REGIONAL DISTRIBUTION OF CRITICAL AND STRATEGIC MINERALS IN THE KANTISHNA HILLS AREA, DENALI NATIONAL PARK AND PRESERVE, ALASKA

by

Rodney E. Jeske
Alaska Field Operations Center, Anchorage, Alaska

**********************************Open File Report 214-84

DEPARTMENT OF THE INTERIOR

William P. Clark, Secretary

U. S. BUREAU OF MINES

Robert C. Horton, Director

CONTENTS

CONTENTS -- Continued

CONTENTS -- Continued

APPENDICES

TABLES

ILLUSTRATIONS

Page

Page

APPENDIX FIGURES

Page

Page

APPENDIX FIGURES -- Continued

Page

APPENDIX TABLES

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot, feet
in.	inch(es)
oz	ounce(s)
%	percent
ppm	parts per million
yd^3	cubic yard(s)

REGIONAL DISTRIBUTION OF CRITICAL AND STRATEGIC MINERALS IN THE KANTISHNA HILLS AREA, DENALI NATIONAL PARK AND PRESERVE, ALASKA

by

Rodney E. Jeske[1/]

ABSTRACT

In 1984, the Bureau of Mines studied the abundance and distribution of critical and strategic minerals in the Kantishna Hills study area of the Denali National Park and Preserve, Alaska. This 1984 study is a continuation of the 1983 mineral resource study of the area mandated by Section 202(3)(b) of the Alaska National Interest Lands Conservation Act. Several areas containing anomalous critical and strategic minerals were identified in the 1984 study.

Analytical results from reconnaissance placer, panned concentrate, and stream sediment samples for the 1983 study were statistically analyzed and anomalous samples and their distribution identified. The elements evaluated were chromium, cobalt, gallium, germanium, manganese, nickel, niobium, palladium, platinum, tantalum, tin, titanium, and tungsten. Anomalies exist within areas of known mining activity and mineral occurrences as well as in areas with no previously known mining activity or mineral occurrences. Ten main anomalous areas identified for cobalt, germanium, nickel, niobium, tantalum, tin, titanium, and tungsten and can be considered target areas for future critical and strategic mineral exploration.

1/Geologist, Alaska Field Operations Center, Bureau of Mines, Anchorage, Alaska (now with Intermountain Field Operations Center, Bureau of Mines, Denver, Colorado)

INTRODUCTION

The Bureau of Mines (Bureau) is conducting ongoing studies to help identify critical and strategic mineral resources in Alaska. Critical and strategic minerals are identified by law (Strategic and Critical Materials Stock Piling Revision Act of 1979, Public Law 96-41), as materials that (1) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national defense emergency, and (2) are not found or produced in the United States in sufficient quantities to meet such needs (31)[2/]. The term "minerals" as used here includes ores, metals, materials processed from ores, and other naturally occurring inorganic substances.

In 1983, the Bureau carried out field studies in the Kantishna Hills study area of the Denali National Park and Preserve, Alaska (fig. 1) to assess the mineral resources and compile information related to the mineral potential of the area. That study was mandated by Congress under section 202(3)(b) Public Law 96-487 [Alaska National Interest Lands Conservation Act (ANILCA), Title X, Section 1010.]. Parts of that study were conducted for the Bureau by Salisbury & Dietz, Inc. (30).

As part of the 1983 field studies, stream sediment, panned concentrate, and reconnaissance placer samples were collected and analyzed to determine the content of various elements and minerals. Time constraints precluded detailed analysis of all the geochemical

2/Underlined numbers in parentheses refer to items in the list of references at the end of this report.

data in 1983. Only major elements and those of historic mining interest, which included antimony and tungsten (critical and strategic minerals) were evaluated by the contractor. The other critical and strategic minerals were not addressed at that time.

This 1984 Bureau study evaluated the 1983 analytical results for the mineral potential of other critical and strategic minerals in the study area. Several areas with potential for critical and strategic mineral occurrences were identified and the regional distribution of the "anomalous" samples in the Kantishna Hills study area was evaluated.

The minerals studied for this report include cobalt (Co), chromium (Cr), gallium (Ga), germanium (Ge), manganese (Mn), nickel (Ni), niobium (Nb), palladium (Pd), platinum (Pt), tantalum (Ta), tin (Sn), titanium (Ti), and tungsten (W).

ACKNOWLEDGMENTS

Uldis Jansons (Chief, Branch of Mineral Land Assessment, Intermountain Field Operations Center, Bureau of Mines, Denver, Colorado) and Bob Hoekzema (Supervisory Physical Scientist, Bureau of Mines, Anchorage, Alaska) provided ideas, technical assistance, and recommendations that were incorporated into this study.

LOCATION AND LAND STATUS

The Kantishna Hills study area is located in Denali National Park and Preserve, Alaska and encompasses approximately 300 square miles (fig. 1). It is in part adjacent to, and northwest of, the original

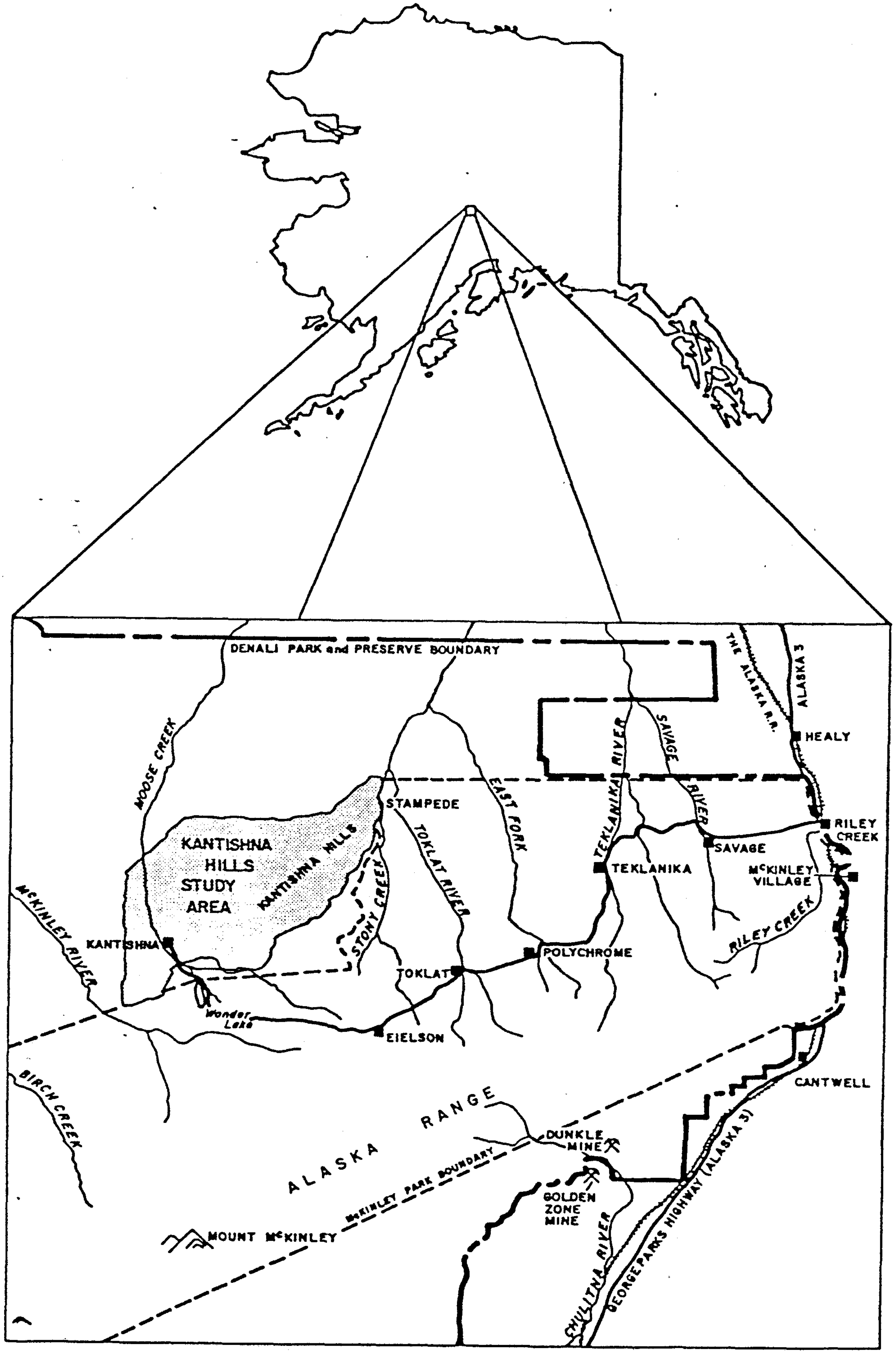


FIGURE 1. Index Map of Alaska showing Kantishna Hills Study Area

McKinley National Park boundary. Land access is provided by one road, the McKinley National Park road (originally the Kantishna Mine road). Landing strips are present at Stampede and Kantishna. The Kantishna mining area is currently closed to new mineral entry but contains 190 unpatented claims and 34 patented claims (30).

PREVIOUS STUDIES

Reports by Prindle (24), Brooks (4, 7), and Capps (12) of the U.S. Geological Survey (USGS) describe geology and mining activity during the original gold rush of the early 1900's. Bulletins entitled "Mineral Resources of Alaska" (2-7) summarize mining activity during the early years of the district. Additional geologic information was provided by Capps (14), Reed (25), Bundtzen, Smith, and Tysdal (10), Hawley (18), and Bundtzen and Turner (11). Tom Bundtzen of the Alaska Department of Natural Resources (DNR), Division of Geological and Geophysical Surveys (DGGS), did most of the recent geologic studies prior to the 1983 Bureau study. Bundtzen (8) completed a Masters thesis on the geology, including a regional geologic map in 1981. In 1983, Bundtzen (9) wrote a resource summary and discussion of possible mineral development scenarios.

Detailed reports of individual mineral deposits are given by Davis (16), Pilgrim (23), Moffit (22), Capps (13), Wells (33), White (34), Ebbley and Wright (17), Seraphim (27-28), Barker (1), Saunders (26), Chadwick (15), and Hawley (18). Regional geochemical sample sites and analytical results are in the 1974 reports by Bundtzen and Turner (11), Van Eeckhout, Wahen, and Hill (32), and in the 1982 report by Hinderman (19).

MINING HISTORY

Placer gold was discovered in the Kantishna Hills area in 1903 by Judge James Wickersham while enroute on his attempted climb of Mount McKinley. A small gold rush followed involving several thousand miners, most of whom had left by 1906 after the high grade pay streaks had been mined out. Recovery of lead and antimony sulfide cobbles from sluice box riffles instigated exploration for lode deposits. Antimony was the first lode deposit to be discovered; the first shipment was made in 1905. Silver- and gold-bearing veins were discovered soon after. Intermittent silver and gold production from lodes occurred from 1919 to 1983.

Mines in the area have produced over 85,000 oz of gold, 265,000 oz of silver, 504,000 lb of lead, 4,600,000 lb of antimony, and an unknown amount of zinc. This area is the second largest antimony producing district in the United States. Gold, silver, lead, and zinc have been mined from several small high-grade vein deposits. Over 90% of the gold was produced by small to medium-scale placer operations.

Mineral resource development of the district has been historically affected by high development and transportation costs, metal price fluctuations, and government policies. The gold price has increased abruptly and drastically twice in the history of the district resulting in the rejuvenation of gold mining interest. Antimony prices have also varied considerably over short periods of time with high prices and production corresponding to wartime demand. Three government policies that have had an impact on mining are: (1) the mandated closure of large gold mines early in 1942; (2) the withdrawal of large areas from mineral location by the Alaska Native Claims Settlement Act in 1971; and (3) the passage of ANILCA which placed the area under U.S. National Park Service jurisdiction in 1980.

1983 FIELD STUDIES

In 1983, Salisbury & Dietz, Inc., under contract to the Bureau, conducted mineral resource studies in the Kantishna Hills study area, as well as the Dunkle Mine area south of and adjacent to the old McKinley National Park boundary. Field work included geologic mapping, geochemical and geophysical surveys, placer studies, and drilling (30).

Sixty-seven square miles were geologically mapped and over 2,000 samples of various types were collected for chemical analysis. Over 100 deposits and mineral occurrences were mapped and sampled. Core drilling, limited to patented claims, aggregated 4,909 ft in 22 holes. Over 400 core samples were assayed and drill logs prepared for each hole. Placer deposits were evaluated at 202 sites with 227 samples analyzed. Approximately 200,000 line-ft of geophysical surveys were conducted. Survey grids, drill holes, sample sites, and mineral occurrences were surveyed at 380 locations.

Bureau personnel monitored field activities, conducted independent placer gold reconnaissance studies, participated in regional and local geologic studies, and assisted with other project activities.

GEOLOGIC SETTING

The Kantishna Hills study area is underlain by metamorphic schists and gneisses of probable Precambrian age containing thrust slices of Paleozoic sedimentary and volcanic rocks. The area is part of the Yukon-Tanana tectonostratigraphic terrane of Jones, Silberling, Berg, and Plafker (20) which is a contiguous geologic assemblage underlying much of the region between the Alaska Range and the Yukon River, and extending easterly into Canada's Yukon Territory. Tertiary dikes and small stocks intrude the basement rocks. Tertiary and Quaternary continental sediments occur in structural basins and stream valleys. The geology of the region was summarized recently by Bundtzen (8) and Salisbury & Dietz, Inc. (30)(fig. 2).

Four major groups of rocks, all with at least some economic significance, exist in the Kantishna Hills study area. From the oldest to youngest they are: (1) Precambrian (early Paleozoic?) Birch Creek Schist, mainly a metamorphosed continental shelf sequence; (2) Paleozoic Spruce Creek Sequence, metamorphosed sediments and felsic volcanics; (3) Devonian Keevy Peak Formation, metamorphosed deep-water marine and submarine fan deposits; and (4) Quaternary alluvial, colluvial, and glacial deposits.

The Spruce Creek Sequence hosts the majority of the known lode mineralization which consists of gold, silver, lead, and zinc in vein and stratiform deposits and is the probable source of most of the placer gold. Quaternary sediments host the gold placers (30).

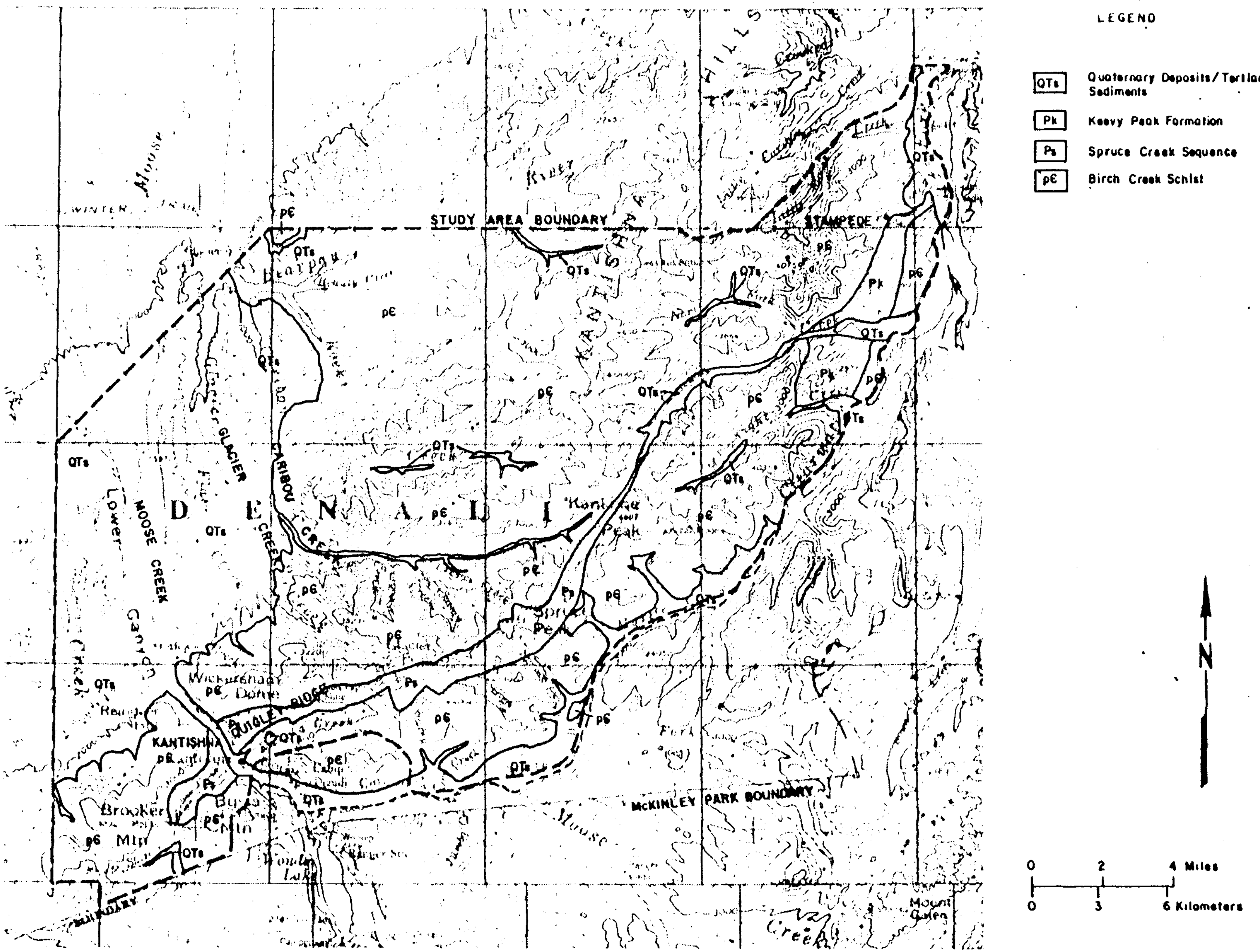


FIGURE 2. Geologic Map, Kantishna Hills study area

The graphitic schist of the Birch Creek Schist and the black slate of the Keevy Peak Formation are both shown to be potential hosts for massive sulfide deposits (30). The Birch Creek Schist hosts the majority of the known antimony deposits (30).

STRUCTURE

The Kantishna Hills area is structurally complex, containing northeasterly-trending well-developed foliations and crenulations in some of the metamorphic rocks, folds of varying amplitude, thrust faults, and high-angle faults. Bundtzen (8) recognized five deformational episodes in the region.

The structural relationships are important in understanding the mineral distribution of the region. Thrust faulting superimposed the less mineralized Birch Creek Schist over the younger mineralized Spruce Creek Sequence. Warping of the area into the Kantishna Anticline and subsequent erosion resulted in the long, narrow exposure of the Spruce Creek Sequence. Additional unrecognized windows may exist in the Birch Creek Schist thrust plate exposing the underlying Spruce Creek Sequence (30).

The Kantishna Anticline fold axis is a possible control for gold and silver vein mineralization. Many veins are in fractures that appear related to tensional forces created during formation of the Kantishna Anticline. The anticline axis has been displaced by subsequent folding and faulting which has complicated the structural continuity of mineralized areas. Mineralization occurs in structurally controlled environments in both the Spruce Creek Sequence and Birch Creek Schist.

Shear zones of various magnitudes appear to have localized many of the mineral deposits. Other shears may be favorable sites for undiscovered lode deposits (30).

MINERAL DEPOSITS

The Kantishna Hills study area contains precious-metal lode and placer deposits, antimony deposits, stratabound massive sulfide deposits, and other deposits (30). Reserves of gold-bearing gravel exist both on and off existing claims. Studies during the 1983 season indicate the presence of geologic environments favorable for base and precious-metal massive sulfide deposits. The precious/base metal veins characteristically are limited in tonnage but high in dollar value per ton of ore. Several of the deposits probably could support small-scale mining (30).

PLACER DEPOSITS

The Kantishna Hills area is one of about 37 producing gold districts in Alaska. It contains an estimated resource of 688,000 oz of placer gold in 43 million yd^3 of gravels (30). In 1983, seventeen placer operators mined at 21 locations and produced an estimated 7,500 oz of gold (30).

PRECIOUS-METAL LODE DEPOSITS

Precious-metal lode production has come from several small high-grade vein deposits located in the vicinity of Quigley Ridge.

The Banjo Mine was the largest, producing 13,693 tons of ore averaging 0.50 oz gold/ton and 0.52 oz silver/ton (30). Scheelite is present at the Banjo Mine and samples containing up to 19% tungsten were collected (30). Several other prospects in the area have a mineralization similar to the Banjo Mine (30). The Little Annie Mine was the largest silver producer in the area with a production of 115,945 ounces of silver from 715 tons of ore.

In 1983, the only precious-metal lode production came from the Wieler Prospect located near the head of Eureka Creek. Approximately 156 tons of ore averaging 2.8 oz gold/ton and 65.3 oz silver/ton were mined (30).

ANTIMONY LODE DEPOSITS

Antimony, a critical and strategic mineral, occurs as vein deposits in the southern and northeastern parts of the study area. Historically, production came mostly from high-grade (>55% Sb) deposits. The Stampede Mine, currently idle, produced 3,700,000 lb of antimony to make it the largest producer in the district and the second largest producer among domestic mines. The Slate Creek Mine produced 800,000 lb of antimony including about 26,000 lb of hand sorted material shipped in 1983. The Last Chance Mine, which had the first lode antimony production, produced approximately 74,000 lb. Antimony oxide minerals are present, but stibnite (antimony sulfide, Sb_2S_3) is the major ore mineral at all deposits.

Known antimony mines and prospects in the area contain modest proven reserves. Additional deposits could be discovered and additional ore developed at extensions of known deposits. Antimony production could be significant in terms of U.S. production but to date has not been significant in terms of annual domestic consumption (30).

STRATABOUND MASSIVE SULFIDE DEPOSITS

The Kantishna Hills study area is underlain by rocks with potential for the occurrence of stratabound massive sulfide deposits containing lead, zinc, copper, silver, gold, germanium, and gallium. Three potential host environments were identified by the 1983 study (30): (1) Quartzite units within the Precambrian Birch Creek Schist; (2) black slate/schist terranes in the Birch Creek Schist and the Devonian Keevy Peak Formation; and (3) volcanogenic environments in the lower Paleozoic (?) Spruce Creek Sequence. Geologic similarities to known mines suggest that several prospects and occurrences in the study area, including the Lloyd Prospect, Red Dirt, and Canyon Creek occurrences, are broadly analogous to major massive sulfide deposits elsewhere in North America (30).

OTHER DEPOSITS AND OCCURRENCES

Other deposits include skarn mineralization in the Iron Dome-Eldorado Creek areas and garnet-bearing amphibolites containing minor free gold in the Birch Creek Schist (30). Tungsten anomalies identified in the Canyon Creek area are related to an unknown deposit type. Rhodochrosite boulders of unknown orgin were found in the east fork of Glen Creek.

SAMPLING PROCEDURES AND SAMPLE DISTRIBUTION

Reconnaissance placer concentrates, panned concentrates, and stream sediments were collected in 1983. Reconnaissance placer concentrates were collected by digging a pit or trench and processing 0.1 yd^3 of floodplain or bench gravels through a 10-in.-wide by 34-in.-long sluice box or a hydraulic concentrator. Samples were collected from major drainages and their principal tributaries which had not recently been mined. When possible, channel samples were taken of gravels from surface to, and including, bedrock. The concentrated material was panned to retain only the gold and other heavy minerals (approximately 2 to 7 oz)(30). This type of sampling results in about a 900-fold concentration of heavy minerals.

Panned concentrate samples consisted of collecting one heaped 16-in. gold pan of sand and gravel from active stream channels and panning it down to get a sample of approximately 2 to 7 oz (30). This type of sampling produces about a 60-fold concentration of heavy mineral content.

Stream sediment samples consisted of 10 to 15 oz of silt-sized material collected from active stream channels (30). Panned concentrate and stream sediment sample sites were selected to obtain fill-in or follow-up data to previous geochemical sampling performed by Bundtzen (8) and Hawley (18).

SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

Reconnaissance placer concentrates were processed at the field placer laboratory in Kantishna (30). Gold particles coarser than approximately 60 mesh were separated from the concentrate using a spiral concentrating wheel, magnet, and blower, and then weighed (30). Samples of this gold were assayed for fineness at the Bureau's laboratory in Juneau, Alaska. The resulting concentrate from each sample was amalgamated to recover as much free gold as possible. The remaining heavy mineral fraction was sent to Skyline Labs, Inc., Wheat Ridge, Colorado, for quantitative analysis of selected elements including gold, silver, tungsten, tin, and platinum and/or 31 element semi-quantitative emission spectrographic analysis (30).

Panned concentrates and stream sediment samples were analyzed at Skyline Labs, Inc. using atomic absorption (AA), fire assay, colorimetric, Induced Coupled Argon Plasma (ICAP), and Fire Assay ICAP methods. The detection limits for each element are summarized on tables 1, 2, and 3. The individual analytical results are not reproduced here, but are available in the 1983 Kantishna Hills study area report (30).

STATISTICAL ANALYSIS OF ANALYTICAL RESULTS

Critical and strategic element content of reconnaissance placer, panned concentrates, and stream sediment samples from the Kantishna Hills study area collected in 1983, were analyzed statistically. Data was available for 139 reconnaissance placer, 53 panned concentrate, and 217 stream sediment samples (30). For reconnaissance placer concentrates analytical results were available for cobalt, chromium, gallium, germanium, manganese, niobium, nickel, tin, tantalum, titanium, and tungsten; for panned concentrates cobalt, chromium, gallium, manganese, nickel, and tungsten; and for stream sediment

TABLE 1. - Statistical summary of reconnaissance placer concentrates, Kantishna Hills study area

(Values in ppm)

Element	Frequency distribution		Cumulative frequency distribution				Detection limit	Samples below detection limit	Total samples analyzed	Comments
	Mean	Std. dev. [1]	Background [2]	Threshold	Anomalous samples	Anomalous sample range				
Co	25	31	21	41	16	45-300	5	3	139	Two lognormal populations.
Cr	155	174	110	640	4	700-1000	10	1	139	Lognormal population.
Ga	17	9	15	32	4	50	1	22	139	Lognormal population.
Ge	ND	ND	ND	1	17	20	1	122	139	17 samples at 20 ppm. Detection limit is threshold.
Mn	5744	3532	5000	11,000	5	11,500-14,000	10	1	139	Three populations.
Nb	28	20	28	38	13	40-160	10	33	139	Excess of high values in population.
Ni	43	50	35	120	4	130-500	5	1	139	Lognormal population.
Sn	164	277	ND	1	76	3-2000	1	63	139	Lognormal upper population. Detection limit is threshold.
Ta	49	31	ND	1	15	20-120	1	124	139	Lognormal upper population. Detection limit is threshold.
Ti	11262	13392	9000	12,800	17	13,000-110,000	1	3	139	Excess of high values in population.

See footnotes at end of table

TABLE 1. - Statistical summary of reconnaissance placer concentrates, Kantishna Hills study area - continued

Element	Frequency distribution		Cumulative frequency distribution				Detection limit	Samples below detection limit	Total samples analyzed	Comments
	Mean	Std. dev.	Background	Threshold	Anomalous samples	Anomalous sample range				
W	93	105	ND	2	60	4-500	2	71	139	Lognormal upper population. 8 samples with high values ranging from 1,000-17,850 ppm omitted from statistical processing. Detection limit is threshold.

ND No data
1/ Standard deviation
2/ Background - Mode, median, and geometric mean on "idealized" lognormal cumulative frequency distribution curve

TABLE 2. - Statistical summary of panned concentrates, Kantishna Hills study area

(Values in ppm)

Element	Frequency Distribution						Detection limit	Samples below detection limit	Total samples analyzed	Comments
	Mean	Std. dev.[1/]	Background	Threshold	Anomalous samples	Anomalous sample range				
Co	ND	ND	ND	5	12	10-45	5	41	53	Insufficient data for frequency distribution. Detection limit taken as threshold.
Cr	ND	ND	ND	10	9	40-130	10	44	53	Insufficient data for frequency distribution. Detection limit taken as threshold.
Ga	ND	ND	ND	1	10	6-10	1	40	53	Insufficient data for frequency distribution. Detection limit taken as threshold.
Mn	ND	ND	ND	10	10	1550-7850	10	43	53	Insufficient data for frequency distribution. Detection limit taken as threshold.
Nb	ND	ND	ND	10	4	10-20	10	51	53	Insufficient data for frequency distribution. Detection limit taken as threshold.

See footnotes at end of table.

TABLE 2. - Statistical summary of panned concentrates, Kantishna Hills study area - continued

(Values in ppm)

Element	Frequency distribution						Detection limit	Samples below detection limit	Total samples analyzed	Comments
	Mean	Std. 1/ dev.	Background	Threshold	Anomalous samples	Anomalous sample range				
Ni	ND	ND	ND	5	12	15-120	5	41	53	Insufficient data for frequency distribution. Detection limit taken as threshold.
W	ND	ND	ND	8	8	3-75	2	17	53	One sample (940 ppm) was eliminated from statistical processing. Anomalous samples determined graphically from histogram.

ND No data
1/ Standard deviation

TABLE 3. - Statistical summary of stream sediment samples
Kantishna Hills study area

(Values in ppm)

	Frequency distribution									
Element	Mean	Std.1/ dev.	2/ Background	Threshold	Anomalous samples	Anomalous sample range	Detection limit	Samples below detection limit	Total samples analyzed	Comments
Co	24	17	ND	41	3	50-80	5	1	25	Anomalous samples were determined from histogram.
Ni	55	40	ND	95	4	110-170	5	1	26	Anomalous samples were determined from histogram.
Sn	ND	ND	ND	1	2	12-17	1	27	29	Two samples above detection limit were anomalous.
W	5	2	4	9	4	9-19	2	17	217	Lognormal population from cumulative frequency distribution. One sample (50 ppm) was eliminated from statistical processing and six samples with 8 ppm were considered anomalous also.

ND No data
1/ Standard deviation
2/ Background - Mode, median, and geometric mean on "idealized" lognormal cumulative frequency distribution curve.

samples cobalt, nickel, tin, and tungsten. All analytical results for palladium and platinum were below the detection limits (30).

Mathematical statistics as well as graphical methods were used to evaluate elements of interest. A frequency histogram and a cumulative frequency histogram were plotted for the critical and strategic elements that had sufficient analytical data (appendices A-C).

Only sample values above the detection limit were used in preparing the histograms. Sample values that appeared to be highly anomalous were eliminated prior to determining statistical parameters.

The analytical data were processed (by Salisbury & Dietz, Inc.) utilizing computer software applications contained in "EARTH SCIENCE INFORMATION SYSTEM" (ESIS), a product of Control Data Corporation. ESIS provides data base management, statistical processing, and data presentation in a variety of formats.

Class intervals between one-quarter and one-half standard deviation were chosen for constructing the histograms (29). This procedure gives 10 to 20 intervals (or classes) for each set of values. Frequencies were cumulated from the lowest values toward the highest. Cumulative frequency curves (figs. 3-13) were constructed on log-probability paper for the various elements which had sufficient analytical data. Anomalous concentrations for the various elements were determined from the cumulative frequency curves or the frequency histogram.

A summary of the results of the statistical analyses is shown on tables 1-3.

