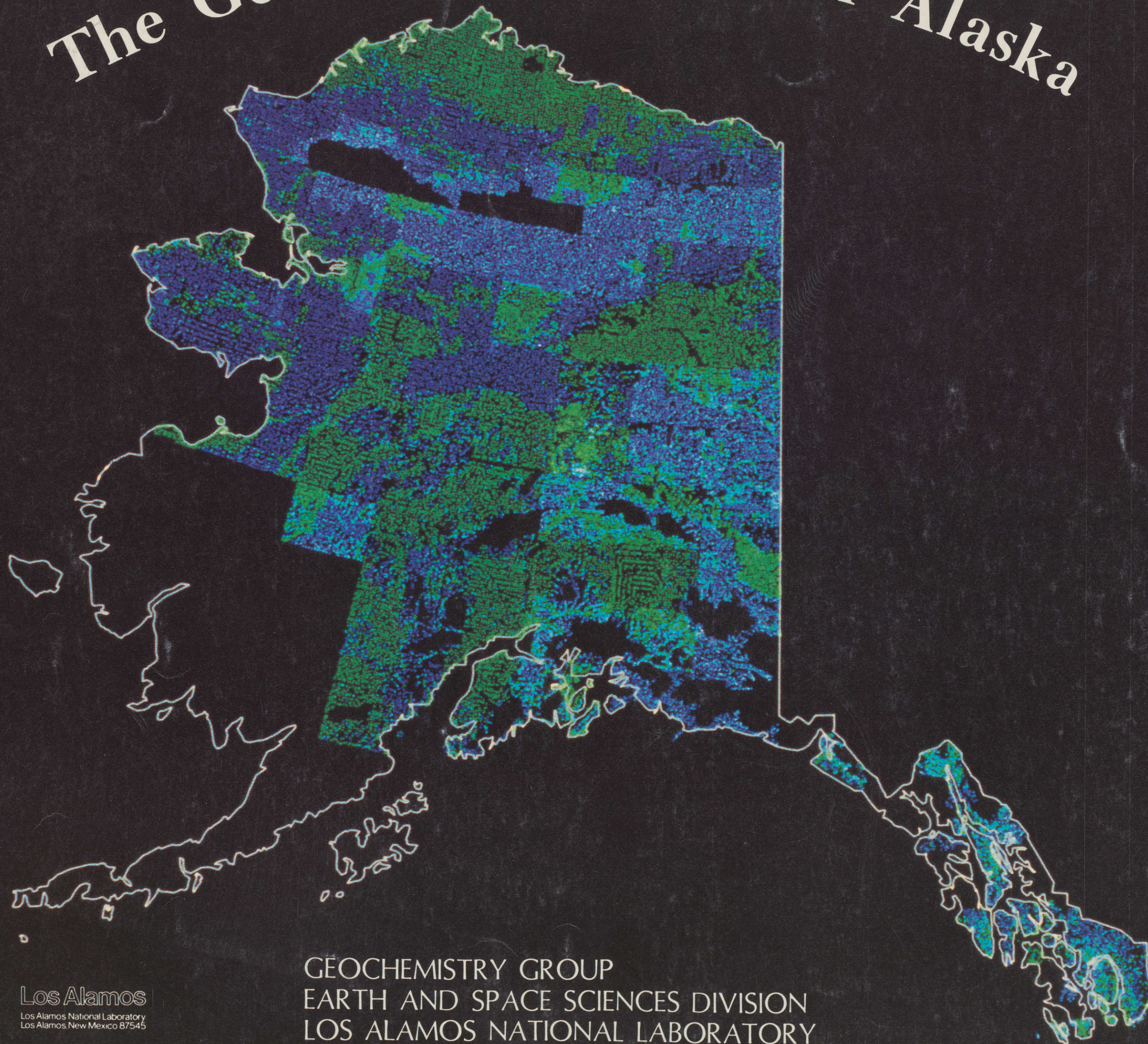


The Geochemical Atlas of Alaska



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COVER ILLUSTRATION: The display on the cover depicts the sample locations used for data in this atlas. Lake sediment sites are displayed in green. Stream sediment sites are displayed in blue.

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COMPILED BY THE GEOCHEMISTRY GROUP
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OCTOBER 1983

SUMMARY

The Geochemical Atlas of Alaska is a 1:6,000,000-scale (1 cm = 60 km) pictorial representation of regional, geochemical-survey data acquired by the Los Alamos National Laboratory as part of the Hydrogeochemical and Stream-Sediment Reconnaissance portion of the U.S. Department of Energy's National Uranium Resource Evaluation program. Stream- and lake-sediment samples from 61,923 locations, distributed over most of Alaska, were collected and analyzed. Standardized field and analytical procedures were employed throughout. Universal kriging techniques were used to interpolate the data to a 5-km by 5-km grid (resulting in 46,276 grid cells), and the results are displayed as images with color and color intensity representing elemental concentrations. Single-element color plates display the concentrations in statistically chosen intervals as different colors and shades of colors. Three-element color plates display three elements simultaneously, each element being displayed in one of the primary colors (red, green, or blue) with 256 levels of color intensity representing the concentrations for each element. Text describing the sampling, chemical analysis, and data-processing procedures, accompanied by transparent overlays providing geographic index information, sample location and type, land control, and mineral occurrence information are also included to aid the reader with the interpretation of the geochemical data on the color plates. Examples of the correlations among the elements and (1) geology and (2) areas of potential mineralization are likewise provided.

ACKNOWLEDGMENTS

In addition to the many able assistants listed on the title page, most of whom were involved directly in the National Uranium Resource Evaluation program at the Los Alamos National Laboratory, the authors gratefully acknowledge the efforts of Patricia O'Rourke and Janice Barber (word processing), Anthony Garcia (illustration), and Glenda Ponder (editing). The geochemical survey of Alaska would not have been possible without the cooperation of the many Federal and State agencies, native corporations, and private land holders who permitted the sampling of the lands managed by them. The financial support of the Grand Junction Office of the U.S. Department of Energy (for the geochemical sampling, analysis, and reporting phases and for atlas production) and of the State of Alaska is also gratefully acknowledged. Critical reviews of the atlas were kindly provided by Hatten Yoder, George Koch, Milton Wiltse, and several members of the staffs of the Grand Junction Offices of the Bendix Field Engineering Corporation and the Department of Energy. Their many helpful suggestions were used to improve the atlas, though the accuracy of the final product is the sole responsibility of the authors. Lastly, the authors express their deeply felt appreciation to Robert R. Sharp, Jr., who designed, implemented, and managed the Los Alamos geochemical sampling program, and to Wayne A. Morris, who managed the program after Bob Sharp left.

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INTRODUCTION

Earth science studies in Alaska are at a relatively youthful stage of development compared to those in most other areas of the United States because of the great size and remote nature of the state. Regional geochemical data published during the past five years can significantly aid in addressing many fundamental questions that remain about the state's geology, geochemistry, and geophysics. These data help delineate the regional geochemical patterns throughout much of the state and provide a comprehensive data set that can be used as baseline information for more detailed studies. Problems with data handling arise when using voluminous geochemical data for a large area. This atlas attempts to overcome these problems and present regional (reconnaissance) geochemical data for Alaska in a format readily usable by researchers.

The data presented are from the Alaska portion of a nationwide, multielement, geochemical survey for uranium in the United States. Geochemical exploration has proven to be a reliable method for determining major, minor, and trace-element distributions in rocks and soils on or near the surface of the Earth (Hawkes and Webb, 1962; Rose et al., 1979; Levinson, 1974 and 1980). This type of exploration involves the systematic collection and chemical analysis of samples and the mapping and interpretation of the resulting data. Samples collected may include: rocks; soils; stream and lake sediments; stream, lake, well, and spring waters; and plant matter. In particular, stream and lake sediments are typically composite geologic samples that represent average elemental abundances within their respective drainage basins. Only the stream- and lake-sediment data from the Alaskan survey have been used to compile this atlas.

The abundance and distribution of elements as determined from systematically collected and analyzed geochemical samples can provide valuable regional geologic information such as the nature of the bedrock and the approximate location of lithologic contacts. Regional geochemical trends and areas of widespread mineralization can also be mapped with these data. The detail with which these maps can be made depends on the sampling density (the number of samples collected per unit area). Used in conjunction with other available geochemical, geophysical, and geologic information, geochemical survey data provide a comprehensive data base on which future regional geologic and geochemical studies can be based. Geochemical surveys, primarily for the purpose of assessing resources, have been successfully conducted in Australia, Canada, Finland, Germany, South Africa, the Soviet Union, and the United Kingdom, as well as the United States.

The Geochemical Atlas of Alaska presents regional geochemical data as computer-generated images having concentration values of the elements displayed as colors and color intensities. The use of color images to project these data enables the reader to gain a synoptic overview of broad geochemical trends, place local geochemical patterns in their proper regional context, and observe some correlations among the elements presented. The methods used to compile and portray elemental concentrations in this atlas are similar to those employed by Webb et al. (1973) and Webb et al. (1978) in their pioneering geochemical atlases of Ireland and of England and Wales.

One caveat cannot be emphasized strongly enough to atlas users. As stated several times by Webb et al. (1978), regional geochemical data are broad scale. For example, sampling densities in Alaska ranged from one sample per 10 km² to one per 23 km². Therefore, these data cannot necessarily be used to pinpoint specific geochemical anomalies or single ore deposits. A second caveat is that interpretation of stream-sediment and lake-sediment data is not commonly straightforward and must take into account the many factors that can influence the composition of these sediments. Stream sediments and lake sediments are two distinct sample types, each of which is influenced by different factors, and some elements concentrate differently in lake environments than in stream environments. Upon careful examination of the elemental plates, together with the overlays of stream- and lake-sediment sample locations, differences in some elements (e.g., iron) can be seen between the areas that were sampled predominantly from lakes and those sampled predominantly from streams. For most elements, these differences are insignificant and unobservable in the elemental plates. Nevertheless, for areal completeness of the atlas, both types of samples have been included in the same data base.

If utilized with proper caution, these data can be successfully used to: (1) identify broad geochemical patterns, (2) determine regional background values for the elements presented, (3) observe some correlations among those elements, and (4) select areas of interest for more detailed study. To assist readers in interpreting the geochemical data on the color plates, there is a text section, a

generalized geologic map (Plate 1), and various transparent overlays (in rear pocket). All plates and overlays are at the same scale (1:6,000,000). The text describes the methodologies used for sample collection, sample analysis, and data processing. Examples of correlations among the geochemical data and geology and among geochemical data and mineralization, recommendations for further work, and principal references cited are also included in the text. The overlays are: (I) a geographic index overlay of Alaska; (II) a quadrangle overlay for Alaska showing the GJBX (Grand Junction/Bendix) report numbers for geochemical-survey sediment data; (III) sample location overlay for stream sediment; (IV) sample location overlay for lake sediment; (V) land control overlay of Alaska; and (VI) mineral occurrence overlay of Alaska.

BACKGROUND

The regional geochemical survey that provided the data used in this atlas was conducted as part of the HSSR (Hydrogeochemical and Stream Sediment Reconnaissance) portion of the NURE (National Uranium Resource Evaluation) program. The NURE program was initiated by the U.S. Atomic Energy Commission in 1974 and later managed successively by the ERDA (Energy Research and Development Administration) and DOE (Department of Energy). NURE was begun during a time when there was increasing concern about the adequacy of the supply of uranium to support an expanding nuclear power capacity. The purpose of NURE was to gather data with which to make an assessment of the uranium resources in the United States, as well as to indicate to the private sector areas favorable for uranium exploration. The HSSR portion of NURE was a nationwide, regional, geochemical survey designed to identify broad areas favorable for the occurrence of uranium deposits.

Responsibility for conducting the HSSR was assigned to four national laboratories: Savannah River, Oak Ridge, Los Alamos, and Lawrence Livermore (Bolivar, 1980). Los Alamos was given responsibility for the HSSR in the Rocky Mountain states and in Alaska. Analytical and field data gathered during the program have been open filed to the public through the Grand Junction Office of DOE (see Overlay II). These open-file reports and digital tapes contain, in tabular format, sample locations and identifiers, field data, and analytical results. Each report or tape contains data for one or more 1:250,000-scale NTMS (National Topographic Map Service) quadrangles. In Alaska, 104 NTMS quadrangles were sampled and reported. The remaining cuts of all samples, all field data forms, and the original field maps are now archived at the Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee.

Geochemical samples collected early in the HSSR were analyzed for uranium only because the NURE program was implemented to evaluate the uranium resources of the United States. It soon became apparent to DOE that the resource evaluators required additional geochemical data to make a complete evaluation and that it would be expedient to analyze the samples for as many elements as possible, particularly for those elements known to be associated with or suspected to be pathfinders for uranium mineralization. Consequently, each laboratory participating in the HSSR developed a multielement suite of analyses that was approved by DOE. As a result, the NURE program has provided users with a tremendous quantity of major, minor, and trace-element data covering approximately two-thirds of the United States.

METHODOLOGIES

The three basic steps necessary to complete this study were sample collection, sample analysis, and data processing and interpretation. The sampling program was largely patterned after successful geochemical surveys in Canada, Scandinavia, the Soviet Union, and similar terranes and climatic regimes elsewhere (Sharp, 1977; Sharp and Bolivar, 1981; and Bolivar, 1981). State-of-the-art methods were used to analyze all samples and efforts were made to maximize the number of elements determined and the quality of the data collected. Large computers were used to process the data because of the large number of samples and the voluminous field and analytical information associated with each sample site.

Sample Collection

The sampling program in Alaska began in 1975 and by 1979 80% of the land area of the state had been covered. Unfortunately, no funds were available for further HSSR field work after 1979, and the southwest portion of the state, the Alaskan Peninsula, and parts of the Panhandle region could not be sampled. Unsampled areas are shown in Fig. 1. These include proposed National Parks and Monuments for which permission to sample was denied after 1977 and the cores of some mountain ranges covered by glaciers and extensive ice sheets.

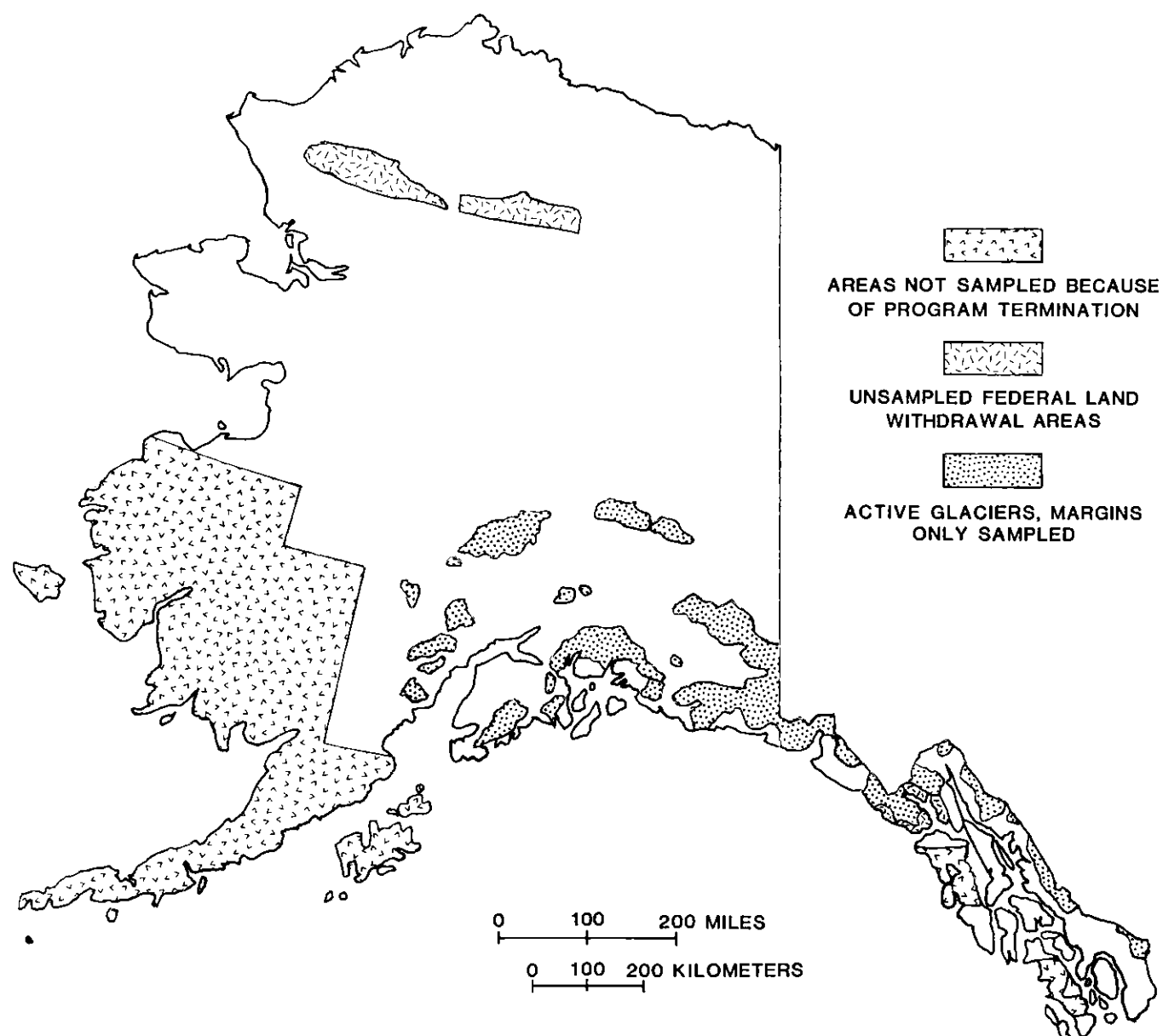


Fig. 1. Alaskan areas not sampled by NURE HSSR.

A nominal sample density of one sample per 10 km² (4 mi²) was selected for areas of Alaska with moderate-to-high relief and one sample per 23 km² (9 mi²) was taken in low-lying areas having abundant lakes (Fig. 2). Sediment samples from small streams were the preferred sample type in regions having well-developed drainage systems. Lake sediments from small lakes were sampled primarily in low, flat areas having poorly integrated drainages. A total of 61,923 sediment samples was collected throughout the state. Of these, 38,021 were from small streams (Overlay III) and 23,902 were from small lakes (Overlay IV).

For stream sites, a composite sample of fine-grained material was collected from three adjacent spots in the active stream bed (Sharp and Aamodt, 1978). Usually about a kilogram of such material was collected from every site to insure that there was at least 25 g of usable sediment left after the sample was dried and sieved to minus 100 mesh (that material passing a 100-mesh screen). For lake samples, a tethered, stainless steel bottom sampler was dropped near the center of the lake from a pontoon-equipped helicopter. On the basis of an extensive survey of the literature (Sharp, 1977) and pilot samplings (e.g., Olsen, 1977), a minus-100-mesh sediment sample was determined to be representative of the total sample with respect to uranium concentrations.

Water samples, along with field measurements and observations were also taken at each sample site. The field measurements that were recorded included water temperature, dissolved oxygen, specific conductance, and pH. Scintillometer measurements were taken at stream-sediment sites. Field observations included general descriptions of bedrock geology, stream and lake characteristics, local vegetation, terrain, and possible contaminants (if any). Field measurements and observations were numerically coded and recorded on prenumbered data forms having the same number that was affixed to each corresponding sample. In each case, this was done at the sample site.

Most sampling was performed on a quadrangle-by-quadrangle basis by commercial contractors according to Los Alamos' specifications. Contracts for 4,000 to 10,000 sample locations each (depending on the number and land area of the NTMS quadrangles involved) were let by competitive bidding. Each contractor and field crew was provided with sampling maps, detailed field-procedures manuals (Sharp and

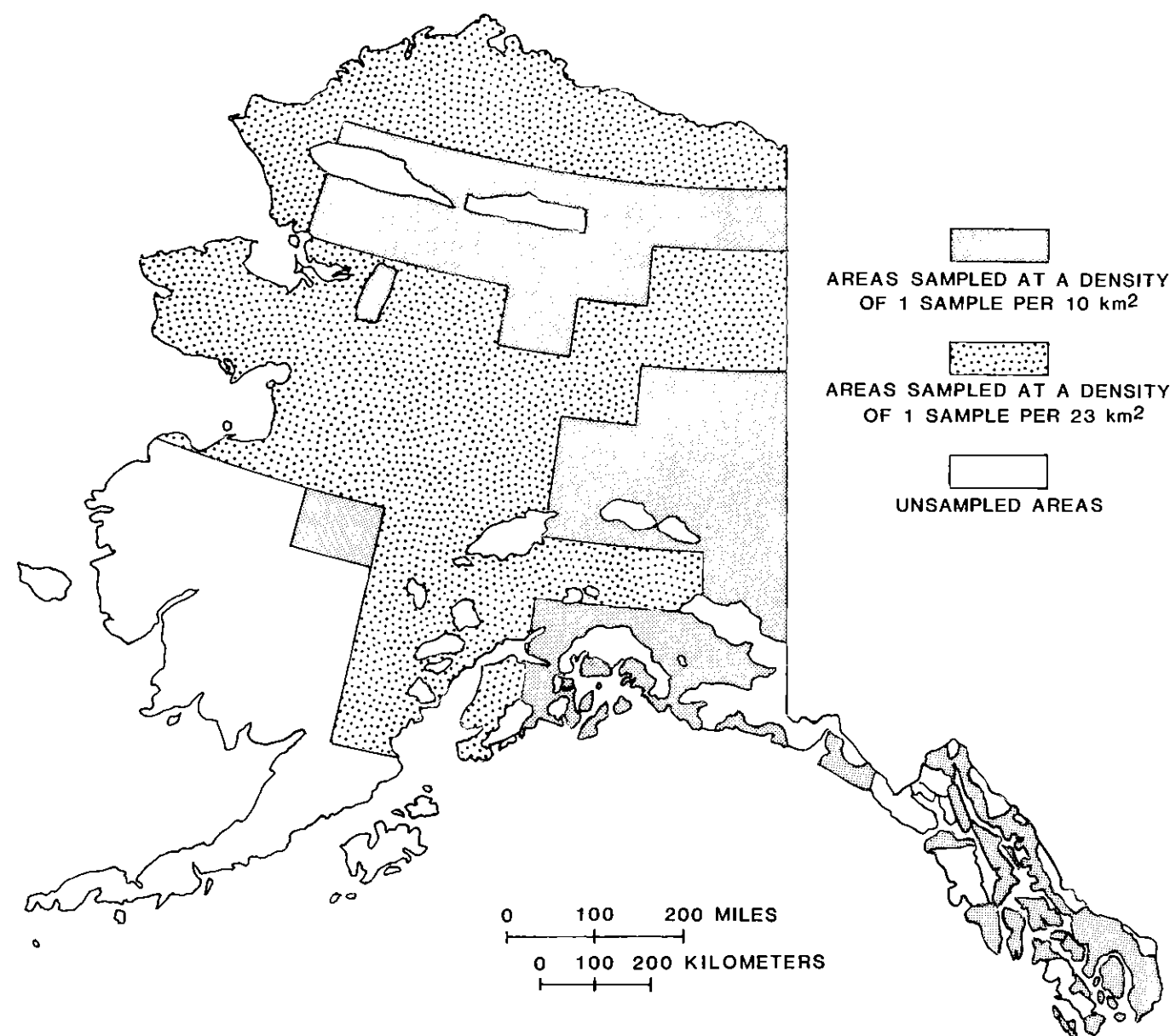


Fig. 2. NURE HSSR sampling densities in Alaska.

Aamodt, 1978), and training sessions by a Los Alamos contract monitor. At least one trained Los Alamos contract monitor or field supervisor was assigned to work with sample collectors in each field camp to answer questions about field procedures and sampling equipment and to verify that the sampling and sample processing work was accomplished according to specifications.

