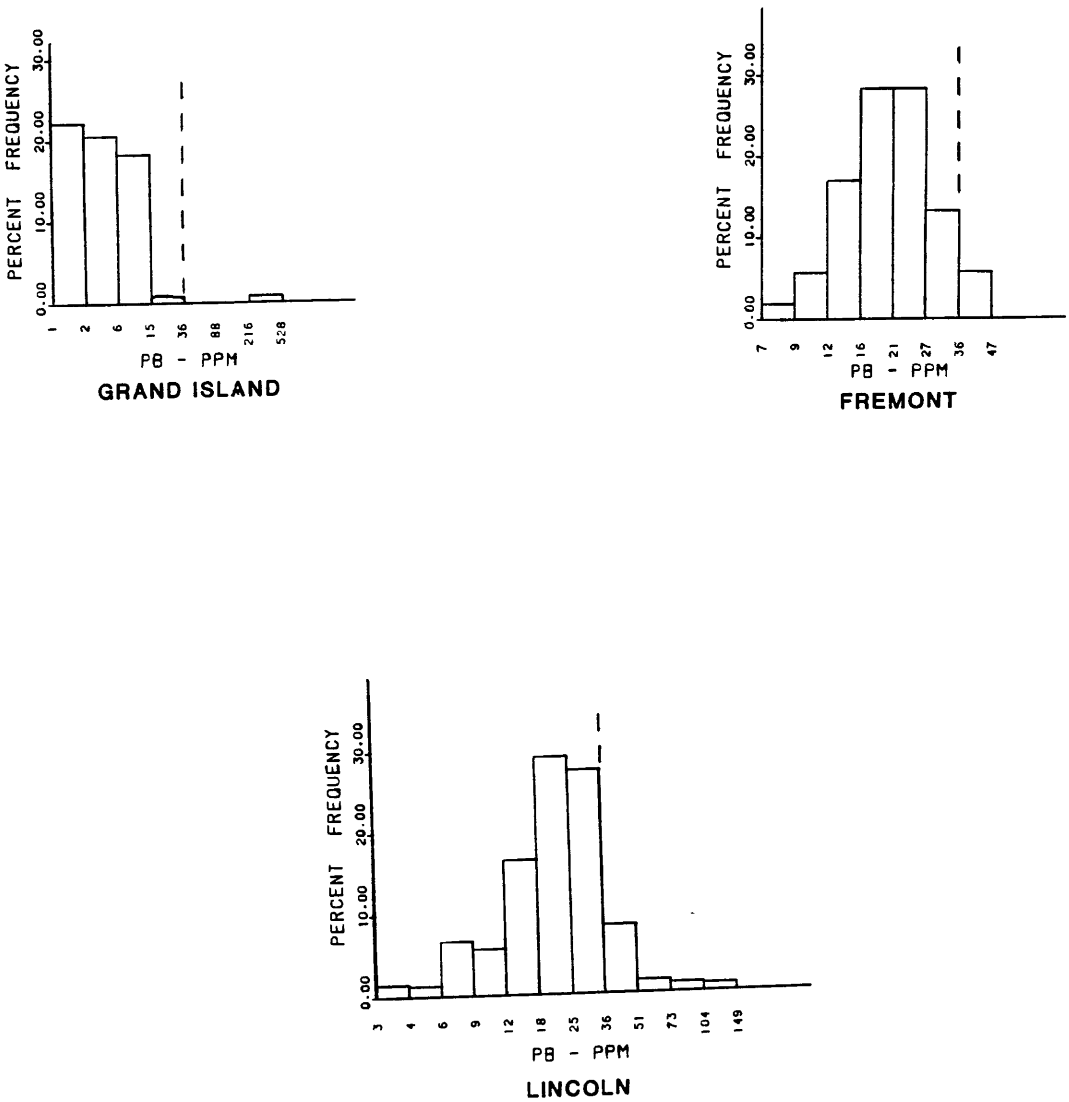

Figure 6a. Log histograms by quadrangle for Pb in the lower Kansas River Basin.