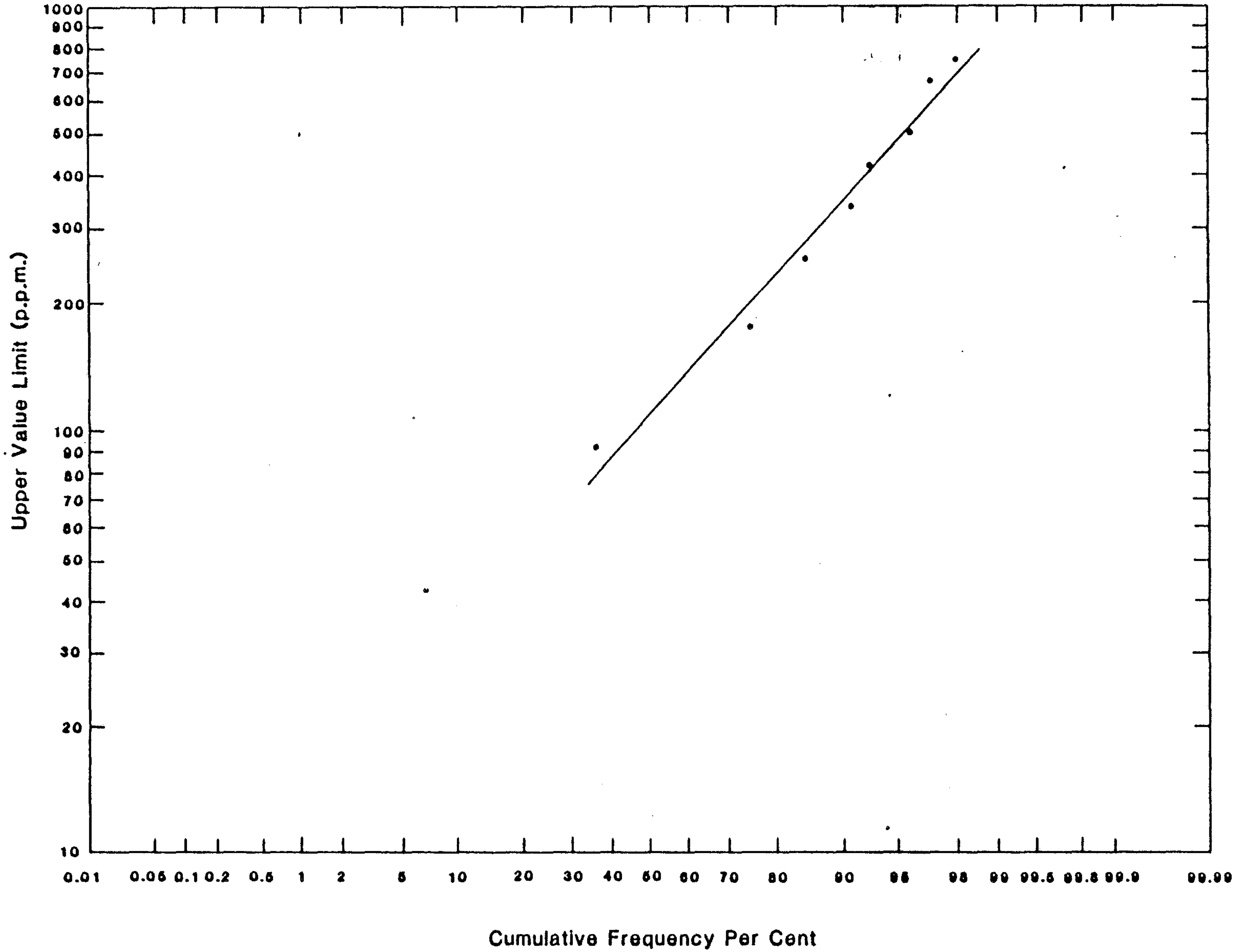


FIGURE 3. Cumulative frequency plot of chromium in reconnaissance placer samples

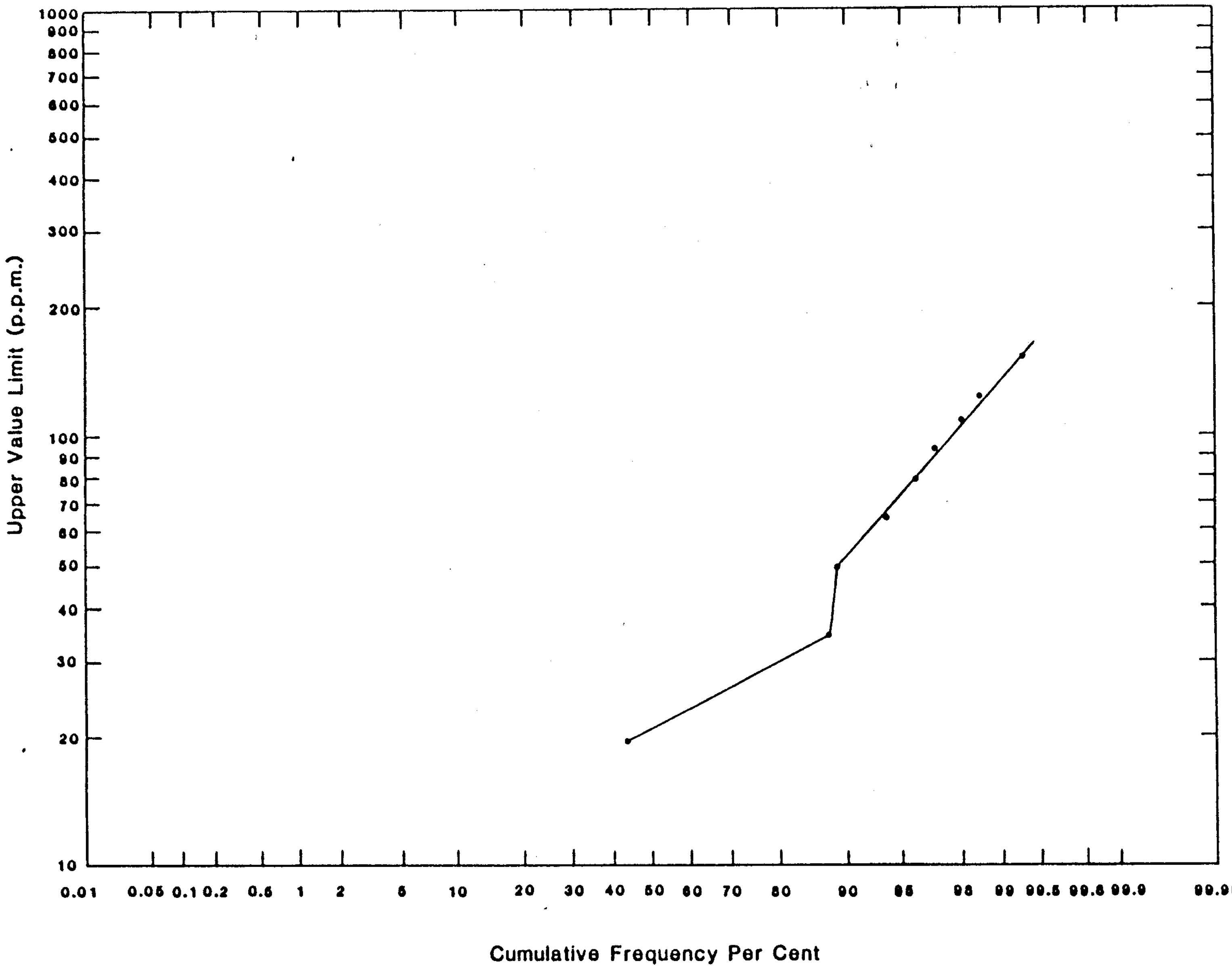


FIGURE 4. Cumulative frequency plot of cobalt in reconnaissance placer samples

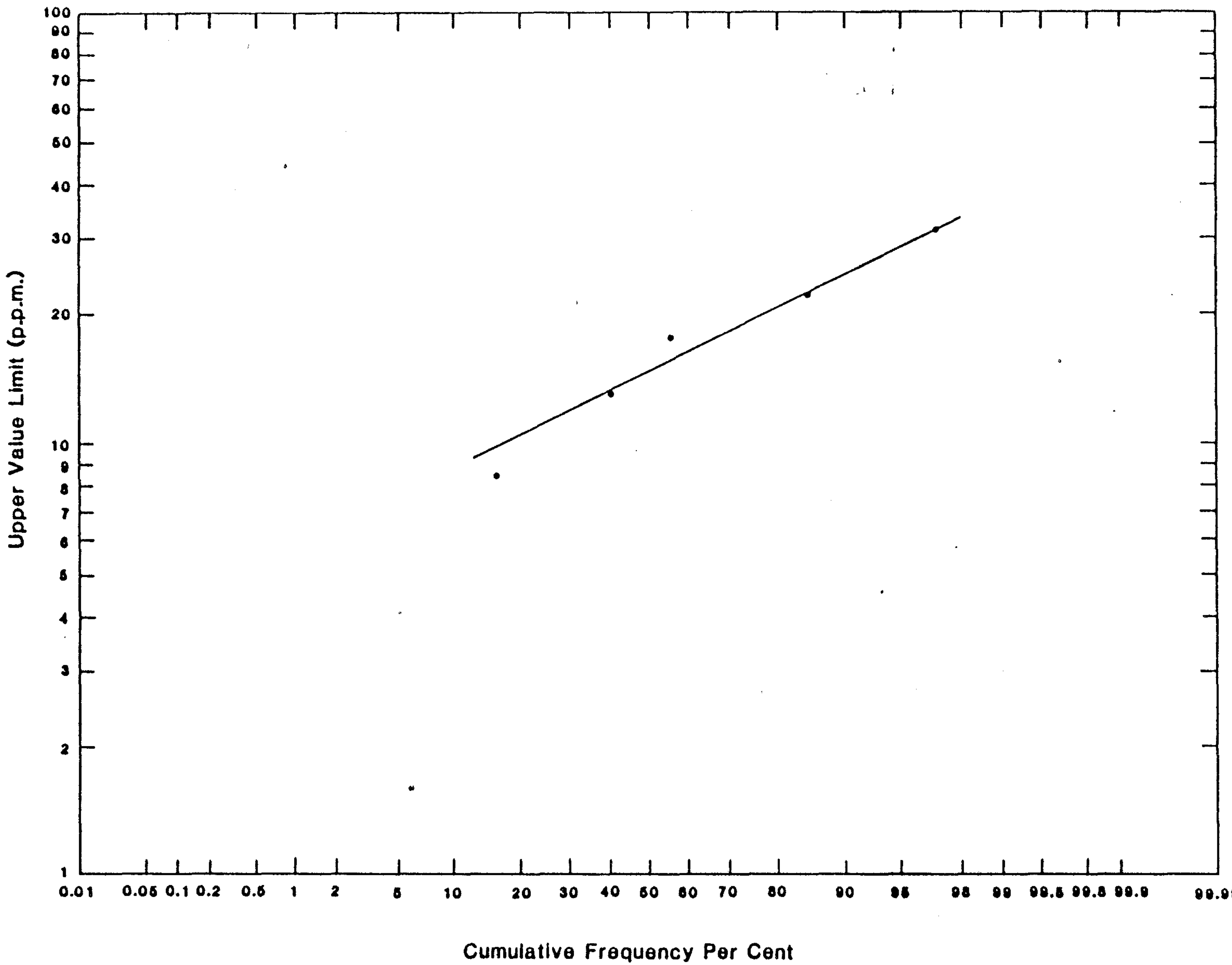


FIGURE 5. Cumulative frequency plot of gallium in reconnaissance placer samples

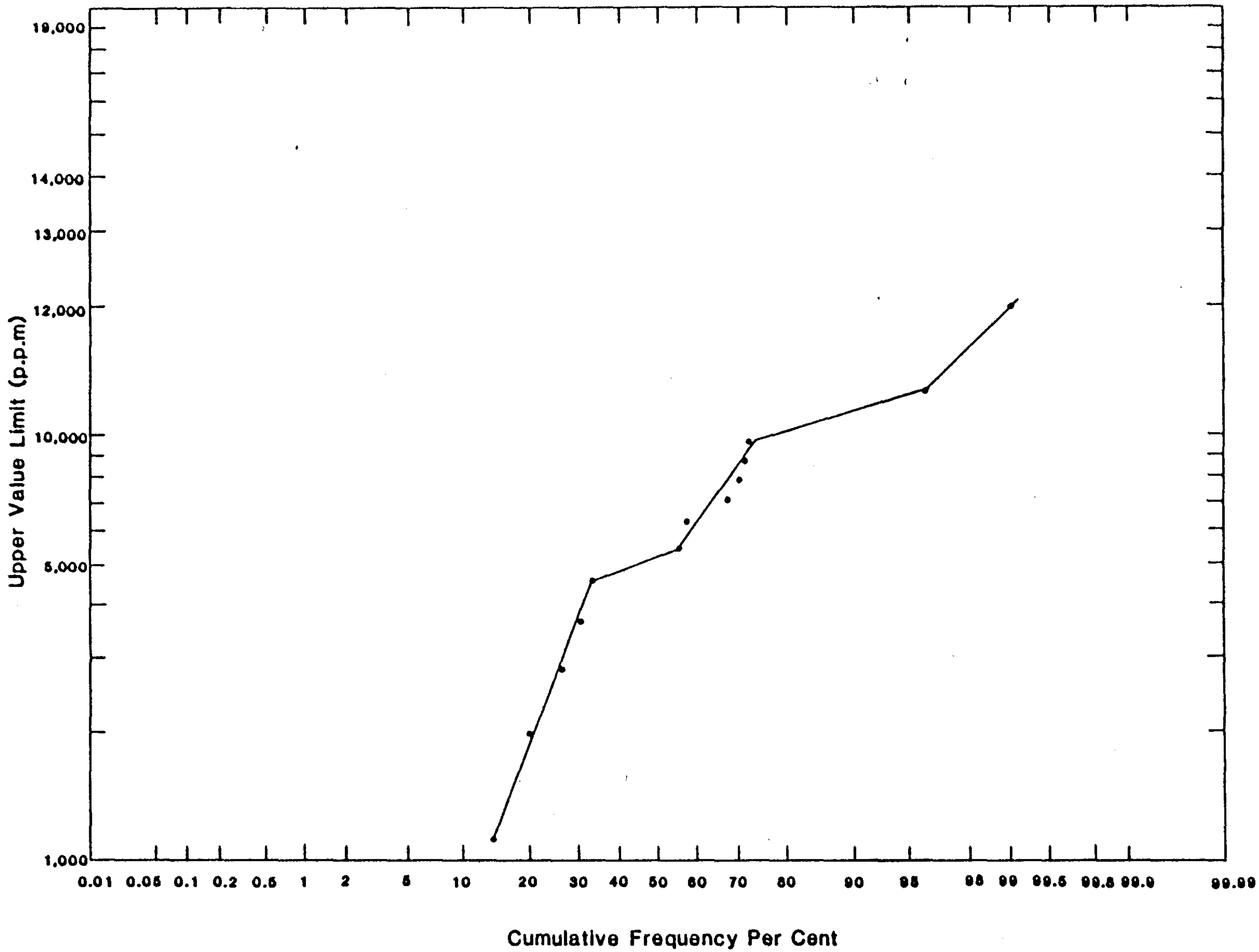


FIGURE 6. Cumulative frequency plot of manganese in reconnaissance placer samples

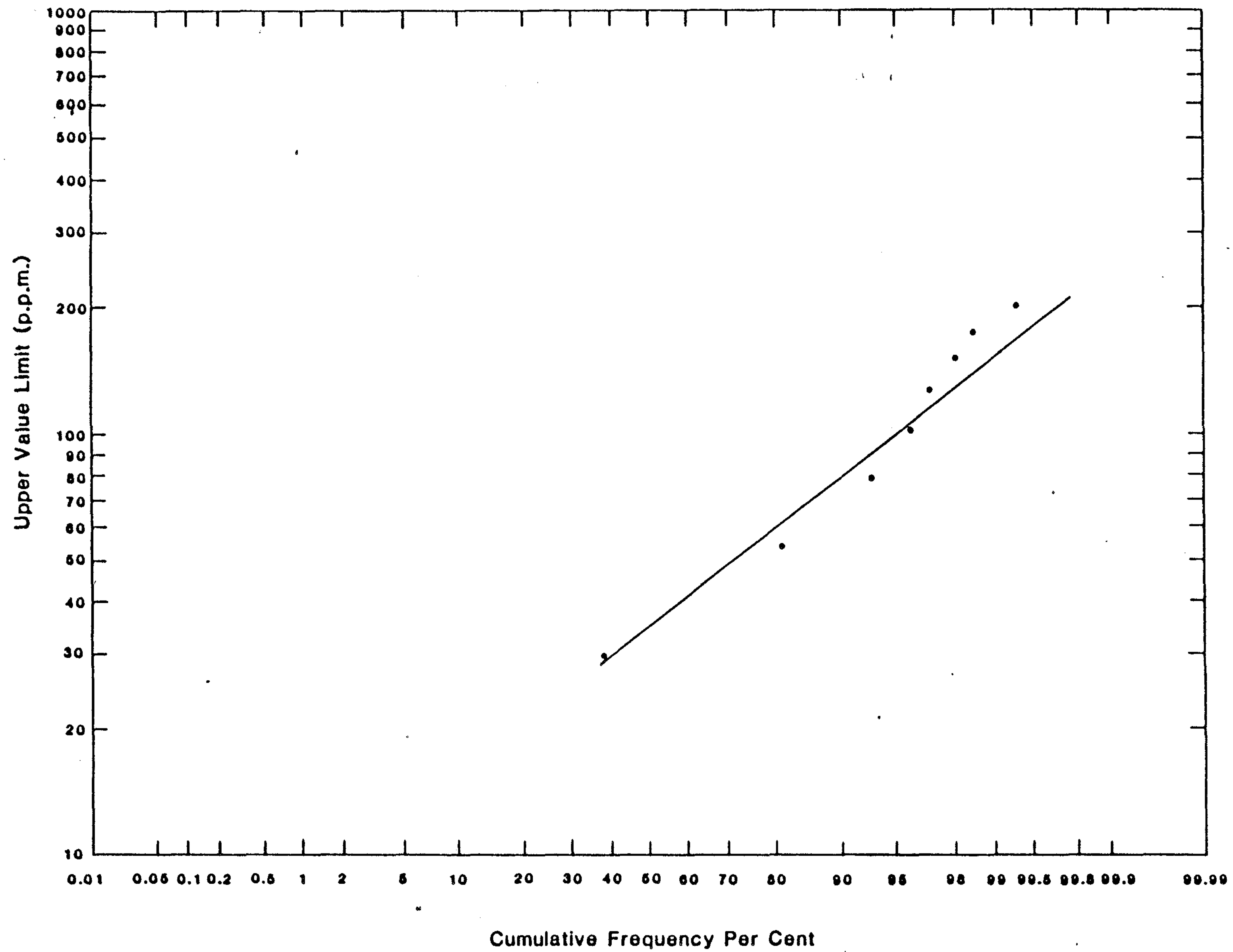


FIGURE 7. Cumulative frequency plot of nickel in reconnaissance placer samples

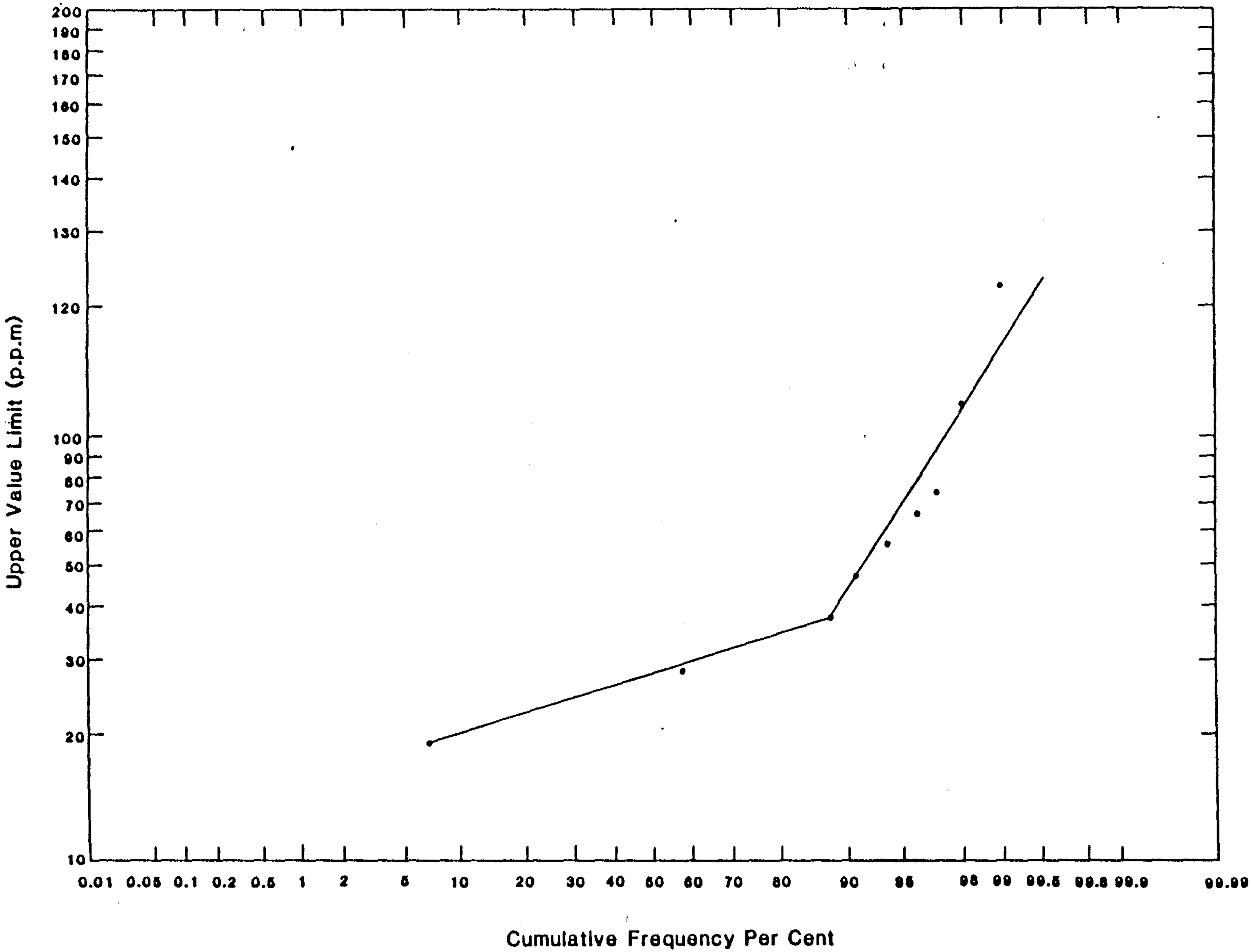


FIGURE 8. Cumulative frequency plot of niobium in reconnaissance placer samples

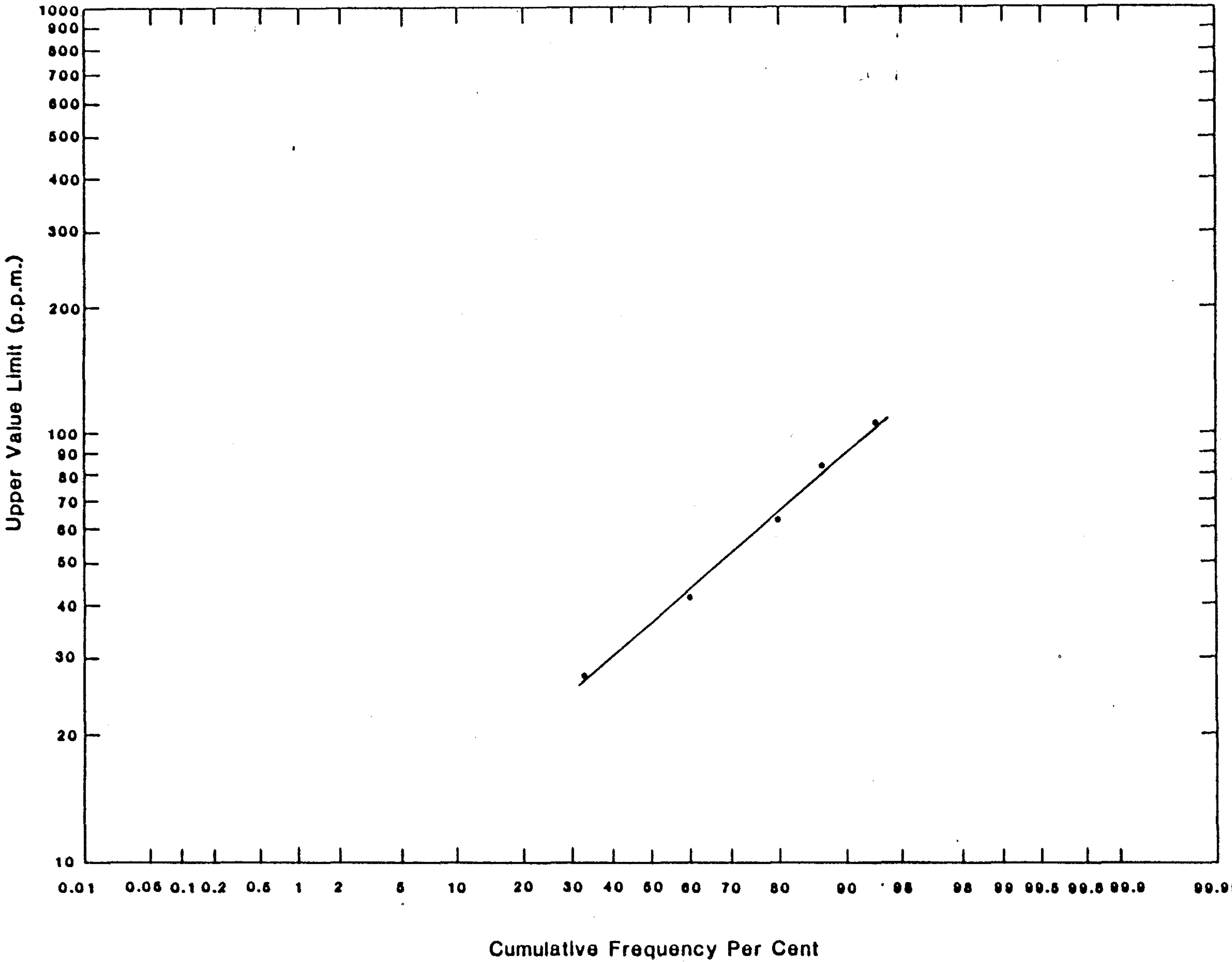


FIGURE 9. Cumulative frequency plot of tantalum in reconnaissance placer samples

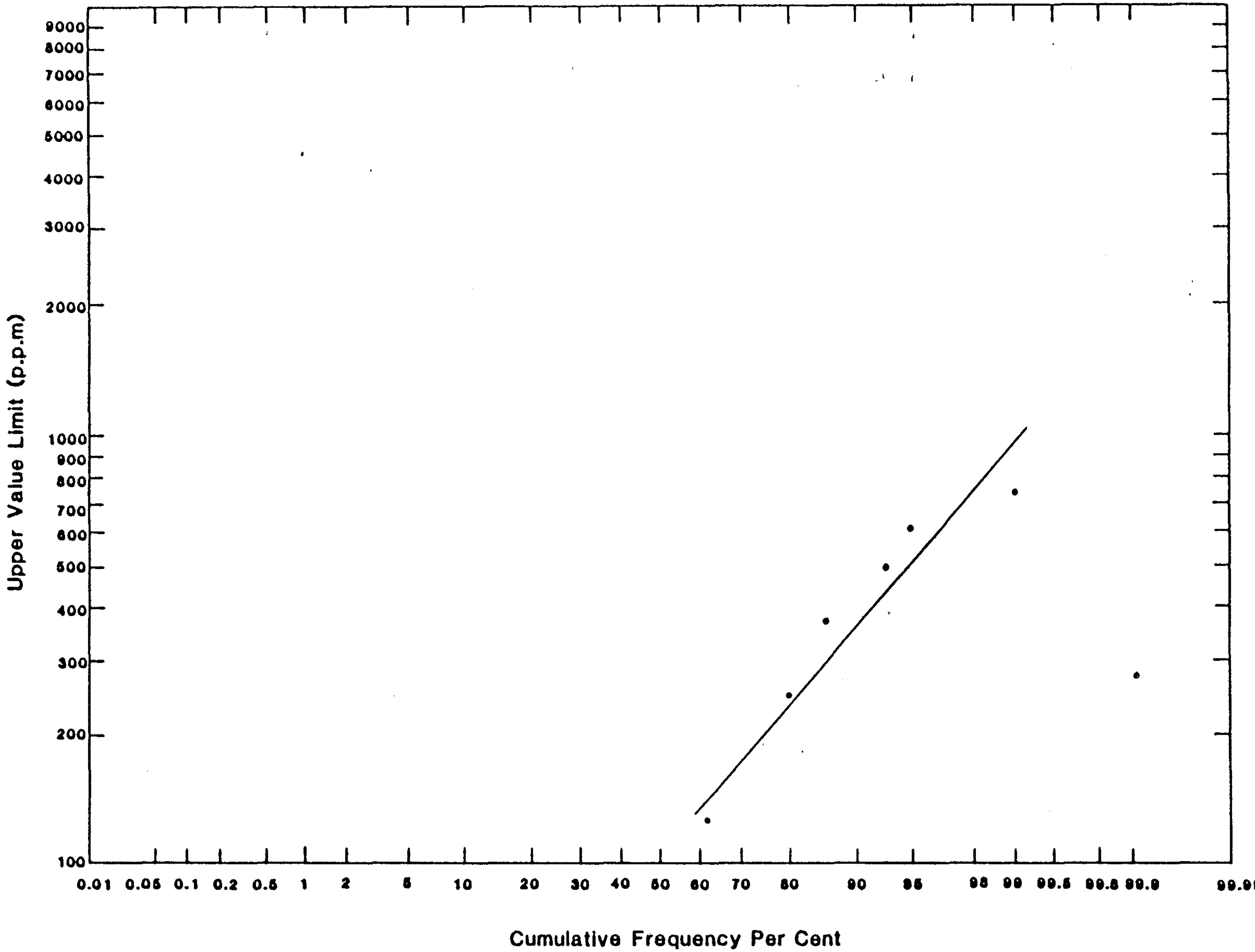


FIGURE 10. Cumulative frequency plot of tin in reconnaissance placer samples

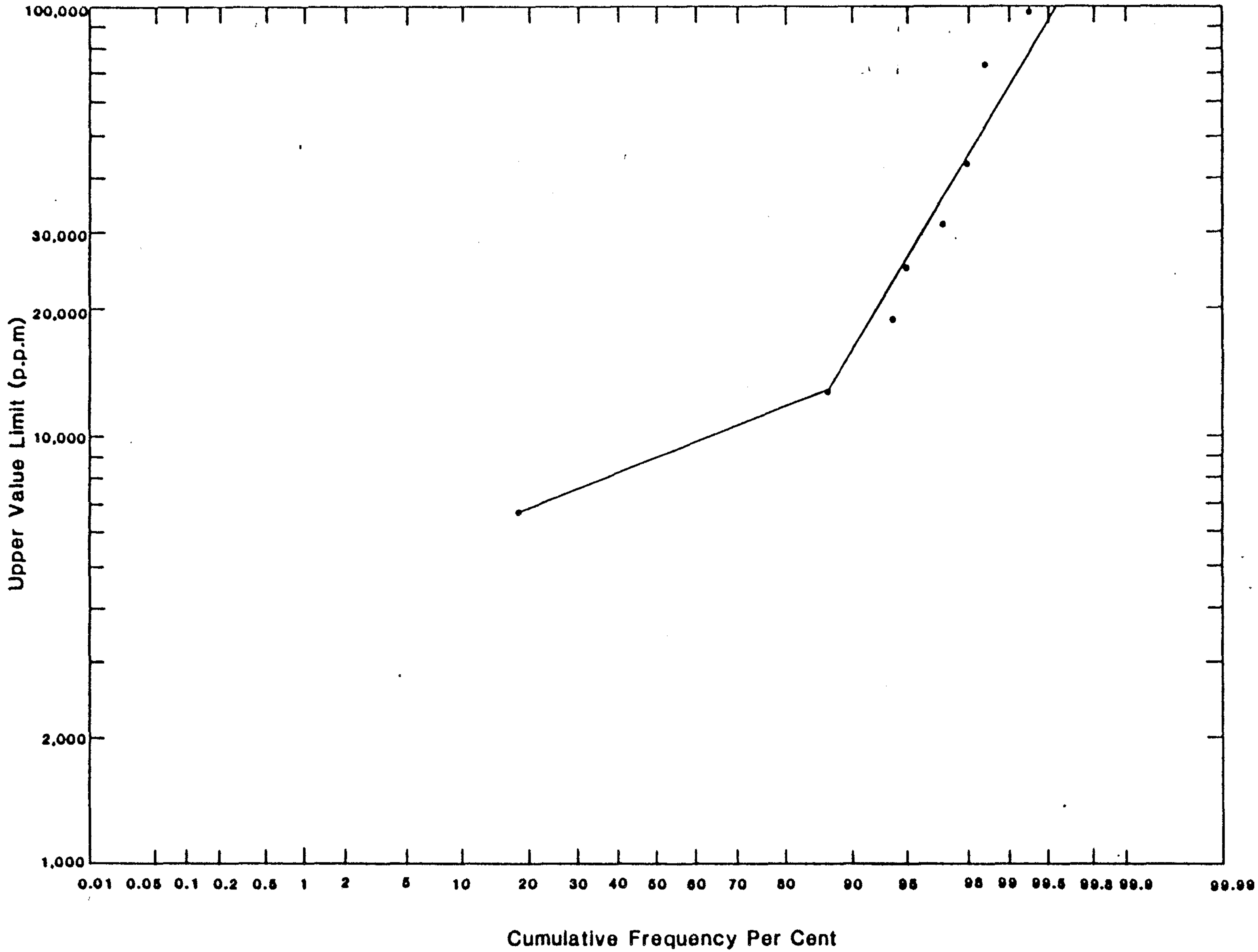


FIGURE 11. Cumulative frequency plot of titanium in reconnaissance placer samples