The lack of roads throughout most of the state made it necessary to sample most areas by helicopters operating from self-sufficient, portable field camps. Food, fuel, and other supplies were flown into these camps by fixed-wing aircraft. Fuel caches in support of the sampling program were also typically delivered by fixed-wing aircraft. Generally, two or three helicopters operated out of each field camp and flew designated routes to preselected sample sites. Helicopter pilots used the quadrangle maps at a scale of 1:250,000 for navigation and to mark the sites actually sampled.

During or immediately after each 8- to 10-hour sampling shift (usually carried out in 2- to 4-hour increments), maps, samples, and data forms were inventoried and crosschecked for errors. Sediment samples were shipped to central processing facilities in Fairbanks or Anchorage where they were dried at <100°C and sieved to minus 100 mesh. A 25-ml vial containing the minus-100-mesh sediment fraction was sent to Los Alamos for analysis; the remainder of the sample was discarded.

Orientation studies, designed by Los Alamos, were conducted by the Geological Survey of Alaska in 1975 and by Los Alamos personnel in 1976 to determine appropriate sampling procedures for Alaska. The first commercial contract for reconnaissance geochemical work was awarded for the Seward Peninsula in 1976 and resulted in collection of samples at 4,468 locations. In 1977, two contract areas, containing a total of about 12,500 locations on 19 (1:250,000-scale) map sheets, were sampled by one commercial contractor in south-central Alaska. An additional 1,435 samples were collected in 1977 from the Fairbanks quadrangle by the University of Alaska as part of another pilot survey. In 1978, four areas that totaled approximately 28,500 sample locations from 37 quadrangles were sampled by two contractors in the central lowlands, along the Alaska-Yukon border, and across the Brooks Range. An additional 900 locations were sampled in 1978 in the Bettles quadrangle by the University of Alaska, and 160

samples were taken from the Dixon Entrance quadrangle area by Los Alamos in that same year. In 1979, samples from approximately 10,500 locations were collected in the Arctic foothills and North Slope by a contractor. Funds for additional sampling became available late in the summer of 1979 and Los Alamos personnel were able to sample about 60% of the Panhandle (nearly 3,750 locations) before winter.

Sample Analysis

Sediment samples were analyzed at Los Alamos by DNC (delayed-neutron counting), INAA (instrumental neutron-activation analysis), XRF (x-ray fluorescence), and arc-source emission spectrography (Table I). The suite of elements analyzed varied over the course of the analytical effort. In the early stages of the program, samples from several quadrangles were analyzed only for uranium by DNC. Later, as funds became available to expand the analytical efforts, these samples were reanalyzed for a multielement suite using the other techniques. About midway through the analytical effort, improvements to the XRF system allowed the inclusion of arsenic, selenium, and zirconium to the multielement suite (52,251 samples were analyzed for

TABLE I

ELEMENTS ANALYZED IN SEDIMENT SAMPLES DURING THE HSSR

| Analytical Technique | Element(s) | Lower Detection Limit (ppm) ^a | Crustal Abundance (ppm) ^b | Percent of Samples > than Detection Limit | |
|---|--|--|--------------------------------------|---|------|
| Delayed Neutron Counting | Uranium | 0.01 | 1.8 | 99.98 | |
| Instrumental Neutron Activation Analysis ^c | Aluminum | 3200 | 81300 | 99.6 | |
| | Barium | 150 | 425 | 87.6 | |
| | Calcium | 1000 | 36300 | 89.8 | |
| | Dysprosium | 0.7 | 3.0 | 92.8 | |
| | Magnesium | 2700 | 20900 | 90.4 | |
| | Manganese | 55 | 950 | 99.9 | |
| | Potassium | 3400 | 25900 | 83.0 | |
| | Sodium | 1000 | 28300 | 99.9 | |
| | Strontium | 400 | 375 | 5.8 | |
| | Titanium | 750 | 4400 | 92.7 | |
| | Vanadium | 6 | 135 | 98.1 | |
| | Short-lived radionuclides counted 21 minutes after irradiation | Antimony | 1 | 0.2 | 5.0 |
| | | Cerium | 10 | 60 | 93.2 |
| | | Cesium | 2 | 3 | 51.1 |
| Chromium | | 10 | 100 | 92.9 | |
| Cobalt | | 1.7 | 25 | 94.5 | |
| Europium | | 0.4 | 1.2 | 90.8 | |
| Gold | | 0.05 | 0.004 | 1.0 | |
| Hafnium | | 1.3 | 3 | 87.2 | |
| Iron | | 1100 | 50000 | 99.0 | |
| Lanthanum | | 7 | 30 | 79.2 | |
| Lutetium | | 0.1 | 0.5 | 81.2 | |
| Scandium | | 0.9 | 22 | 99.5 | |
| Tantalum | | 1 | 2 | 2.4 | |
| Terbium | | 1 | 0.9 | 4.8 | |
| Thorium | 1 | 7.2 | 90.7 | | |
| Ytterbium | 1 | 3.4 | 60.9 | | |
| Zinc | 100 | 70 | 46.4 | | |
| Energy-Dispersive X-Ray Fluorescence | Arsenic | 5 | 1.8 | 73.9 | |
| | Bismuth | 5 | 0.2 | 9.9 | |
| | Copper | 10 | 55 | 90.8 | |
| | Lead | 5 | 13 | 55.1 | |
| | Nickel | 15 | 75 | 76.6 | |
| | Selenium | 5 | 0.05 | 0.3 | |
| | Silver | 5 | 0.07 | 0.3 | |
| | Tin | 10 | 2 | 1.6 | |
| | Tungsten | 15 | 1.5 | 5.8 | |
| | Zirconium | 5 | 165 | 85.2 | |
| Arc-Source Emission Spectrography | Beryllium | 1 | 2.8 | 70.0 | |
| | Lithium | 1 | 20 | 99.3 | |

^a Parts per million.

^b Crustal abundances are average values from Mason (1966), p. 45-46.

^c The lower detection limits for INAA are a complex function of sample composition and weight. Here, the lower detection limits are average values calculated from typical 4-g samples (Minor et al., 1982).

these elements). Because of the low number of samples having selenium concentrations above the detection limit, the arsenic or zirconium plates should be consulted to identify the areas for which selenium analyses were run. At about the same time, budgetary considerations led to the elimination of the emission spectrography line and resulted in the loss of lithium and beryllium data for the remainder of the program (only 15,660 samples were analyzed by this method). Because of the addition of arsenic, selenium, and zirconium and the early termination of lithium and beryllium analyses, the statewide coverage of these elements is less complete than for most other elements in the atlas. In addition to the elements listed in Table I, the samples were also analyzed for cadmium, chlorine, niobium, rubidium, and samarium, but the resulting data were not of sufficient quality or consistency to include in this atlas. This was due primarily to detection limits that were too high (the analytical systems had not been optimized for these elements), which resulted in sparse data, much of which was near the detection limit where the analytical errors are at a maximum. Table I still includes 11 elements for which the detection limit is greater than the average crustal abundance. These elements (antimony, arsenic, bismuth, gold, selenium, silver, strontium, terbium, tin, tungsten, and zinc) are included either because they are economic in their own right or are important for environmental studies.

Uranium Determination by Delayed-Neutron Counting. All sediment samples were analyzed for total uranium by DNC. A split of each sample was transferred to a clean 4-ml rabbit, weighed, and the weight (less the weight of the rabbit) recorded along with the appropriate sample location number. The rabbits were then loaded into a 50-sample transfer clip. The reactor pneumatic transfer system and background radiation levels were checked, and standards were run for calibration. The transfer clip was installed in the transfer line and the samples cycled through the system. A 20-s irradiation, 10-s delay, and a 30-s count was used. The uranium concentration was determined by delayed-neutron counting, converted to ppm, and entered into a data base. Above the 1-ppm level, the uranium values in sediment samples have a one-sigma error of less than 4%. The specially designed delayed-neutron detectors, built by Los Alamos and used for these analyses, are described by Balestrini et al. (1976).

Elemental Determinations by Instrumental Neutron Activation Analysis.* Upon completion of the uranium analysis by DNC, the same 4-ml sediment splits were entered into the INAA sequence. Concentrations of 27 additional elements were determined by this procedure (Table I). The full DNC/INAA timing sequence used for each sample was: 20-s irradiation, 10-s delay, 30-s DNC analysis, 20-min delay, 500-s gamma-ray count for short-lived radionuclides, irradiation for 96 s, a delay for 14 days, and then a 1000-s gamma-ray count for long-lived radionuclides. Gamma-ray counting was done by lead-shielded Ge(Li) detectors; 4096-channels of gamma-ray data were recorded and later interpreted for each individual element by computer. Elemental concentrations for each sample were printed out automatically, along with their associated statistical errors. Concentrations for which the statistical counting error exceeded 50% were considered below the detection limit of the system and marked as such. The lower detection limit for each element in INAA is a complex function of the total composition and mass of the individual sample. Therefore, the lower detection limits in Table I are average values calculated on the basis of typical 4-g samples (Minor et al., 1982). At concentration values exceeding one order of magnitude above the statistical detection limit for each element in each sample, the relative errors were generally less than 10%. The INAA system used at Los Alamos is described by Garcia et al. (1982) and Minor et al., (1982).

Elemental Determinations using Energy-Dispersive X-Ray Fluorescence. A computer-controlled, energy-dispersive x-ray fluorescence system was used to determine elemental concentrations of copper, lead, nickel, silver, tin, and tungsten and, in the latter portion of the program, arsenic, selenium, and zirconium. The system consists of an automatic 20-position sample changer, a lithium-drifted silicon detector, a pulsed, molybdenum-transmission-target x-ray tube, a multichannel analyzer, and a minicomputer. The sediment samples were

*During the course of atlas compilation, it was noticed that some elements displayed concentration discontinuities at quadrangle boundaries (samples were generally collected and analyzed by quadrangle). Because the NURE HSSR was primarily a uranium detection program, the INAA was not optimized for several of the trace elements, although it could have been. An early calibration error in magnesium caused the first seven quadrangles to have magnesium concentrations approximately 30% greater than actual. In order to characterize the observed discontinuities, several representative samples from the quadrangles on each side of the discontinuities were reanalyzed. Only in the case of magnesium were sufficient data obtained to recalibrate the data set. Minor discontinuities can still be seen on the cesium, cobalt, and rare-earth elements plates.

prepared for analysis by grinding 6 g of each sample to a minus-325-mesh powder. A computer positioned the 6-g samples in the x-ray beam, unfolded overlapping peaks (deconvolution procedure), determined the peak intensities for each element, and calculated the ratio of the intensity of each peak to that of the molybdenum K(alpha) Compton peak. Concentrations of each element were then calculated using equations obtained by analyzing prepared standards. The relative standard deviation is 10% or less at the 100-ppm level and 20% or less at the 20-ppm level for each element. Details of the methods and equipment are described by Hansel and Martell (1977).

Beryllium and Lithium Determinations by Arc-Source Emission Spectrography. A 5-mg portion of the minus-325-mesh sample already analyzed by x-ray fluorescence was mixed with 10 mg of a buffer of one part graphite and one part spectroscopically pure SiO₂. This mixture was placed into a graphite electrode that was used as the anode of a DC arc having a short circuit current of 6 A for 10 s, then 17 A for 50 s. Photomultiplier tubes in a direct-reading spectrograph were used to measure the second order 313.0-nm line of beryllium, the first order 670.7- and 610.3-nm lines of lithium, background spectra in the vicinity of these lines, and the 327.6-nm line of vanadium. The first order 670.7-nm lithium line was used for lithium concentrations up to 10 ppm and the 610.3-nm line of lithium was used for concentrations above 10 ppm. The vanadium line was used to correct the beryllium value when measurable quantities of vanadium were present. Output signals from the photomultiplier tubes were read by a digital voltmeter and processed by a desk-top calculator. Results were simultaneously printed on paper and written on cassette tape for later transmission to a computer data file. Total elemental concentrations of beryllium and lithium were determined from processed spectra based on the results of previously run standards. Precision at the lower detection limit was approximately 50% for both elements and improved to 25% at concentration values greater than one order of magnitude above the lower limit.

Data Analysis

The Los Alamos Geochemistry Group has produced the Alaskan geochemical data as images to make these data available to more users. Analytical and location data for all sediment samples from Alaska were combined into elemental data bases for processing and interpretation. Both statistical analyses and visual projection of element concentrations were necessary to interpret the geochemical data--statistics to indicate population distributions of the elements and visual projection to display the spatial distributions. Mean, median, minimum, maximum, and cumulative frequency of concentration values greater than the detection limit were determined for each element. The data for each element were statistically interpolated to a regular grid. Estimates of average elemental concentration values were made for small areas, and the data were put into a format that is compatible with standard image-processing and display techniques.

Data Processing. Universal kriging was the technique used to interpolate the data to a 5-km x 5-km grid. Statistical theory of kriging assumes that the concentration values of a sample are related to or influenced by the corresponding values of surrounding samples (Olea, 1974). The semivariance, or one-half the variance of the difference in corresponding values between sample pairs, was calculated as a function of distance for each element. A variogram, a plot of semivariance vs distance, was used to determine the distance over which concentrations were interdependent and to determine a function that approximated the relation. Smoothing algorithms used that function to determine a weighted average value for each grid cell. The smoothing algorithms were restricted to averaging only data points having values above detection limit within a 6-km radius of the center of the cell. Five elements (gold, selenium, silver, tin, and tungsten) had so many locations having concentrations below detection limit that a function could not be estimated. For these elements, values above the detection limit that fell within the grid cell were averaged, with no consideration given to the values in adjacent cells.

Data Display. Two types of visual displays were used to project the geochemical data: a color-contour image, which shows the spatial and statistical distribution for each element; and a three-element image, which projects the spatial correlations of three elements simultaneously. The majority of the displays in this atlas are of the first type; a few displays of the second type are included to illustrate the dynamic range and subtleties inherent in the data.

The color-contour image projects the value range for the data in each grid cell as a color. Nine contour levels were used corresponding to percentile ranges of concentration values greater than the detection limit as determined from the statewide statistics of the

sample data for each element. The colors and associated percentile ranges used* are:

| | |
|-------------|------------------|
| dark blue | <10th percentile |
| blue-green | 10th - 20th |
| light green | 21st - 40th |
| green | 41st - 60th |
| gold | 61st - 80th |
| yellow | 81st - 90th |
| pink | 91st - 95th |
| magenta | 96th - 99th |
| red | >99th percentile |

The three-element image projects each element in a different primary color (red, green, or blue). Each color has 256 levels of intensity to display concentration intervals for the element. Low concentrations are represented as subdued colors, high concentrations as bright colors. When all three are projected simultaneously, new colors are created by the rules of color addition. The hue of the color represents the correlations or relative concentrations of the elements; intensity is a measure of the absolute concentrations. Correlations between the elements displayed in red and green are displayed as shades of yellow; red and blue correlations are displayed as shades of magenta, and green and blue correlations are displayed as shades of blue-green. If all three elements have concentrations in the same percentile ranking with respect to their individual populations, a shade of grey or white is generated. Intense white indicates a very strong correlation for the elements displayed and that each element is in one of the highest percentile levels for its population. In every case, the first element listed at the top of the plate is displayed in red; the second, in green; and the third, in blue.

EXAMPLES OF ANALYSIS AND INTERPRETATION OF ALASKAN GEOCHEMICAL DATA

The examples described in the first subsection below demonstrate the ability to map lithologies, particularly felsic plutons, at several levels of detail using geochemical data. Regional geochemical data can map a variety of major lithologies (and specific rock units) including granites, carbonates, mafic and ultramafic igneous rocks, and clastic sedimentary rocks of distinct provenance. The ability to recognize and delineate major lithologic units depends on several factors. Most important, outcrops of lithologies must be areally extensive and continuous enough that the samples collected adequately represent the unit. Lithologies having outcrop areas on the order of 10 km² may be represented by no more than one sample in this survey. Identification of rock types having such small outcrops is unlikely, particularly using kriged data. Secondly, recognition of distinct lithologies is facilitated where chemical signatures of adjacent units contrast sufficiently to allow differentiation. Finally, the elemental assemblages in lake sediments may be only indirect indicators of regional geochemical trends for some elements. Lake sediments have undergone a greater degree of chemical weathering and contain significant quantities of authigenic minerals and organic material that may be depleted or enriched in many elements present in the original parent rock. Stream sediments, on the other hand, are primarily the product of mechanical weathering and represent a composite sample of the geology of a stream basin.

Another way these data might be used is in mineral exploration to delineate areas favorable for more detailed investigations. Mineral deposits often occur in geochemical or metallogenic provinces characterized by enhanced concentrations of elements of economic interest. These provinces can be recognized because mineral deposits are generally associated with areas of widespread, low-level mineralization and tend to group into districts. The districts often cluster along specific stratigraphic or structural trends that extend over large areas. In some places, geochemical provinces can be recognized through the enrichment of elements over normal crustal values in one or more stratigraphic units within a region (e.g., Phair and Gottfried, 1966). Related exploration targets can be suitably limited to areas within the province.

Felsic Plutons

One of the most striking examples of the use of regional geochemical data to map lithologies is the delineation of felsic plutons

*For seven elements (beryllium, bismuth, lutetium, selenium, silver, tantalum, and terbium), the range of concentration values was very small and the percentiles listed are only approximate.

throughout Alaska. Because of their chemistry, they stand out in marked contrast to the country rock they intrude. Not only can these plutons be delineated, but differences in chemistry both within and among plutonic provinces are recognizable.

The felsic plutons are characterized by strong enrichment of lithophile elements such as uranium, thorium, hafnium, potassium, and rare earths. When compared to the state as a whole, these elements are enriched in the plutons by factors of as much as two (Table II). Elements characteristic of mafic environments, such as nickel, chromium, and cobalt, generally have very low concentrations in these areas. Among the plutonic bodies delineated by high concentrations of lithophile elements are the Coast Range batholith, Alaska-Aleutian

TABLE II
COMPARISON OF MEDIANS AND MEANS FOR SELECTED ELEMENTS IN FELSIC PLUTONS WITH STATEWIDE AVERAGES^a

| Element | Felsic Plutons | | Statewide Average ^b | |
|------------|----------------|--------|--------------------------------|--------|
| | Mean | Median | Mean | Median |
| Uranium | 7.5 | 4.2 | 3.5 | 2.8 |
| Thorium | 17.3 | 11.7 | 9.7 | 8.4 |
| Hafnium | 10.9 | 7.7 | 7.2 | 6.0 |
| Potassium | 16616 | 15090 | 14198 | 13450 |
| Cerium | 92.8 | 76.0 | 67.5 | 61.0 |
| Dysprosium | 6.1 | 5.0 | 5.0 | 5.0 |
| Lanthanum | 57.5 | 44.0 | 36.5 | 32.0 |
| Lutetium | 0.5 | 0.4 | 0.4 | 0.4 |
| Nickel | 33.2 | 27.0 | 37.3 | 32.0 |
| Chromium | 86.6 | 75.0 | 114.9 | 92.0 |
| Cobalt | 17.6 | 15.2 | 18.0 | 15.6 |

^a All elemental averages listed as ppm.

^b Determined from all HSSR samples from Alaska having concentrations greater than the detection limit.

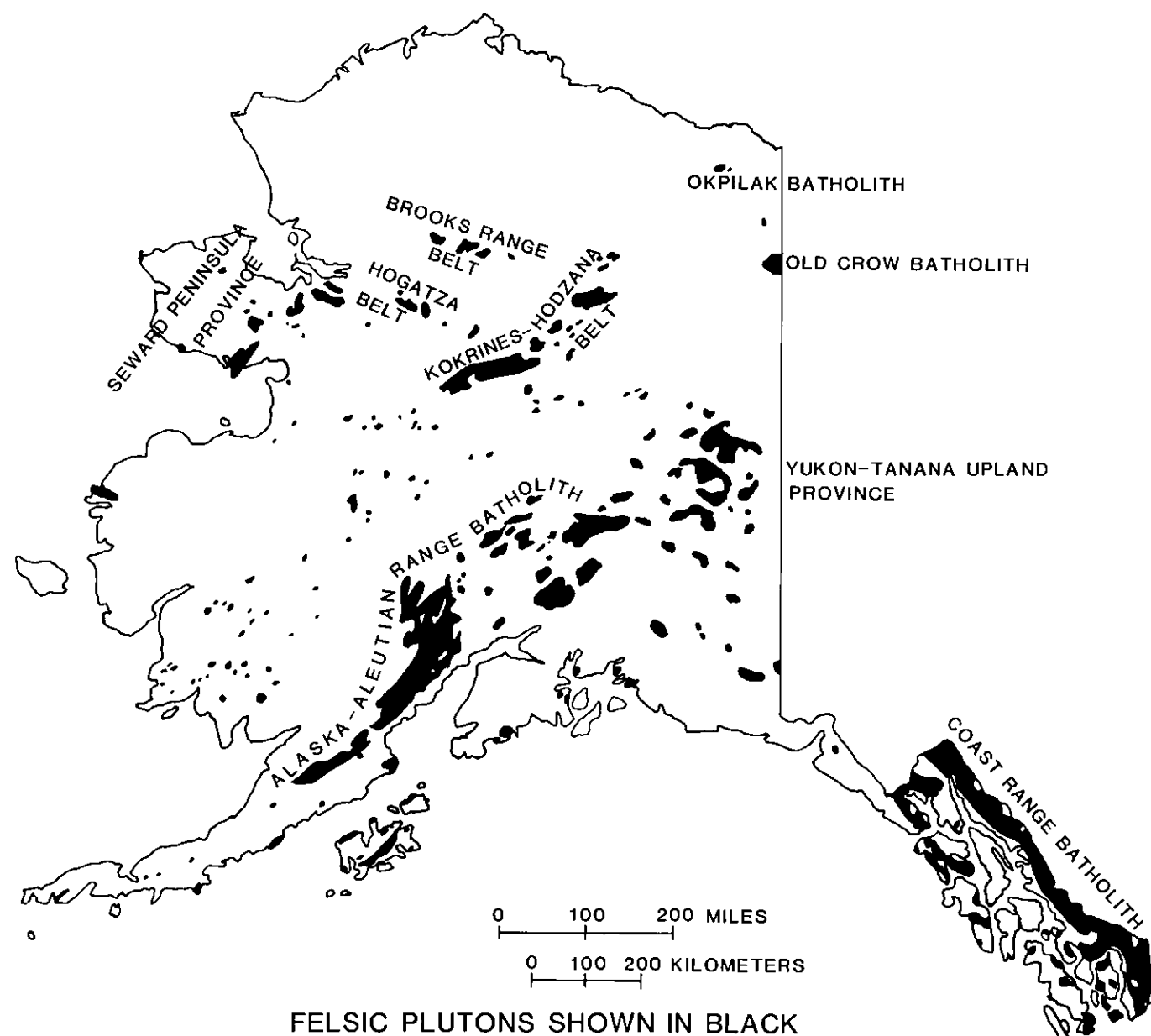


Fig. 3. Distribution of felsic plutons in Alaska (King, 1969).

Range batholith, plutons of the Seward Peninsula, the Hogatza plutonic belt, the Kokrines-Hodzana plutonic belt, the Brooks Range plutonic belt, Old Crow batholith, and Okpilak batholith (Fig. 3).

Although the felsic plutons share many characteristics, there are subtle differences in the chemistry of plutons in different geographic settings. One of the more obvious differences is the sodium enrichment of plutons south of the Denali fault system. Rocks of the Coast Range and Alaska-Aleutian Range batholiths are significantly richer in sodium than their counterparts to the north (compare Fig. 3 with Plate 30). Such a pattern suggests fundamental chemical differences in the crust and/or mantle beneath these two regions or differences in their depth and history of origin.