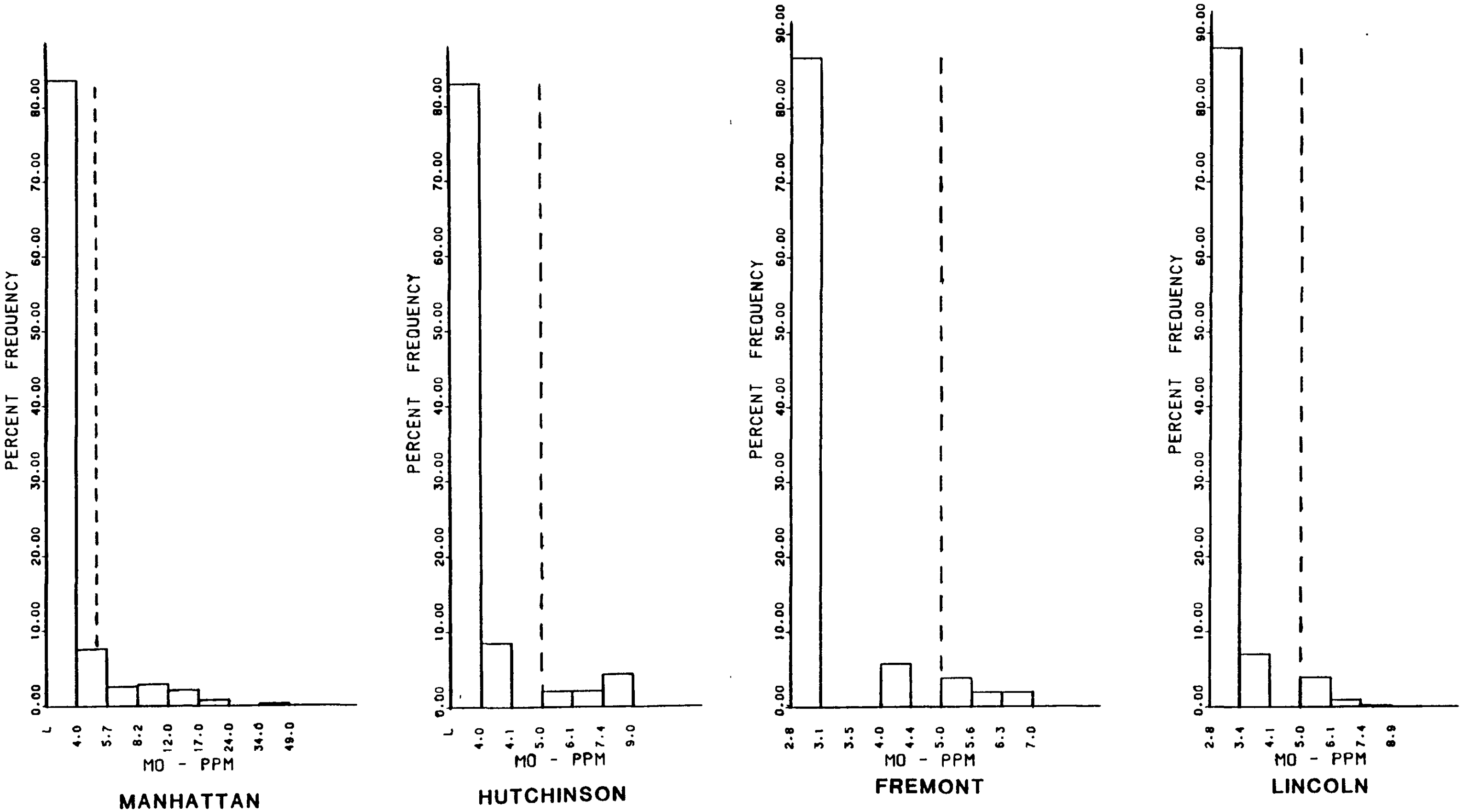

Figure 6b. Log histograms by quadrangle for Mo in the lower Kansas River Basin.