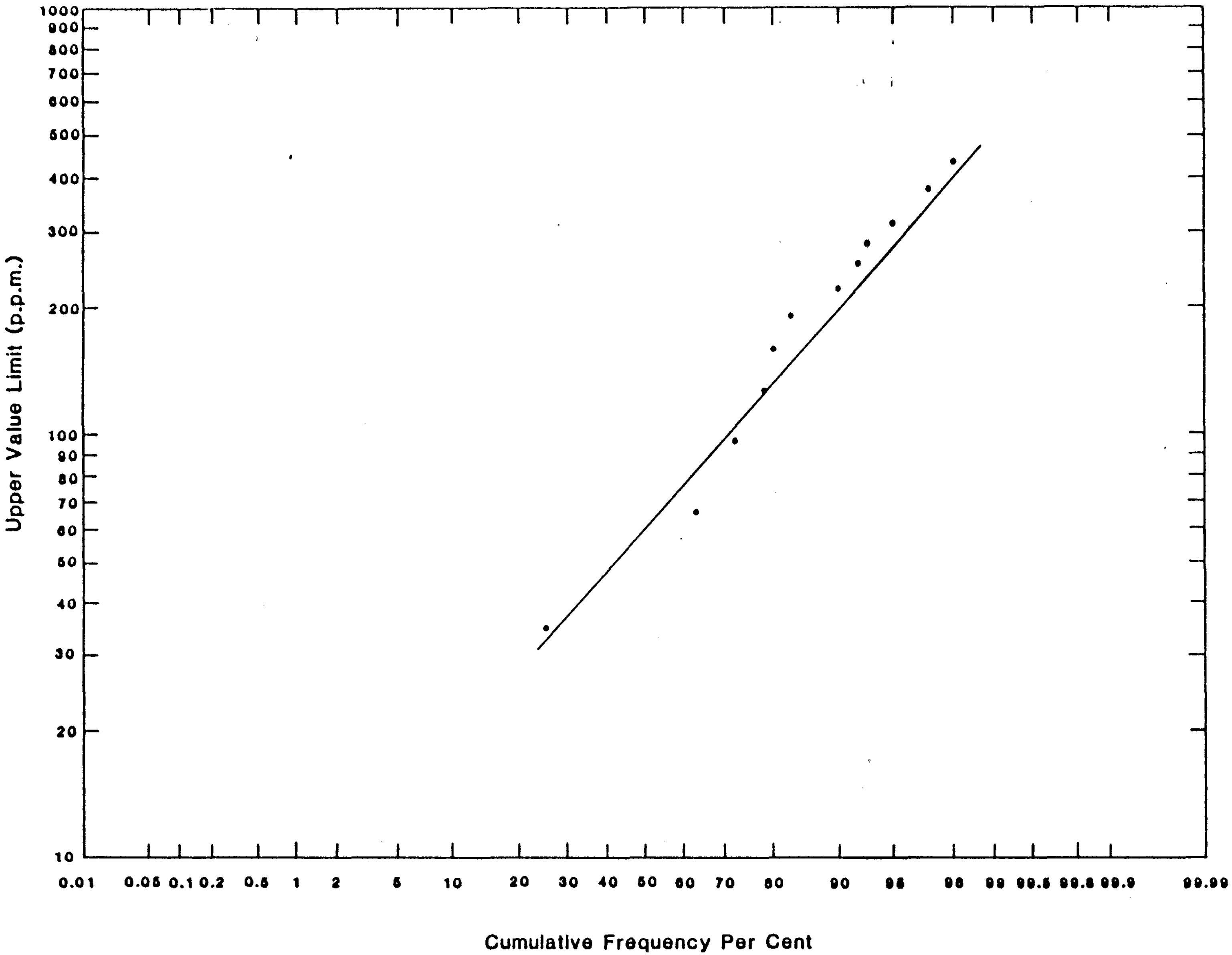


FIGURE 12. Cumulative frequency plot of tungsten in reconnaissance placer samples

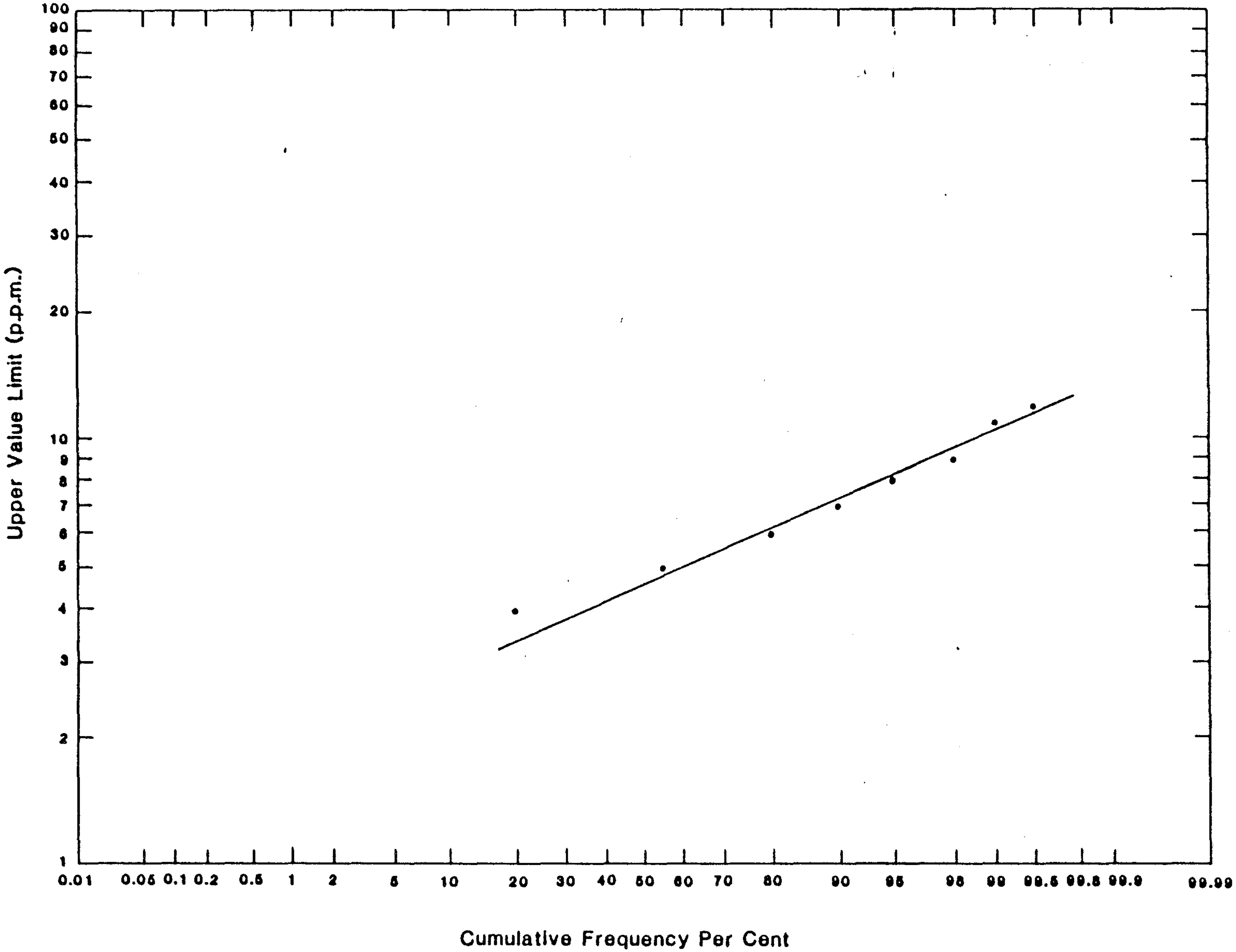


FIGURE 13. Cumulative frequency plot of tungsten in stream sediment samples

GRAPHICAL ANALYSIS OF ANALYTICAL RESULTS

Anomalous concentrations of cobalt, chromium, gallium, manganese, niobium, nickel, and titanium in reconnaissance placer samples and tungsten in stream sediment samples were determined graphically from the cumulative frequency curve.

Chromium, gallium, and nickel values in reconnaissance placer samples and tungsten in stream sediment samples are lognormally distributed (figs. 3, 5, and 7). Anomalous values (tables 1 and 3), are those equal to or greater than the threshold. The threshold level, mean plus two standard deviations, is read directly on the cumulative frequency curve at the 97.5% probability level (21).

The cumulative frequency curves for cobalt, manganese, niobium, and titanium values in reconnaissance placer samples show non-homogenous distribution (figs. 4, 6, 8, and 11). Anomalous values for these were determined by the graphical technique described by Lepeltier (21). The cobalt cumulative frequency curve suggests the existence of two populations (fig. 4), assumed to be a main "background" population mixed with a small anomalous one. The manganese cumulative frequency curve suggests the existence of three populations (fig. 6), with the "upper" population assumed anomalous. The niobium and titanium cumulative frequency curve shows an excess of high values in the population (figs. 8 and 11)(21).

Anomalous tungsten values in panned concentrates (table 2) and cobalt and nickel in stream sediments (table 3) were determined graphically from histograms (appendices B and C) because there were insufficient analytical data for plotting cumulative frequency curves.

For several elements, a large percentage of samples contained values below the detection limit. Therefore, all values greater than the detection limit were considered anomalous. Anomalous values were determined this way for germanium, tantalum, tin, and tungsten in reconnaissance placer samples (table 1); chromium, cobalt, gallium, manganese, nickel, and niobium in panned concentrates (table 2); and tin in stream sediments (table 3). Tantalum, tin, and tungsten values in reconnaissance placer samples have lognormal distribution (figs. 9, 10, and 12) for the values greater than their detection limit.

The locations of samples with anomalous element contents are shown on figures 14-17.

Geochemically anomalous areas are shown on figures 18-23.

ANOMALOUS RECONNAISSANCE PLACER SAMPLES

Reconnaissance placer samples contained anomalously high chromium, cobalt, gallium, germanium, manganese, nickel, niobium, tantalum, tin, titanium, and tungsten.

CHROMIUM

The average chromium content in 138 samples is 110 ppm and the threshold is 640 ppm (fig. 3).

Four samples contained anomalous chromium (fig. 14). Sample 35[3/] (1,000 ppm) was taken on Myrtle creek which has no known prospects in

---

3/Sample numbers used in this report. Original field sample numbers used in the 1983 Mineral Resources Studies by Salisbury & Dietz, Inc. (30) are referenced in appendix D.

its drainage. Samples 36 (200 ppm) and 37 (1,000 ppm) on Moose Creek, and 39 (940 ppm) on Eldorado Creek are from known mining areas.

Chromite was not identified in the concentrates, although a detailed study of the mineralogy of the heavy mineral fraction has not been done. The anomalous chromium samples may reflect the presence of fuchsite (a chromium mica) which was identified in rock samples in the Spruce Creek Sequence (30). Anomalous chromium values were not obtained from samples collected in the western and northern portions of the study area away from the Spruce Creek Sequence.

COBALT

The average cobalt content of 136 samples is 21 ppm and the threshold is 41 ppm (fig. 4).

Sixteen samples contained anomalous cobalt (fig. 14). Four of the five highest cobalt values occur in samples taken from drainages with no known prospects. They include samples 2 (80 ppm) from Little Moose Creek which is underlain by the Birch Creek Schist; 3 (300 ppm) from a tributary to Stampede Creek; and 23 (110 ppm) from the mouth of Moonlight Creek which are underlain by the Keevy Peak Formation; and 28 (100 ppm) from upper Canyon Creek which is underlain by the Spruce Creek Sequence. Sample 38 (150 ppm) was taken from an area underlain by the Spruce Creek Sequence on Eldorado Creek, a known mining area with no previously reported cobalt occurrences.

GALLIUM

The average gallium content of 117 samples is 15 ppm and the threshold is 32 ppm (fig. 5).

Four samples (3, 29, 32, 37) contained anomalous gallium (fig. 14). There appears to be no correlation of gallium values with rock type as they occur in the Spruce Creek Sequence, Birch Creek Schist, and Keevy Peak Formation.

GERMANIUM

Seventeen of 139 samples contained detectable germanium (fig. 14). Each sample contained 20 ppm germanium and was considered anomalous. The detection limit for germanium is 1 ppm (table 1). These anomalous samples were from a large zone underlain by the Birch Creek Schist in the northern part of the study area (figs. 14 and 20). Germanium was not detected elsewhere in the study area. The source and significance of this germanium occurrence is unknown.

MANGANESE

The average manganese content of 138 samples is 5,000 ppm and the threshold is 11,000 ppm (fig. 6).

Five samples contained anomalously high manganese concentrations (fig. 14). These five samples range from 1.15% to 1.4% manganese and occur within the Spruce Creek Sequence away from known mining areas. The samples were collected on Little Moose Creek (2), a tributary to North Fork of Canyon Creek (13), a tributary to Rock Creek (20) Clearwater Fork (24), and Rock Creek (27).

NICKEL

The average nickel content of 138 samples is 35 ppm and the threshold is 120 ppm (fig. 7).

Four samples contained anomalous nickel (fig. 14). One sample, 38 (170 ppm) is from Eldorado Creek, a known mining area, but the other 3 are from the northeast corner of the study area in areas of no known prospects. Two samples, 3 (500 ppm) on a tributary to Stampede Creek and 23 (200 ppm) on Moonlight Creek are underlain by the Keevy Peak Formation. Sample 24 (130 ppm) on the Clearwater Fork is underlain by the Birch Creek Schist.

NIOBIUM

The average niobium content of 106 samples is 28 ppm and the threshold is 38 ppm (fig. 8).

Thirteen samples contained anomalous (40-160 ppm) niobium (fig. 15). The samples with the highest values occur along Moose Creek. The majority of the anomalous samples appear related to the Birch Creek Schist.

TANTALUM

Fifteen samples, containing from 20 to 120 ppm tantalum, were considered anomalous (fig. 15) because 124 samples (89%) contained less than the detection limit (1 ppm)(table 1). The values in the anomalous population are lognormally distributed (fig. 9). The majority of the anomalous samples appear related to the Birch Creek Schist.

TIN

Sixty-three of 139 samples (45%) contained less than 1 ppm tin, the detection limit (table 1). Seventy-four samples contained from 3 to 2,000 ppm and were classed as anomalous (fig. 15). The values in this anomalous population are lognormally distributed (fig. 10). Anomalous tin values occur in samples from areas underlain by both the Spruce Creek Sequence and the Birch Creek Schist. Several anomalous values occur in samples from the northern half of the study area away from known prospects and mining activity. In areas of mineralization, cassiterite has been identified in vein deposits (8, 33). The highest tin value (sample 96, 2,000 ppm) came from a stream draining easterly from Spruce Peak where several prospects are located. Tin anomalies also occur along Moose Creek, Rainy Creek, Myrtle Creek, Glen Creek, and Eldorado Creek.

TITANIUM

The average titanium content of 136 samples is 9,000 ppm and the threshold is 12,800 ppm (fig. 11).

Seventeen samples containing from 1.3 to 11% titanium, are anomalous (fig. 15). The majority of the high values were in samples obtained along Moose Creek. This area is underlain mostly by the Birch Creek Schist, with possibly some samples related to the Spruce Creek Sequence. Sample 104, containing 11% titanium the highest value of all samples, is located in the Upper Canyon of Moose Creek. Abundant ilmenite has been visually identified in Moose Creek placer samples but the source of the ilmenite is unknown. Other possibly significant anomalous samples 42, with 2.6% titanium collected near the mouth of Stampede Creek and include 111, with 6.9% titanium which was collected from lower Moose Creek.

TUNGSTEN

Sixty-eight of 139 samples containing greater than 2 ppm tungsten (the detection limit) were classed as anomalous (fig. 15). The anomalous values ranged from 4 to 17,850 ppm tungsten.

The values in the anomalous population are lognormally distributed (fig. 12). The background value of this upper population is 60 ppm with a threshold level of 370 ppm (fig. 12). Eight highly anomalous samples not included in this statistical evaluation contained 1,000 to 17,850 ppm tungsten.

Potentially significant anomalies were detected in the Canyon Creek drainage. Anomalous samples collected from the middle fork of Canyon Creek outline a 4-mile long anomalous tungsten zone. These samples (63-70) contained from 200 to 17,850 ppm tungsten. Coarse-grained scheelite (up to 1/4-in.) was visually identified with a black light in sample 69 (30). This drainage basin is underlain by the Birch Creek Schist. No intrusive rocks, calcareous rocks, or skarns, indicative of common tungsten environments, are known to occur in the area. An anomaly was also detected in the North Fork of Canyon Creek (58, 375 ppm) and in a small south-flowing tributary (60, 265 ppm) draining calcareous schist of the Birch Creek Schist. These anomalies may be related to the projected trend of the Spruce Creek Sequence.

Anomalies present in several other stream drainages underlain by the Birch Creek Schist include: Caribou Creek (77, 500 ppm); Rock Creek (72, 55 ppm); and a tributary to the upper Bearpaw River (49, 50 ppm) (fig. 15).

Five anomalies were detected in the northeast corner of the study area. Three of these anomalies are in stream drainages underlain by the Birch Creek Schist and include samples: 43 (240 ppm) from Little Moose Creek; and 44 (2,000 ppm) and 45 (200 ppm) from Stampede Creek and its tributary near the Stampede Mine. Anomalous sample 42 (17,500 ppm) was collected from near the mouth of Stampede Creek, where the area is underlain by the Birch Creek Schist and Keevy Peak Formation. An anomalous sample (46, 3,000 ppm) was collected from a northerly flowing tributary of Stampede Creek which also contained high concentrations of cobalt (300 ppm), nickel (500 ppm), gallium (50 ppm), gold (17.9 ppm), barium (1%), copper (1,000 ppm), lead (2,000 ppm), and antimony (300 ppm). This tributary is underlain by the Keevy Peak Formation. No prospects or mineral occurrences are known to exist in this drainage.

Scheelite was visually identified in most reconnaissance placer samples using a black light. Scheelite is known to be associated with veins in the Spruce Creek Sequence. Samples collected at the Banjo Mine contained up to 19% tungsten (30). Sample 107 (1,950 ppm) was collected from Lucky Gulch below the Banjo Mine. Other tungsten anomalies were identified in proximity to mining areas. These include those on Eldorado Creek (samples 124-127, 129-131), Slate Creek (sample 132), Eureka Creek (sample 121), and Moose Creek (samples 104, 106, 111-115, 118-120).

ANOMALOUS PANNED CONCENTRATE SAMPLES

Panned concentrate samples contained anomalously high chromium, cobalt, gallium, manganese, nickel, niobium, and tungsten (fig. 16).

CHROMIUM

Nine of 53 samples containing greater than 10 ppm chromium (the detection limit) were classed as anomalous (fig. 16). The anomalous values ranged from 40 to 130 ppm chromium (samples 135, 138, 139, 141, 143, 144, 145, 146, 148, and 149). They occur throughout the Kantishna Hills study area within areas underlain by the Birch Creek Schist. The highest value, sample 138 (130 ppm), was taken from a tributary of the Bearpaw River 1/4 mile below reconnaissance placer sample 5 (fig. 14) which had a low (150 ppm) chromium content.

COBALT

Twelve of 53 samples containing greater than 5 ppm cobalt (the detection limit) were classed as anomalous (fig. 16). The anomalous values ranged from 10 to 45 ppm (samples 135, 138, 139, 141, 142, 143, 144, 145, 146, 148, 150, and 151). All but one of the anomalous samples were collected from areas underlain by the Birch Creek Schist. The exception (sample 150) is from Eldorado Creek and may be related to the Spruce Creek Sequence. Most of the reconnaissance placer samples taken at the same location as the panned concentrates were not anomalous.

GALLIUM

Ten of 53 samples containing greater than 1 ppm gallium (the detection limit) were classed as anomalous (fig. 16). The anomalous values ranged from 6 to 10 ppm gallium (samples 135, 138, 139, 141, 142, 143, 144, 145, 146, and 148). All anomalous samples were collected from areas underlain by the Birch Creek Schist.

MANGANESE

Ten of 53 samples containing greater than 10 ppm manganese (the detection limit) were classed as anomalous (fig. 16). The anomalous values ranged from 1,550 to 7,850 ppm manganese (samples 135, 138, 139, 141, 142, 143, 144, 145, 146, and 148). The anomalous samples were collected from areas underlain by the Birch Creek Schist. The two highest anomalous values were from samples 143 (7,850 ppm) from upper Canyon Creek and 135 (7,700 ppm) from the mouth of Little Moose Creek.

NICKEL

Twelve of 53 samples containing greater than 5 ppm nickel (the detection limit) were classed as anomalous (fig. 16). The anomalous values ranged from 15 to 120 ppm nickel (samples 135, 138, 139, 141, 142, 143, 144, 145, 146, 148, 150, and 151). All but one of the anomalous samples were collected from areas underlain by the Birch Creek Schist. The exception is sample, 150 (120 ppm), from Eldorado Creek which is underlain by the Spruce Creek Sequence.

NIOBIUM

Four of 53 samples containing greater than 10 ppm niobium (the detection limit) were classed as anomalous (fig. 16). Two anomalous samples, 138 and 141, contained 10 ppm and two anomalous samples, 143 and 148, contained 20 ppm. The four anomalous samples were collected from an area underlain by the Birch Creek Schist.

TUNGSTEN

Nine of 35 samples containing greater than or equal to 8 ppm tungsten were classed as anomalous as determined graphically from the histogram (appendix B). One highly anomalous sample was not included in the statistical evaluation. The anomalous values range from 8 to 940 ppm tungsten (samples 136, 137, 140, 142, 143, 146, 147, 149, and 151)(fig. 16). They were collected throughout the study area, dominantly from areas underlain by the Birch Creek Schist. The sample with the highest value, 151 (940 ppm) was taken on Slate Creek.

ANOMALOUS STREAM SEDIMENT SAMPLES

Stream sediment samples contained anomalously high cobalt, nickel, tin, and tungsten (fig. 17).

COBALT

Three out of 25 samples containing greater than 41 ppm cobalt were classed as anomalous (fig. 17) as determined graphically from the histogram (appendix C). Sample 163 (50 ppm) is from a tributary of Eldorado Creek. Sample 164 (60 ppm) is from upper Slate Creek near the vicinity of the Slate Creek Mine. Both areas are underlain by the Birch Creek Schist. Sample 167 (80 ppm) was collected from Eldorado Creek within an area underlain by the Spruce Creek Sequence.

NICKEL

Four of 26 samples containing greater than 95 ppm nickel were classed as anomalous as determined graphically from the histogram (appendix C). The anomalous values ranged from 110 to 170 ppm nickel and include sample 162 (170 ppm), 163 (120 ppm), 164 (130 ppm), and 167 (110 ppm)(fig. 17). Three of these (samples 163, 164, and 167) were also anomalous in cobalt (see cobalt section). Sample 167 is from a side tributary of upper Slate Creek near the vicinity of Slate Creek Mine in an area underlain by the Birch Creek Schist.

TIN

Two of 29 samples containing greater than 1 ppm tin (the detection limit) were classed as anomalous (fig. 17). Samples 154 (17 ppm) and 155 (12 ppm) were collected from nearby tributaries to the Bearpaw River within an area underlain by the Birch Creek Schist .

TUNGSTEN

The average tungsten content of 199 samples is 4 ppm and the threshold is 9 ppm (fig. 13). Eleven samples contained anomalous tungsten values (fig. 17). The highest value, sample 166 (50 ppm), was from the Slate Creek Mine area. Sample 152 (8 ppm) was from the Stampede Mine area and sample 165 (8 ppm) was taken from the Slate Creek area. Other anomalous samples occur in several areas unrelated to previously identified mineralization. They include samples: 153 (9 ppm) from the headwaters of a south-flowing tributary into North Fork of Canyon Creek below the Red Dirt occurrence (30); 154 (19 ppm) from a north-flowing tributary to the Bearpaw River; 156 and No. 157 (8 ppm) from the North Fork of Canyon Creek drainage; 158 (9 ppm) from a tributary of the Clearwater Fork, an area underlain by the Keevy Peak Formation and the Birch Creek Schist; 159 (8 ppm) from the Middle Fork of Canyon Creek drainage; 160 (8 ppm) from an upper tributary to Rock Creek along a north trending fault; and 161 (10 ppm) from a tributary near the headwaters of Rock Creek within a drainage underlain by the Birch Creek Schist and Spruce Creek Sequence.

REGIONAL GEOCHEMICALLY ANOMALOUS AREAS

Eleven of 13 critical and strategic elements evaluated were present in anomalous concentrations in various samples. Of the thirteen, only palladium and platinum were not detected in any samples. Areas with anomalous concentrations of cobalt, germanium, nickel, niobium, tantalum, tin, titanium, and tungsten are shown on figures 18-23. Isolated samples containing chromium and gallium are shown on figure 14.

Three areas anomalous in cobalt and nickel were identified (fig. 18). The areas include: (1) Eldorado Creek with possible source rocks in the Spruce Creek Sequence; (2) Moonlight Creek with possible source

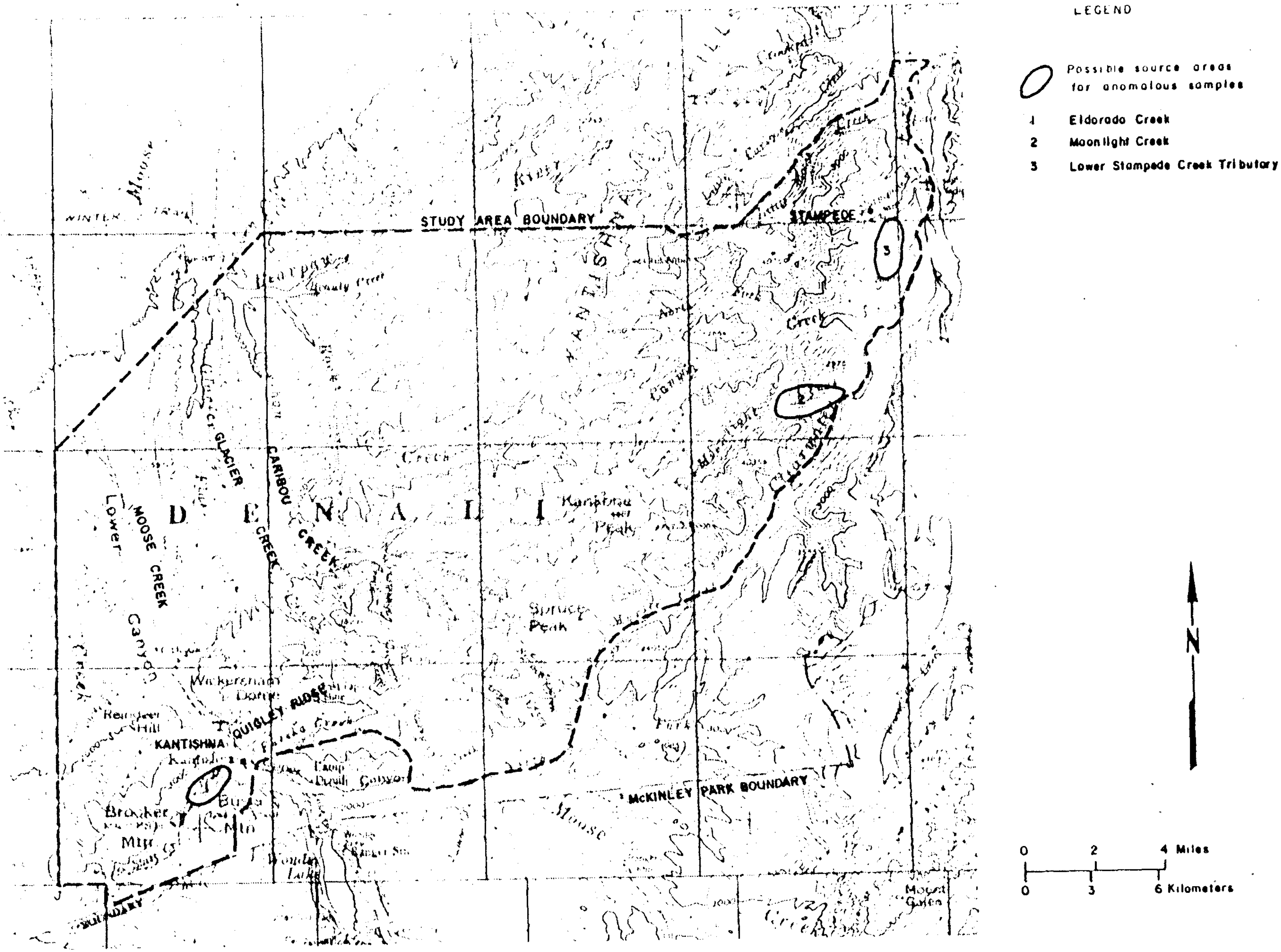


FIGURE 18. Geochemically anomalous areas - Cobalt and nickel, Kantishna Hills study area