In some places, mapping of lithologies within individual batholiths is possible using regional geochemical data. For example, differences in chemistry are readily apparent in parts of the Alaska-Aleutian Range batholith. The southern and eastern parts of the batholith, from Becharof Lake to Talkeetna Mountains (Fig. 4), are made up primarily of diorite and quartz diorite of Jurassic age (Reed and Lanphere, 1969, 1972, and 1973 a,b). The western and northern parts of the batholith are largely composed of quartz monzonite and granodiorite of two ages, late Cretaceous-early Tertiary and middle Tertiary. Geochemical data in this atlas illustrate well the fundamental geochemical differences between the intermediate rocks of Jurassic age and the more silicic rocks of the later two magmatic epochs. Enrichment of iron, calcium, manganese, and scandium, which commonly indicate a relatively mafic environment, characterizes the Jurassic plutonic rocks. Potassium, uranium, thorium, hafnium, and rare earths, which commonly indicate a more silicic environment, are enriched in the late Cretaceous-early Tertiary and middle Tertiary

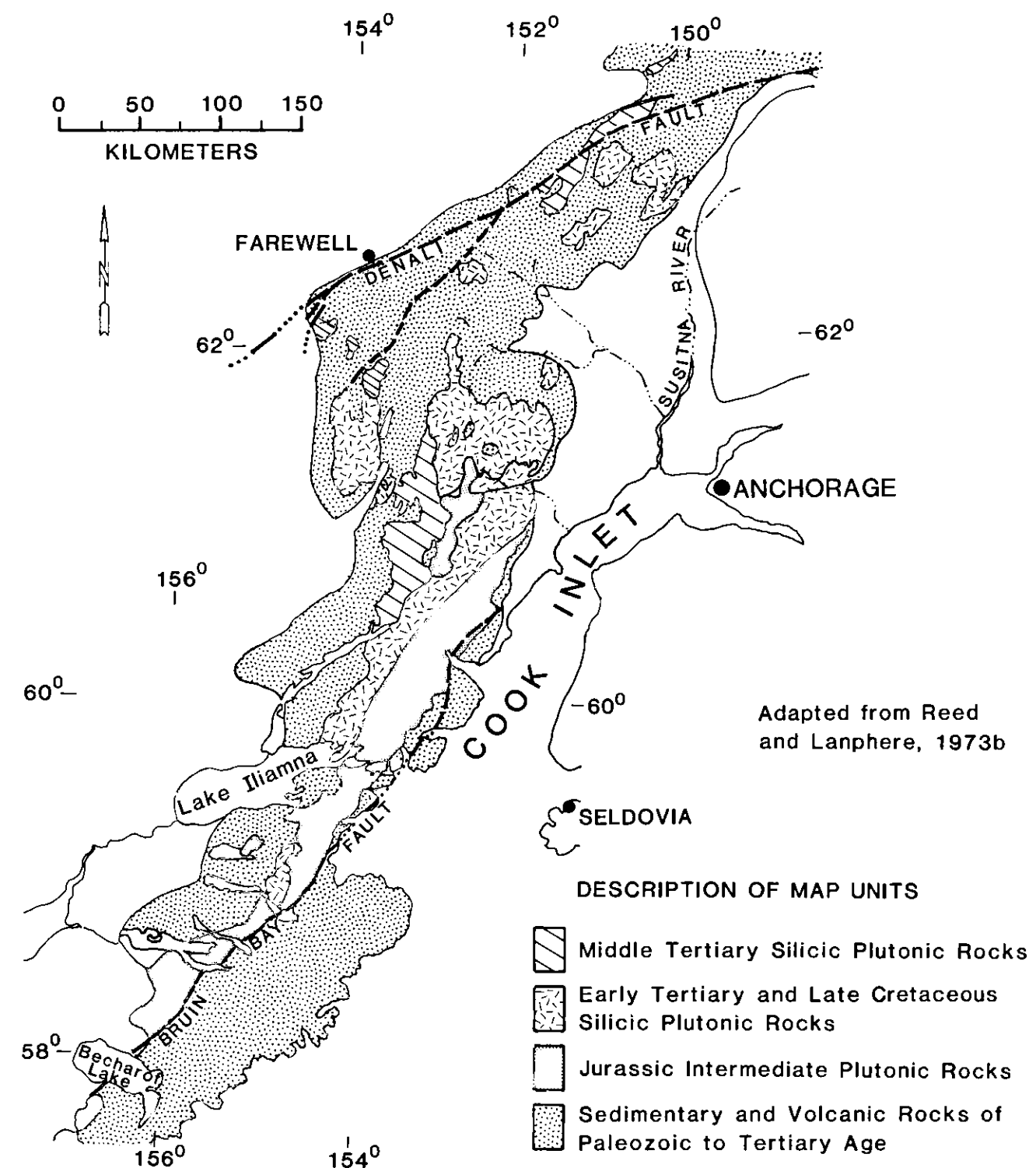


Fig. 4. Generalized geologic map of the Alaska-Aleutian Range batholith.

rocks of the batholith. Although well exposed, the batholith is in a remote area where high costs and poor access have limited detailed geologic investigations. Reconnaissance geologic mapping, age dating, and chemical analyses have delineated the major geologic features of the batholith (Reed and Lanphere, 1969, 1972, and 1973 a,b). For most areas of the batholith, geologic data are sparse and tentative conclusions have been extrapolated from widely scattered areas where geologic control exists. The systematic and areally complete geochemical data presented in this atlas, when used in conjunction with the geologic data of earlier investigations, may aid the delineation of major geologic units over little-studied areas of the batholith and allow a more confident extrapolation of rock units between areas of control.

Utilizing Geochemical Data to Identify Areas of Potential Mineralization

Whereas the primary correlation is most often between geochemistry and geology (specifically lithology), a correlation between geochemistry and mineralization is often quite strong. Most of the mineral terranes depicted by AEIDC (Arctic Environmental Information and Data Center, 1979) can be seen on many of the elemental plates included in this atlas. In addition, the Brooks Range mineral belt, described by Marsh and Cathrall (1981), correlates well with anomalous concentrations of several elements. Because there are many different mineral terranes in Alaska and each has its own corresponding suite of anomalous elemental concentrations, we will describe the correlations observed for only a few.

Mineralized terranes typically are associated with elevated concentrations of one or more elements with respect to the regional background. Dispersion haloes commonly form around the areas of most intense mineralization. In sediment samples, this is due to the various processes that affect the constitution of the sample, such as mixing with unmineralized material, geochemical alteration, and rate of sediment transport (mechanical effects). To look for a particular commodity, examine the plate for that element and identify the areas where the concentrations are the highest. Usually economic elements are found in association with other elements. Hawkes and Webb (1962), Levinson (1974 and 1980), Boyle (1974), and Mason (1966) discuss the associations of elements used for mineral exploration. The plates for these associated elements can be searched for correlations with the selected element to identify areas for further analysis. Three-element plates provide a rapid visual correlation capability. To highlight the strongest correlations among three elements, a statistical cut-off or concentration slice can be employed. Plates 44, 46, and 48 are the three-element plots for chromium-copper-nickel, barium-copper-nickel, and uranium-thorium-hafnium, respectively, dividing all of the data for each element into 256 color levels representing 256 concentration intervals. Plates 45, 47, and 49 contain the same three-element combinations, but only concentrations greater than one standard deviation above the statewide mean for each element are displayed) in 256 color intervals.

The chromium-copper-nickel and barium-copper-nickel plates highlight mafic and ultramafic terranes. Two major trends can be seen on both plates: the Brooks Range and the Alaska Range. Both regions have extensive occurrences of base-metal mineralization. It is interesting to note the changes that occur when one element is exchanged in the three-element combination--in this case, chromium and barium. The base-metal occurrences correlate well with the barium-copper-nickel plates and mafic/ultramafic terranes correlate well with the chromium-copper-nickel plates. The region from Kavalina to Anaktuvak Pass contains many occurrences of base and precious metals and several ultramafic terranes (AEIDC, 1979). These four plates (44-47) not only delineate the base-metal and mafic/ultramafic terranes already known but also delineate many new areas where these terranes have not been mapped. Another interesting observation is that the chromium concentrations are highest, and apparently uncorrelated with copper and nickel, in the central North Slope, south of Barrow. These high North Slope chromium values strongly suggest that the continental sedimentary rocks in which they are found have their provenance in the Brooks Range to the south, which contains major outcrops of ultramafic rocks.

The Brooks Range mineral belt was characterized by Marsh and Cathrall (1981) of the U.S. Geological Survey, on the basis of the Survey's regional geochemical sampling program. As described by Marsh and Cathrall, the belt is a structurally controlled zone of mineral occurrences and anomalous elemental concentrations in a central metamorphic belt and adjacent metasedimentary units, extending from 147°W to 159°W and 67°N to 69°N. Their studies identified two geochemical suites--a base-metal suite of copper-lead-zinc, and a molybdenum suite of molybdenum-tin-tungsten--which suggests several

types of mineralization in the mineral belt. The data in this atlas show elevated concentrations of these elements with respect to statewide averages in the mineral belt, with the exception of molybdenum, which was not analyzed during the NURE program. In addition, several other elements, (e.g., arsenic, iron, manganese, nickel, and uranium) have higher than average concentrations in this zone. The three-element plates for chromium-copper-nickel and barium-copper-nickel and their corresponding greater than one standard deviation above the mean plates show the belt as two thin blue-green lines in the south flank of the Brooks Range. These lines extend almost continuously from 148°W to 159°W and map the extent of the central metamorphic belt. A detailed examination (done previously on the raw sample data) of the character of these elemental anomalies suggest three modes of mineralization in the belt: (1) within Cretaceous, granitic plutons that intrude the metamorphic rocks; (2) at the contacts of these plutons and the metamorphic rocks; and (3) in metavolcanic rocks of the belt and not associated with the plutons. Portions of the Brooks Range mineral belt are also identified as mineral terranes on the AEIDC (1979) maps.

The examples above describe the correlation between the geochemical data and known mineralized terranes. Given below is an example of how the data might be used to direct a reconnaissance exploration program.

Mineral deposits form in association with felsic plutonic rocks when the proper combination of source rock, host rock, structural ground preparation, fluids, and heat occur in concert (e.g., copper porphyry systems). In some cases, the source of anomalous metals can be associated with unusual enrichments of major and/or trace elements within the plutons themselves (e.g., the association of uranium deposits with peralkaline granites at Bokan Mountain and the anomalous concentrations of tin, lithium, beryllium, lead, tantalum, uranium, thorium, and cesium in the tin-bearing granites of Seward Peninsula). In cases where the chemistry of the plutons is an important factor in controlling the formation of mineral deposits, the data presented in this atlas may be useful in distinguishing potential mineralized plutons from their barren companions.

One case in which this approach could be applied is the evaluation of uranium potential in felsic plutons. These plutons can be evaluated in terms of their favorability for hosting vein-type uranium deposits or as potential source rocks for stratabound uranium deposits. Using enrichment of elements such as uranium, rare earths, hafnium, and potassium as criteria for favorability, some plutons such as the intermediate-composition Jurassic rocks of the Alaska-Aleutian Range batholith, and many of the plutons in the Yukon-Tanana Upland province can be eliminated from consideration (Fig. 3 and Plate 49). For the remaining felsic plutons, favorability criteria can be based on models for the formation of uranium deposits. For example, ratios of uranium/thorium, uranium/hafnium, and uranium/rare earth elements can be used to characterize the availability of mobile uranium for transport and concentration into deposits. In theory, relatively high values of these ratios identify either mobile uranium or high original uranium endowment. Low ratios signify that the uranium is tied up in an immobile form in accessory minerals such as monazite, allanite, and zircon, which are relatively impervious to dissolution. Examination of Plate 39 shows that large areas of the plutonic belts can be eliminated from consideration in an exploration program (note particularly the extremely low U/Th found in the region of the Old Crow batholith) and efforts can be concentrated in the few areas of particularly high ratios.

Another approach is to establish favorability criteria based on chemical characteristics of granites known to host deposits. For example, if uranium deposits occur in plutons characterized by enrichment of uranium and hafnium but depletions of thorium, the three-element greater than one standard deviation above the mean plots, such as those on Plate 49, could be used to identify those plutons or areas within plutons where these characteristics occur.

RECOMMENDATIONS

1. Serious users of the Alaskan HSSR data should definitely obtain and utilize the raw digital data. For consistency, this atlas uses primarily a single interpolation routine and a single display routine throughout. Further, stream- and lake-sediment data have been combined for areal completeness. Specific problems will almost certainly require some modification of any or all of these procedures. At Los Alamos, all of the kriged and raw data are available on computer files. In addition, the geologic map of Beikman (1980) has been digitized for 61 lithologic groups instead of the 15 groups on the geologic plate in this atlas; these are also on a computer file at

Los Alamos. Using the raw digital data, researchers can reformat the data, add in data of their own, interpolate using kriging or another scheme, and display to a resolution suitable to the specific problem. Further, the field data and water-sample analyses, which are not included in this atlas, can be of importance for specific problems.

2. The state of Alaska should consider sampling and analyzing the samples from the portions of the state not sampled during the NURE HSSR. Approximately 15,000 samples would be required to complete the sampling to the densities obtained during the HSSR. To maximize the comparability with existing data, it is further recommended that sampling and analytical procedures similar to those employed herein be used.

3. Future analyses of geologic materials should be optimized for minor and trace elements. Although state-of-the-art methods were used throughout the HSSR, for financial reasons they were not necessarily the methods of choice for some elements. Subsequent to the HSSR analyses, the Research Reactor Group at Los Alamos has developed a three-delay procedure for INAA that includes several additional

elements (e.g., arsenic, bromium, gallium, tungsten) in addition to improving the detection limits for many of the INAA-detected elements in this atlas (Minor et al., 1982).

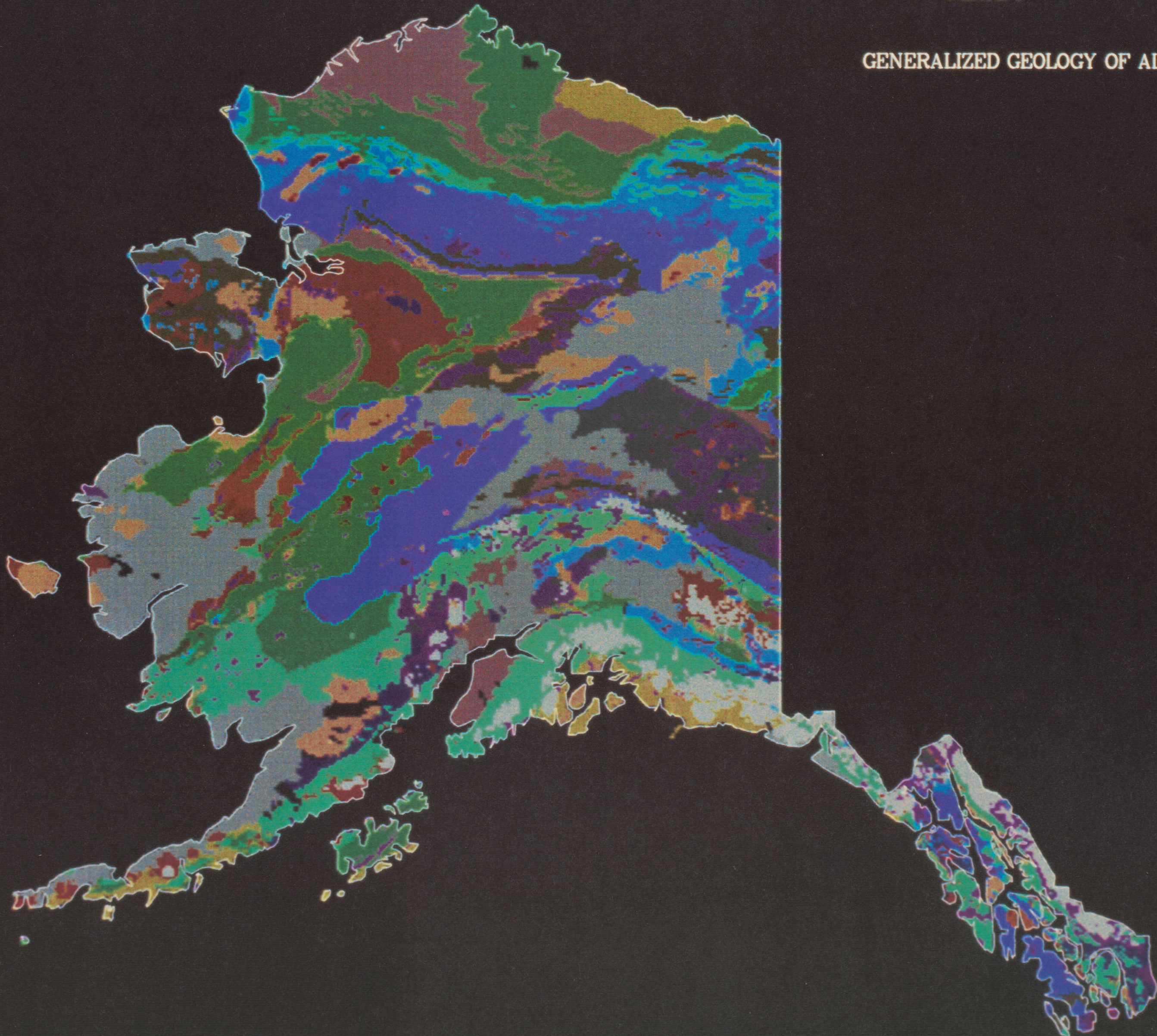
4. Researchers on such topical problems as environmental monitoring for health and safety, agricultural and livestock management, and land-use-capability studies should be made aware of the existence of regional geochemical data of which this atlas is an example. In Alaska, these data are from samples from a relatively pristine environment, which can be used as a baseline against which to monitor changes.

5. Researchers interested in specific areas should not ignore information contained in the individual raw sample data. This atlas presents the data from nearly 62,000 sediment samples in a regional context (statistics presented are based on statewide averages, etc.). All other appropriate things considered, the relative concentrations for single elements in small areas and the relative concentrations for all elements in a single sample are very important pieces of information when looking for mineralization, etc.

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GENERALIZED GEOLOGY OF ALASKA



LEGEND FOR PLATE I





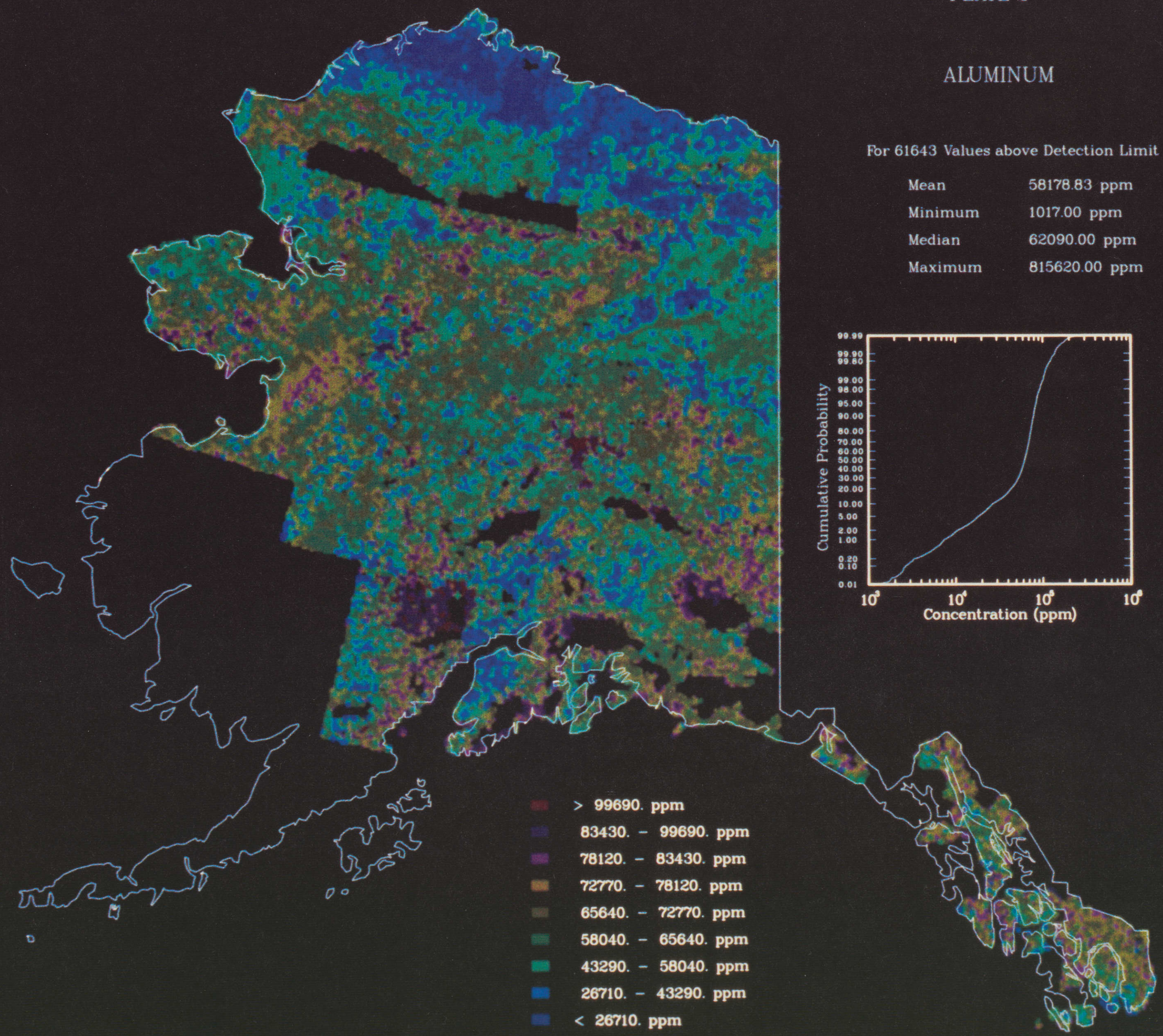
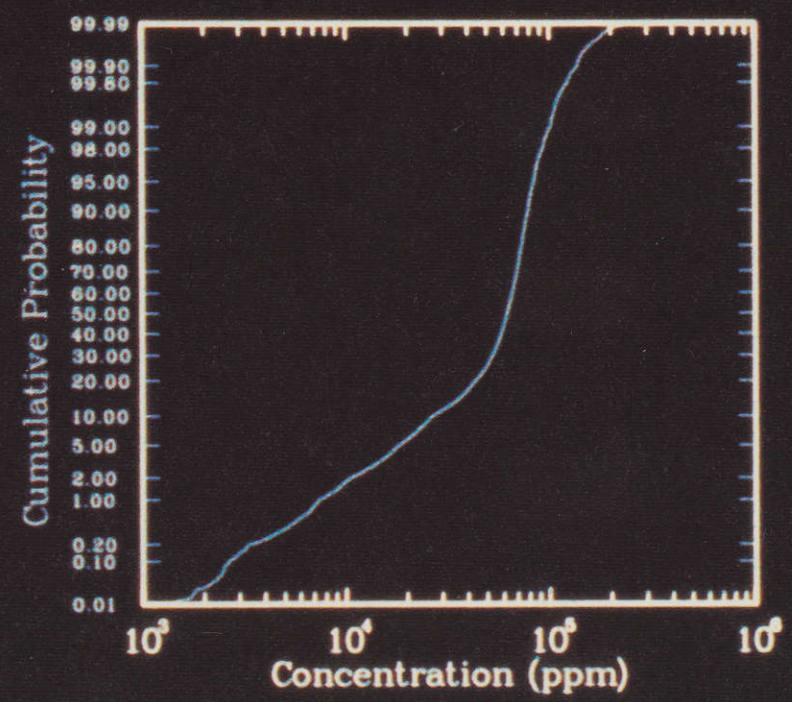
| Color of Geologic Unit | Description of Map Units | Corresponding Units of Beikman, 1980 |
|---|--|---|
| I. STRATIFIED SEDIMENTARY SEQUENCE | | |
|  | <u>Quaternary Deposits.</u> Alluvial, glacial, lake, swamp, eolian, flood plain, estuarine, and beach deposits. | Qh, Q, Qp |
|  | <u>Tertiary Sedimentary Rocks.</u> Mainly marine, in part highly deformed and metamorphosed. Includes sandstone, siltstone, shale, greywacke, and locally interbedded volcanic rocks. | Tp, uT, Tm, To, Te, T, mT, lT |
|  | <u>Tertiary and Cretaceous Continental Deposits.</u> Sandstone, arkose, siltstone, shale, claystone, conglomerate, and coal beds. | Tpc, uTc, Tmc, mTc, lTc, Txc, Tc, TKc, uKc, lKc |
|  | <u>Upper Mesozoic Sedimentary Rocks.</u> Mainly marine, consist of Cretaceous greywacke, sandstone, shale, siltstone with minor argillite, conglomerate, limestone, and locally includes volcanic and volcanoclastic rocks. | uK, K, lK |
|  | <u>Middle and Lower Mesozoic Sedimentary Rocks.</u> Mainly rocks ranging in age from early Cretaceous to Triassic, but locally include late Paleozoic rocks. Consists of argillite, shale, greywacke, quartzite, conglomerate, lava, tuff, agglomerate, and limestone. In southern Alaska and in the Panhandle region includes melange with blocks of flysch, greenstone, limestone, chert, granodiorite, greenschist, layered gabbro, and serpentinite in a pelitic matrix. | KJ, KJ ₁ , KJ ₂ , KJ ₃ , uJ, mJ, lJ, J, J ^R , ^R , ^{RP} , u ^R , JP, MzPz |
|  | <u>Upper Paleozoic Sedimentary Rocks.</u> Argillite, chert, shale, siltstone, limestone, greywacke, basaltic to andesitic volcanic rocks and derivative volcanoclastic sediments. Locally metamorphosed to greenschist and amphibolite facies. | P, P ^P , ^P , ^{PM} , M, JM, RD , uPz, Pz, MD |
|  | <u>Lower Paleozoic Sedimentary Rocks.</u> Include rocks of Cambrian through Devonian age, in places metamorphosed to greenschist and amphibolite facies. Sedimentary rocks include limestone, dolomite, argillite, chert, and greywacke. Metasedimentary rocks include schist, quartzite, slate, gneiss, greenstone, marble, and phyllite. | D, uD, umD, DS, S, O, SO, E, OpE, lPz |
|  | <u>Upper Precambrian Rocks.</u> Siltite, phyllite, greywacke, quartz-mica schist, graphite schist, calcareous schist, argillite, marble, limestone, gneiss, and migmatite. | lPzpE, Z, Z ₁ , Z ₂ |
| II. METAMORPHIC ROCKS | | |
|  | <u>Mesozoic through Precambrian Metamorphic Rocks.</u> Metasedimentary, metaplutonic, and metavolcanic rocks, including phyllite, schists, and gneiss of many compositions, primarily of blueschist, greenschist, or amphibolite facies. | IJm, Mzm, JPm, Pzm, PzpEm |
| III. VOLCANIC ROCKS | | |
|  | <u>Felsic Volcanic Rocks.</u> Range in age from Cretaceous through Quaternary, include rhyolites, quartz latites, and dacites. | Qhvf, Tvf, TKvf, uKvf, Kvf, vf |
|  | <u>Intermediate Volcanic Rocks.</u> Primarily Jurassic through Quaternary in age, but include some early Paleozoic-late Precambrian volcanic rocks. Consist primarily of andesites, latites, and trachytes. | Qhv, Qpv, Qv, QTv, Qhvi, Qpvi, Qtvi, Tmvi, lTvi, Tvi, Tpv, Tmv, uTv, Txv, lTv, Tv, TKv, lKvi, Kvi, KJvi, Jvi, lKv, Kv, KJv, Dv, Ov, Zv |
|  | <u>Mafic Volcanic Rocks.</u> Paleozoic through Cenozoic in age. Consist primarily of basalts. | Qhvm, Qpvm, Qvm, QTvm, lTvm, Tvm, TKvm, KJvm, ^R vm, JPvm, MzPzvm, Pvm, Dvm, Cvm, Pzvm |
| IV. INTRUSIVE ROCKS | | |
|  | <u>Felsic Intrusive Rocks.</u> Paleozoic through Cenozoic granite, quartz monzonite, and granodiorite. | Tmif, Toif, Teif, Txif, Tif, TKif, TMzif, Ti, TKi, uKif, uKi, Ki, Kif, Jif, Mzif, Mzi, MzPzi, MzPzif, ^P i, ^P if, uPzif, Oi, Pzi, lPzpEi, PzpEi, if, i |
|  | <u>Intermediate Intrusive Rocks.</u> Paleozoic through Cenozoic diorite, monzonite, and syenite. | mTii, Tii, TKii, uKii, Kii, KJii, Jii, J ^R ii, Mzii, MzPzii, Sii, Pzii |
|  | <u>Mafic and Ultramafic Intrusive Rocks.</u> Late Precambrian through Cenozoic in age. Consist of gabbro, peridotite, and serpentinite. | Tmim, mTim, Tim, TKim, TMzim, Kim, Jim, Mzim, Pim, lPim, uPzim, lPzim, Pzim, Zim, im, Tu, TKu, Ku, Mzu, JPu, MzPzu, ^P u, Ou, lPzu, Pzu, u |