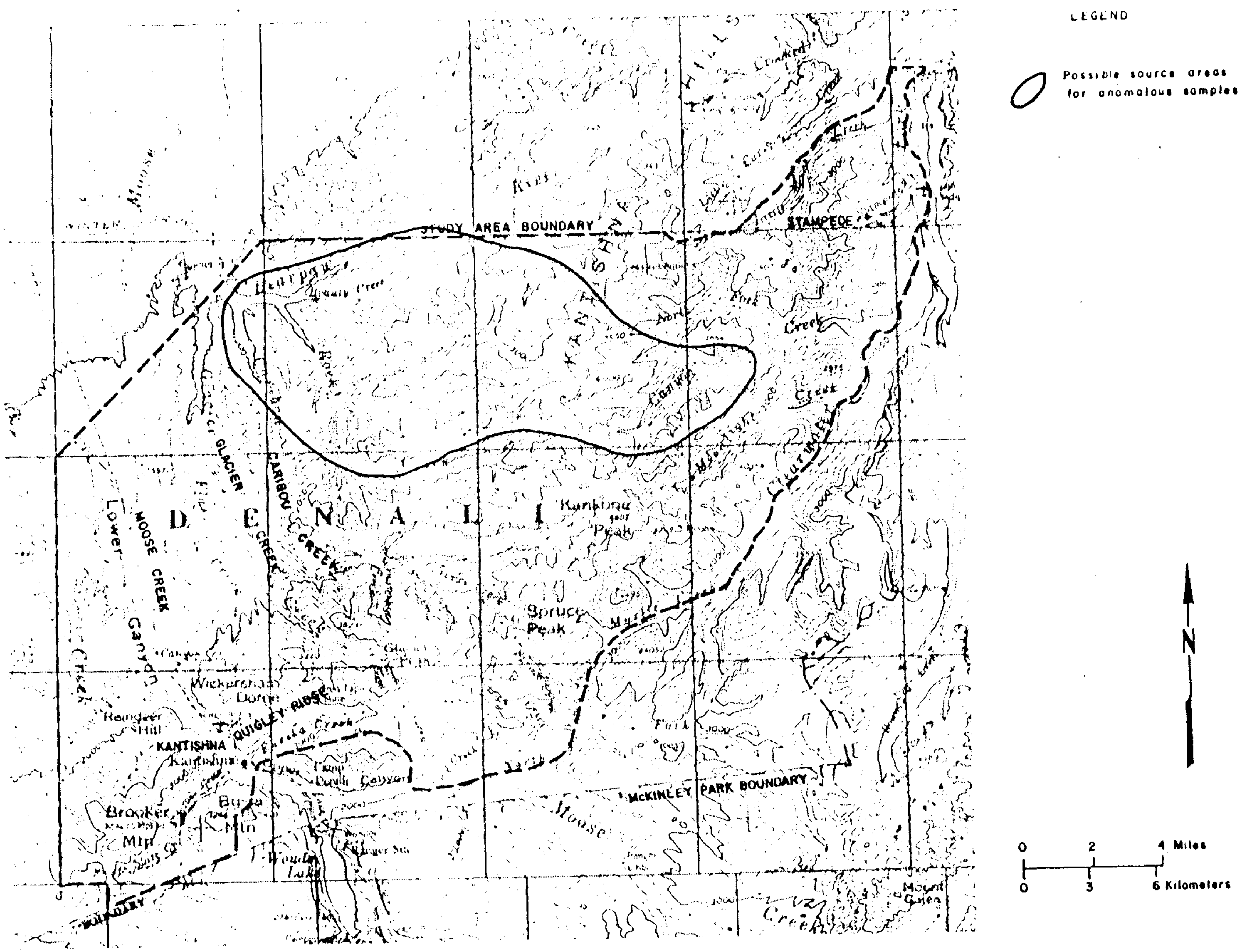
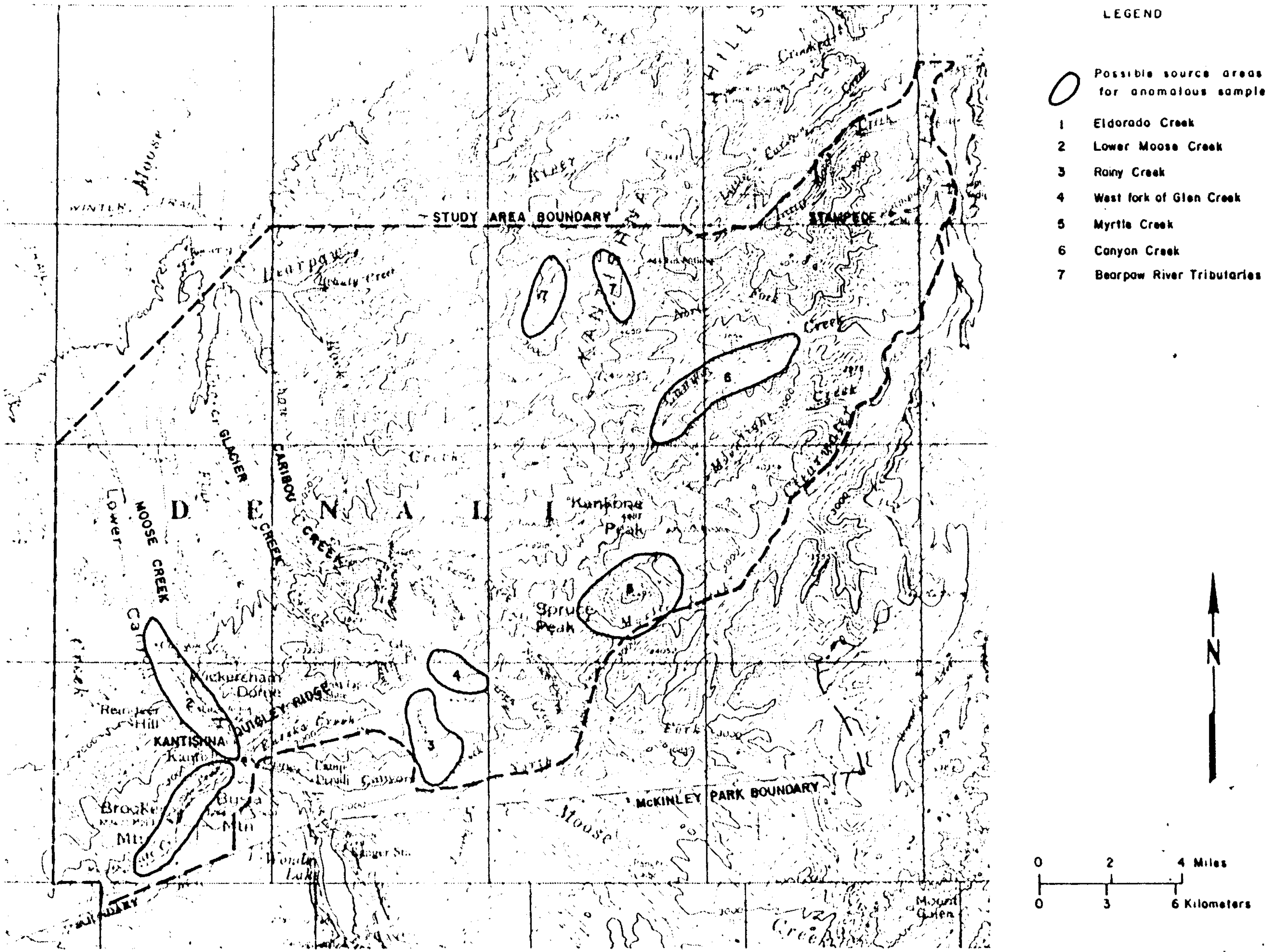


FIGURE 19. Geochemically anomalous areas - Germanium, Kantishna Hills study area



LEGEND
Possible source areas for anomalous samples
1 Eldorado Creek
2 Lower Moose Creek
3 Rainy Creek
4 West fork of Glen Creek
5 Myrtle Creek
6 Canyon Creek
7 Bearpaw River Tributaries
N
0 2 4 Miles
0 3 6 Kilometers
STUDY AREA BOUNDARY
STAMPEDE
McKINLEY PARK BOUNDARY
KANTISHNA
QUIGLEY RIDGE
GLACIER CREEK
CARIBOU CREEK
MOOSE CREEK
Lower
D E N A L I
Kankone Peak
Spruce Peak

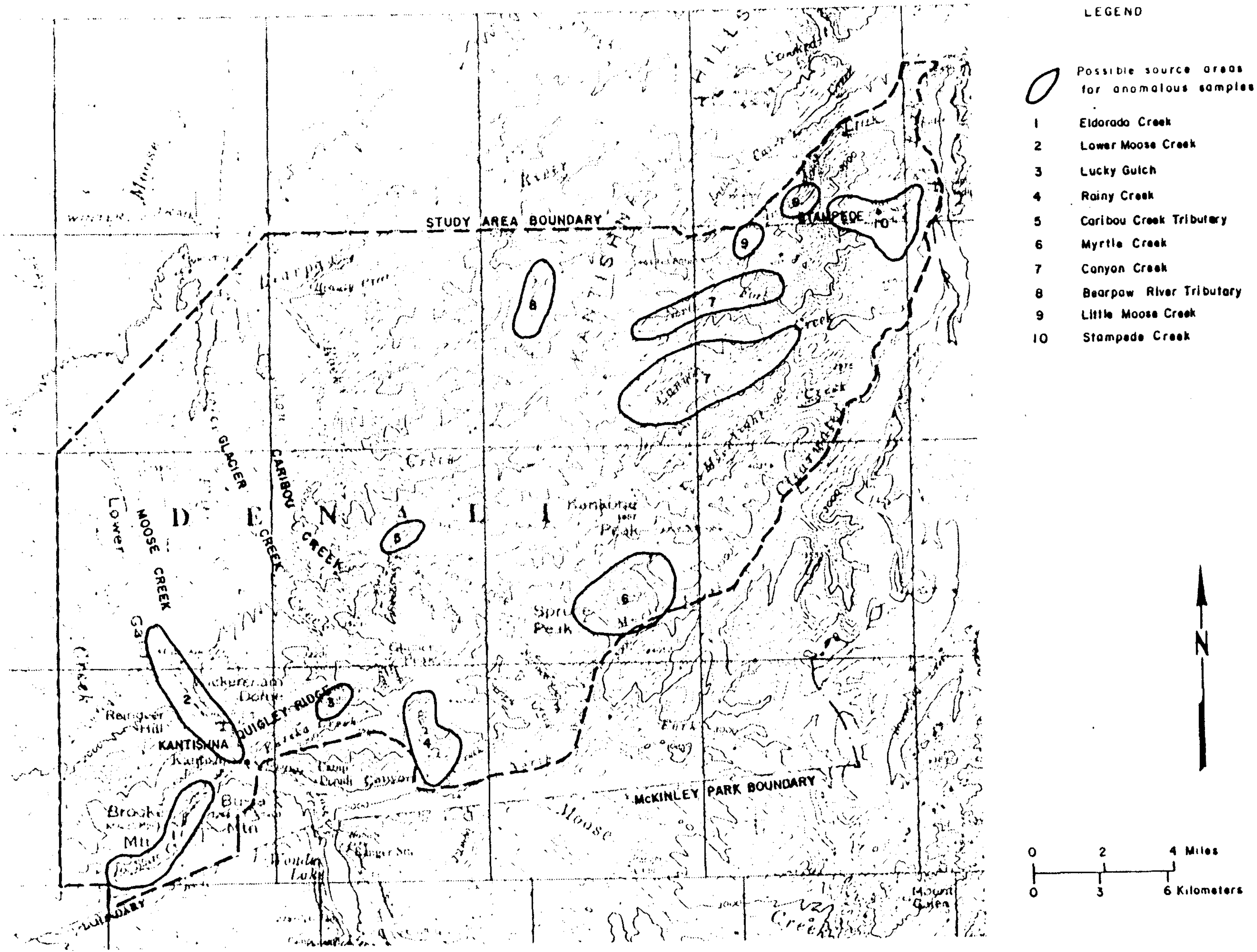


FIGURE 21. Geochemically anomalous areas - Tungsten, Kantishna Hills study area

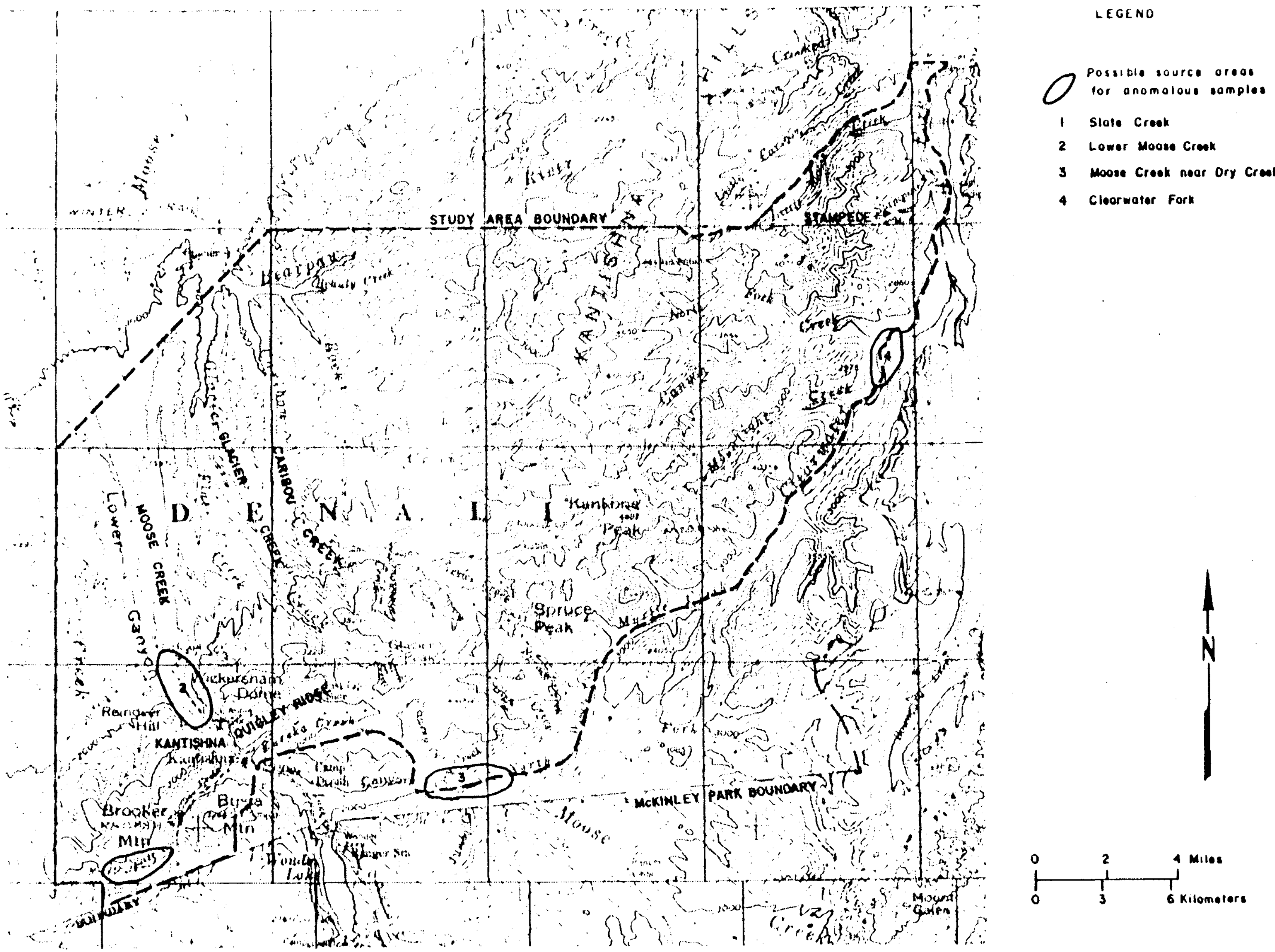


FIGURE 22. Geochemically anomalous areas - Titanium, tantalum, and niobium, Kantishna Hills study area

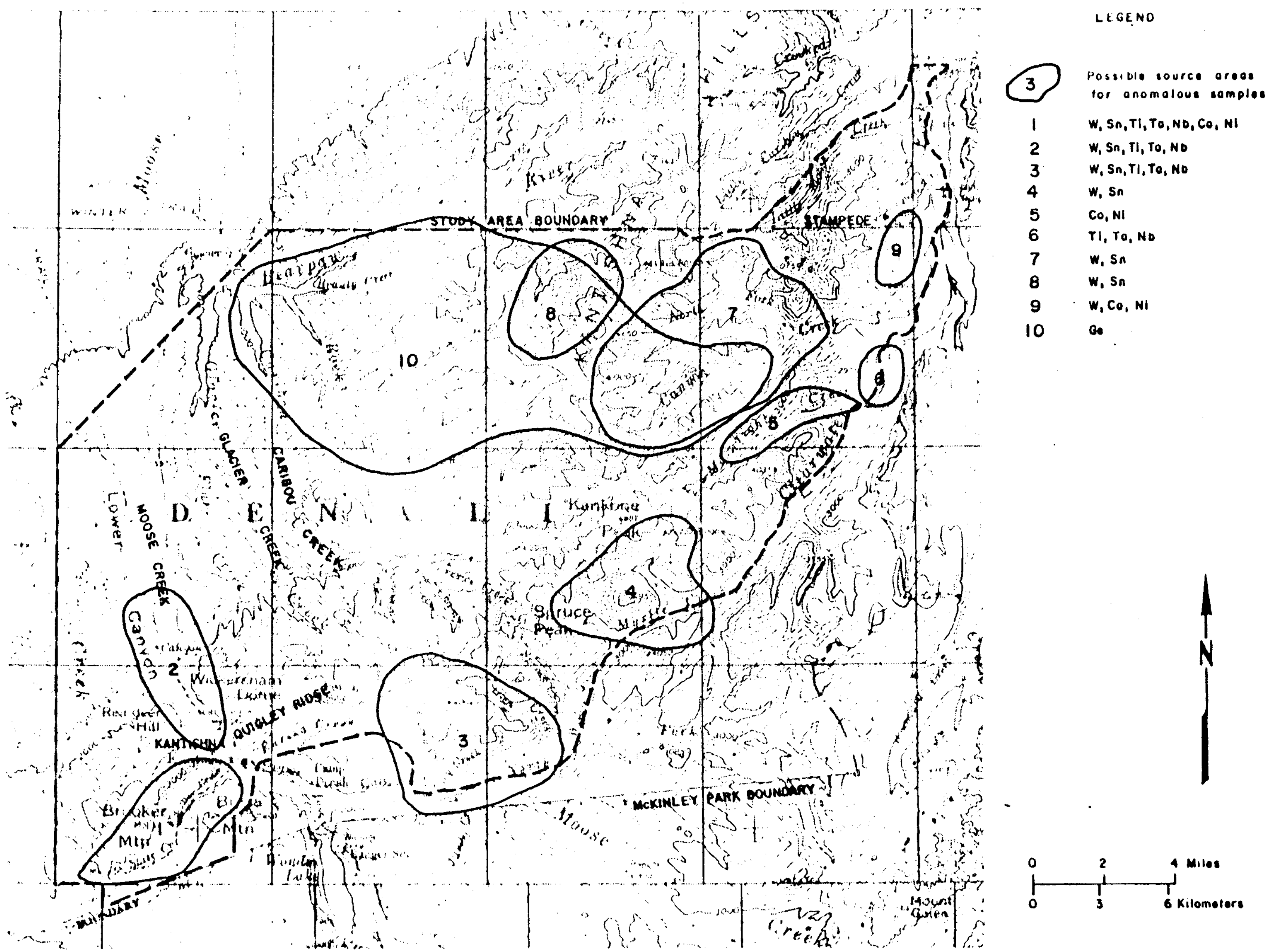


FIGURE 23. Main geochemically anomalous areas, Kantishna Hills study area

rocks in the Keevy Peak Formation or Birch Creek Schist; and (3) a tributary to lower Stampede Creek with possible source rocks in the Keevy Peak Formation.

A large area anomalous in germanium (fig. 19) was identified in the northern half of the study area. The area is underlain by the Birch Creek Schist but the source of the germanium is unknown.

Anomalous tin and tungsten samples are widespread throughout the study area (figs. 15-17). Usually tin and tungsten occur together in the same sample and often in all three sample types (reconnaissance placer concentrates, panned concentrates, and stream sediments) collected at the same site.

Anomalous tin drainages (fig. 20) include: (1) Eldorado Creek; (2) lower Moose Creek; (3) Rainy Creek; (4) West Fork of Glen Creek; (5) Myrtle Creek; (6) Canyon Creek; and (7) two tributaries to the Bearpaw River.

Anomalous tungsten drainages (fig. 21) include: (1) Eldorado Creek; (2) lower Moose Creek; (3) Lucky Gulch (Banjo Mine); (4) Rainy Creek; (5) a tributary to Caribou Creek; (6) Myrtle Creek; (7) Canyon Creek; (8) a tributary to the Bearpaw River; (9) Little Moose Creek; and (10) Stampede Creek including a newly identified area on a tributary to lower Stampede Creek.

Four areas anomalous in titanium, tantalum, and niobium occur in the Kantishna Hills study area (fig. 22). The anomalous areas include: (1) Slate Creek; (2) lower Moose Creek; (3) Moose Creek near the mouth of Dry Creek; and (4) Clearwater Fork. The anomalous samples from the Clearwater Fork possibly were from rocks of the Keevy Peak Formation. The source rocks for the anomalous samples in the other areas could be either the Spruce Creek Sequence or Birch Creek Schist.

CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the critical and strategic mineral content in reconnaissance placer concentrates, panned concentrates, and stream sediment samples and the distribution of the samples has led to the identification of several anomalous zones in the Kantishna Hills study area (figs. 18-22). Several anomalies are in or near areas of known mineral occurrences and mining activity. Others are located in areas with no previous known mineral occurrences or mining activity.

Ten anomalous areas identified are shown on figure 23. They include: (1) Eldorado Creek drainage for cobalt, nickel, niobium, tantalum, tin, titanium, and tungsten; (2) lower Moose Creek drainage for niobium, tantalum, tin, titanium, and tungsten; (3) Rainy Creek to Glen Creek area for niobium, tantalum, tin, titanium, and tungsten; (4) Myrtle Creek drainage for tin and tungsten; (5) Moonlight Creek drainage for cobalt and nickel; (6) Clearwater Fork drainage for niobium, tantalum, and titanium; (7) Canyon Creek drainage for tin and tungsten; (8) two Bearpaw River tributaries for tin and tungsten; (9) a tributary to lower Stampede Creek for cobalt, nickel, and tungsten; and (10) the northern part of study area for germanium.

Reconnaissance placer samples provided the best means to look for critical and strategic elements in this study because of the number of samples of this type that were collected and analyzed.

Insufficient analytical results for the stream sediment samples, except tungsten, and an insufficient number of samples for panned concentrates made the interpretation of their data tenuous. Additional panned concentrate samples need to be collected and all critical and strategic elements analyzed in the stream sediment samples to obtain a more thorough understanding of their source and abundance. The entire study area needs to be uniformly sampled to fill in the gaps where there is insufficient data and to obtain more data on the identified anomalous areas.

Geochemical and statistical analysis of reconnaissance placer concentrates, panned concentrates, and stream sediment samples indicate several areas for critical and strategic mineral exploration. Additional geological, geochemical, and geophysical data is needed to determine the significance and economic potential of the anomalous zones.

REFERENCES

1. Barker, F. Exploration of antimony deposits at Stampede Mine, Kantishna District, Alaska. U.S. Geol. Surv. Bull. 1155, 1963, pp. 10-17.

2. Brooks, A. H. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 379, 1909, p. 56.

3. -----. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 442, 1910, p. 44.

4. -----. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 520, 1911A, p. 38.

5. -----. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 542, 1913, p. 45.

6. -----. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 592, 1914, p. 68.

7. -----. Mineral Resources of Alaska. U.S. Geol. Surv. Bull. 649, 1916B, 67 pp.

8. Bundtzen, T. K. Geology and mineral deposits of the Kantishna Hills, Mount McKinley Quadrangle, Alaska. M.S. Thesis, Univ. AK, Fairbanks, AK., 1981.

9. -----. Mineral-resource modeling, Kantishna-Dunkle Mine - study areas, Alaska. AK Div. Geol. and Geophys. Surv. RI 83-12, 1983, 51 pp.

10. Bundtzen, T. K., T. E. Smith, and R. E. Tysdal. Progress report - Geology and mineral deposits of the Kantishna Hills. AK Div. Geol. and Geophys. Surv. OFR AOF98, 1976.

11. Bundtzen, T. K., and D. L. Turner. Geochronology of metamorphic and igneous rocks in the Kantishna Hills, Alaska. AK Div. Geol. and Geophys. Surv. Geological Report 61, 1979, pp. 25-30.

12. Capps, S. R. Mineral resources of the Kantishna region. U.S. Geol. Surv. Bull. 662-E, 1918, pp. 229-231.

13. -----. Mineral investigation in the Alaska Railroad belt. U.S. Geol. Surv. Bull. 844-B, 1933, 32 pp.

14. -----. Geology of the Alaska Railroad region. U.S. Geol. Surv. Bull. 907, 1940, 201 pp.

15. Chadwick, R. Mineral appraisal of properties in the proposed Mount McKinley addition. Natl. Park Service confidential unpubl. rep., 1976, 300 pp.

16. Davis, J. The Kantishna Region. Territorial Dep. Mines, Minerals MR 66-0, 1922, pp. 1-29.

17. Ebbley, J. Jr., and W. S. Wright. Antimony deposits in Alaska. BuMines RI 4173, 1948.

18. Hawley, C. C. Mineral appraisal of lands adjacent to Mount McKinley National Park. BuMines OFR 24-78, 1978, 184 pp.

19. Hinderman, T. K., and C. C. Hawley & Associates. Mount McKinley Quadrangle, Alaska. NURE Program, Bendix Field Eng. Corp. rep. PFJ/F-054(82), 1982

20. Jones, D. L., N. J. Silberling, H. C. Berg, and G. Plafker. Map showing tectonostratigraphic terranes of Alaska, columnar sections, and summary descriptions. U.S. Geol. Surv. OFR 81-9792, 1981.

21. Lepeltier, A. Simplified statistical treatment of geochemical data by graphical representation. Econ. Geol., v. 64, 1969, pp. 538-550.

22. Moffit, F. H. The Kantishna District. U.S. Geol. Surv. Bull. 836-D, 1933, pp. 301-338.

23. Pilgrim, E. R. Report on Shannon lode properties, Kantishna District. AK Territory Dep. Mines unpubl. PE rep., 1929, 10 pp.

24. Prindle, L. M. The Bonnifield and Kantishna regions, Alaska. U.S. Geol. Surv. Bull. 314-I, 1907, pp. 5-6.

25. Reed, J. C. Geology of the Mount McKinley Quadrangle, Alaska. U.S. Geol. Surv. Bull. 1108-A, 1961, 36 pp.

26. Saunders, R. H. Report on the Bonnell silver-lead prospect, Mount McKinley Quadrangle, Alaska. AK Div. Geol. and Geophys. Surv. unpubl. PE rep., 1964, 12 pp.

27. Seraphim, R. H. Kantishna District. BuMines confidential rep. MK-193-2, 1961, 22 pp.

28. -----. Summary of exploration on Quigley Ridge, Kantishna District. AK Div. Geol. and Geophys. Surv. unpubl. PE rep. 66-2, 1962, 2 pp.

29. Shaw, D. M. Interpretation geochimique des elements en trace dans les roches cristallines; Masson et Cie, 1964, Paris.

30. Salisbury & Dietz, Inc. 1983 Mineral Resource Studies Kantishna Hills and Dunkle Mine Areas, Denali National Park and Preserve, Alaska (contract S0134031). BuMines OFR 129-84, 1984, Volume I: text, 234 pp.; Volume II: appendices; Volume III: plates.

31. U.S. Bureau of Mines. The Domestic Supply of Critical Minerals. Spec. Publ., 1983, 49 pp.

32. Van Eeckhout, E. M., R. G. Wanen, and B. E. Hill. Uranium hydrogeochemical and stream sediment reconnaissance of the Medfra and Mount McKinley NTMS Quadrangle, Alaska, including concentrations of forty-three additional elements. Los Alamos Scientific Lab rep. GJBX-30-79, 1979.

33. Wells, F. G. Lode deposits of Eureka and vicinity, Kantishna district, Alaska. U.S. Geol. Surv. Bull. 849-F, 1933, pp. 335-379.

34. White, D. H. Antimony deposits of Stamped Creek area, Kantishna district, Alaska. U.S. Geol. Surv. Bull. 936-N, 1942, pp. 331-348.

APPENDIX A

Histograms and cumulative histograms for reconnaissance placer samples

APPENDIX A. Histograms and cumulative histograms for reconnaissance placer samples

Explanation:

N	Number of samples
BARS	Number of class intervals
SD	Standard deviation
y-axis	Shows number and percent (PCT) of samples
x-axis	Shows concentration of the element in parts per million (Where there is more than one value for the class interval, the low and high value within the class interval is shown).

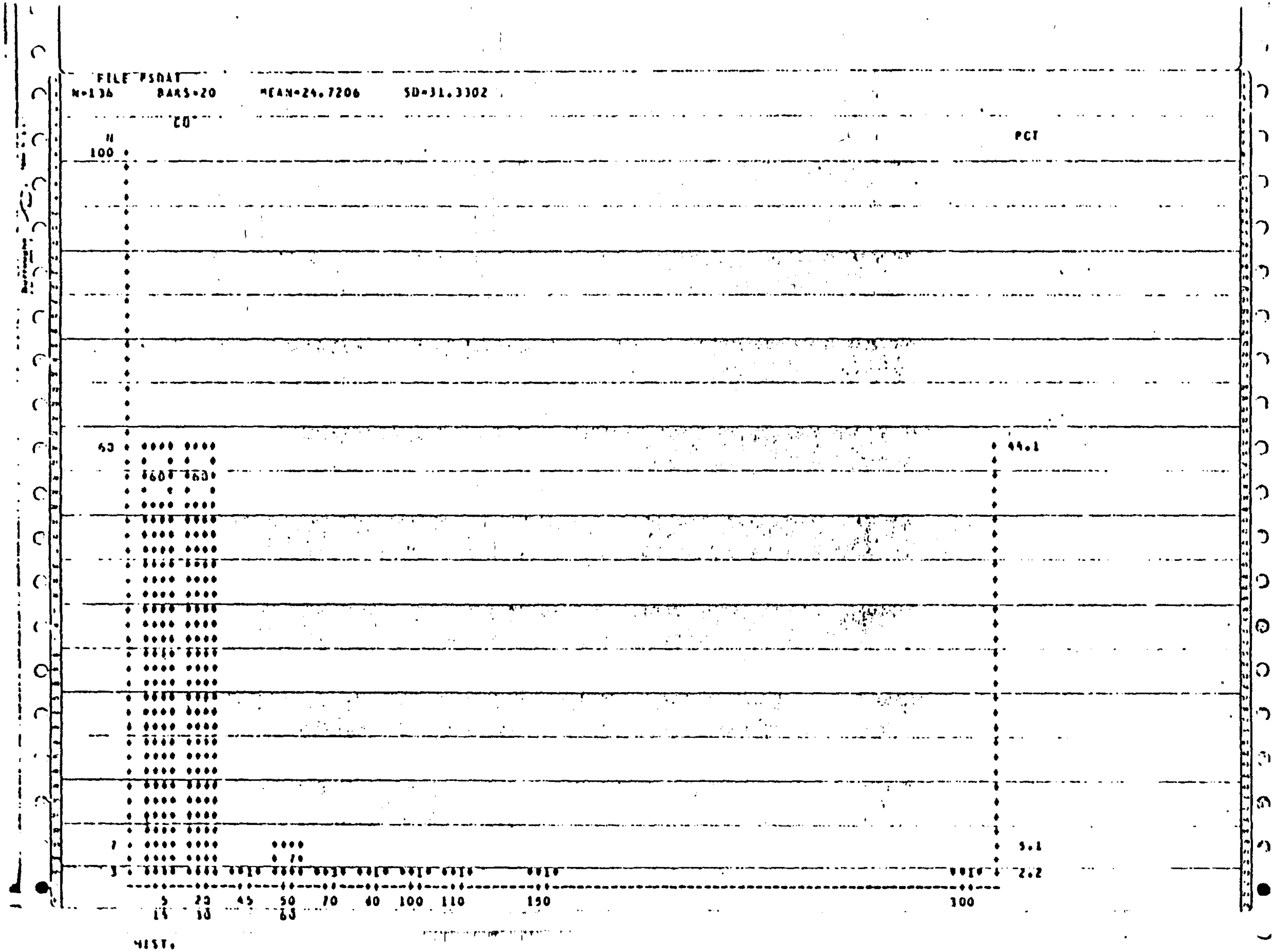


FIGURE A-1. Histogram and statistical parameters of cobalt concentrations in reconnaissance placer samples.

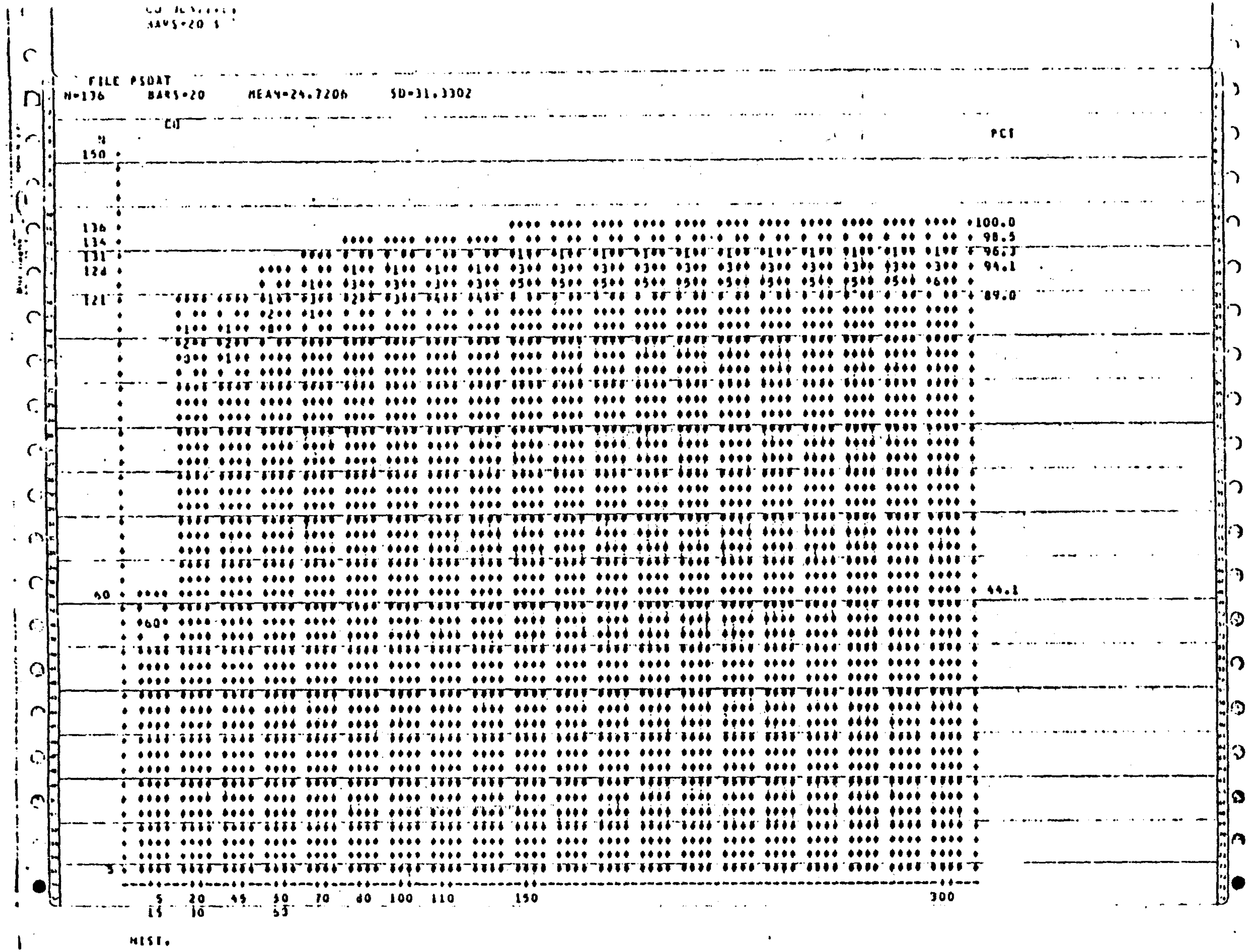


FIGURE A-2. Cumulative histogram and statistical parameters of cobalt concentrations in reconnaissance placer samples

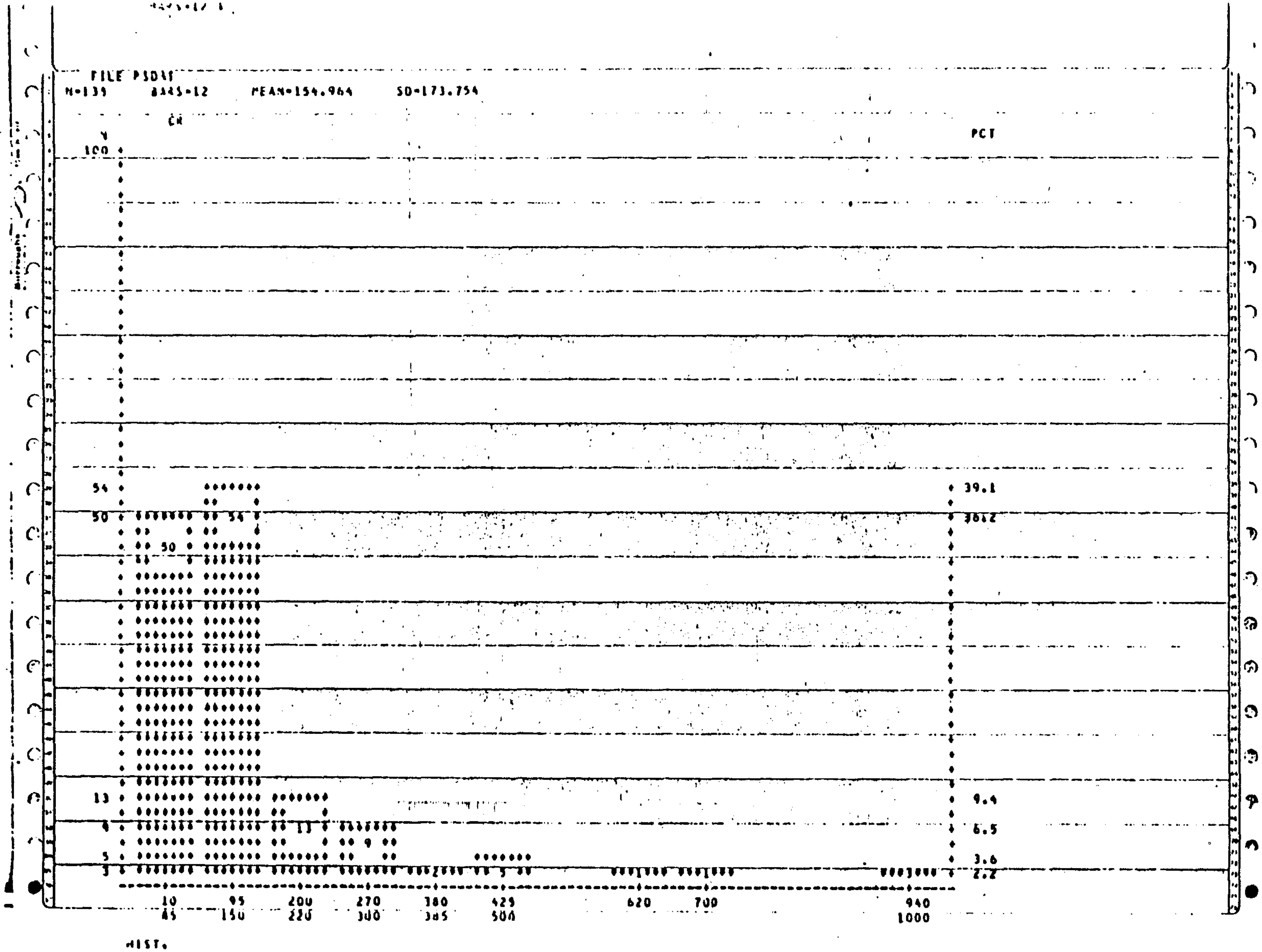


FIGURE A-3. Histogram and statistical parameters of chromium concentrations in reconnaissance placer samples,

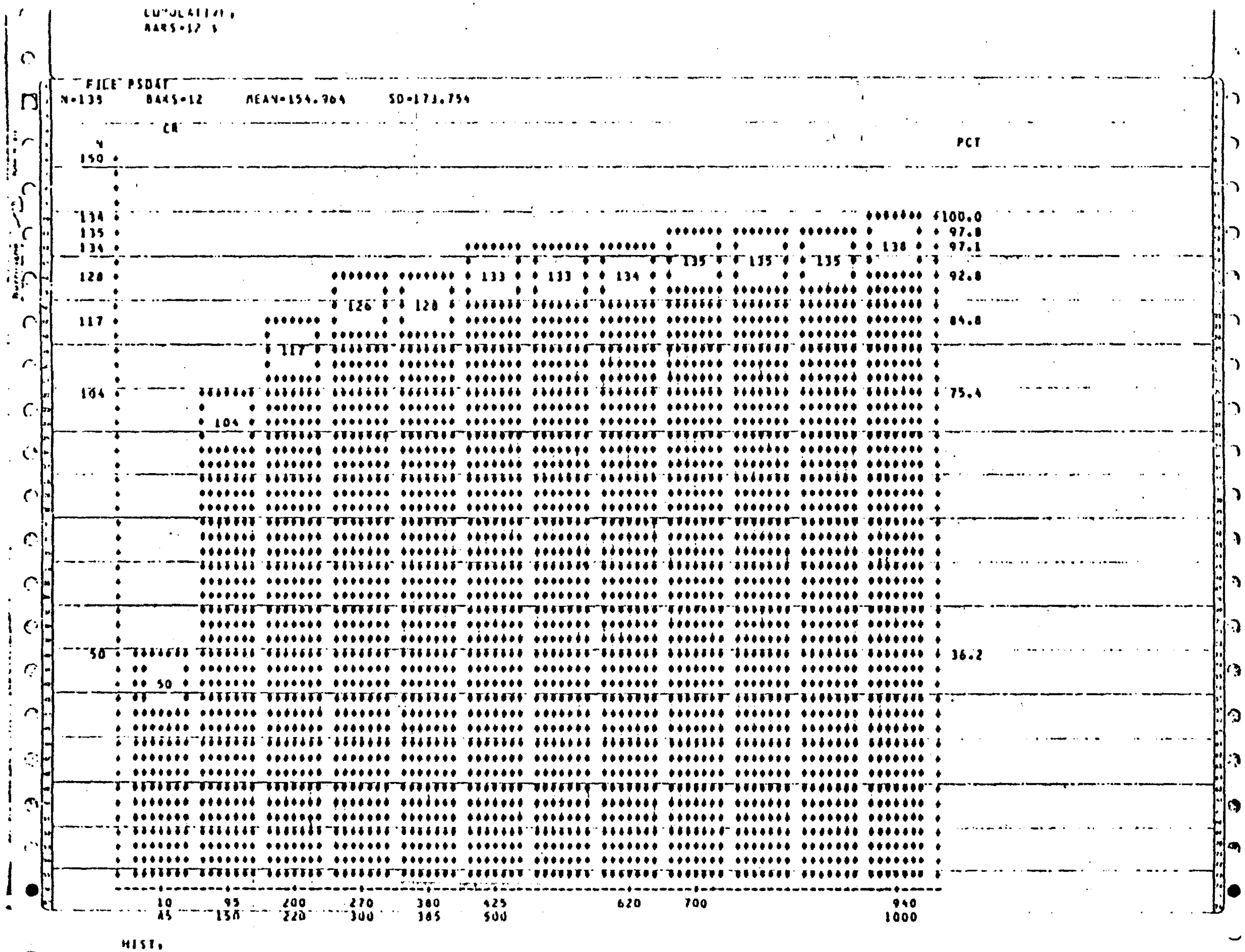


FIGURE A-4. Cumulative histogram and statistical parameters of chromium concentrations in reconnaissance placer samples.

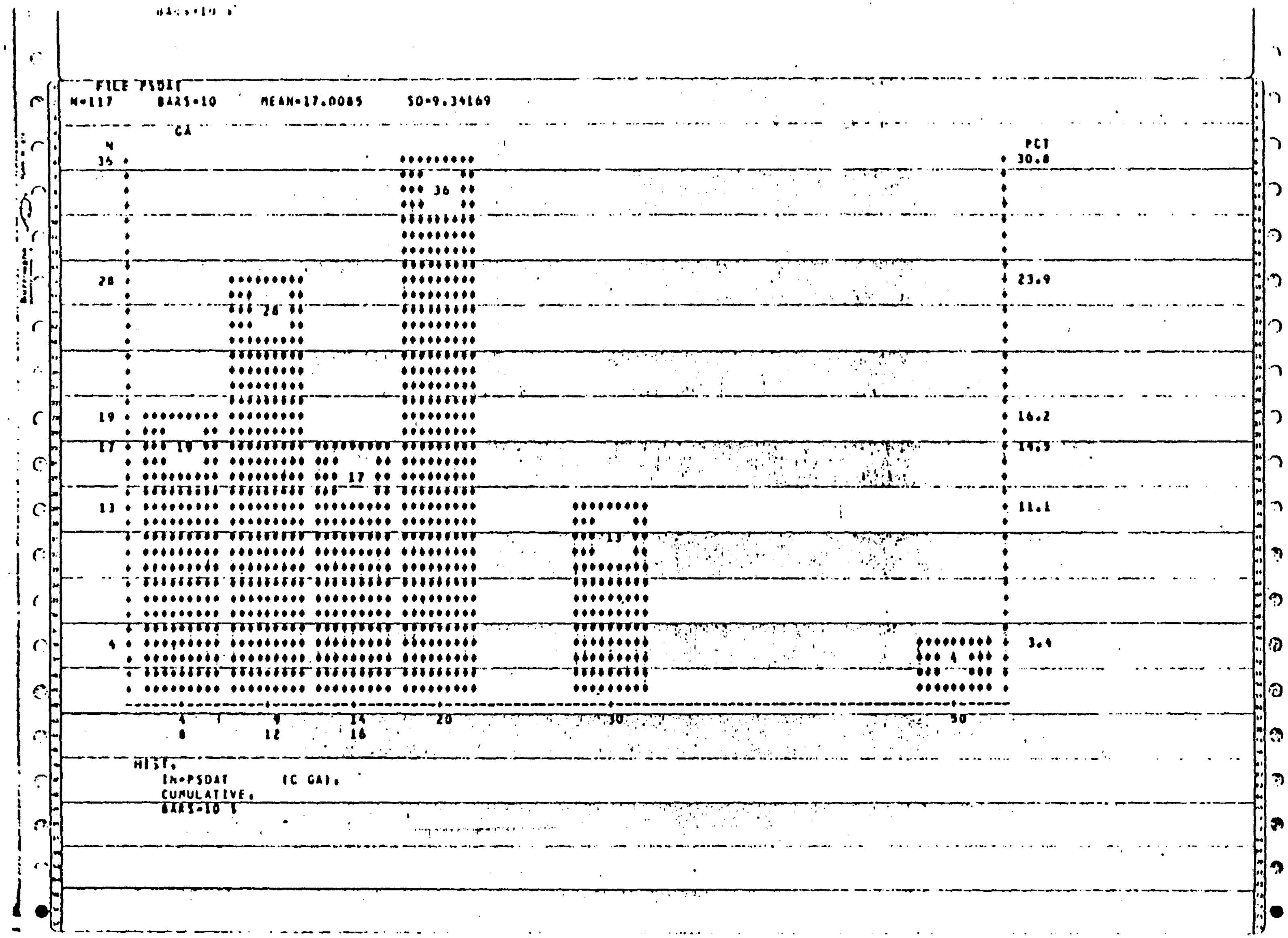


FIGURE A-5. Histogram and statistical parameters of gallium concentrations in reconnaissance placer samples.

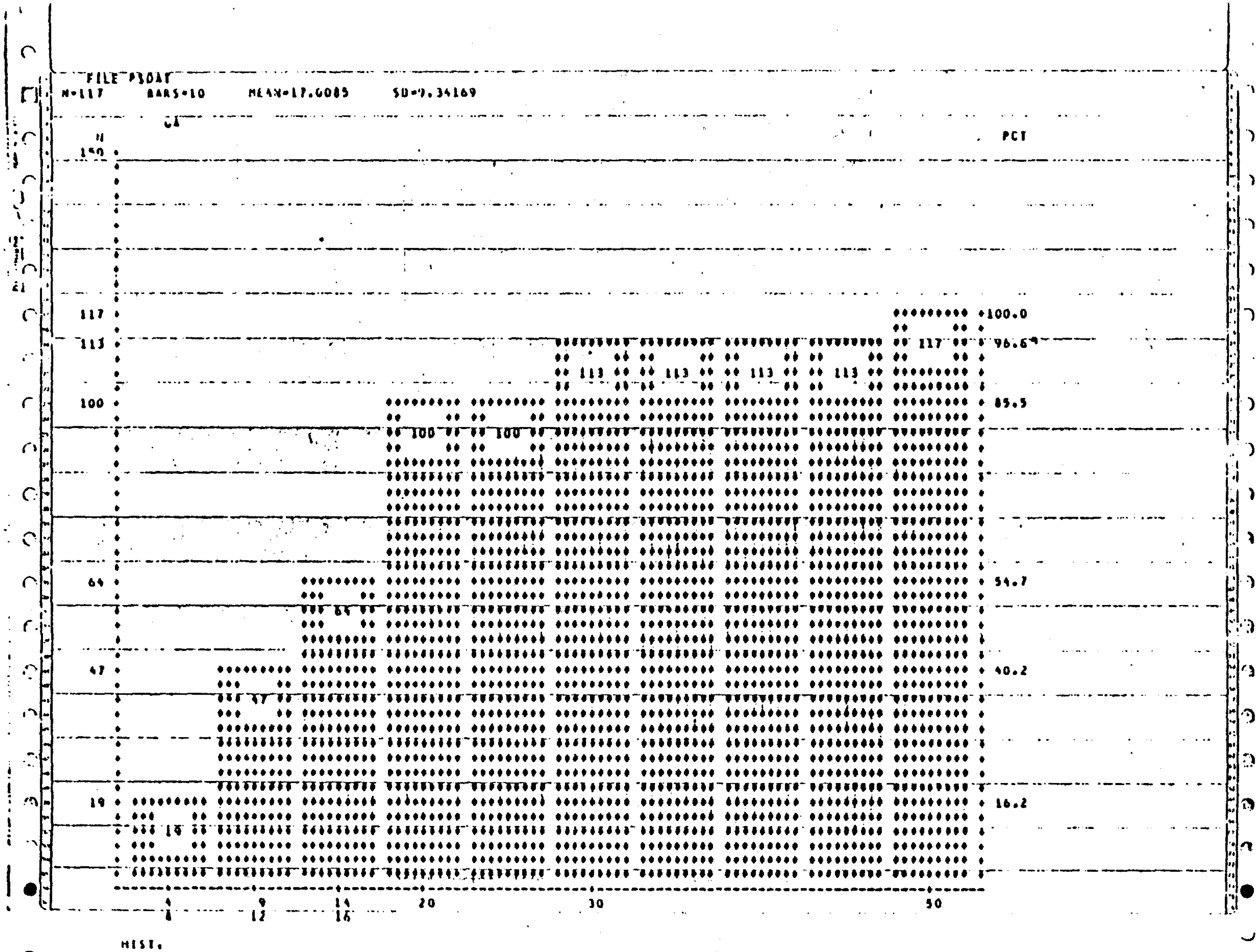


FIGURE A-6. Cumulative histogram and statistical parameters of gallium concentrations in reconnaissance placer samples.

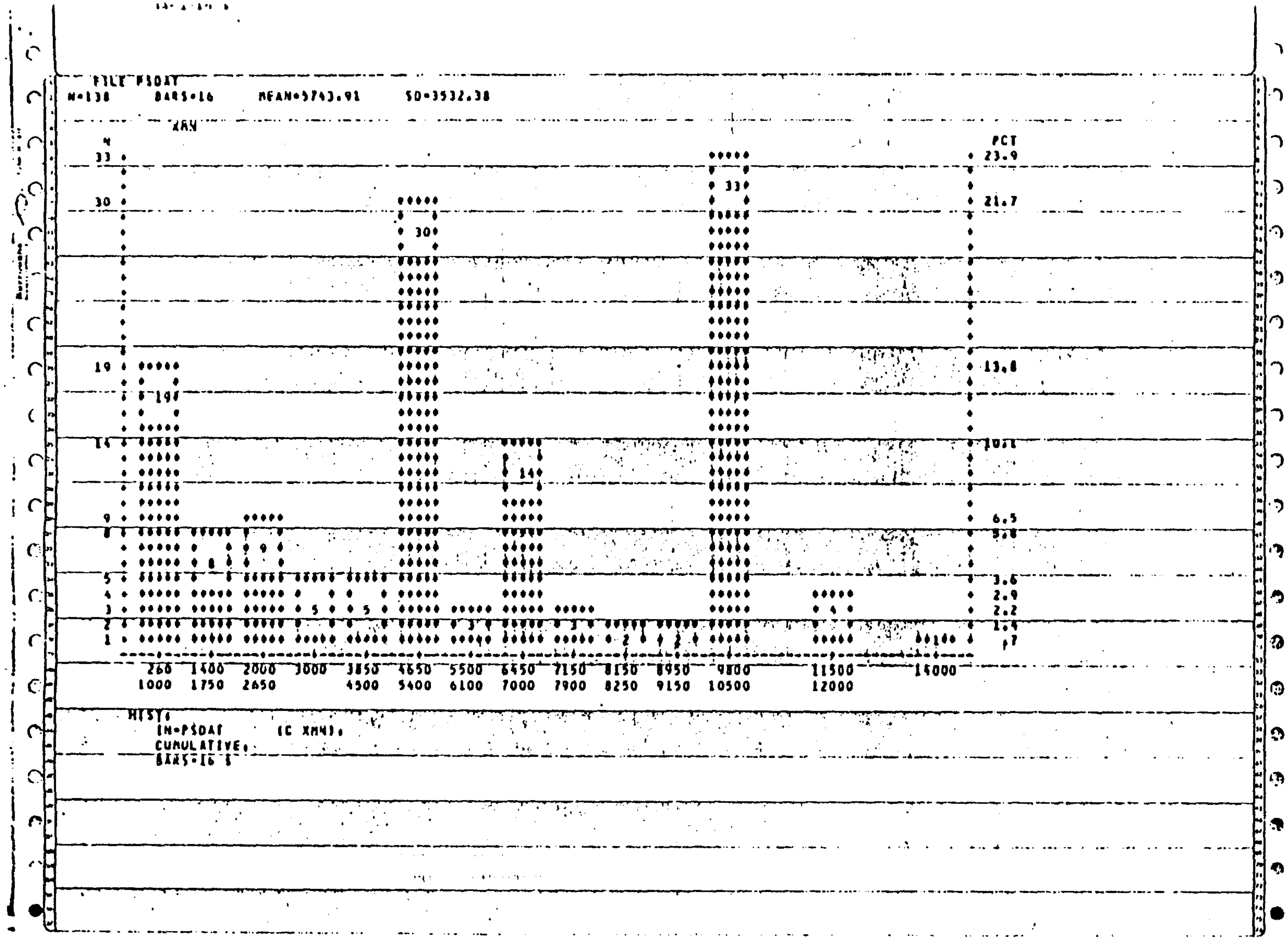


FIGURE A-7. Histogram and statistical parameters of manganese concentrations in reconnaissance placer samples.

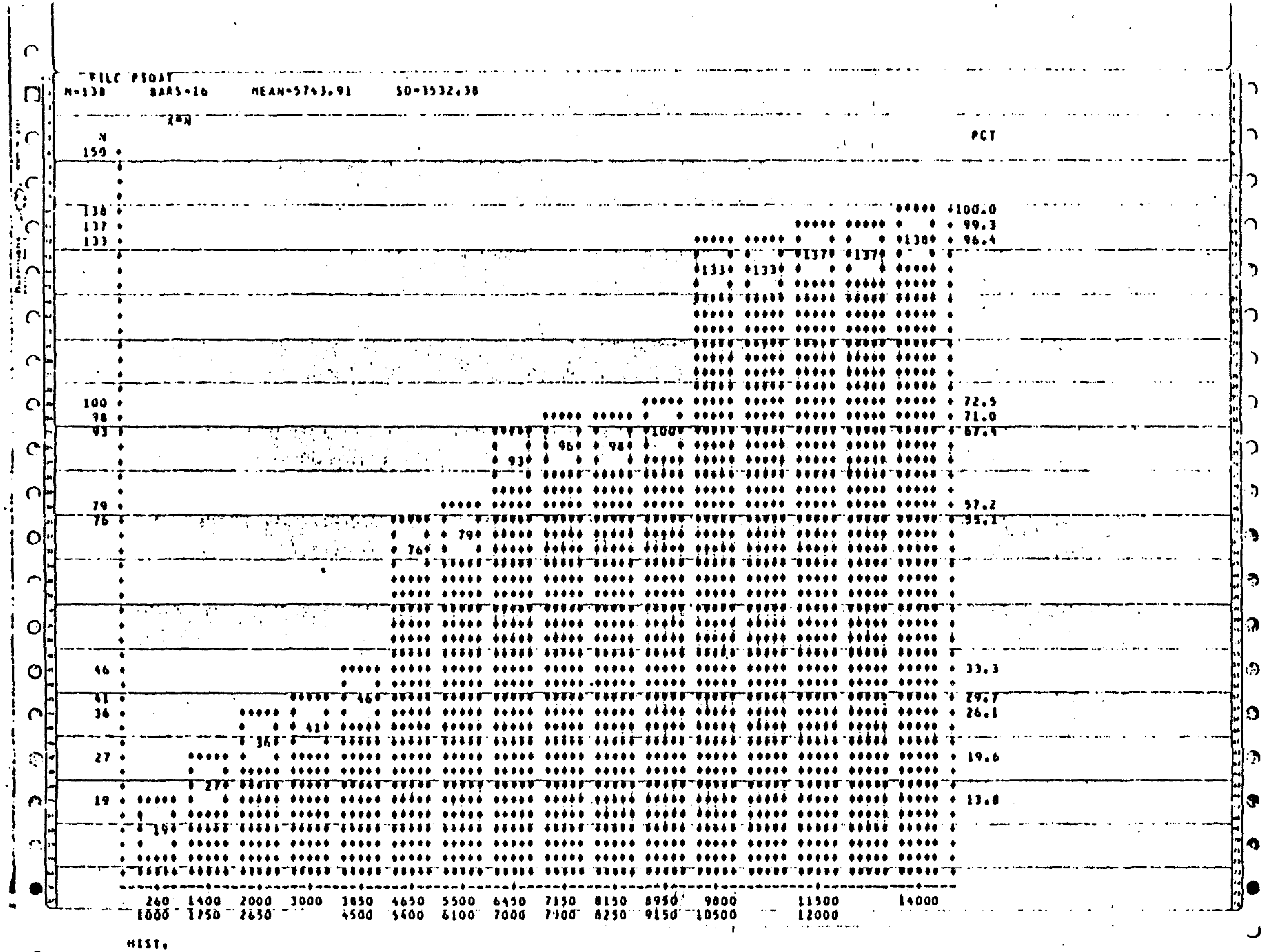


FIGURE A-8. Cumulative histogram and statistical parameters of manganese concentrations in reconnaissance placer samples.

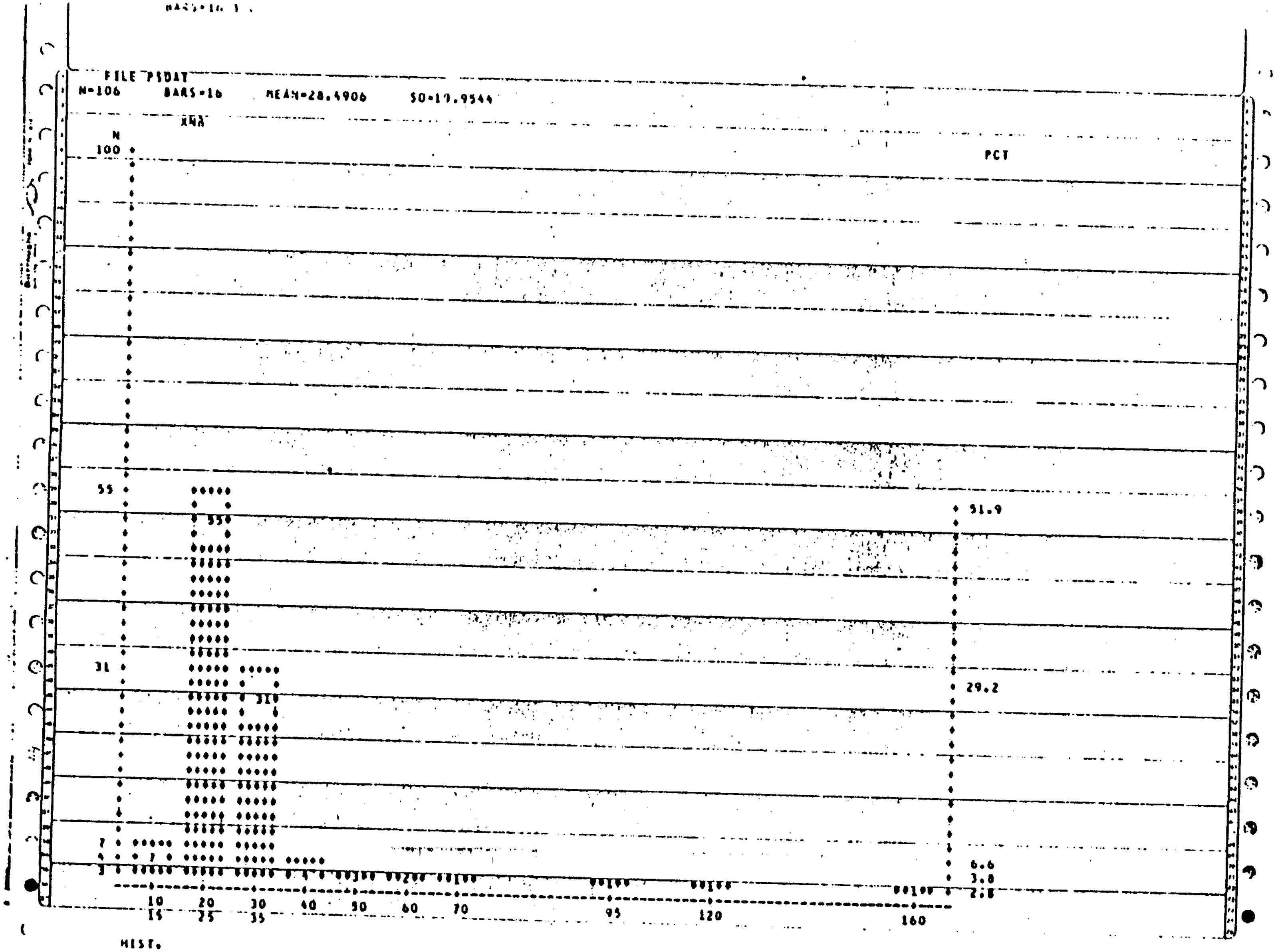


FIGURE A-9.- Histogram and statistical parameters of niobium concentrations in reconnaissance placer samples.

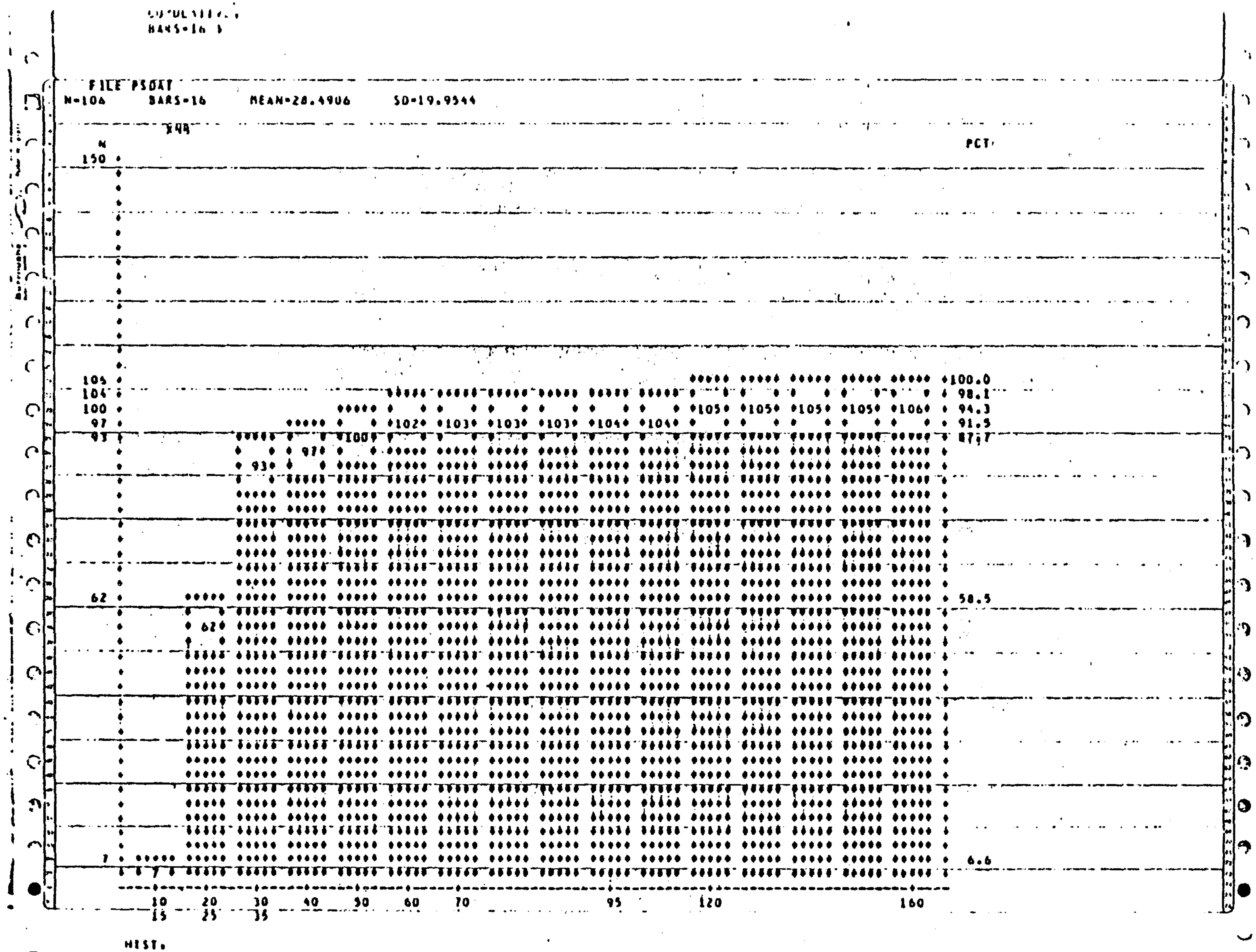


FIGURE A-10. Cumulative histogram and statistical parameters of niobium concentrations in reconnaissance placer samples.