PLATE 2

ALUMINUM

For 61643 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 58178.83 ppm |
| Minimum | 1017.00 ppm |
| Median | 62090.00 ppm |
| Maximum | 815620.00 ppm |



- > 99690. ppm
- 83430. - 99690. ppm
- 78120. - 83430. ppm
- 72770. - 78120. ppm
- 65640. - 72770. ppm
- 58040. - 65640. ppm
- 43290. - 58040. ppm
- 26710. - 43290. ppm
- < 26710. ppm

PLATE 3

ANTIMONY

For 3064 Values above Detection Limit

| | |
|---------|------------|
| Mean | 6.39 ppm |
| Minimum | 1.00 ppm |
| Median | 4.00 ppm |
| Maximum | 350.00 ppm |

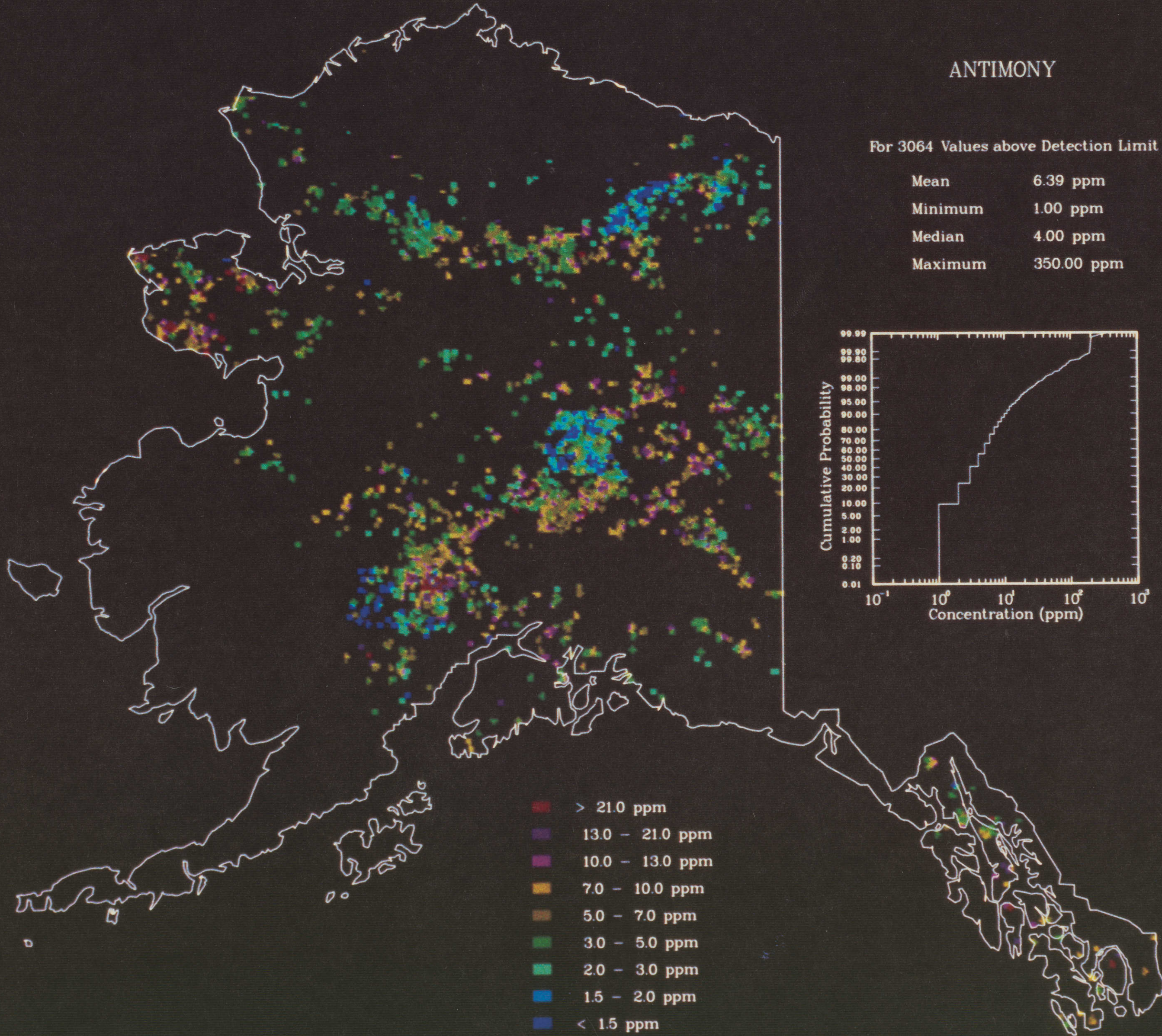
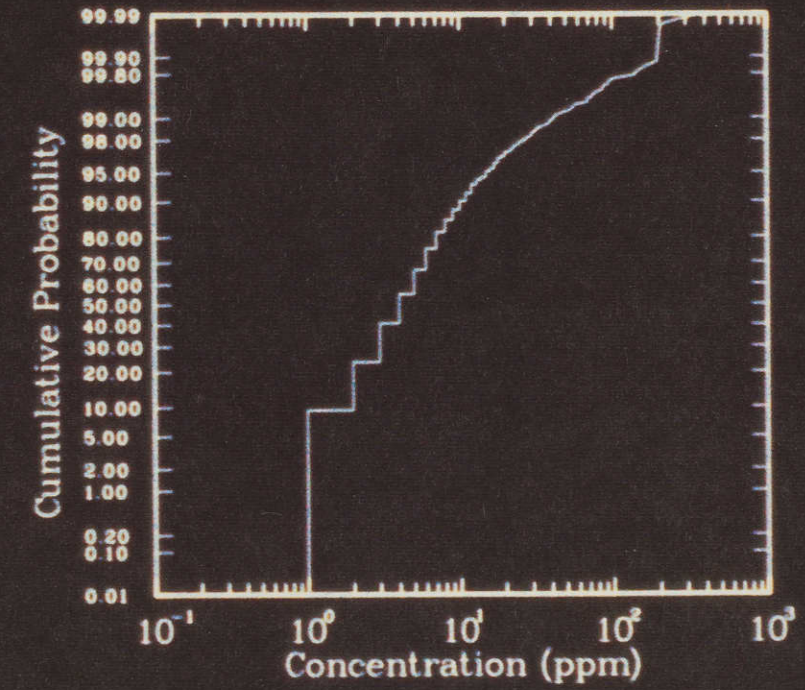
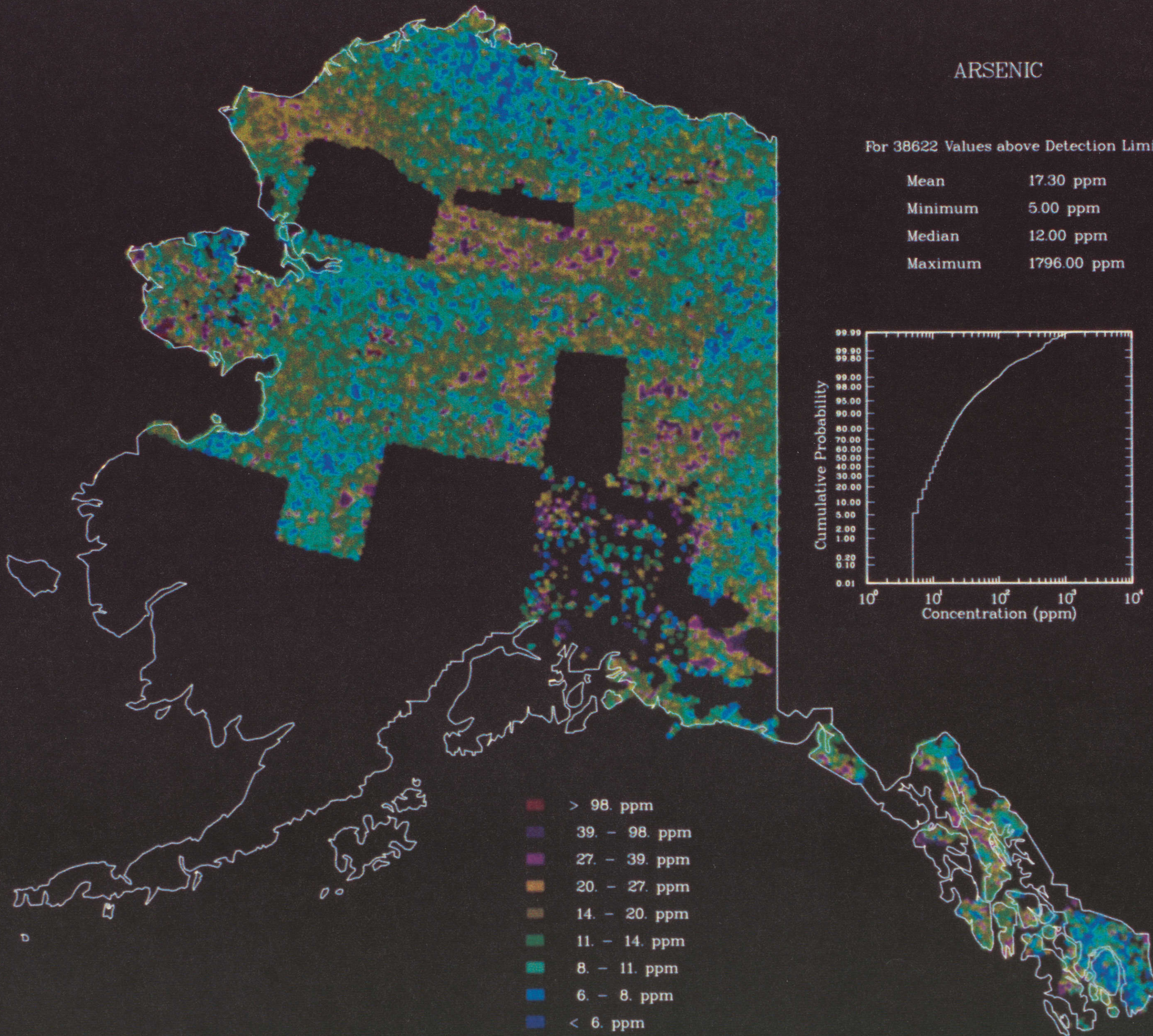
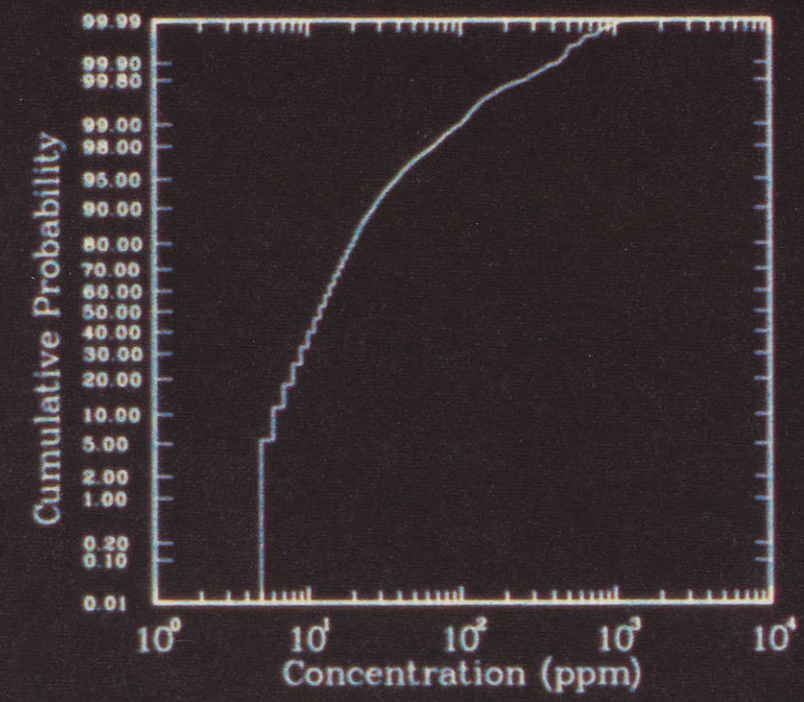


PLATE 4

ARSENIC

For 38622 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 17.30 ppm |
| Minimum | 5.00 ppm |
| Median | 12.00 ppm |
| Maximum | 1796.00 ppm |



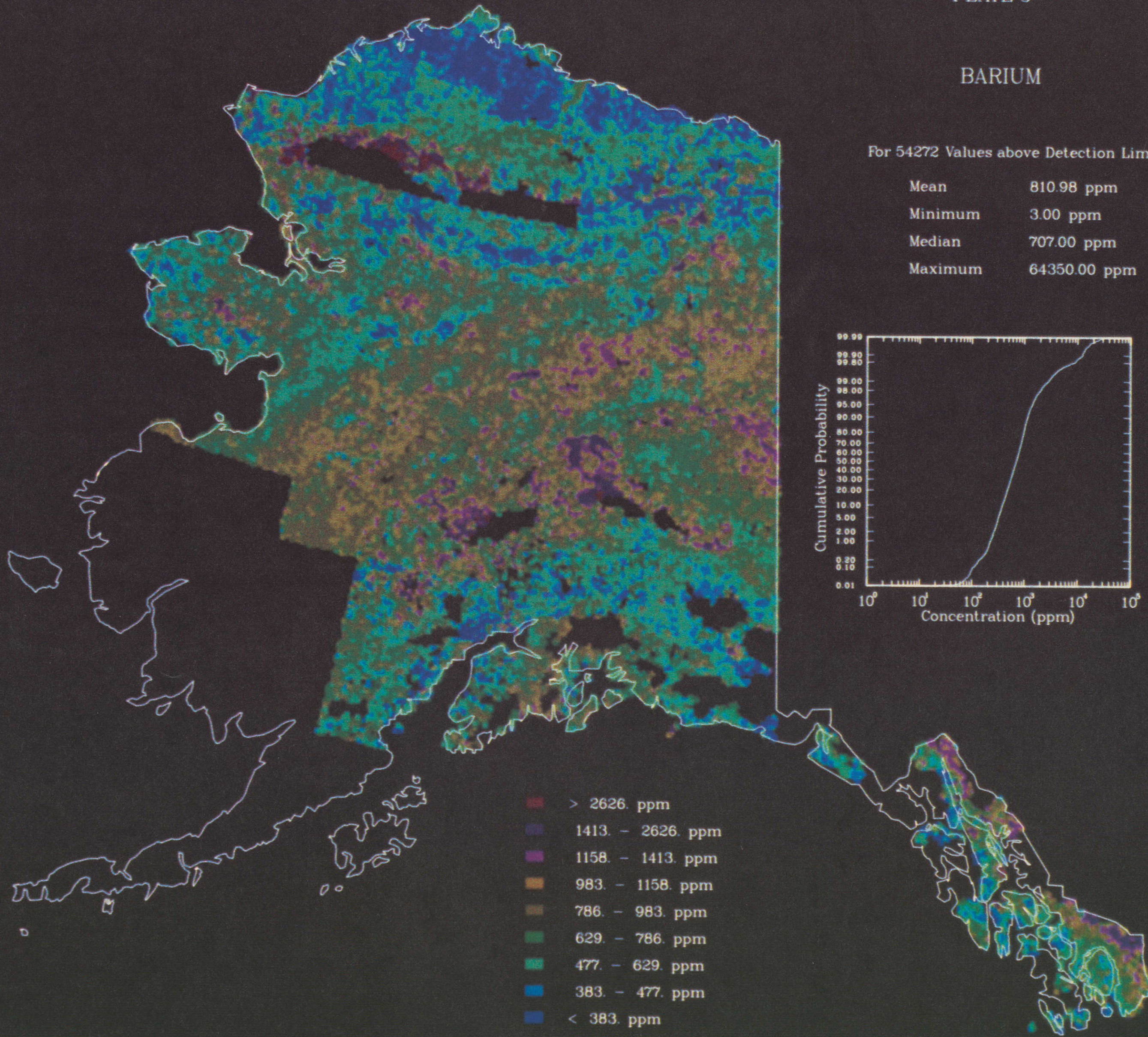
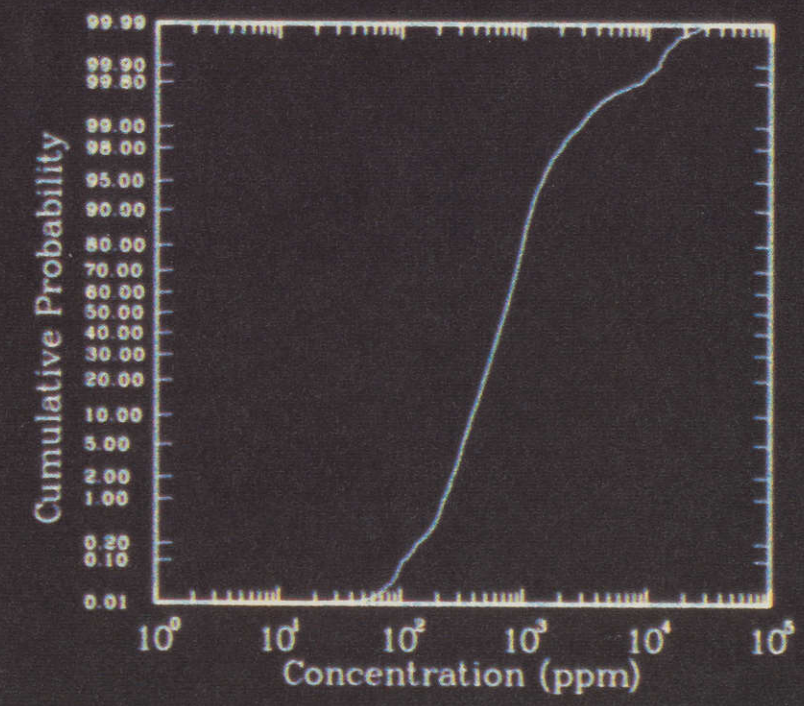
- > 98. ppm
- 39. - 98. ppm
- 27. - 39. ppm
- 20. - 27. ppm
- 14. - 20. ppm
- 11. - 14. ppm
- 8. - 11. ppm
- 6. - 8. ppm
- < 6. ppm

PLATE 5

BARIUM

For 54272 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 810.98 ppm |
| Minimum | 3.00 ppm |
| Median | 707.00 ppm |
| Maximum | 64350.00 ppm |



- > 2626. ppm
- 1413. - 2626. ppm
- 1158. - 1413. ppm
- 983. - 1158. ppm
- 786. - 983. ppm
- 629. - 786. ppm
- 477. - 629. ppm
- 383. - 477. ppm
- < 383. ppm

PLATE 6

BERYLLIUM

For 10963 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 1.96 ppm |
| Minimum | 1.00 ppm |
| Median | 2.00 ppm |
| Maximum | 12.00 ppm |

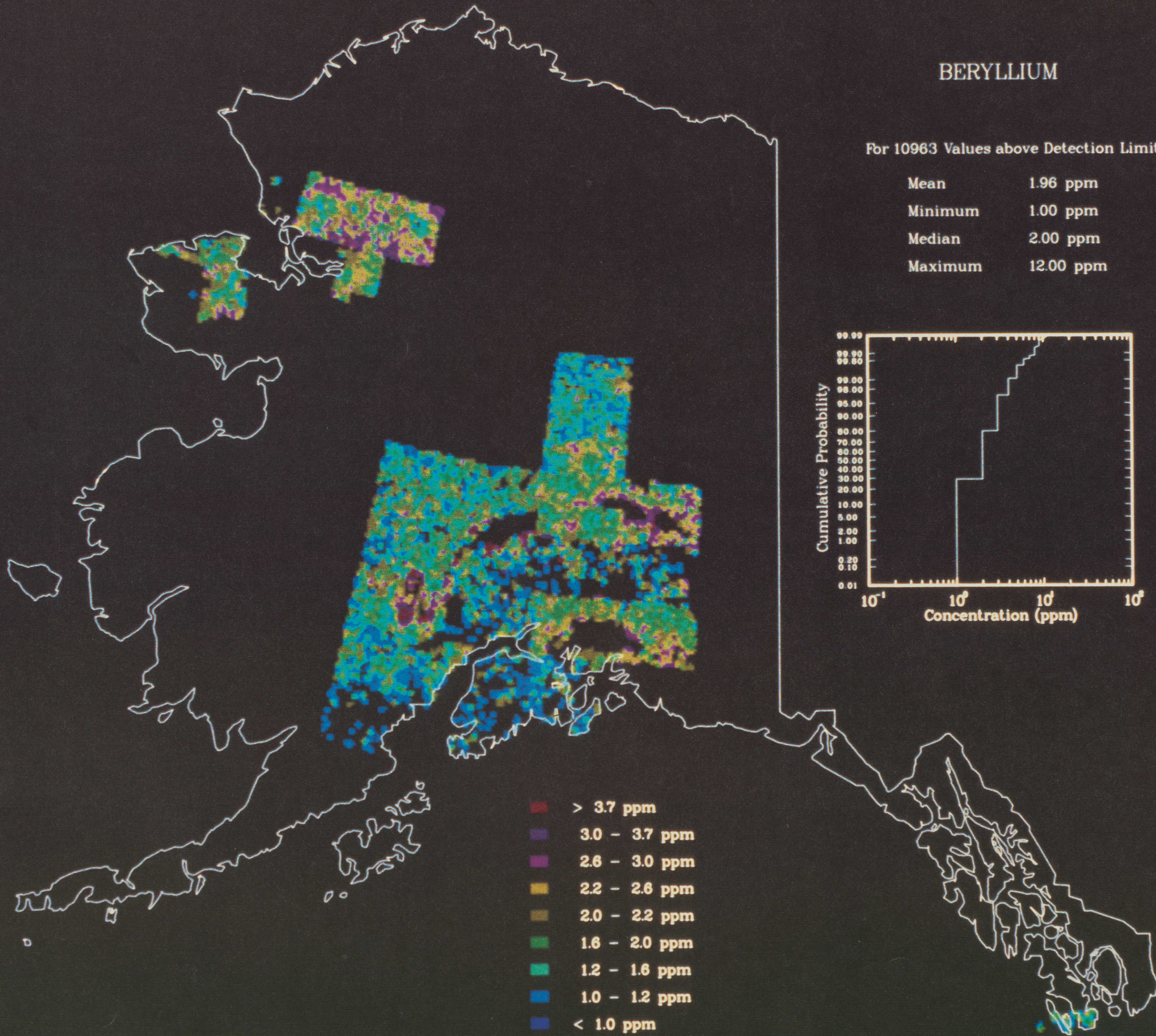
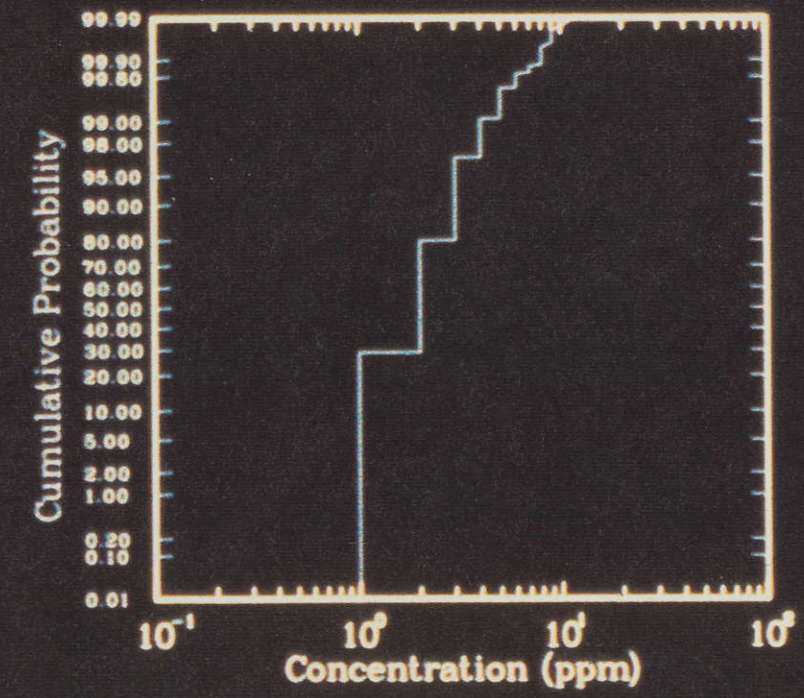
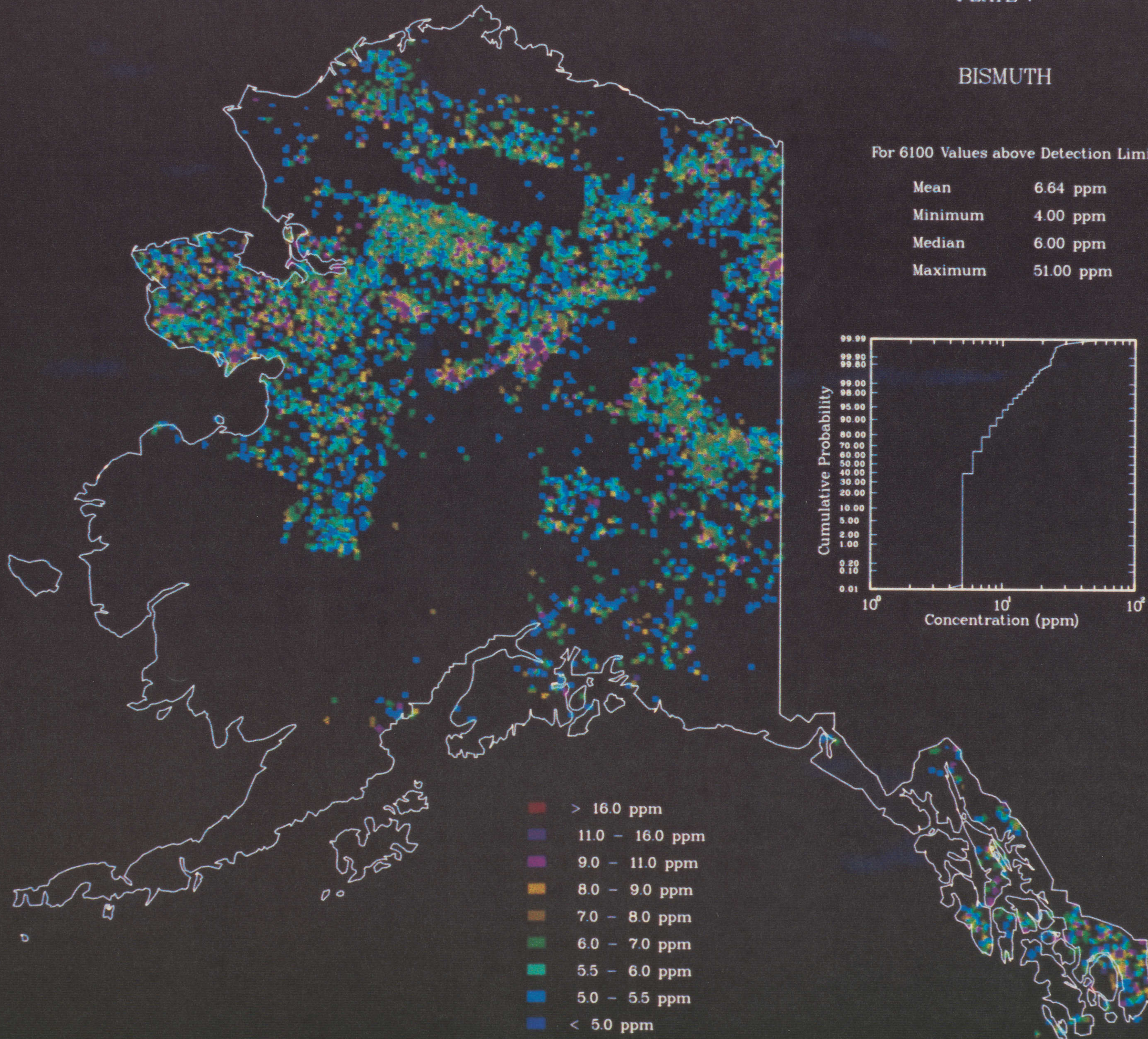
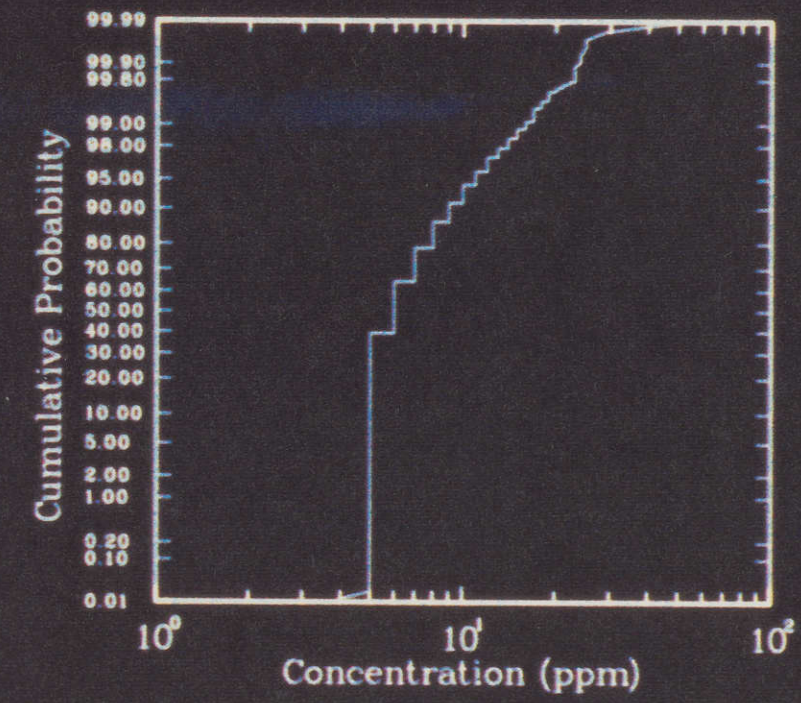


PLATE 7

BISMUTH

For 6100 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 6.64 ppm |
| Minimum | 4.00 ppm |
| Median | 6.00 ppm |
| Maximum | 51.00 ppm |



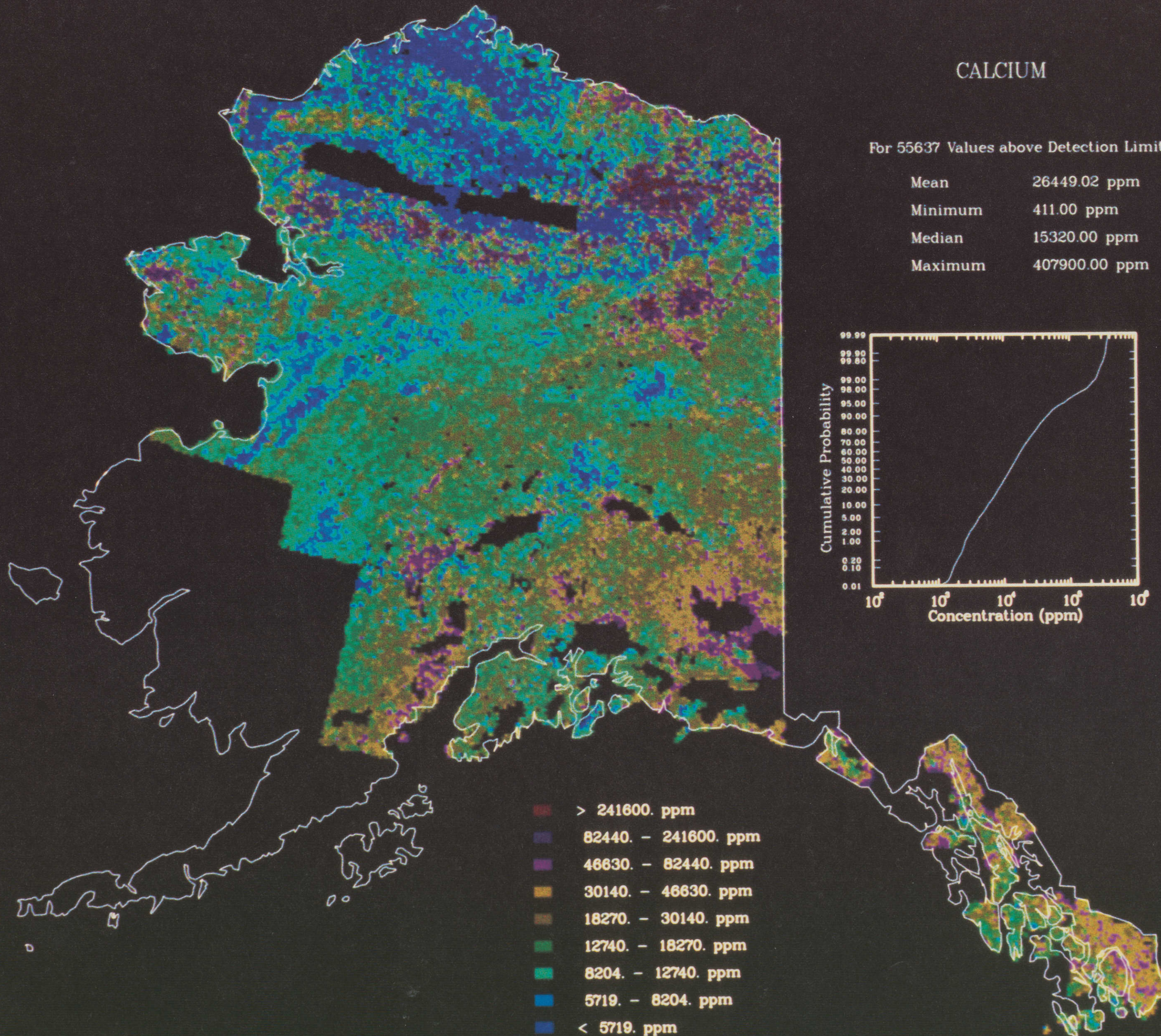
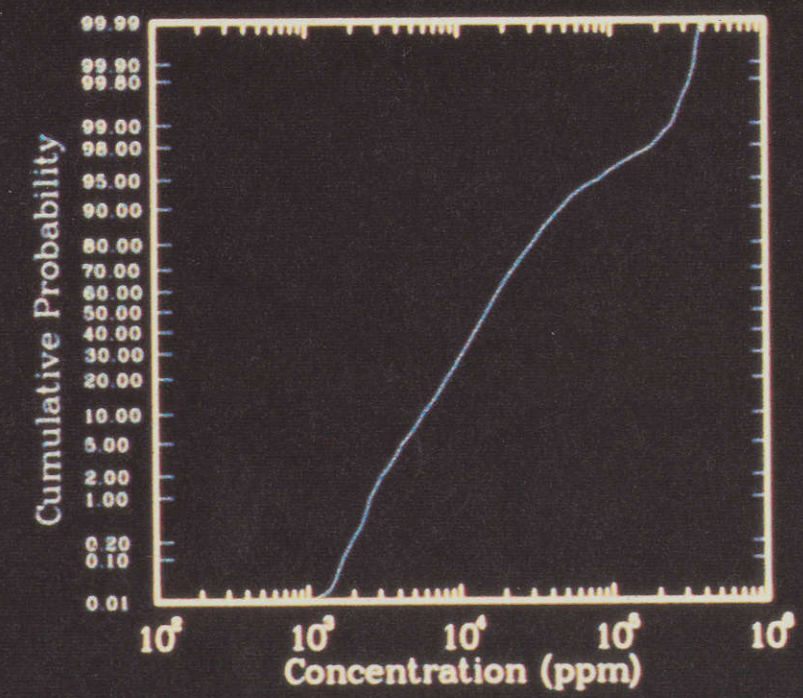
- > 16.0 ppm
- 11.0 - 16.0 ppm
- 9.0 - 11.0 ppm
- 8.0 - 9.0 ppm
- 7.0 - 8.0 ppm
- 6.0 - 7.0 ppm
- 5.5 - 6.0 ppm
- 5.0 - 5.5 ppm
- < 5.0 ppm

PLATE 8

CALCIUM

For 55637 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 26449.02 ppm |
| Minimum | 411.00 ppm |
| Median | 15320.00 ppm |
| Maximum | 407900.00 ppm |



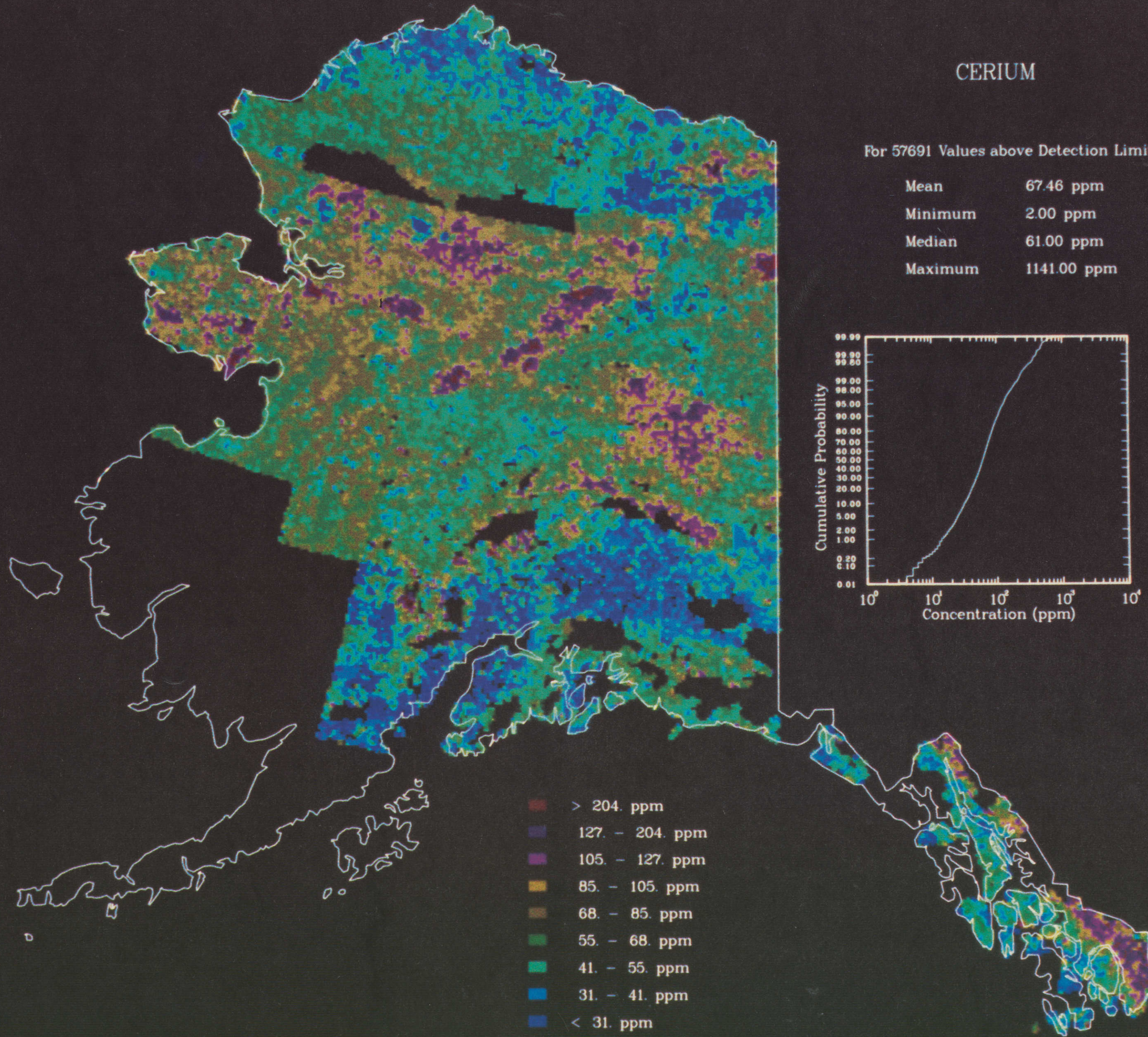
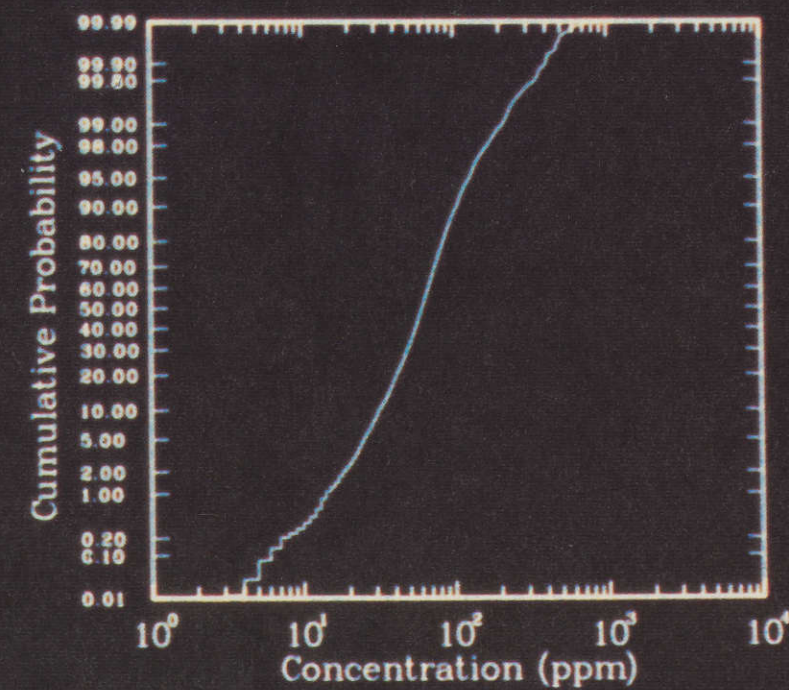
- > 241600. ppm
- 82440. - 241600. ppm
- 46630. - 82440. ppm
- 30140. - 46630. ppm
- 18270. - 30140. ppm
- 12740. - 18270. ppm
- 8204. - 12740. ppm
- 5719. - 8204. ppm
- < 5719. ppm

PLATE 9

CERIUM

For 57691 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 67.46 ppm |
| Minimum | 2.00 ppm |
| Median | 61.00 ppm |
| Maximum | 1141.00 ppm |



- > 204. ppm
- 127. - 204. ppm
- 105. - 127. ppm
- 85. - 105. ppm
- 68. - 85. ppm
- 55. - 68. ppm
- 41. - 55. ppm
- 31. - 41. ppm
- < 31. ppm