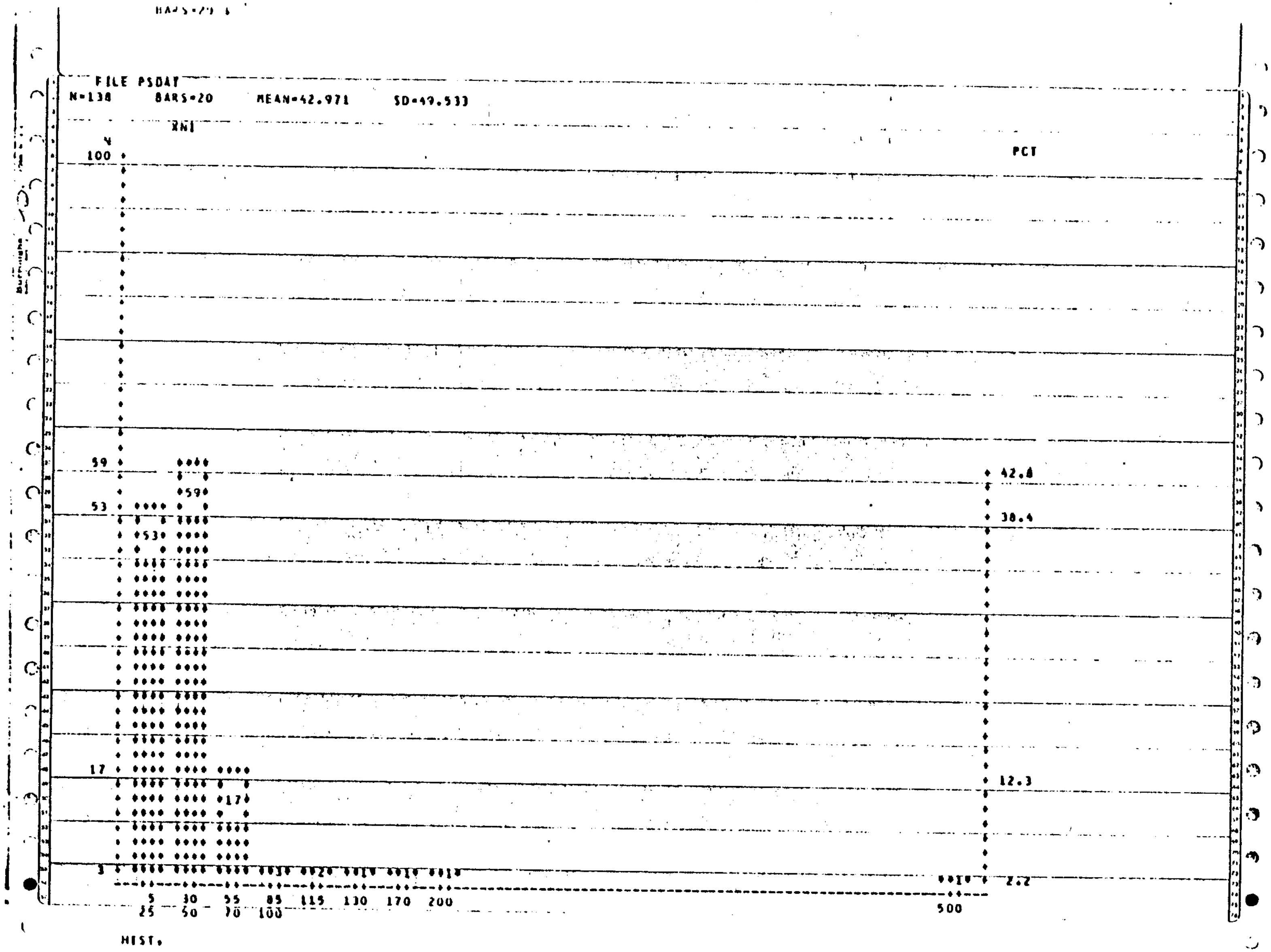


FIGURE A-11. Histogram and statistical parameters of nickel concentrations in reconnaissance placer samples.

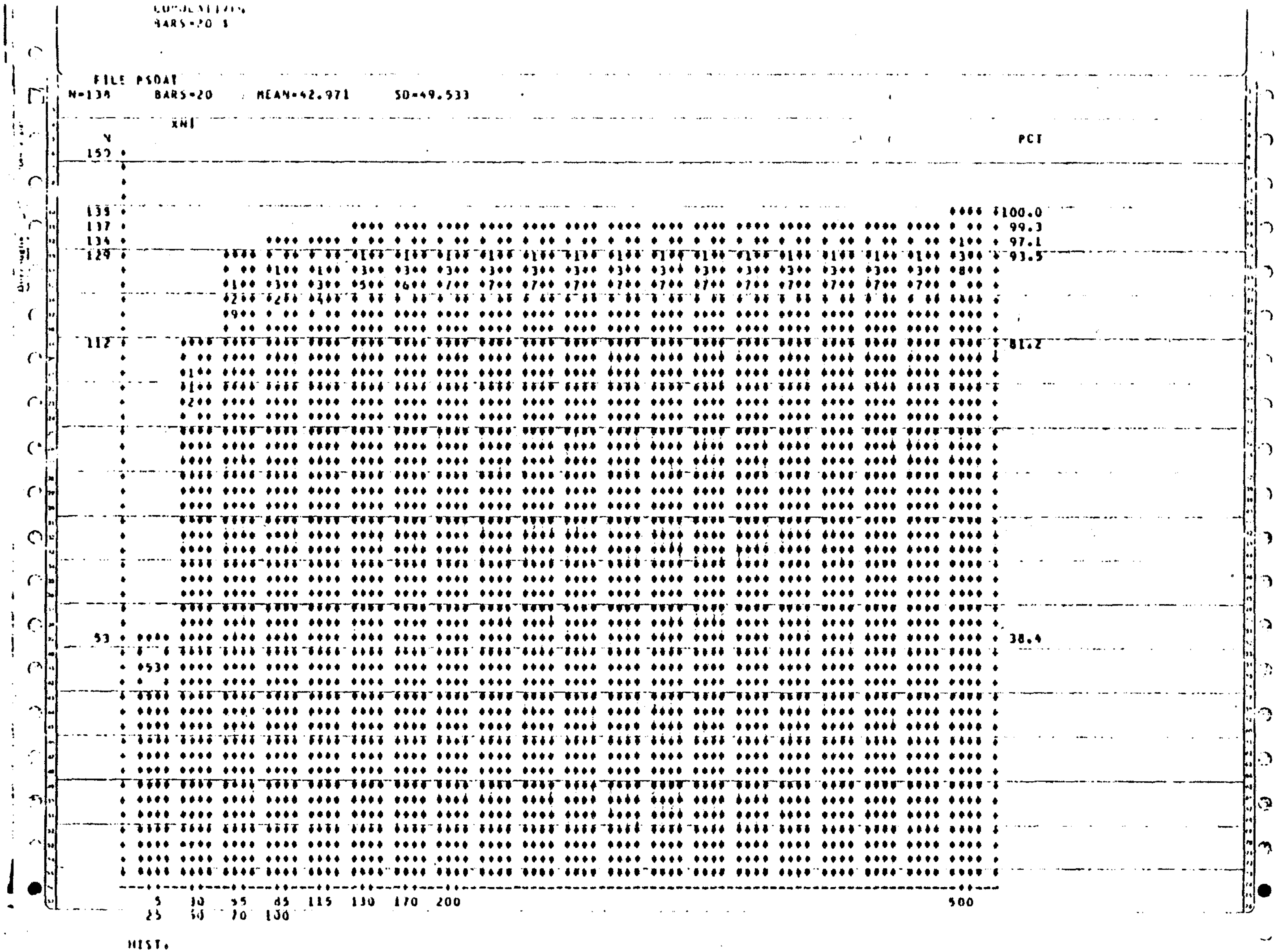


FIGURE A-12. Cumulative histogram and statistical parameters of nickel concentrations in reconnaissance placer samples.

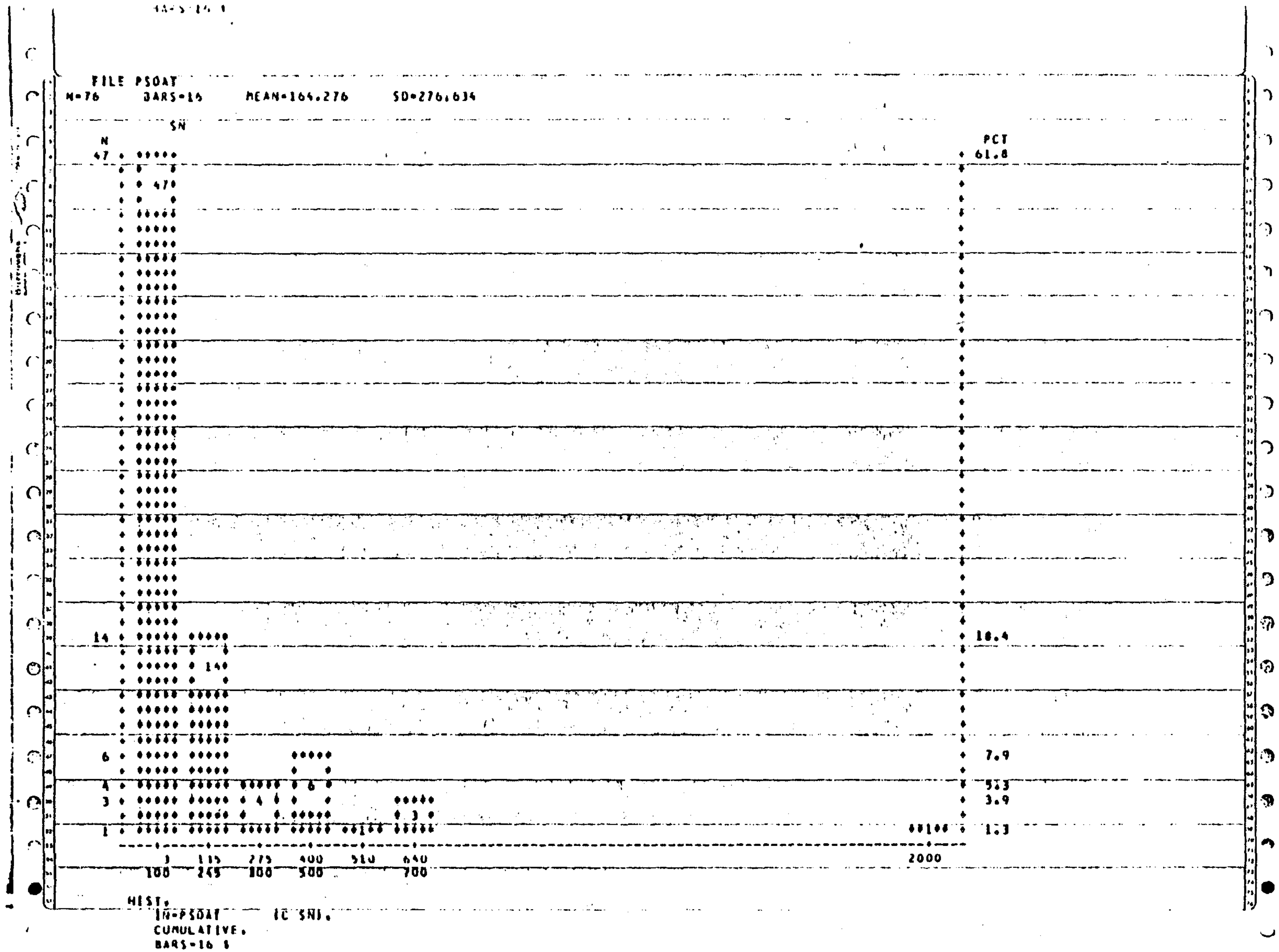


FIGURE A-13. Histogram and statistical parameters of tin concentrations in reconnaissance placer samples.

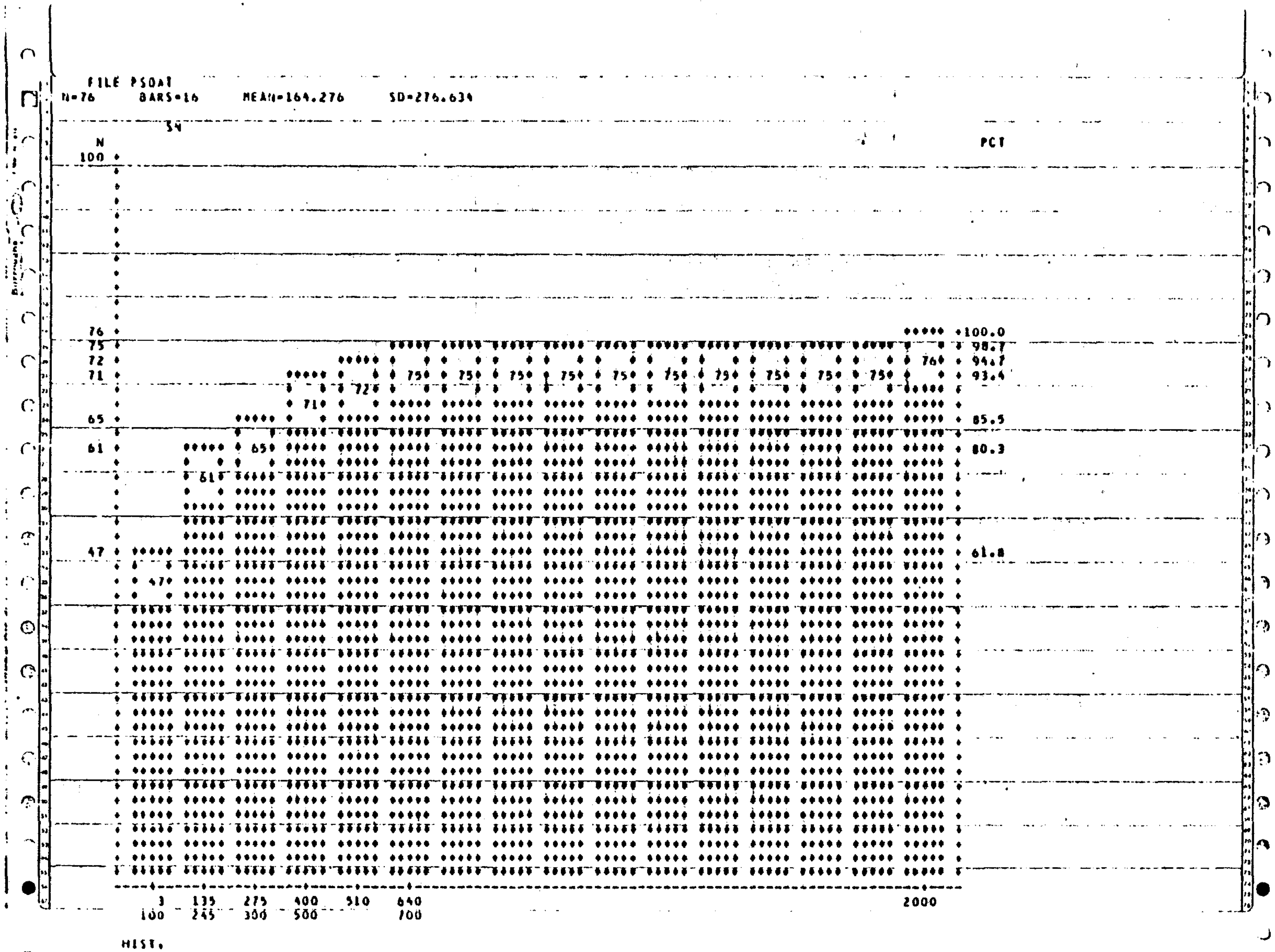


FIGURE A-14. Cumulative histogram and statistical parameters of tin concentrations in reconnaissance placer samples.

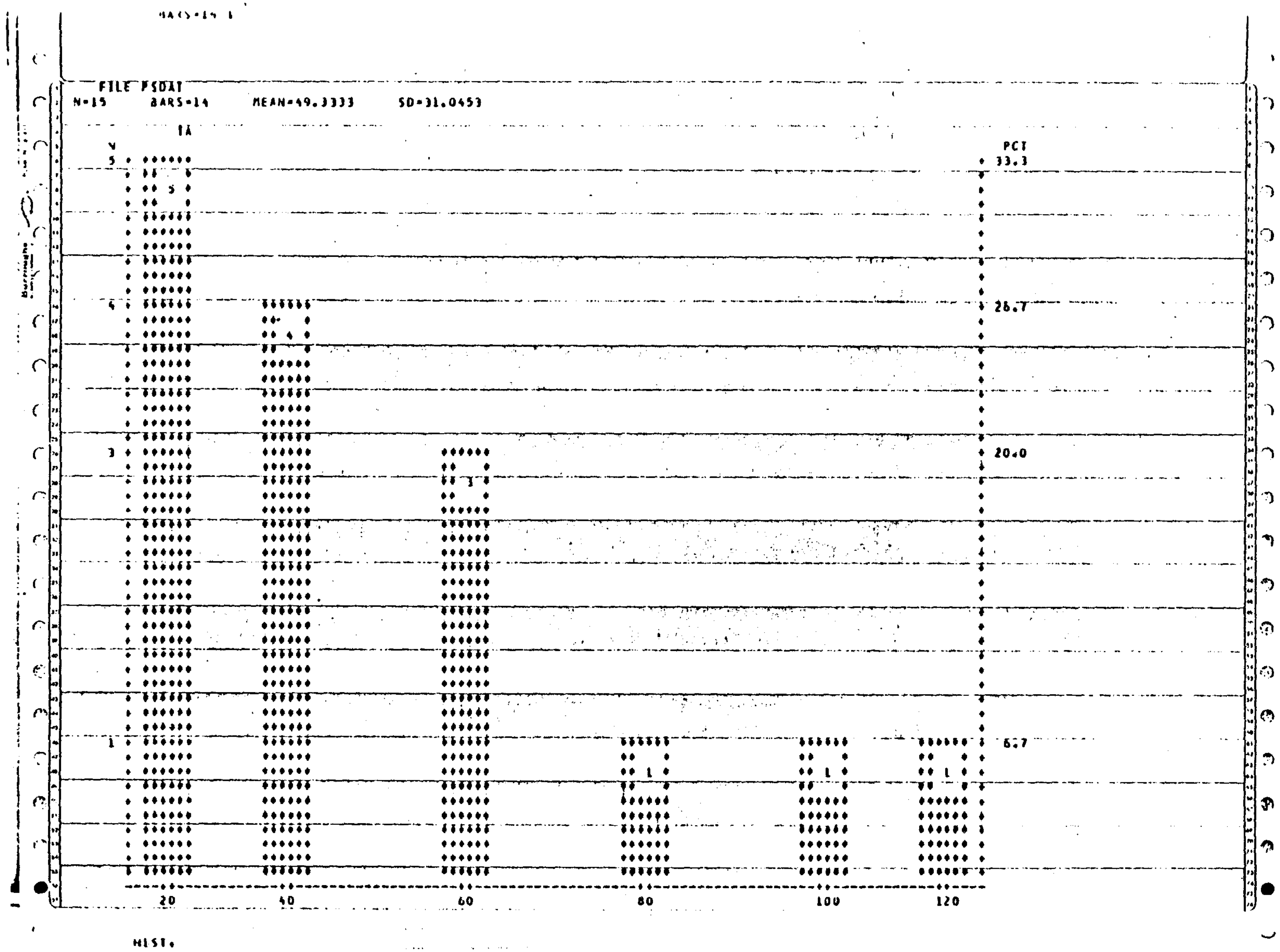


FIGURE A-15. Histogram and statistical parameters of tantalum concentrations in reconnaissance placer samples.

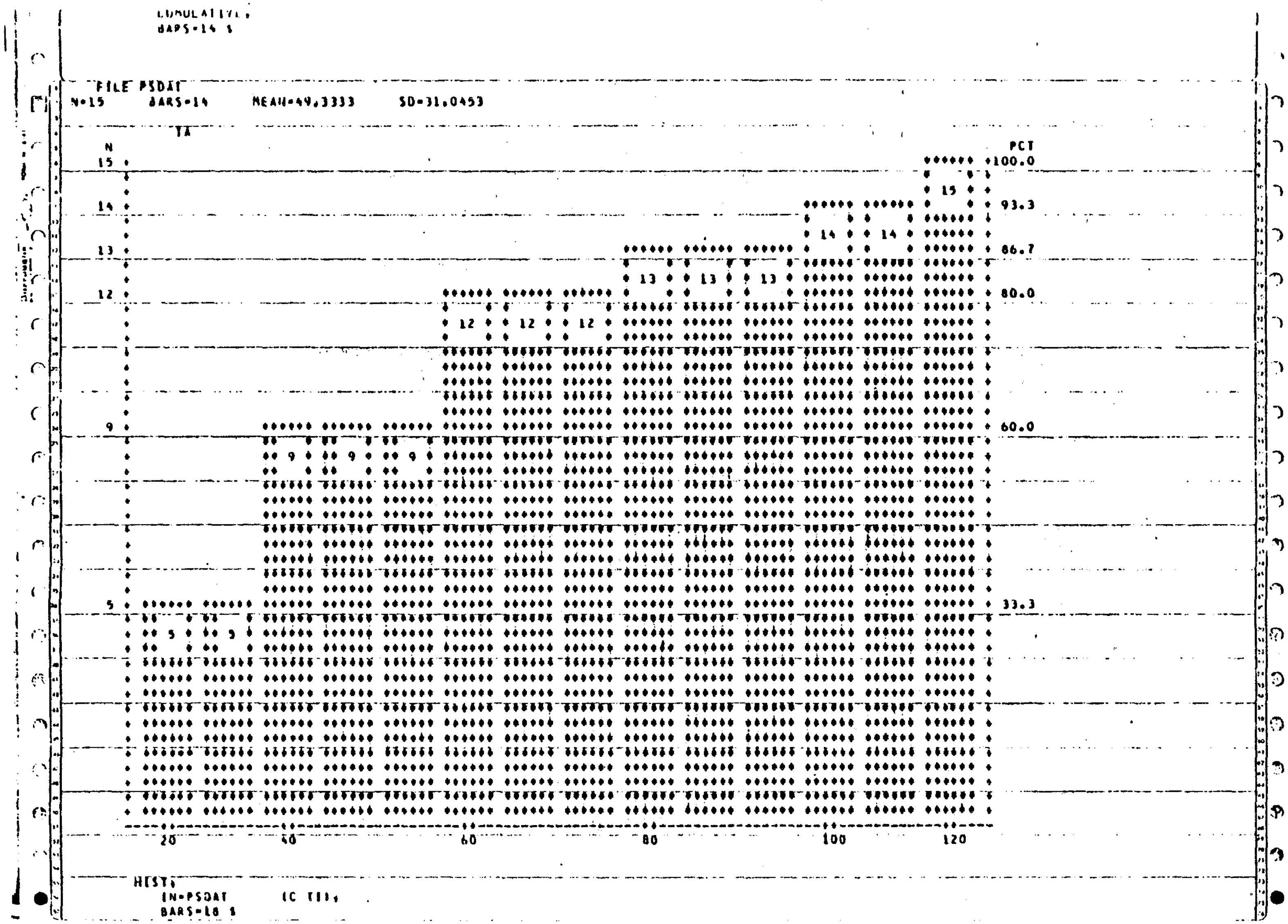


FIGURE A-16. Cumulative histogram and statistical parameters of tantalum concentrations in reconnaissance placer samples.

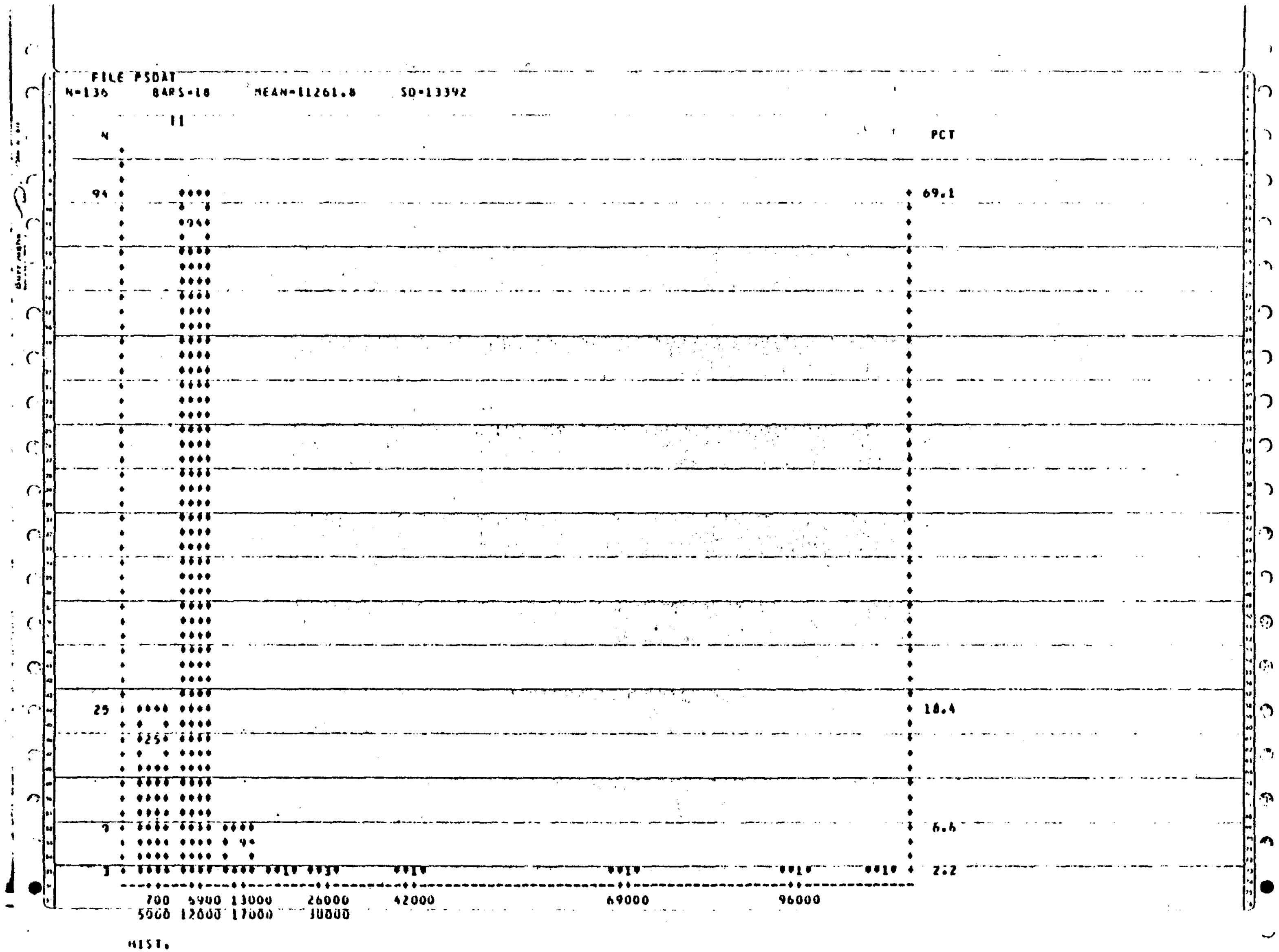


FIGURE A-17. Histogram and statistical parameters of titanium concentrations in reconnaissance placer samples.

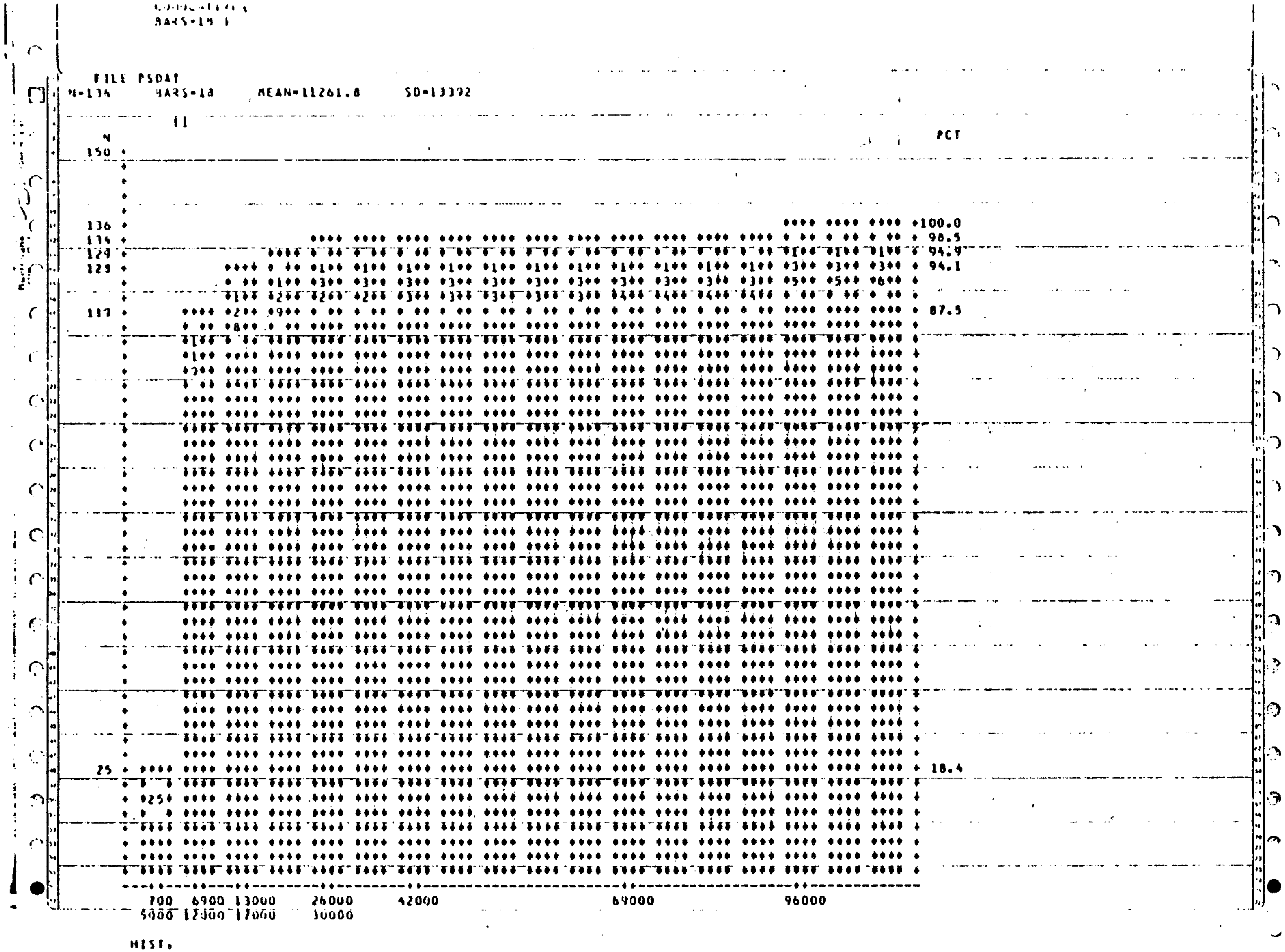


FIGURE A-18. Cumulative histogram and statistical parameters of titanium concentrations in reconnaissance placer samples.