PLATE 10

CESIUM

For 31658 Values above Detection Limit

| | |
|---------|------------|
| Mean | 5.01 ppm |
| Minimum | 0.10 ppm |
| Median | 4.40 ppm |
| Maximum | 247.40 ppm |

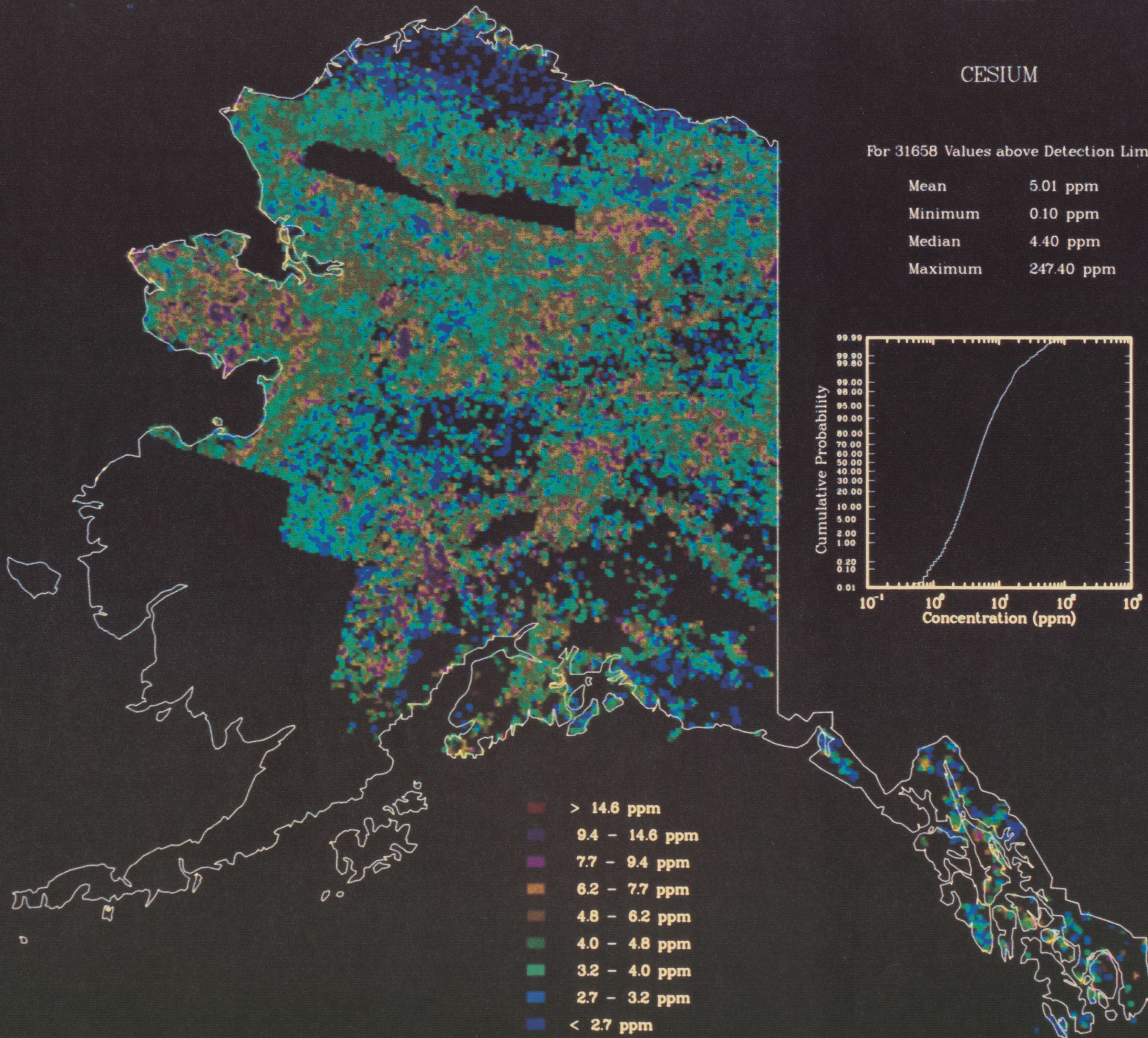
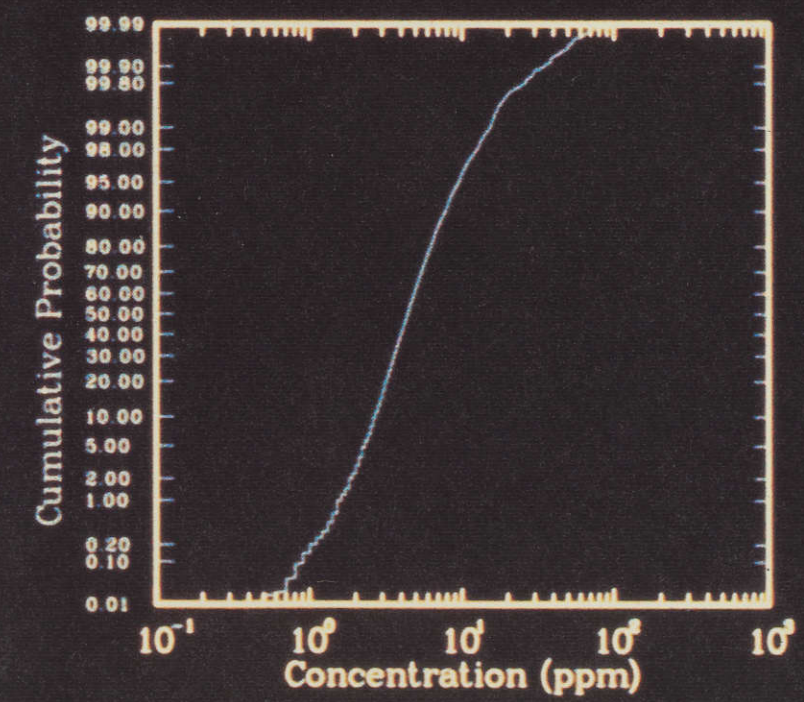
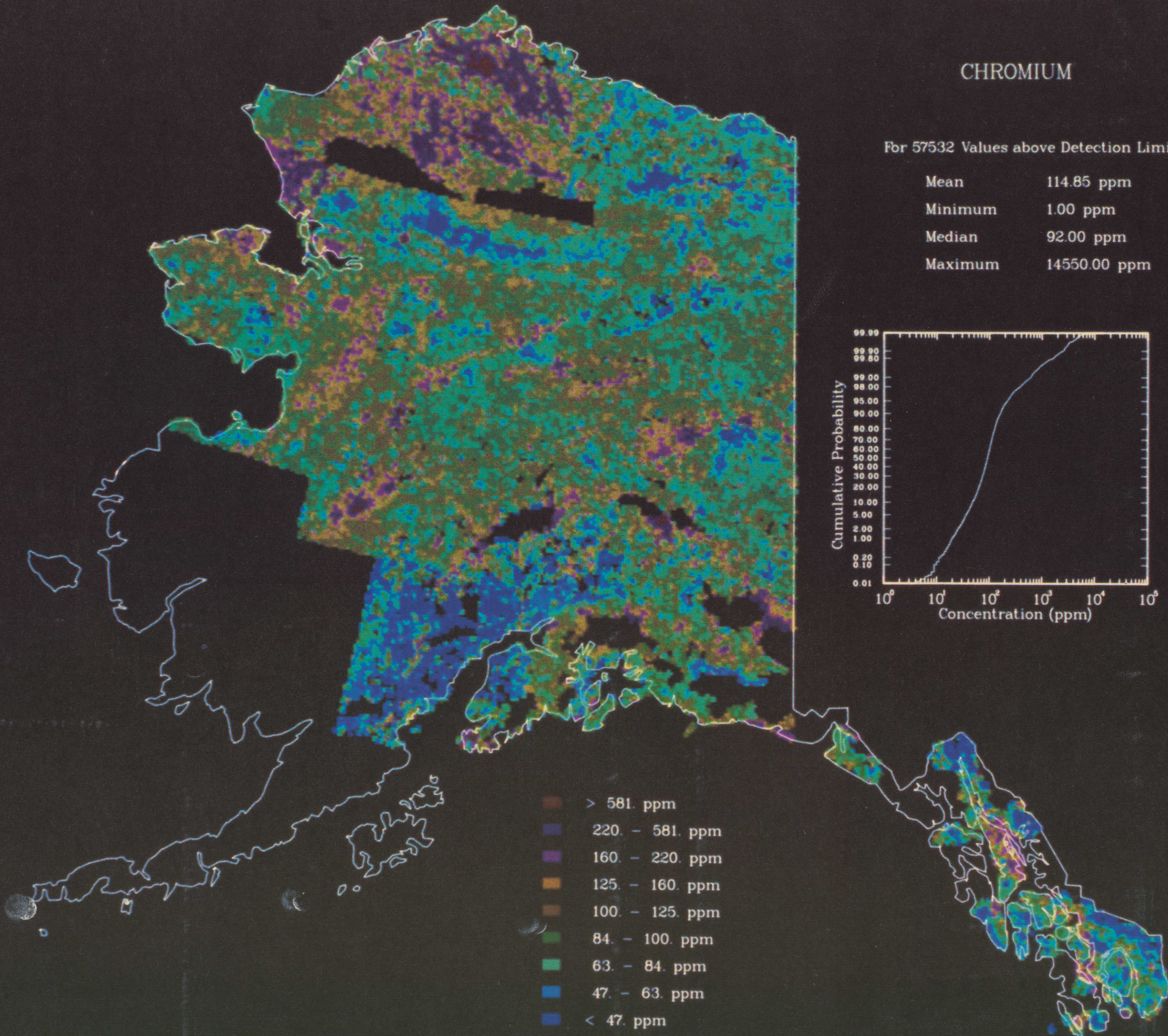
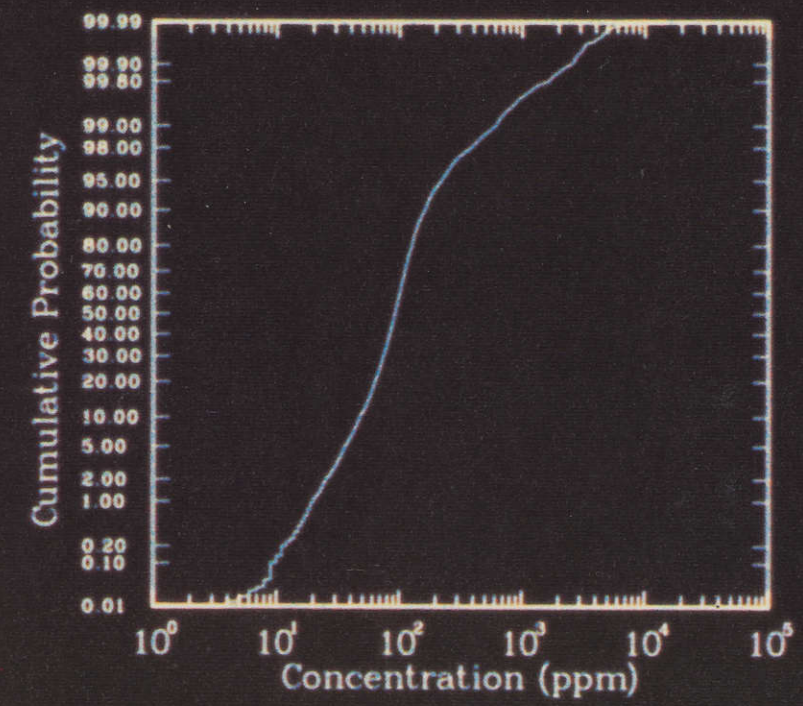


PLATE 11

CHROMIUM

For 57532 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 114.85 ppm |
| Minimum | 1.00 ppm |
| Median | 92.00 ppm |
| Maximum | 14550.00 ppm |



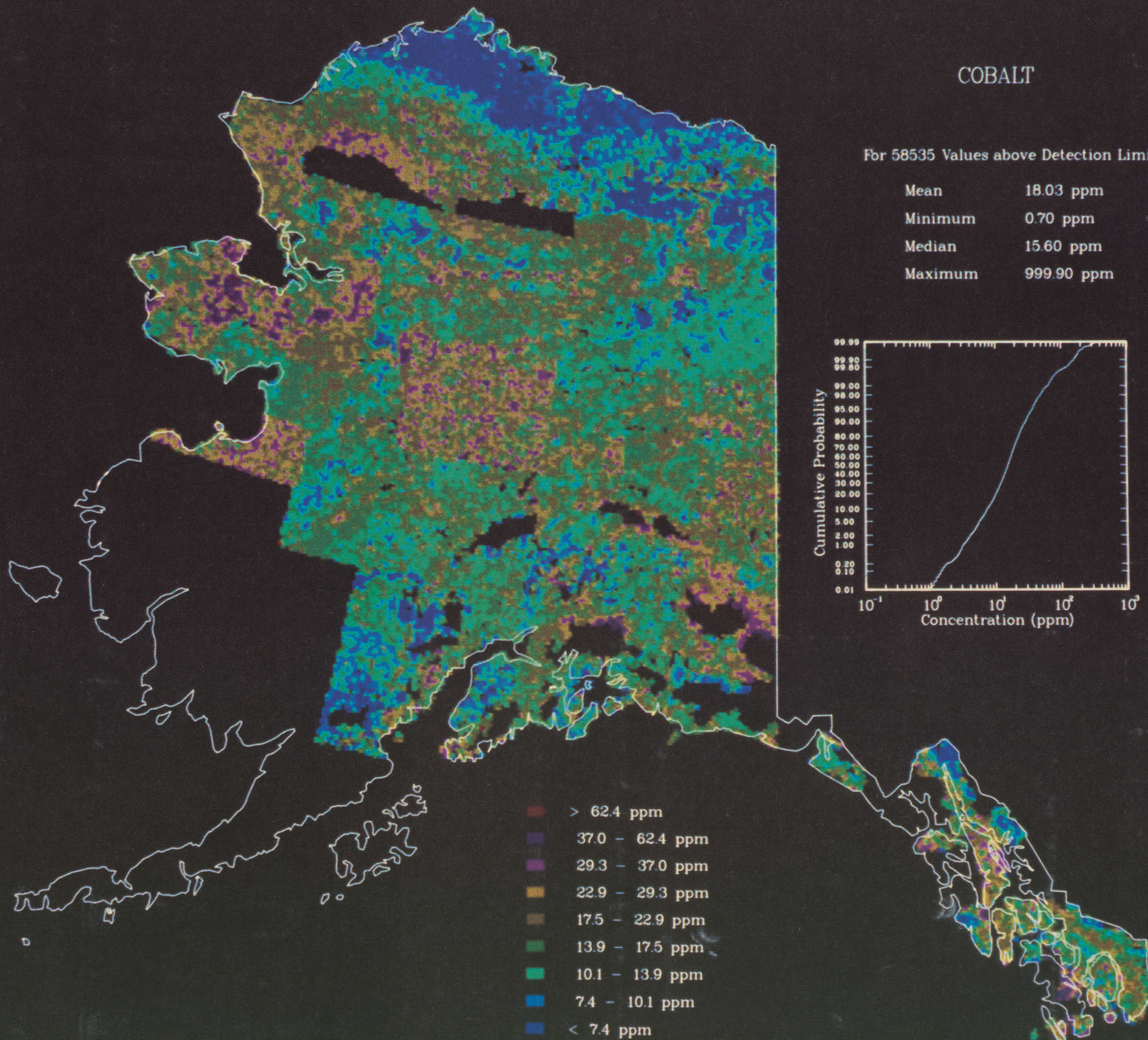
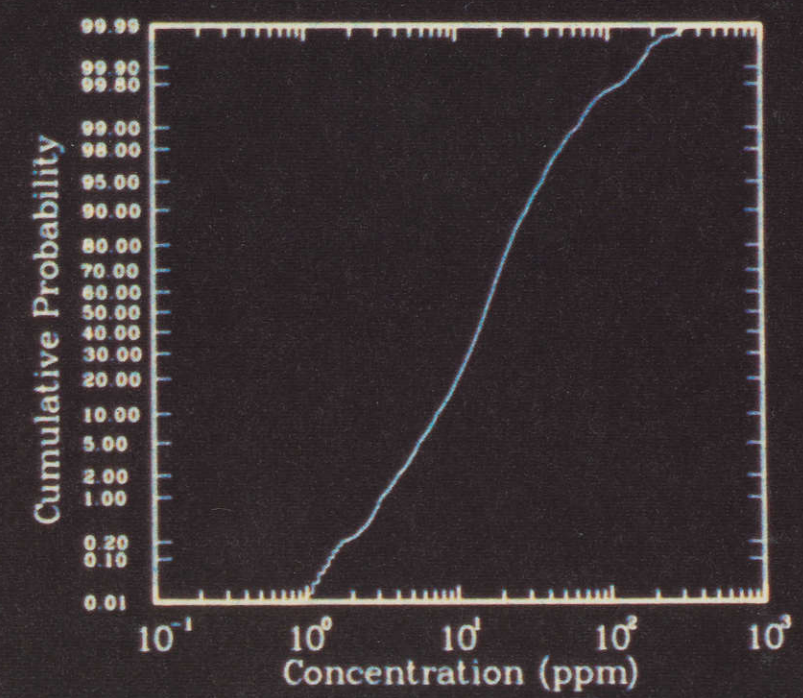
- > 581. ppm
- 220. - 581. ppm
- 160. - 220. ppm
- 125. - 160. ppm
- 100. - 125. ppm
- 84. - 100. ppm
- 63. - 84. ppm
- 47. - 63. ppm
- < 47. ppm

PLATE 12

COBALT

For 58535 Values above Detection Limit

| | |
|---------|------------|
| Mean | 18.03 ppm |
| Minimum | 0.70 ppm |
| Median | 15.60 ppm |
| Maximum | 999.90 ppm |



- > 62.4 ppm
- 37.0 - 62.4 ppm
- 29.3 - 37.0 ppm
- 22.9 - 29.3 ppm
- 17.5 - 22.9 ppm
- 13.9 - 17.5 ppm
- 10.1 - 13.9 ppm
- 7.4 - 10.1 ppm
- < 7.4 ppm

PLATE 13

COPPER

For 56227 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 37.06 ppm |
| Minimum | 7.00 ppm |
| Median | 32.00 ppm |
| Maximum | 13863.00 ppm |

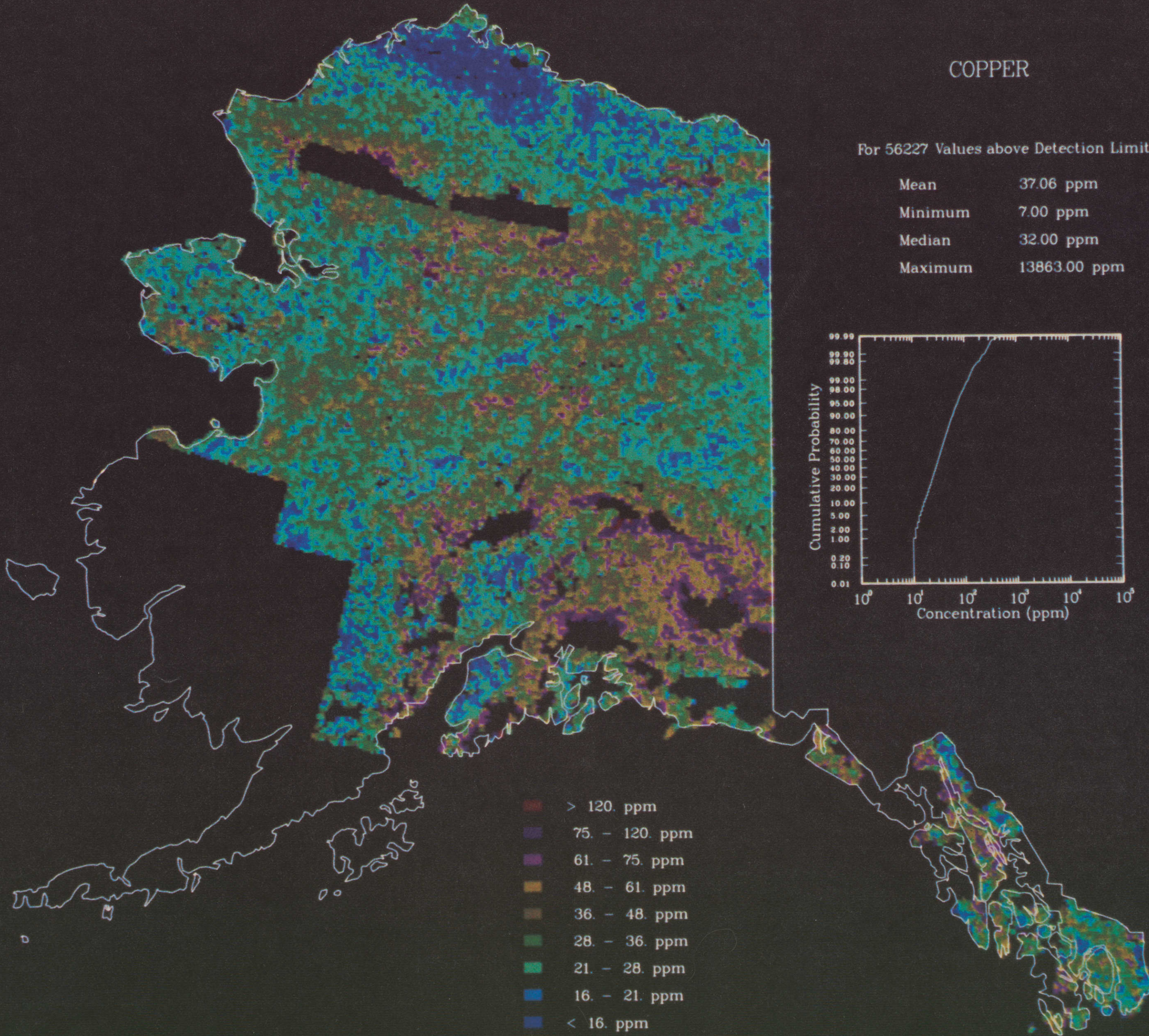
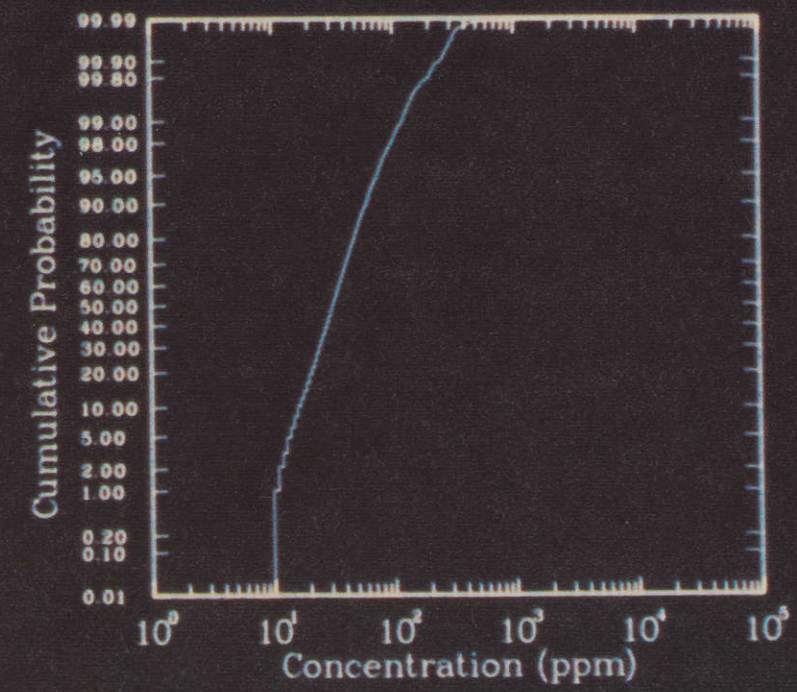