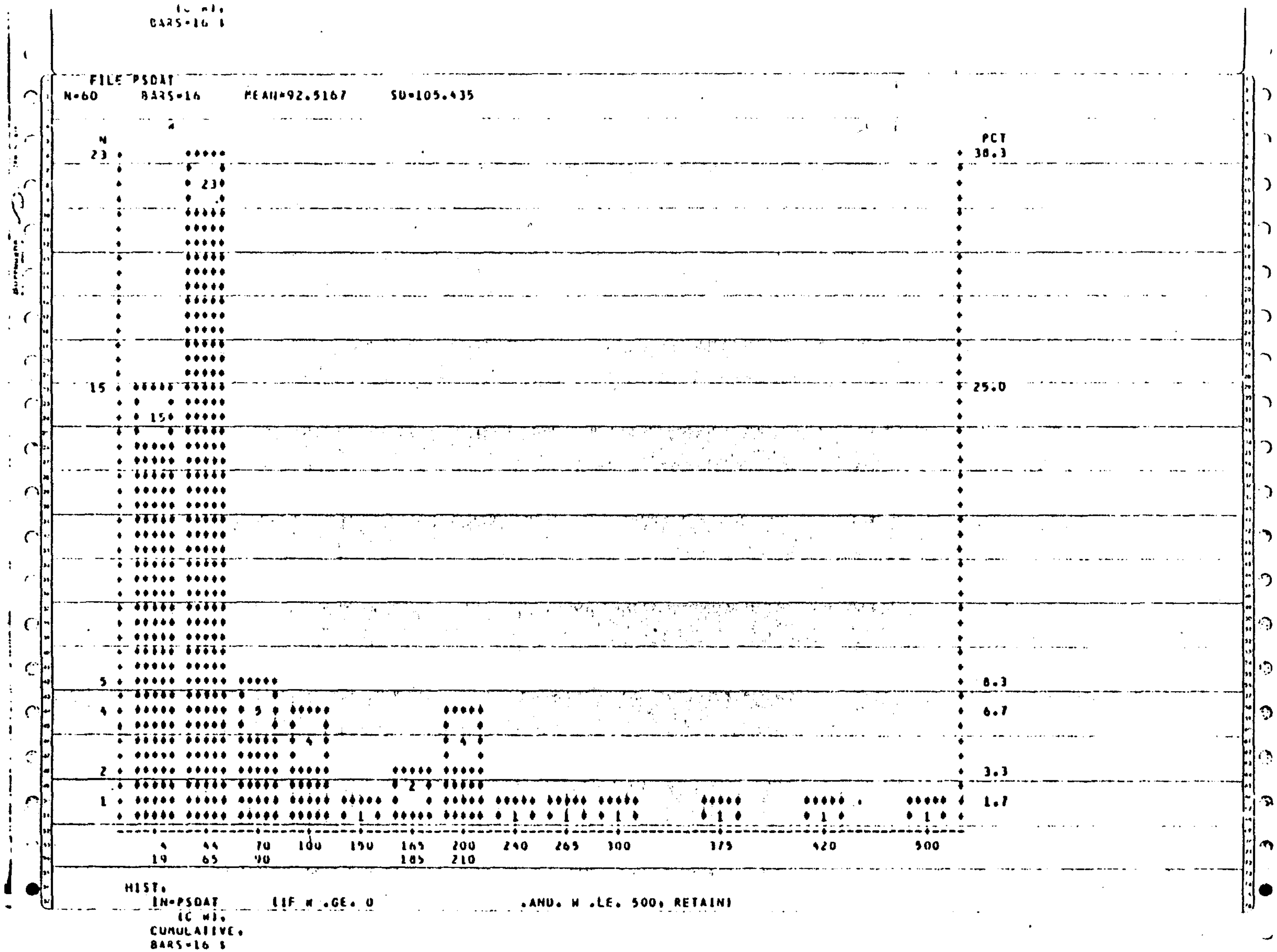


FIGURE A-19. Histogram and statistical parameters of tungsten concentrations in reconnaissance placer samples.

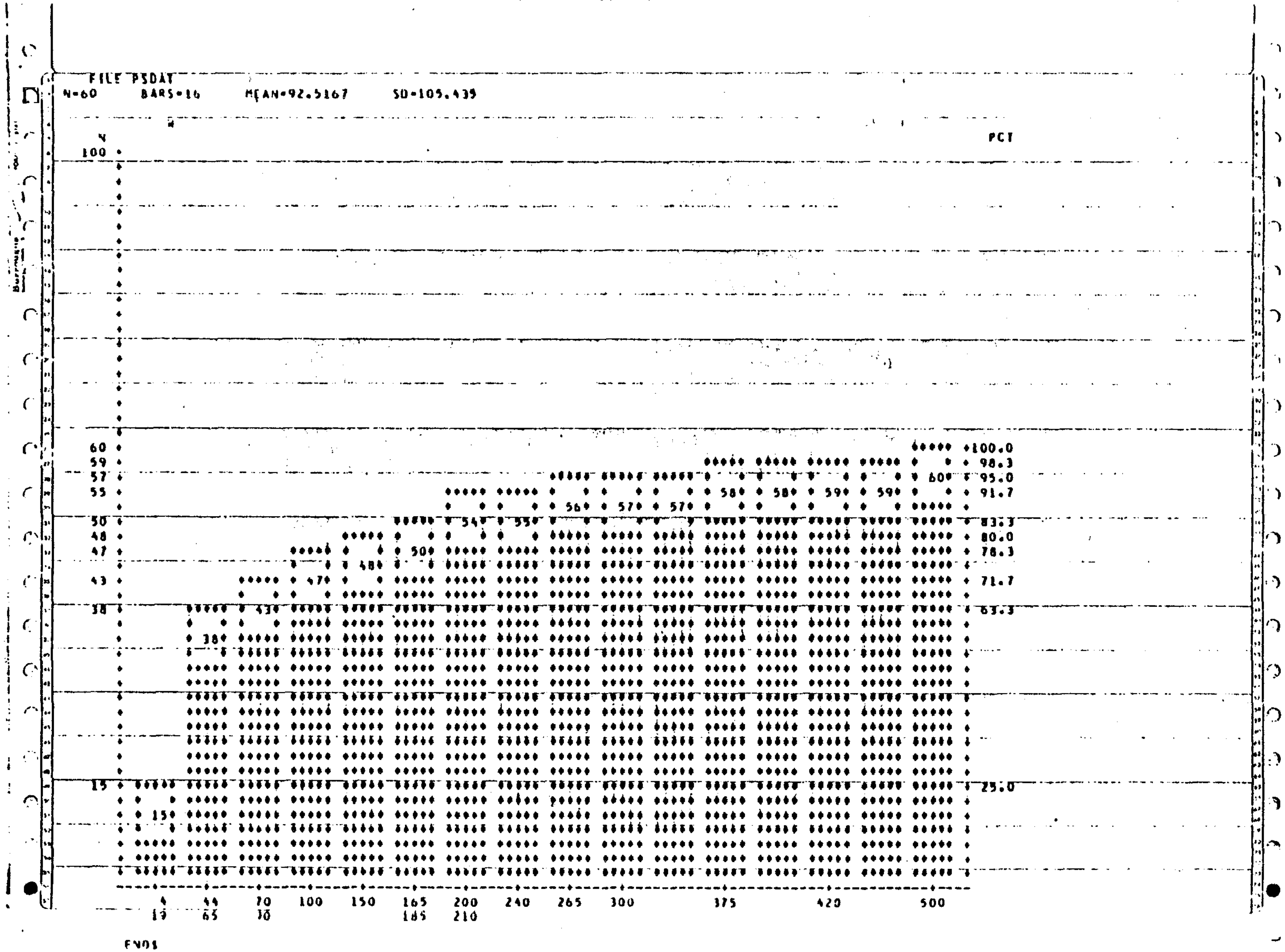


FIGURE A-20. Cumulative histogram and statistical parameters of tungsten concentrations in reconnaissance placer samples.

APPENDIX B

Histograms and cumulative histograms

for panned concentrate samples

APPENDIX B. Histograms and cumulative histograms for panned concentrate placer samples

Explanation:

N	Number of samples
BARS	Number of class intervals
SD	Standard deviation
y-axis	Shows number and percent (PCT) of samples
x-axis	Shows concentration of the element in parts per million (Where there is more than one value for the class interval, the low and high value within the class interval is shown).

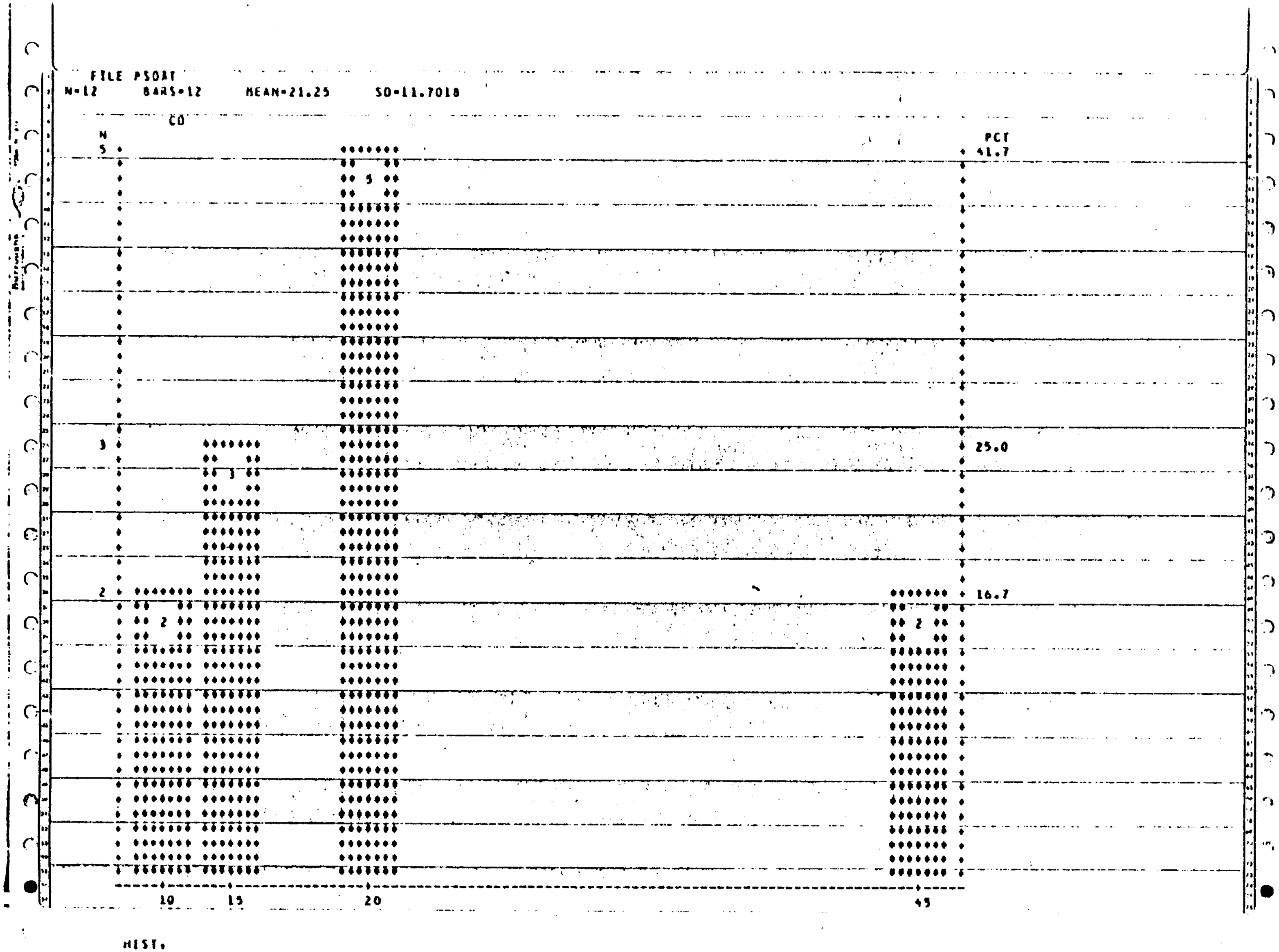


FIGURE B-1. Histogram and statistical parameters of cobalt concentrations in panned concentrate samples.

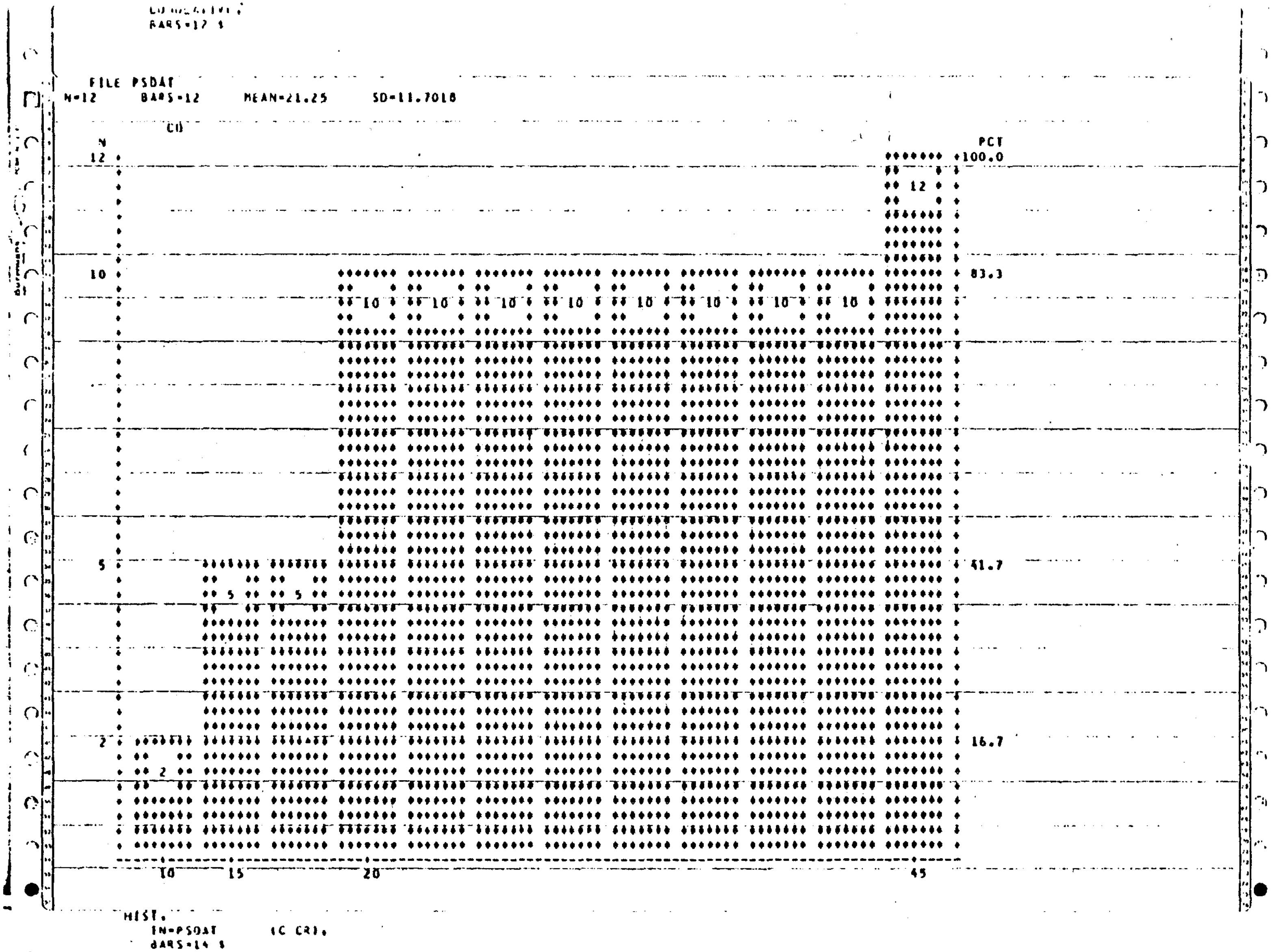


FIGURE B-2. Cumulative histogram and statistical parameters of cobalt concentrations in panned concentrate samples.

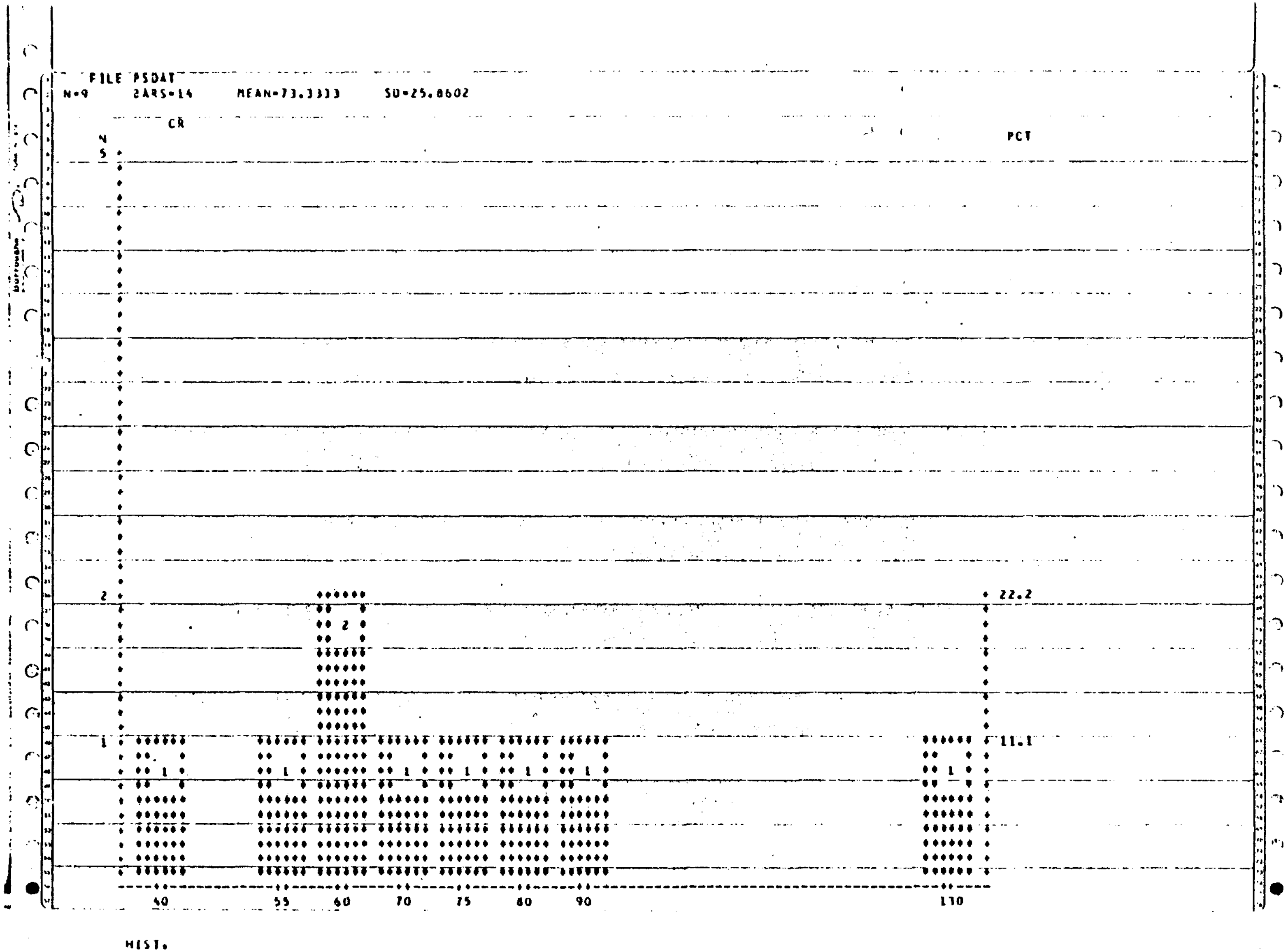


FIGURE B-3. Histogram and statistical parameters of chromium concentrations in panned concentrate samples.

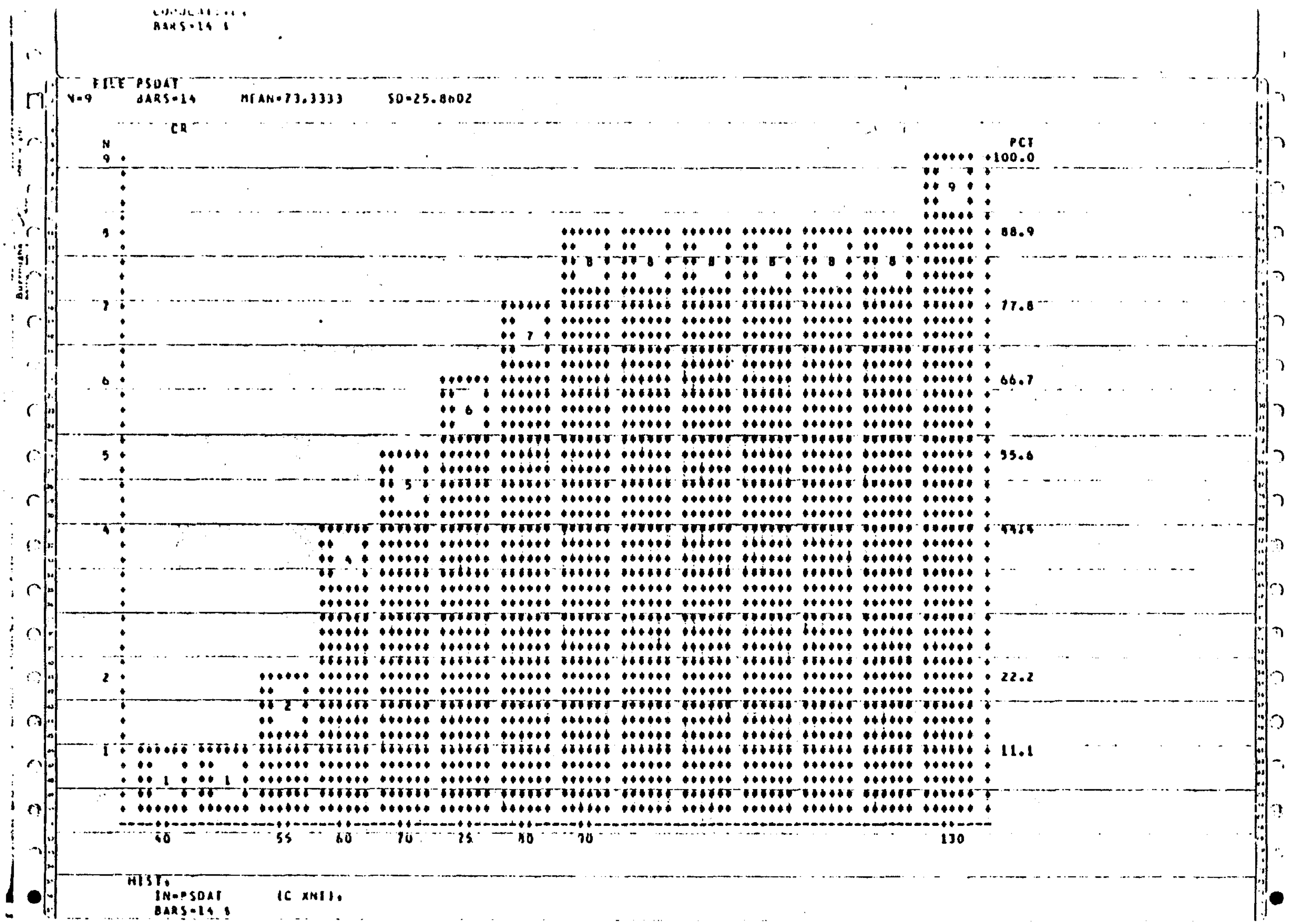


FIGURE B-4. Cumulative histogram and statistical parameters of chromium concentrations in panned concentrate samples.

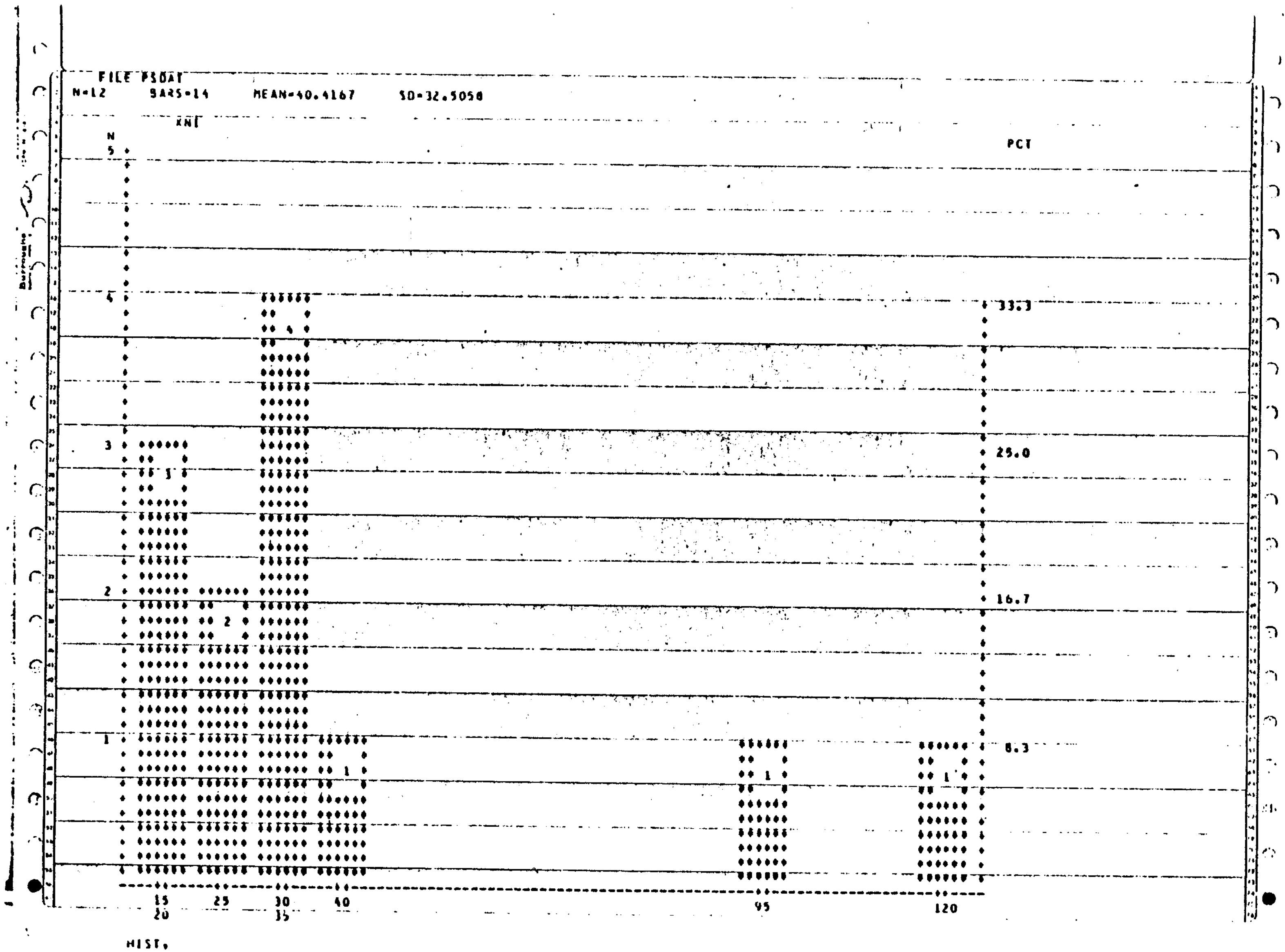


FIGURE B-5. Histogram and statistical parameters of nickel concentrations in panned concentrate samples.

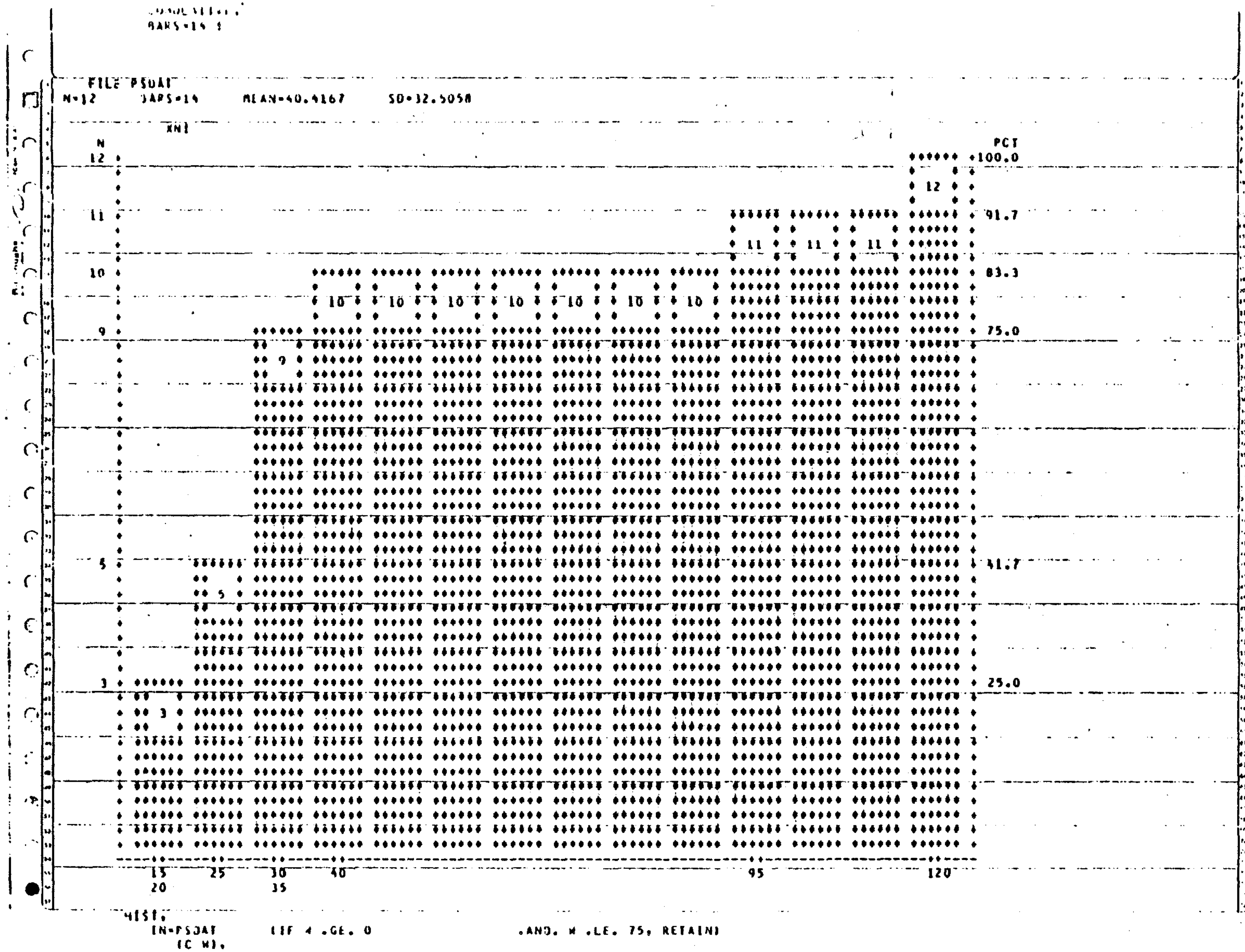


FIGURE B-6. Cumulative histogram and statistical parameters of nickel concentrations in panned concentrate samples.