PLATE 14

DYSPROSIUM

For 57437 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 4.95 ppm |
| Minimum | 1.00 ppm |
| Median | 5.00 ppm |
| Maximum | 90.00 ppm |

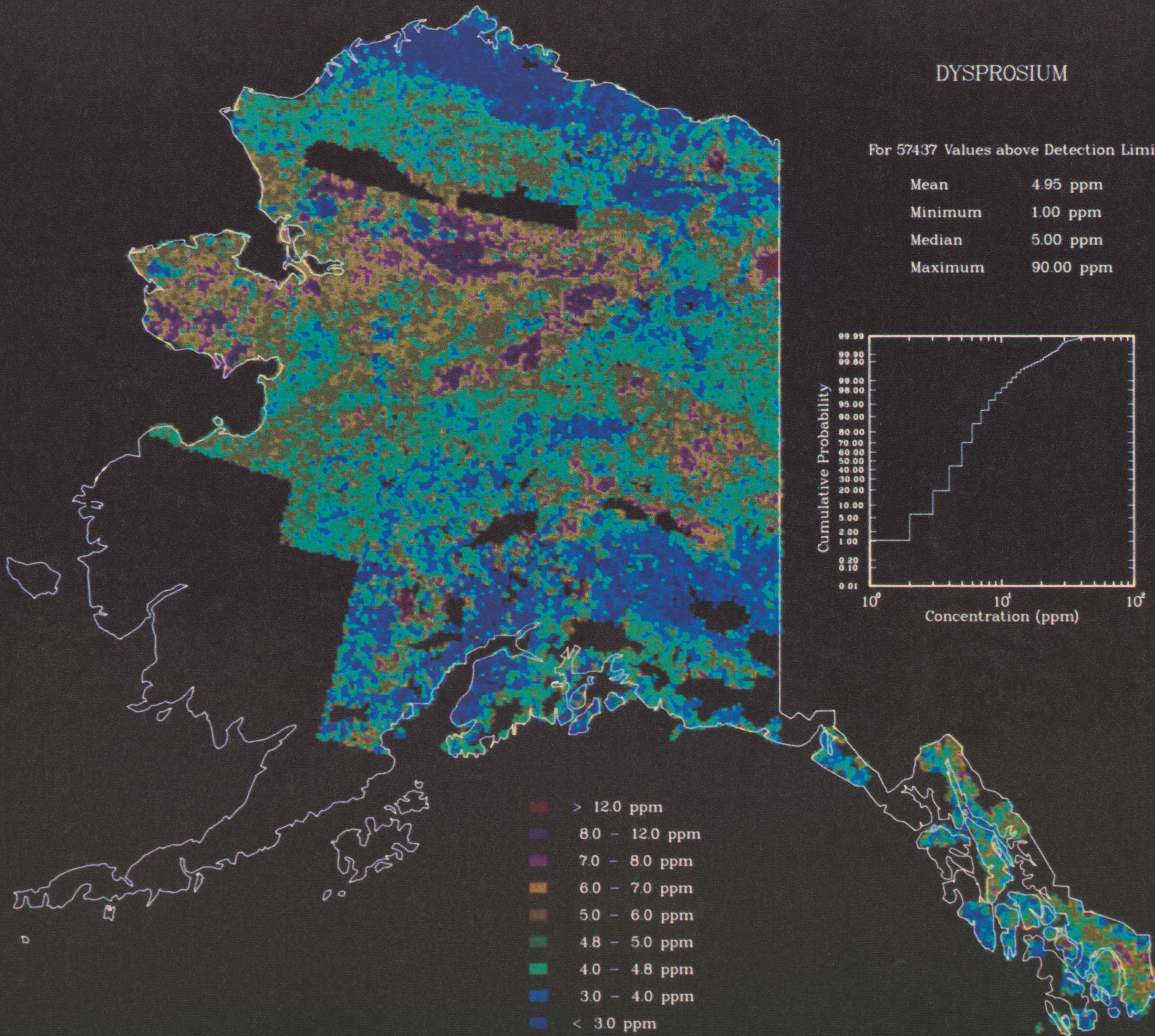
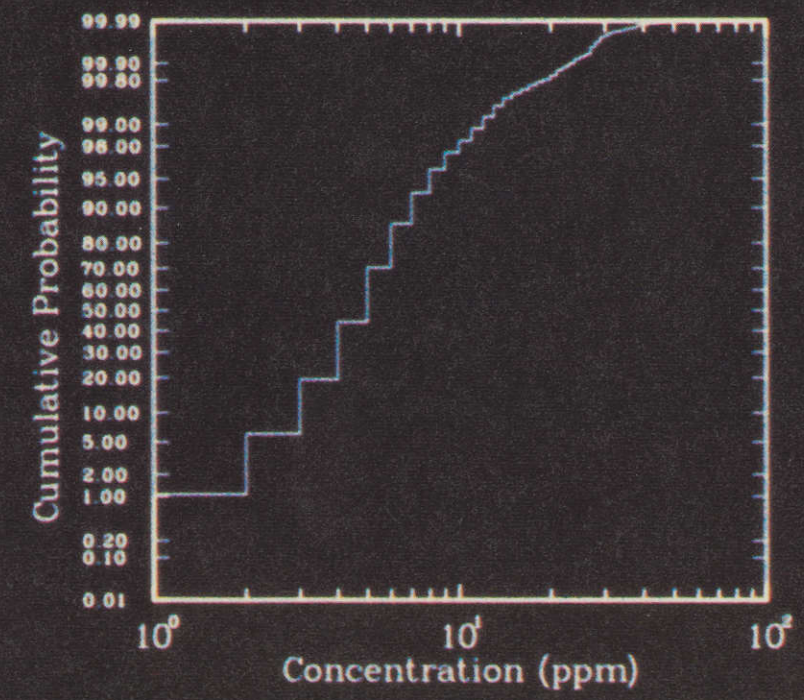


PLATE 15

EUROPIUM

For 56203 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 1.34 ppm |
| Minimum | 0.10 ppm |
| Median | 1.30 ppm |
| Maximum | 27.80 ppm |

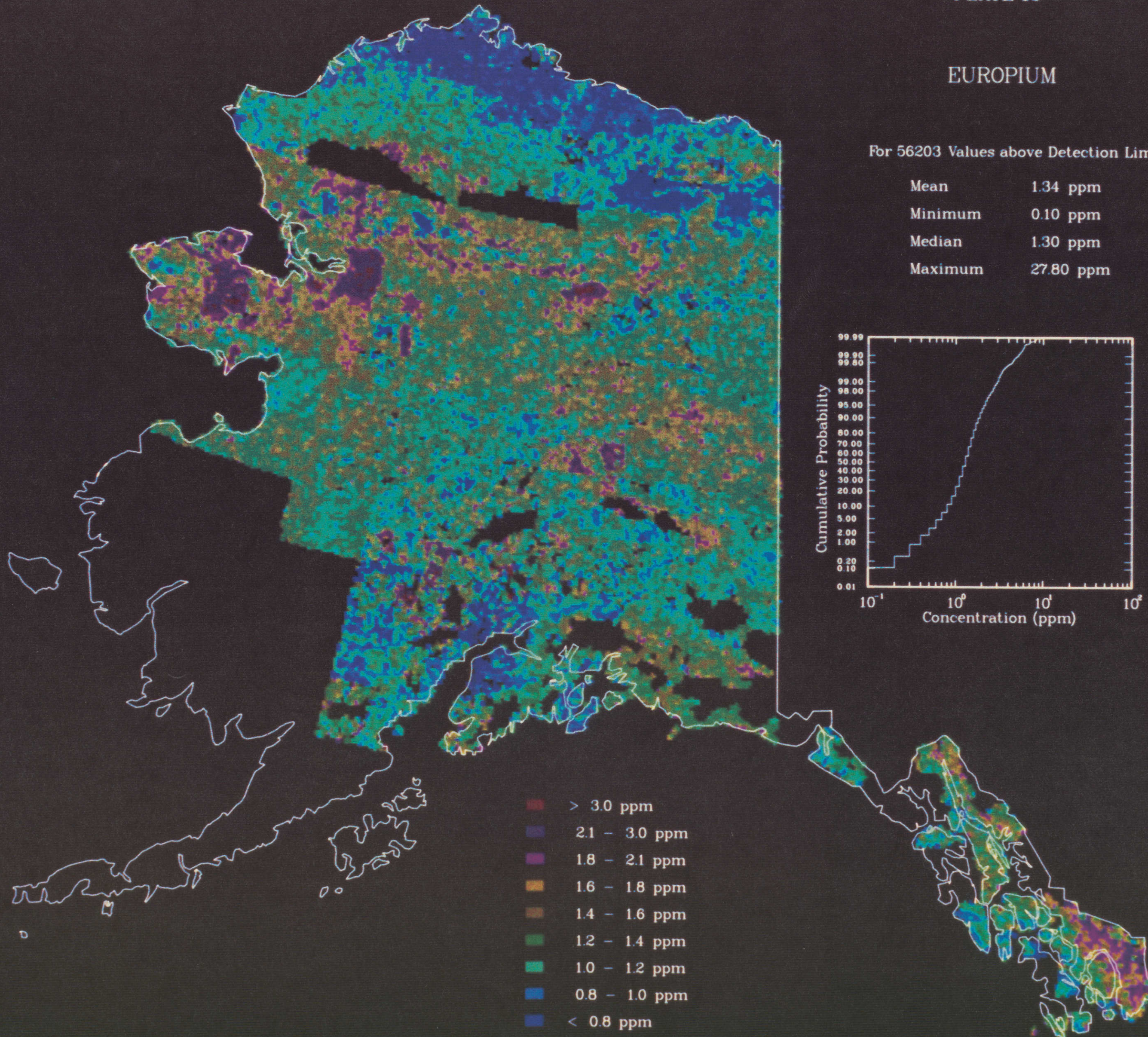
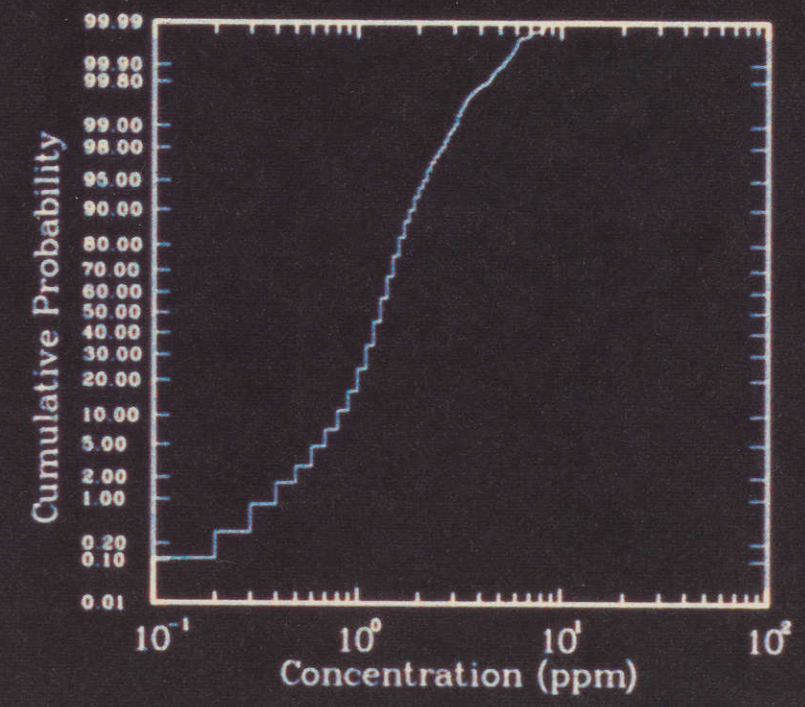
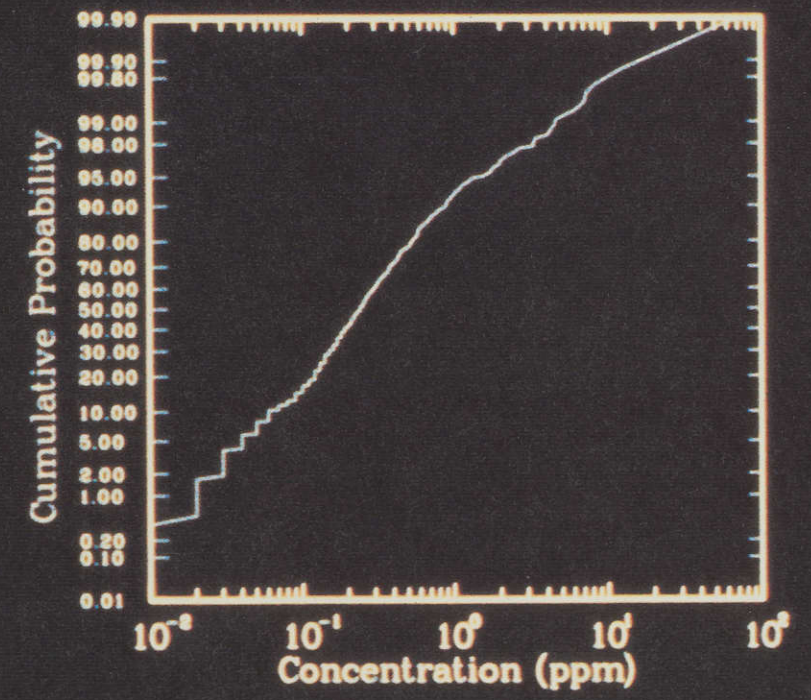


PLATE 16

GOLD

For 626 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 0.57 ppm |
| Minimum | 0.01 ppm |
| Median | 0.24 ppm |
| Maximum | 68.63 ppm |



Numeric averaging, instead of kriging, was used for this element (see p. 4).

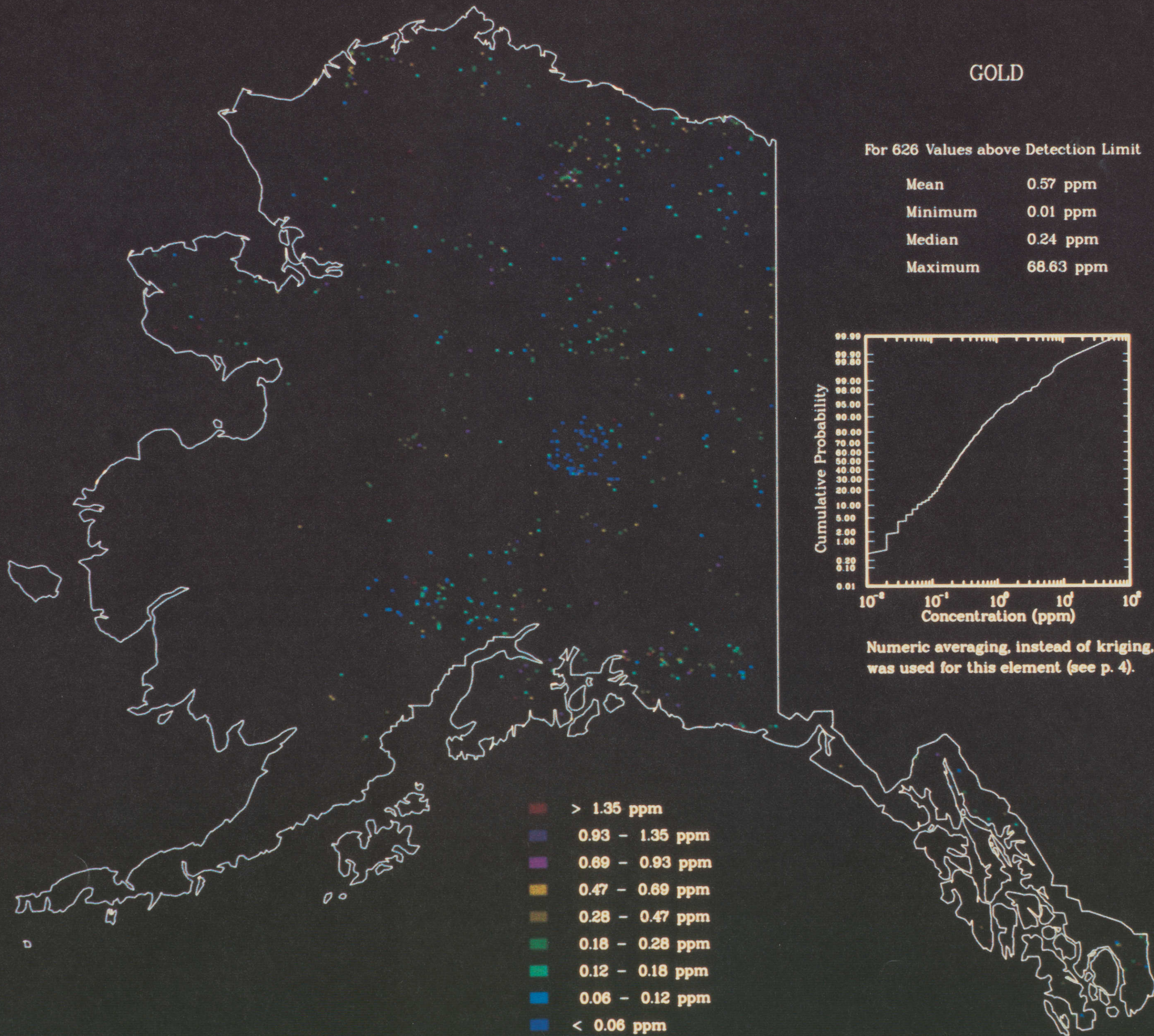


PLATE 17

HAFNIUM

For 54000 Values above Detection Limit

| | |
|---------|------------|
| Mean | 7.19 ppm |
| Minimum | 0.10 ppm |
| Median | 6.00 ppm |
| Maximum | 662.00 ppm |

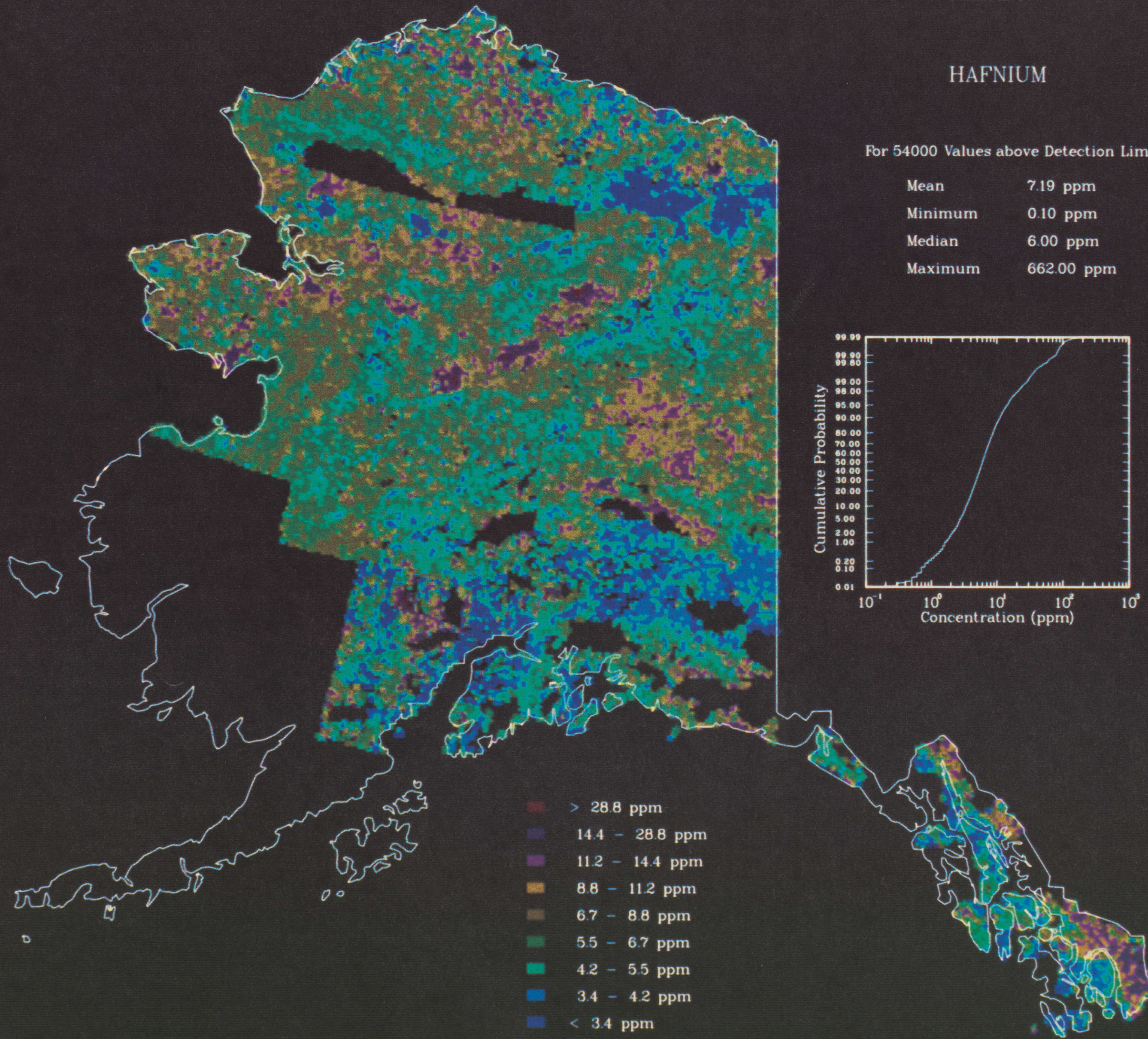
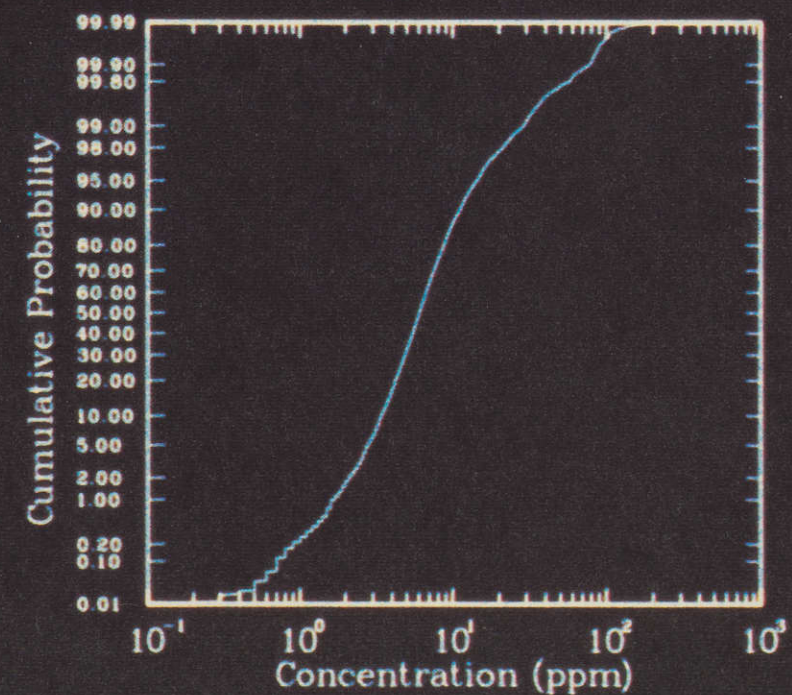
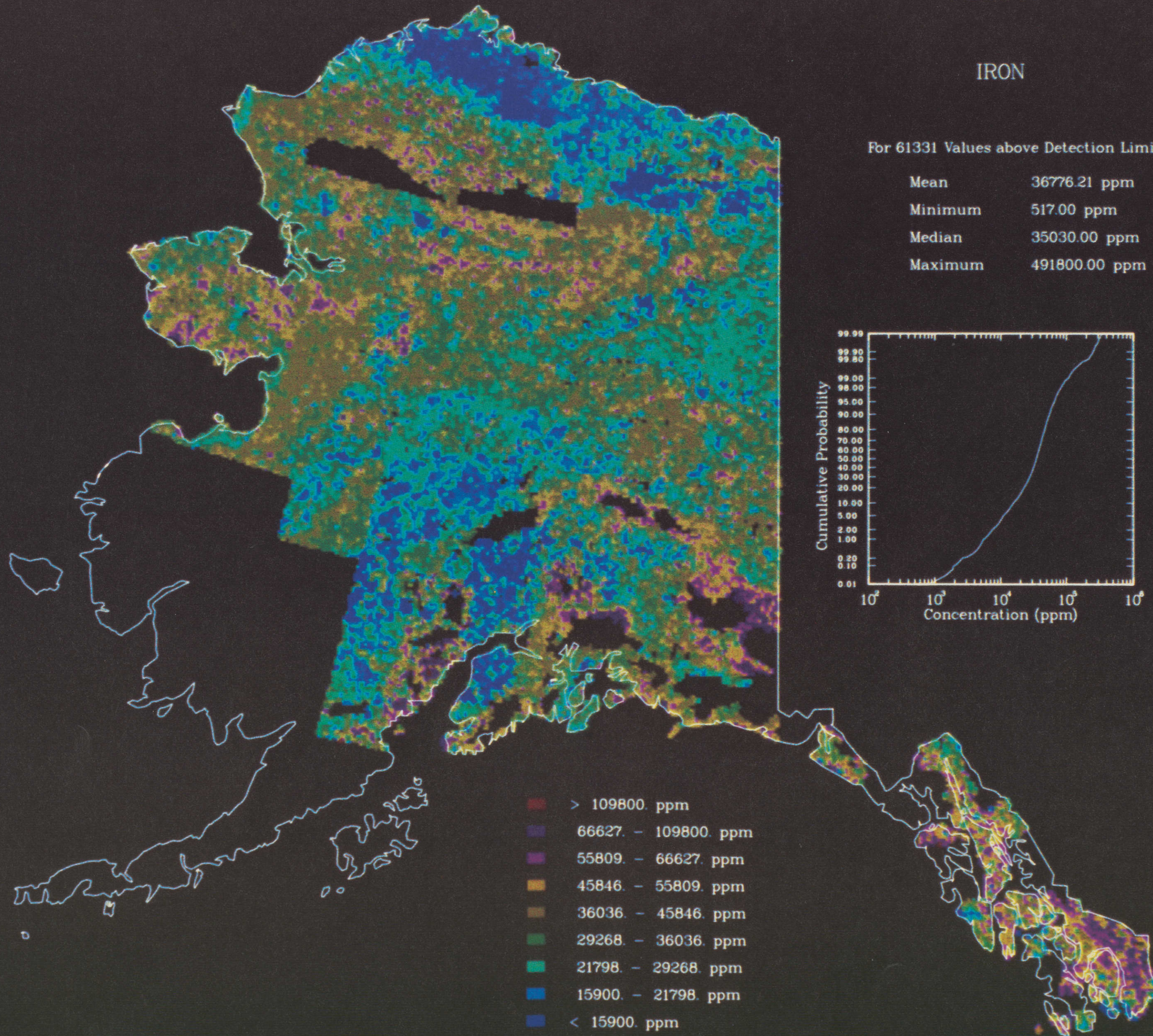
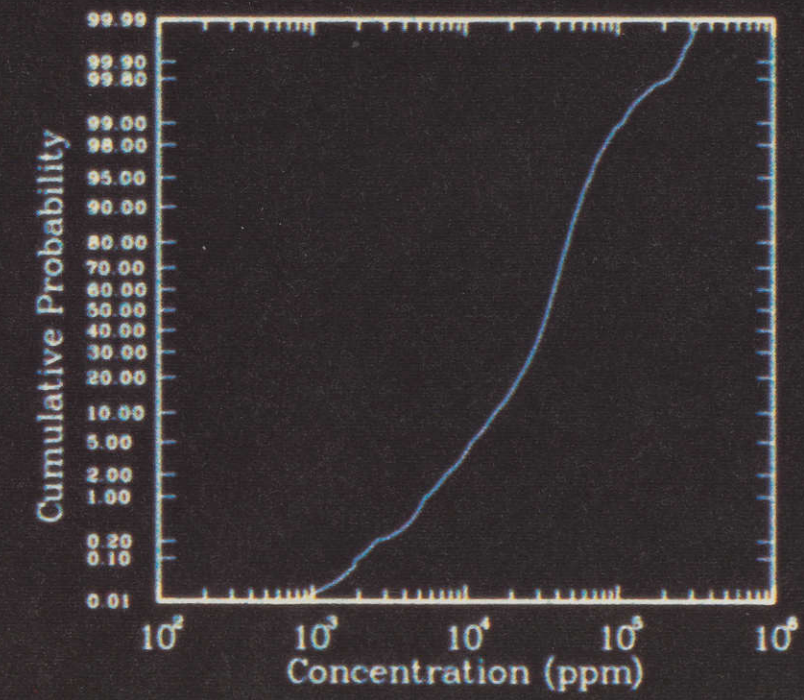