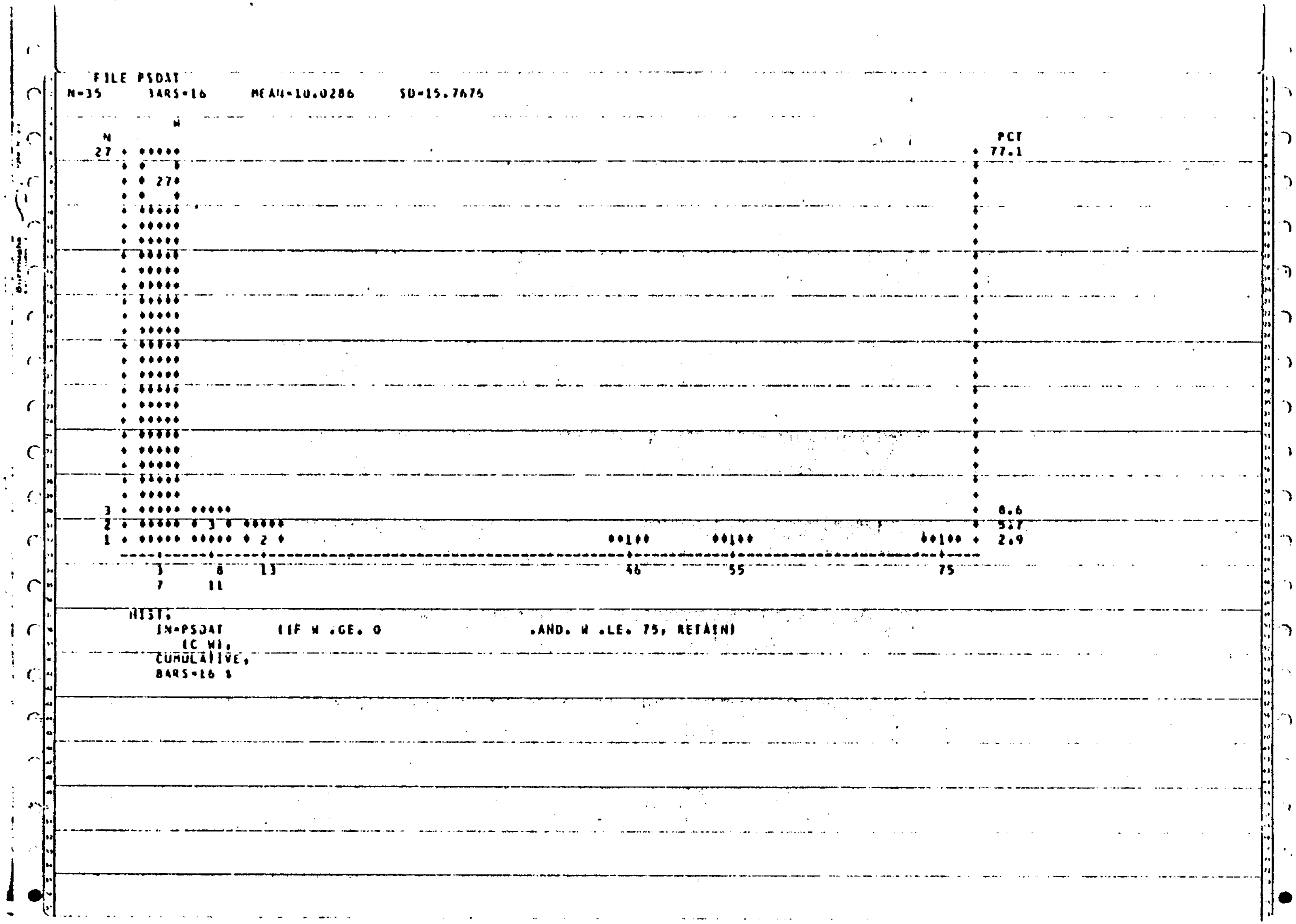


FIGURE B-7. Histogram and statistical parameters of tungsten concentrations in panned concentrate samples.

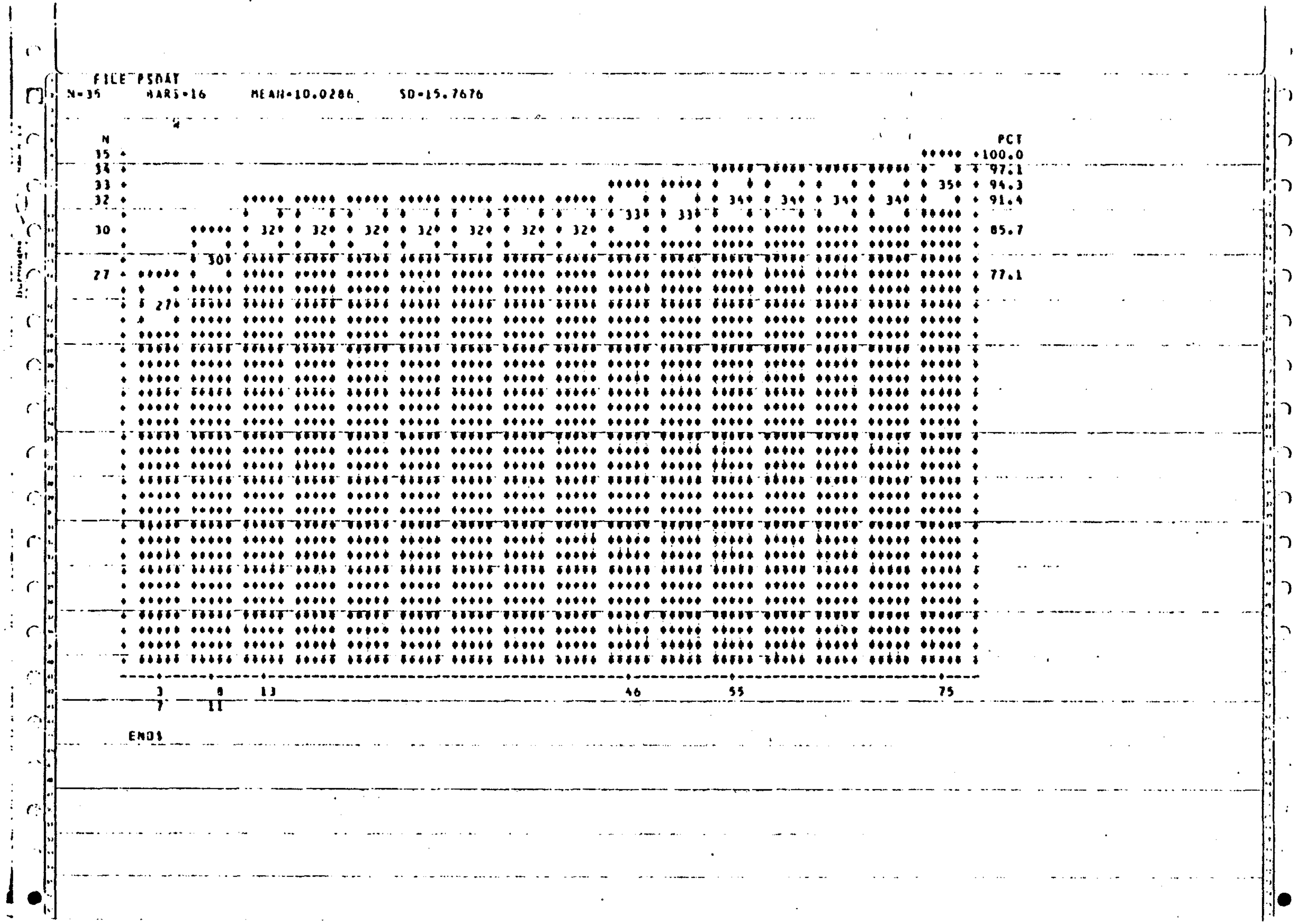


FIGURE B-8. Cumulative histogram and statistical parameters of tungsten concentrations in panned concentrate samples.

APPENDIX C

Histograms and cumulative histograms

for stream sediment samples

APPENDIX C. Histograms and cumulative histograms for stream sediment samples

Explanation:

N	Number of samples
BARS	Number of class intervals
SD	Standard deviation
y-axis	Shows number and percent (PCT) of samples
x-axis	Shows concentration of the element in parts per million (Where there is more than one value for the class interval, the low and high value within the class interval is shown).

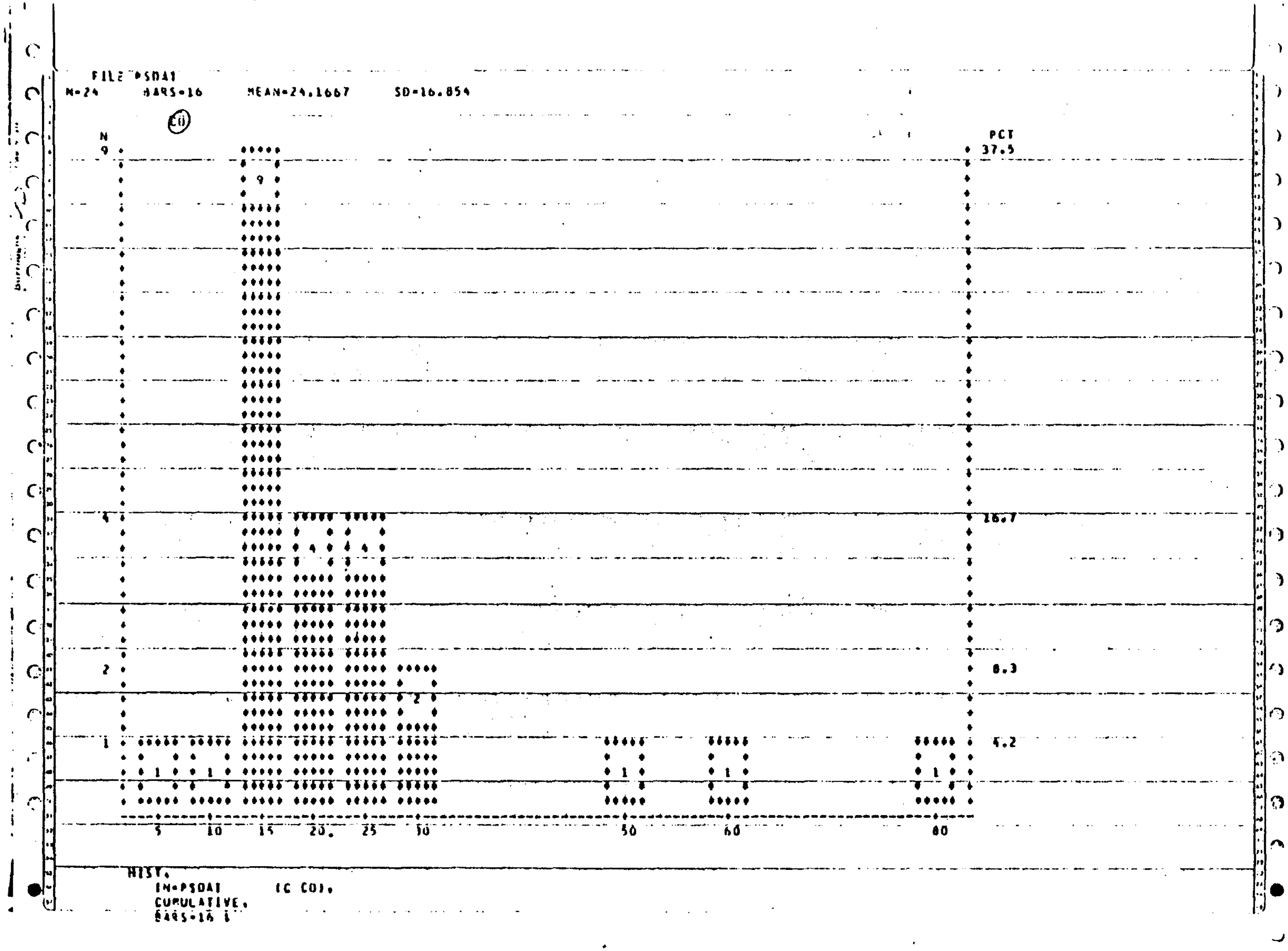


FIGURE C-1. Histogram and statistical parameters of cobalt concentrations in stream sediment samples.

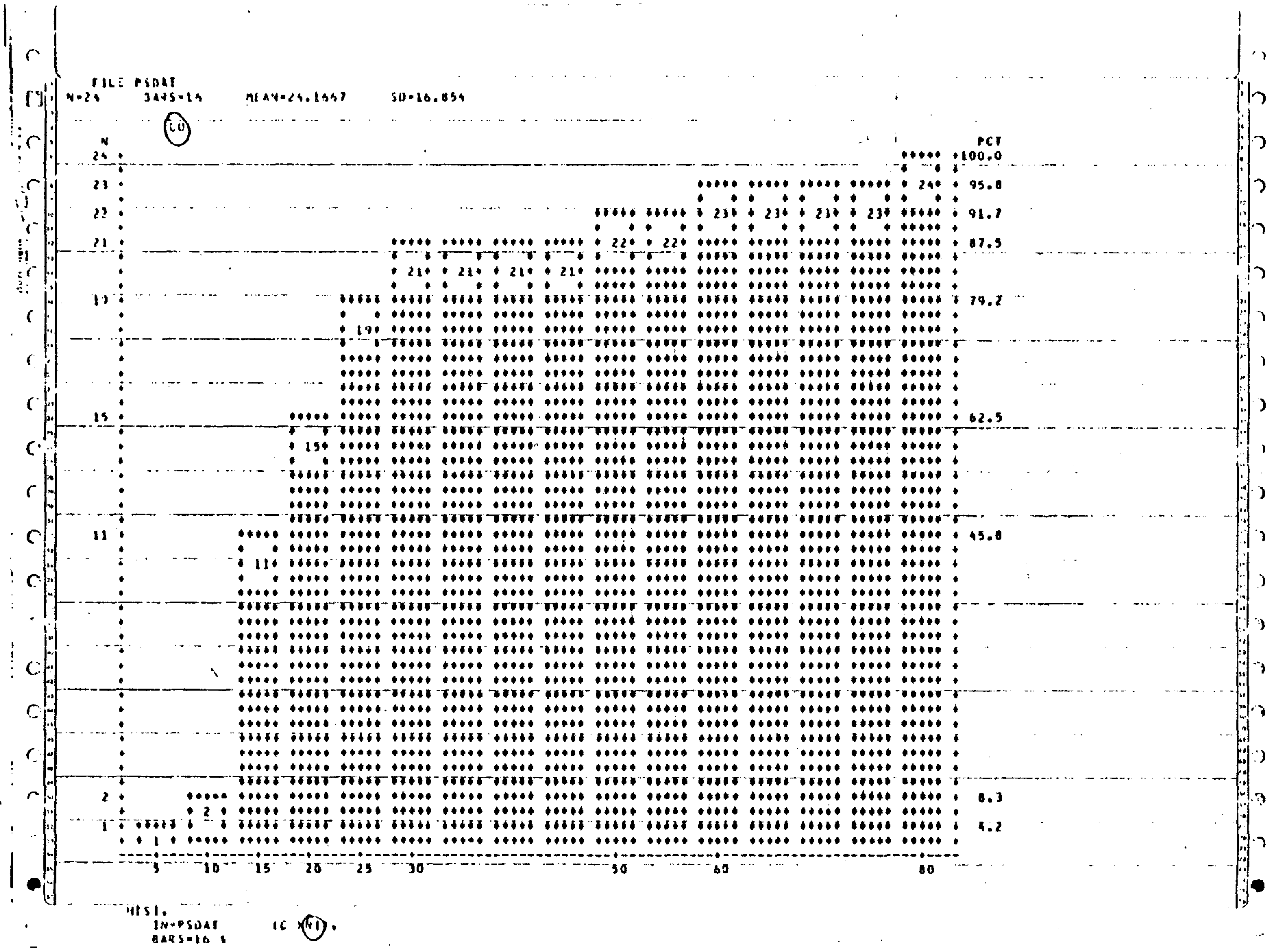


FIGURE C-2. Cumulative histogram and statistical parameters of cobalt concentrations in stream sediment samples.

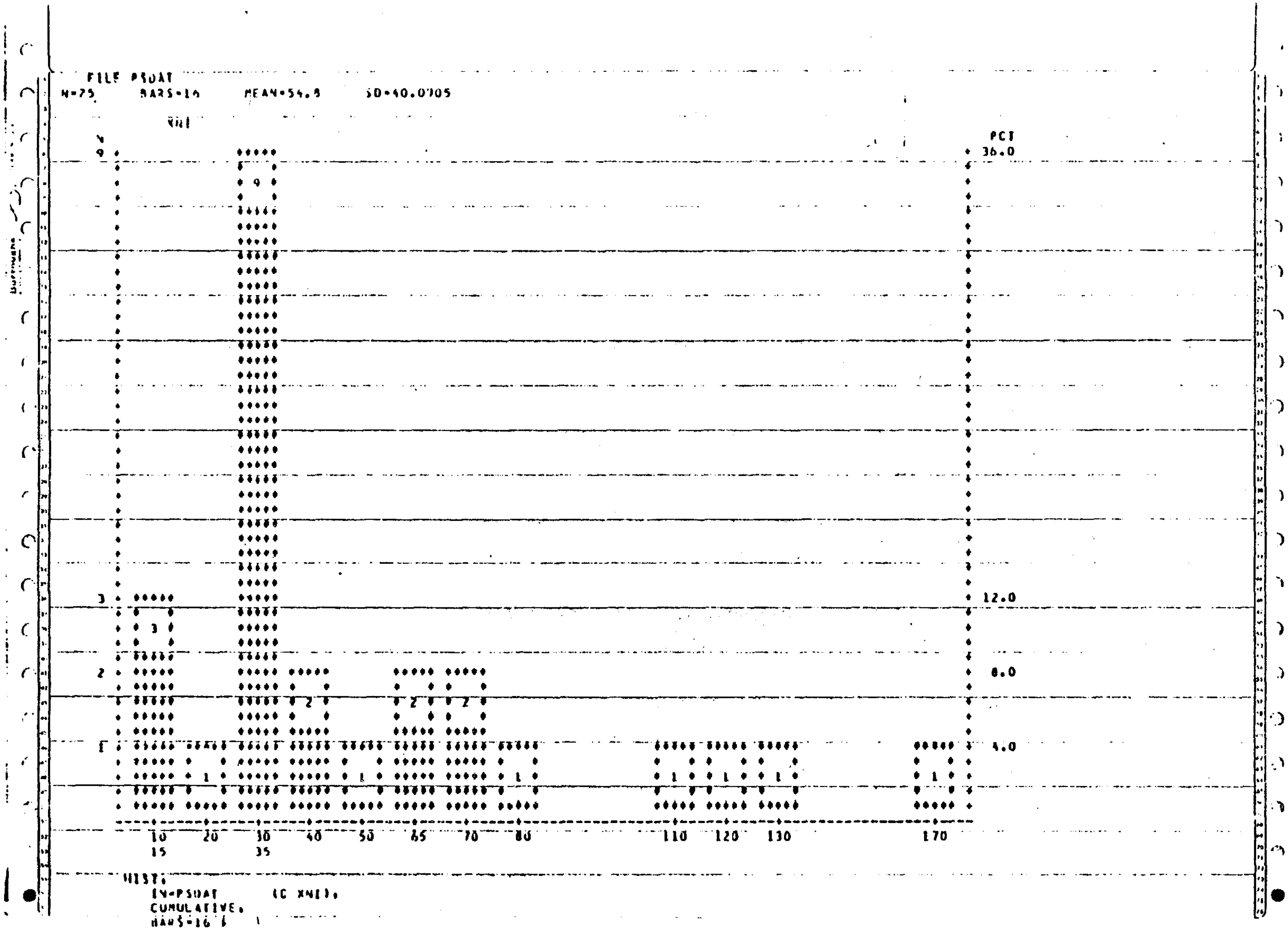


FIGURE C-3. Histogram and statistical parameters of nickel concentrations in stream sediment samples.

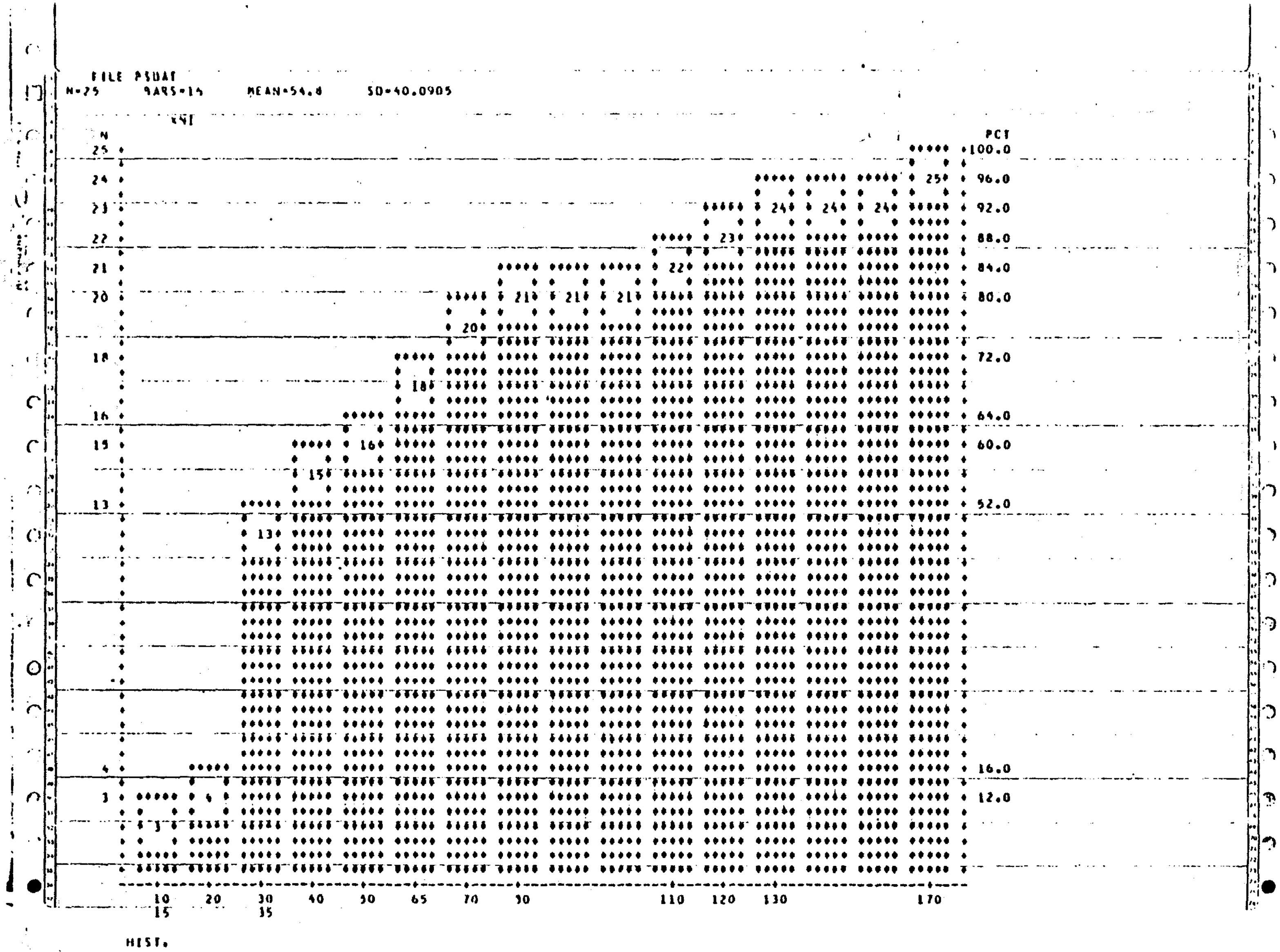


FIGURE C-4. Cumulative histogram and statistical parameters of nickel concentrations in stream sediment samples.

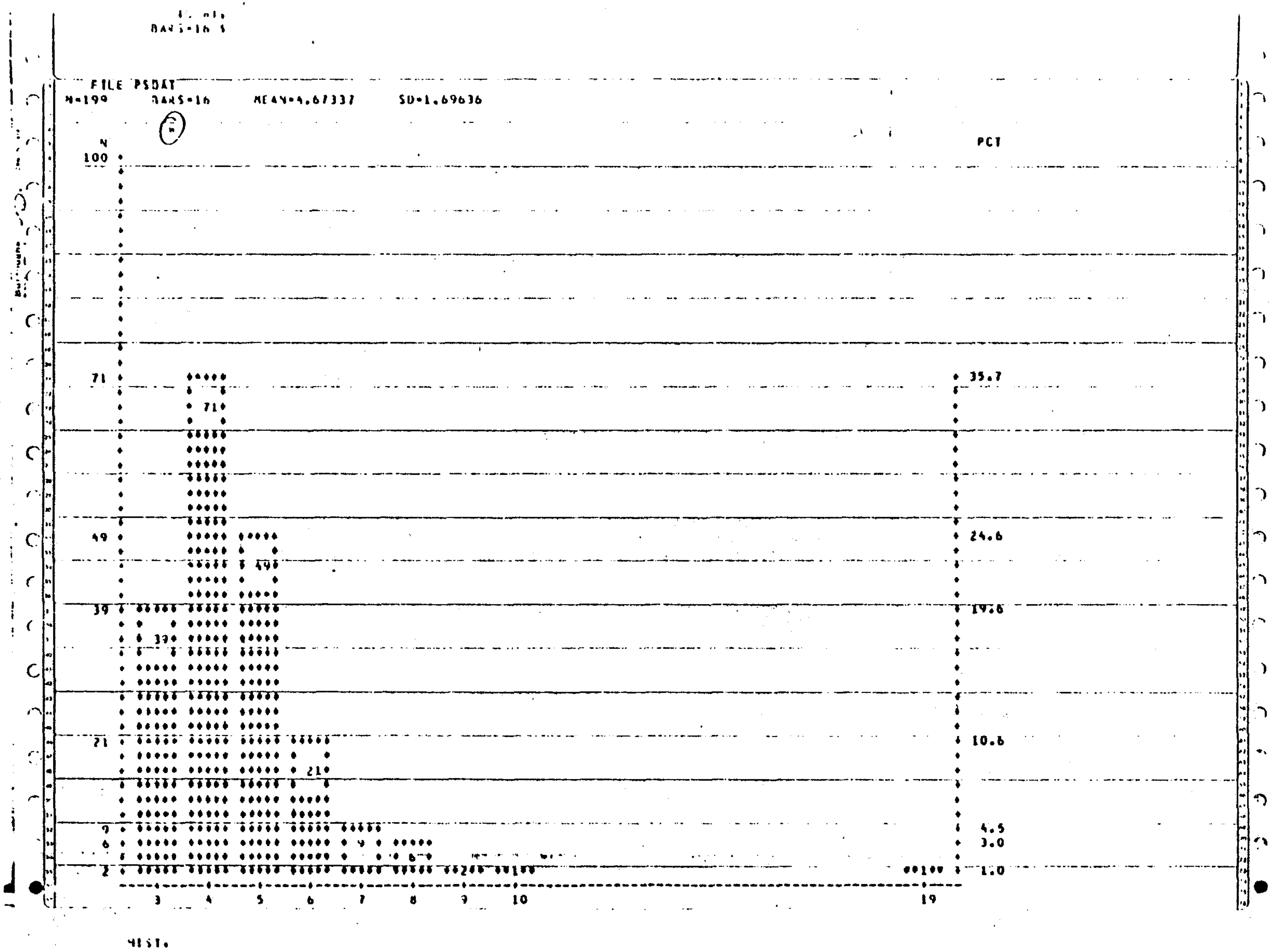


FIGURE C-5. Histogram and statistical parameters of tungsten concentrations in stream sediment samples.

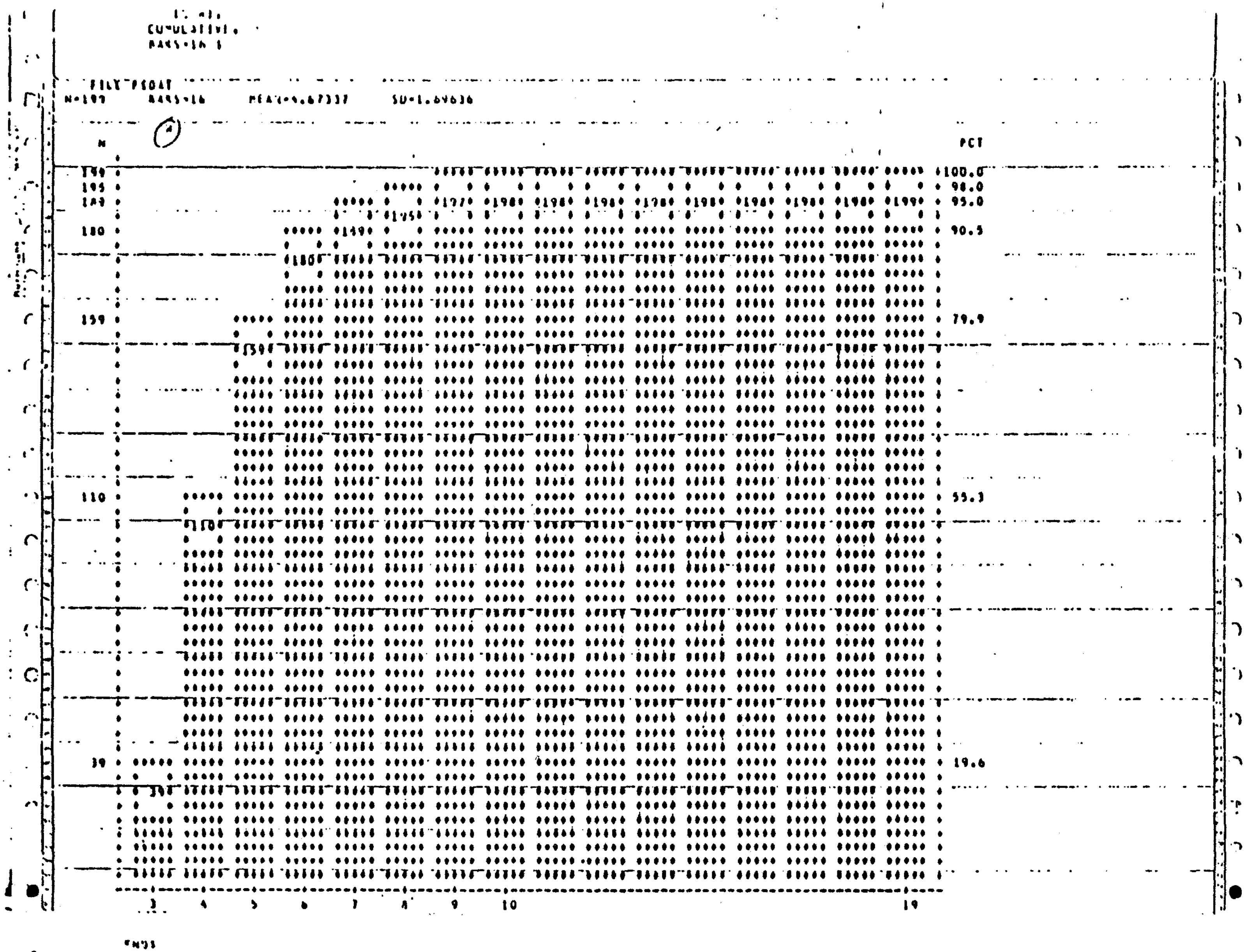


FIGURE C-6. Cumulative histogram and statistical parameters of tungsten concentrations in stream sediment samples.

APPENDIX D

Cross reference between original field sample numbers and map numbers used in this report

APPENDIX D-1. Cross reference between original field sample numbers and map numbers used in this report

Map Number[1/]	Field Number[2/]	Map Number	Field Number
1	A3029	51	A989
2	A3026	52	A1406
3	A1416	53	A1402
4	A968	54	A1400
5	A986	55	A1000
6	A989	56	A999
7	A1403	57	A3030
8	A1406	58	A3031
9	A1401	59	A3035
10	A1402	60	A3036
11	A1400	61	A3040
12	A999	62	A3039
13	A3036	63	A3037
14	A1404	64	A985
15	A998	65	A977
16	A981	66	A984
17	A985	67	A982
18	A994	68	A981
19	A995	69	A983
20	A970	70	A976
21	A969	71	A969
22	A983	72	A970
23	A3039	73	A997
24	A3040	74	A994
25	A975	75	A993
26	A992	76	A3065
27	A3065	77	A1413
28	A973	78	A1411
29	A1412	79	A980
30	A3048	80	A978
31	A1411	81	A3049
32	A1409	82	A3048
33	A3083	83	A3087
34	A3086	84	A3086
35	A3084	85	A3085
36	A3100	86	A3083
37	A3093	87	A3084
38	A3022	88	A3080
39	A3057	89	A3077
40	A3051	90	A3076
41	A3027	91	A3078
42	A3029	92	A3079
43	A3026	93	A3075
44	A1414	94	A3074
45	A1415	95	A3073
46	A1416	96	A3072
47	A966	97	A3060
48	A967	98	A3066
49	A968	99	A3042
50	A987	100	A3043

APPENDIX D-1. Cross reference between original field sample numbers and map numbers used in this report

Map Number[1/]	Field Number[2/]	Map Number	Field Number
101	A3044	135	A3008
102	A3069	136	A3007
103	A3070	137	A3009
104	A3071	138	A1509
105	A3046	139	A3013
106	A3045	140	A3015
107	A3023	141	A3019
108	A3032	142	A2933
109	A3021	143	A928
110	A3099	144	A2759
111	A961	145	A3016
112	A962	146	A2912
113	A958	147	A1304
114	A3058	148	A807
115	A3100	149	A1310
116	A961	150	A951
117	A3033	151	A945
118	A3094	152	A2918
119	A3093	153	A2923
120	A3020	154	A924
121	A963	155	A925
122	A960	156	A1257
123	A3022	157	A1260
124	A3095	158	A913
125	A3096	159	A2932
126	A3056	160	A2701
127	A3053	161	A2907
128	A3055	162	A810
129	A3054	163	A950
130	A3052	164	A955
131	A3051	165	A946
132	A3067	166	A940
133	A3092	167	A939
134	A3090		

1/Map number - number used in this report and on figures 14-17.
2/Field number - original sample number used in 1983 Mineral Resources studies report by Salisbury & Dietz, Inc. (30).