PLATE 18

IRON

For 61331 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 36776.21 ppm |
| Minimum | 517.00 ppm |
| Median | 35030.00 ppm |
| Maximum | 491800.00 ppm |



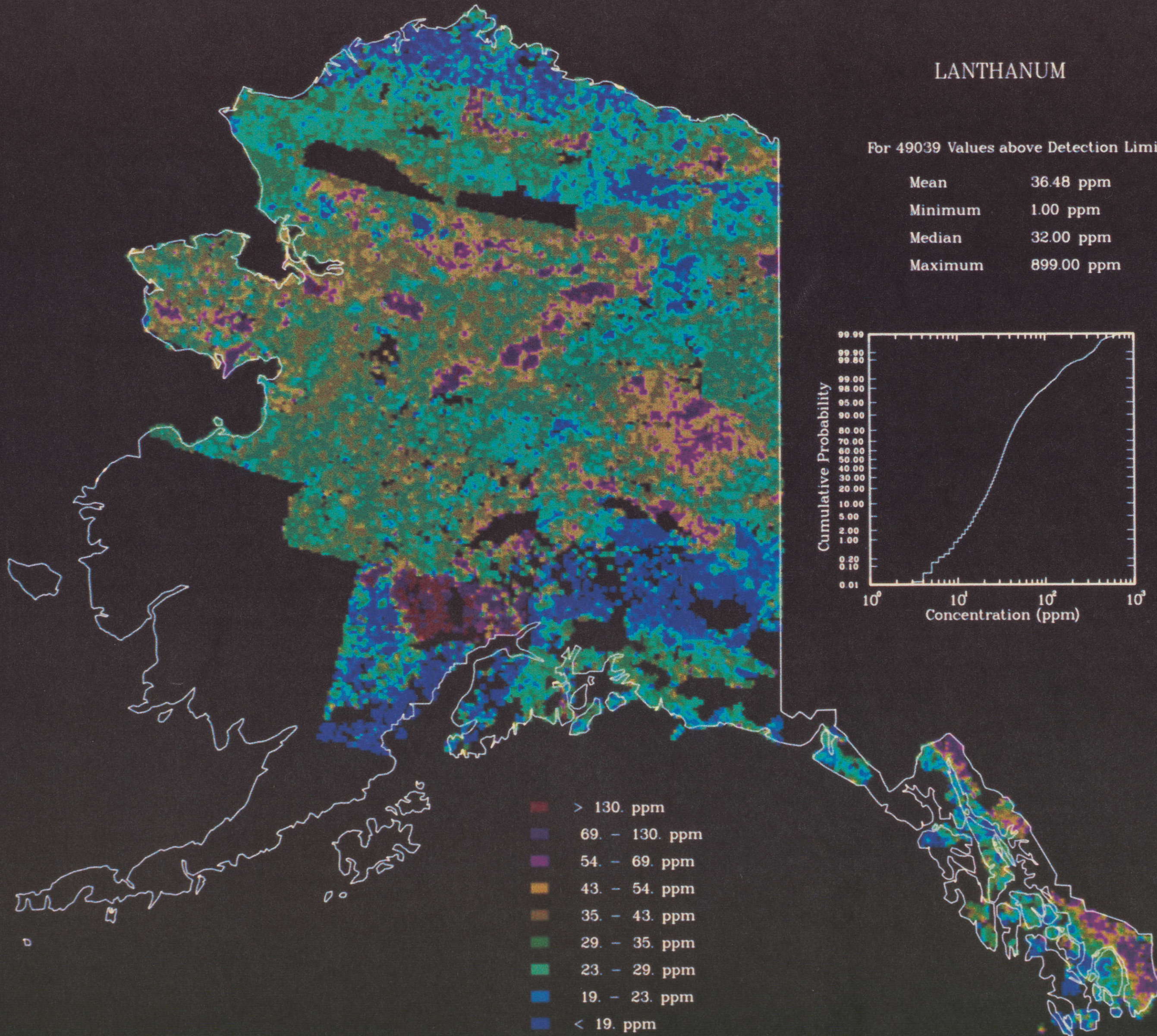
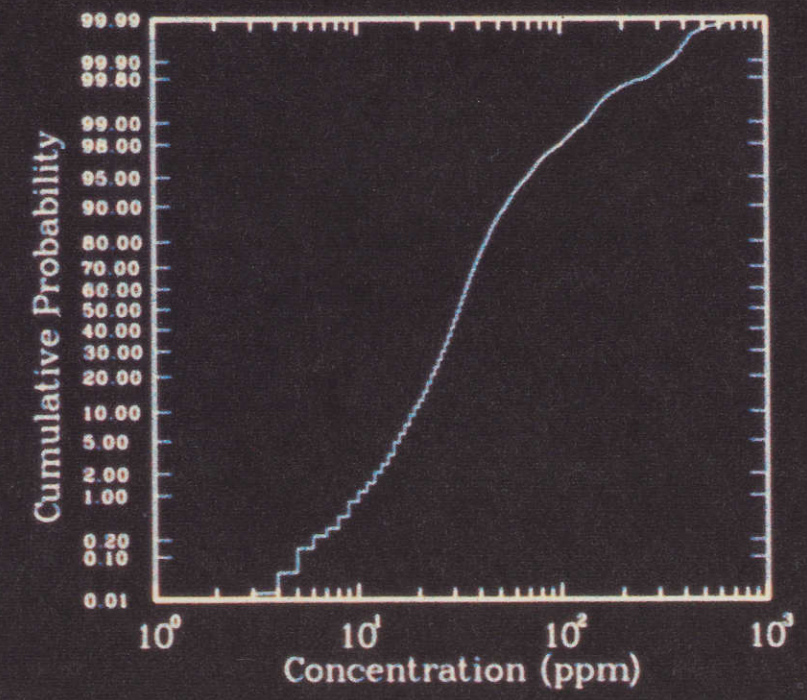
- > 109800. ppm
- 66627. - 109800. ppm
- 55809. - 66627. ppm
- 45846. - 55809. ppm
- 36036. - 45846. ppm
- 29268. - 36036. ppm
- 21798. - 29268. ppm
- 15900. - 21798. ppm
- < 15900. ppm

PLATE 19

LANTHANUM

For 49039 Values above Detection Limit

| | |
|---------|------------|
| Mean | 36.48 ppm |
| Minimum | 1.00 ppm |
| Median | 32.00 ppm |
| Maximum | 899.00 ppm |



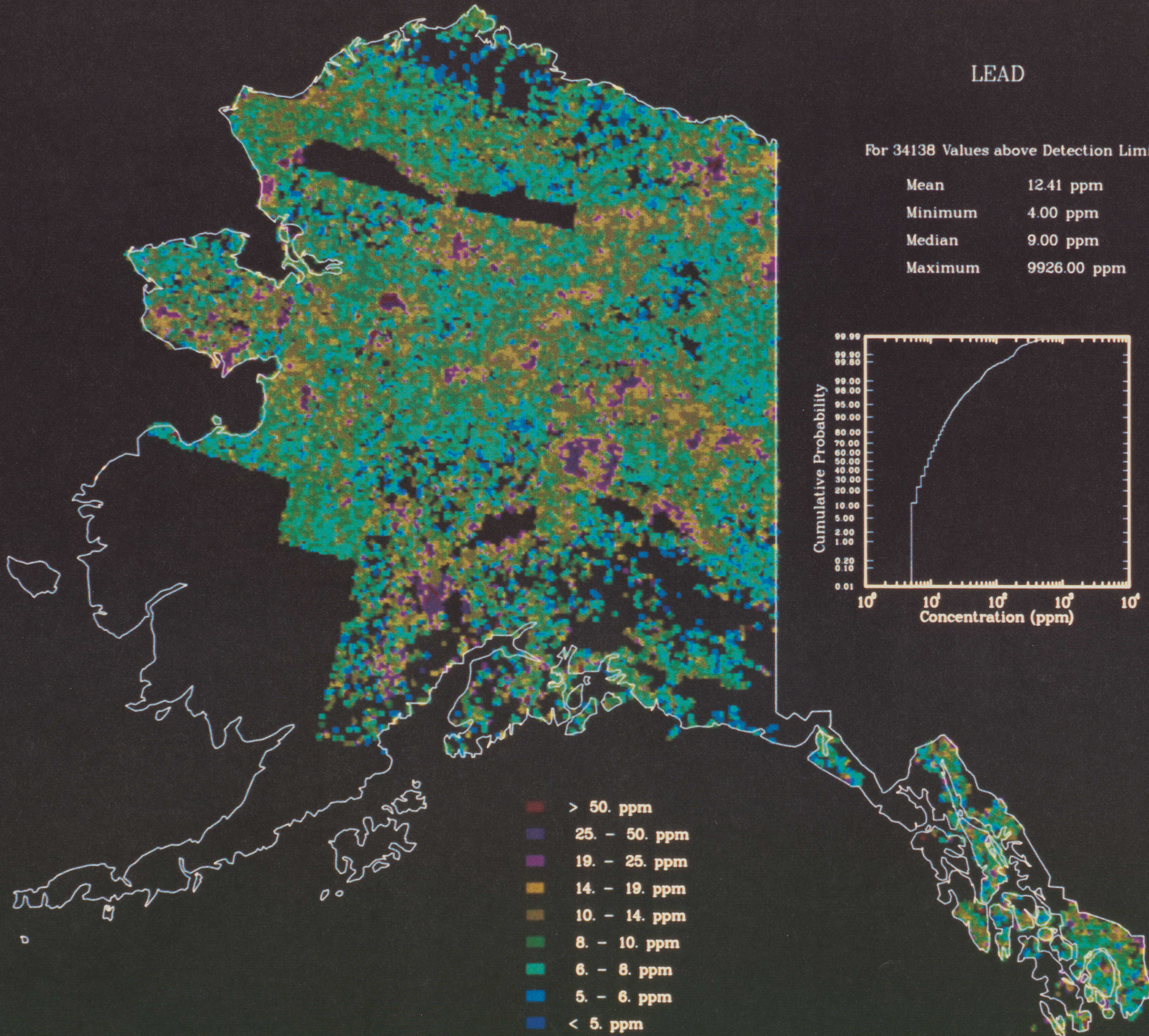
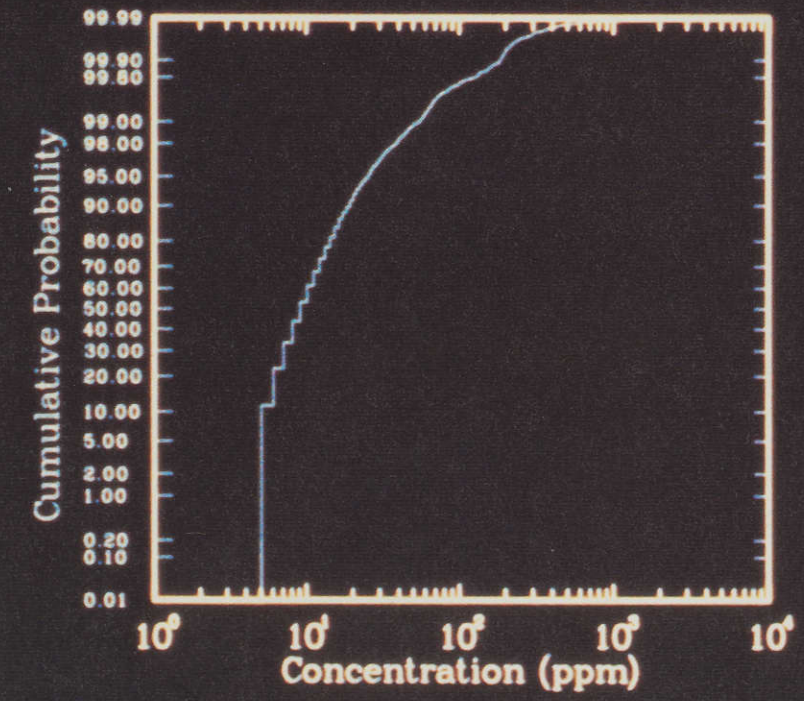
- > 130. ppm
- 69. - 130. ppm
- 54. - 69. ppm
- 43. - 54. ppm
- 35. - 43. ppm
- 29. - 35. ppm
- 23. - 29. ppm
- 19. - 23. ppm
- < 19. ppm

PLATE 20

LEAD

For 34138 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 12.41 ppm |
| Minimum | 4.00 ppm |
| Median | 9.00 ppm |
| Maximum | 9926.00 ppm |



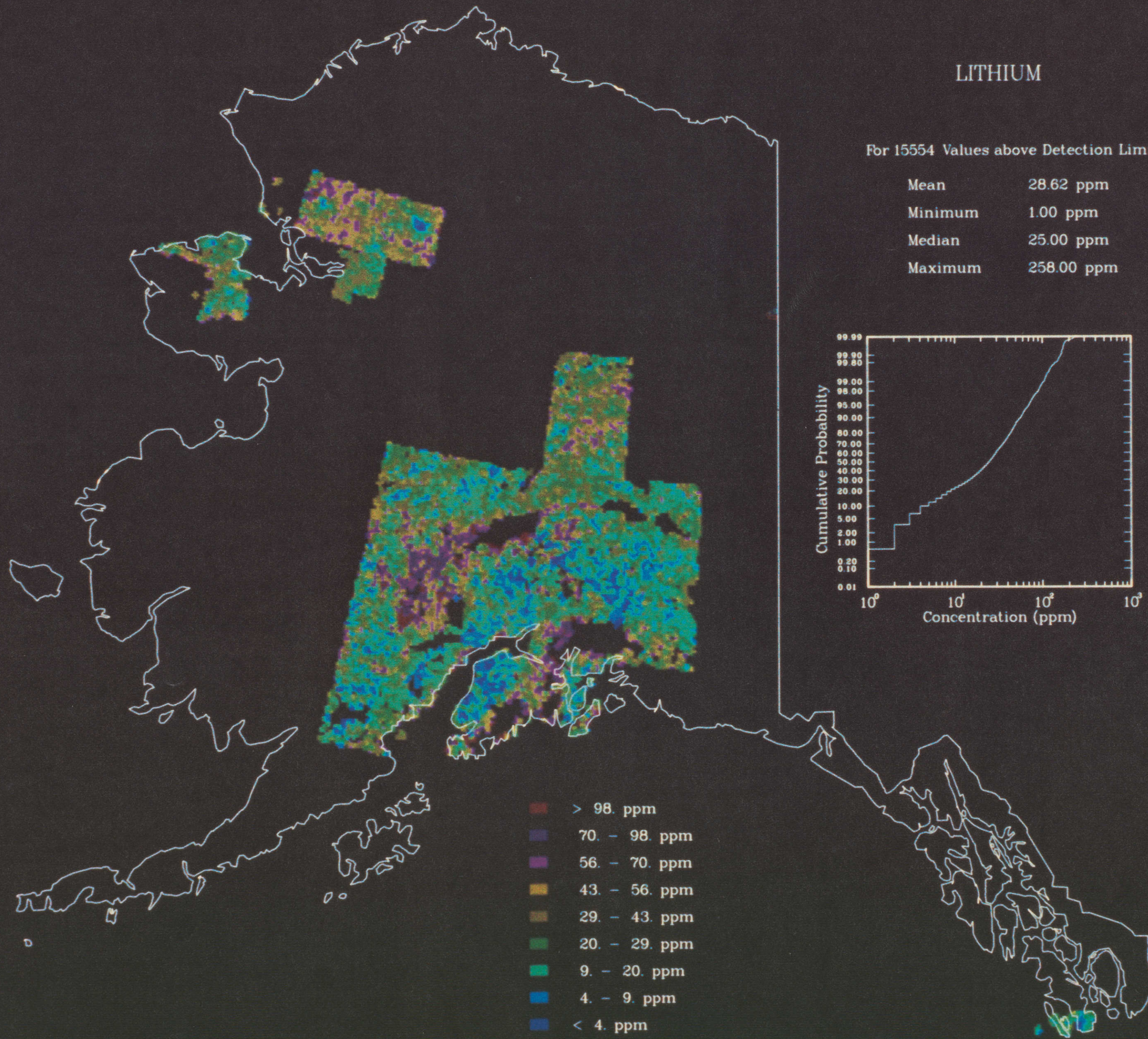
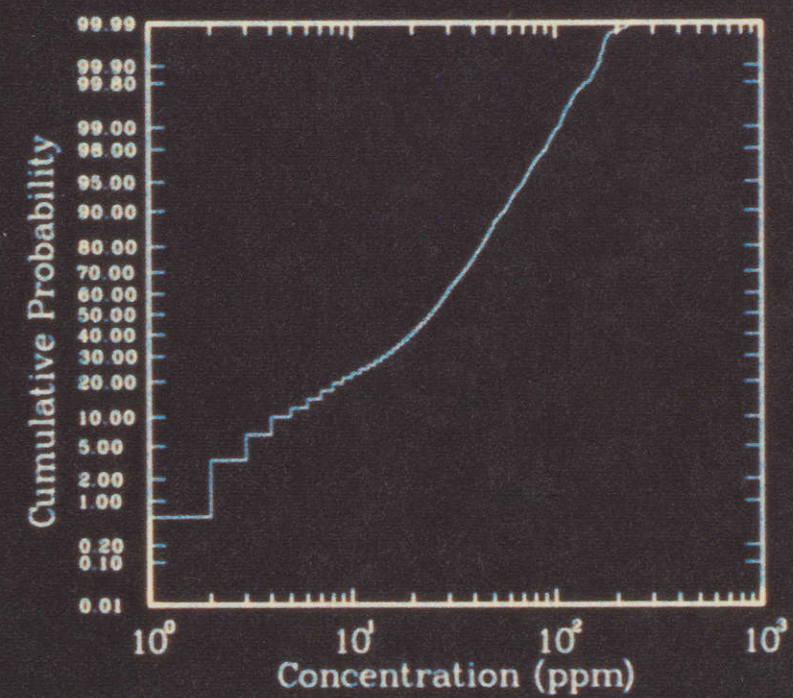
- > 50. ppm
- 25. - 50. ppm
- 19. - 25. ppm
- 14. - 19. ppm
- 10. - 14. ppm
- 8. - 10. ppm
- 6. - 8. ppm
- 5. - 6. ppm
- < 5. ppm

PLATE 21

LITHIUM

For 15554 Values above Detection Limit

| | |
|---------|------------|
| Mean | 28.62 ppm |
| Minimum | 1.00 ppm |
| Median | 25.00 ppm |
| Maximum | 258.00 ppm |



- > 98. ppm
- 70. - 98. ppm
- 56. - 70. ppm
- 43. - 56. ppm
- 29. - 43. ppm
- 20. - 29. ppm
- 9. - 20. ppm
- 4. - 9. ppm
- < 4. ppm

PLATE 22

LUTETIUM

For 50255 Values above Detection Limit

| | |
|---------|----------|
| Mean | 0.39 ppm |
| Minimum | 0.10 ppm |
| Median | 0.40 ppm |
| Maximum | 8.20 ppm |

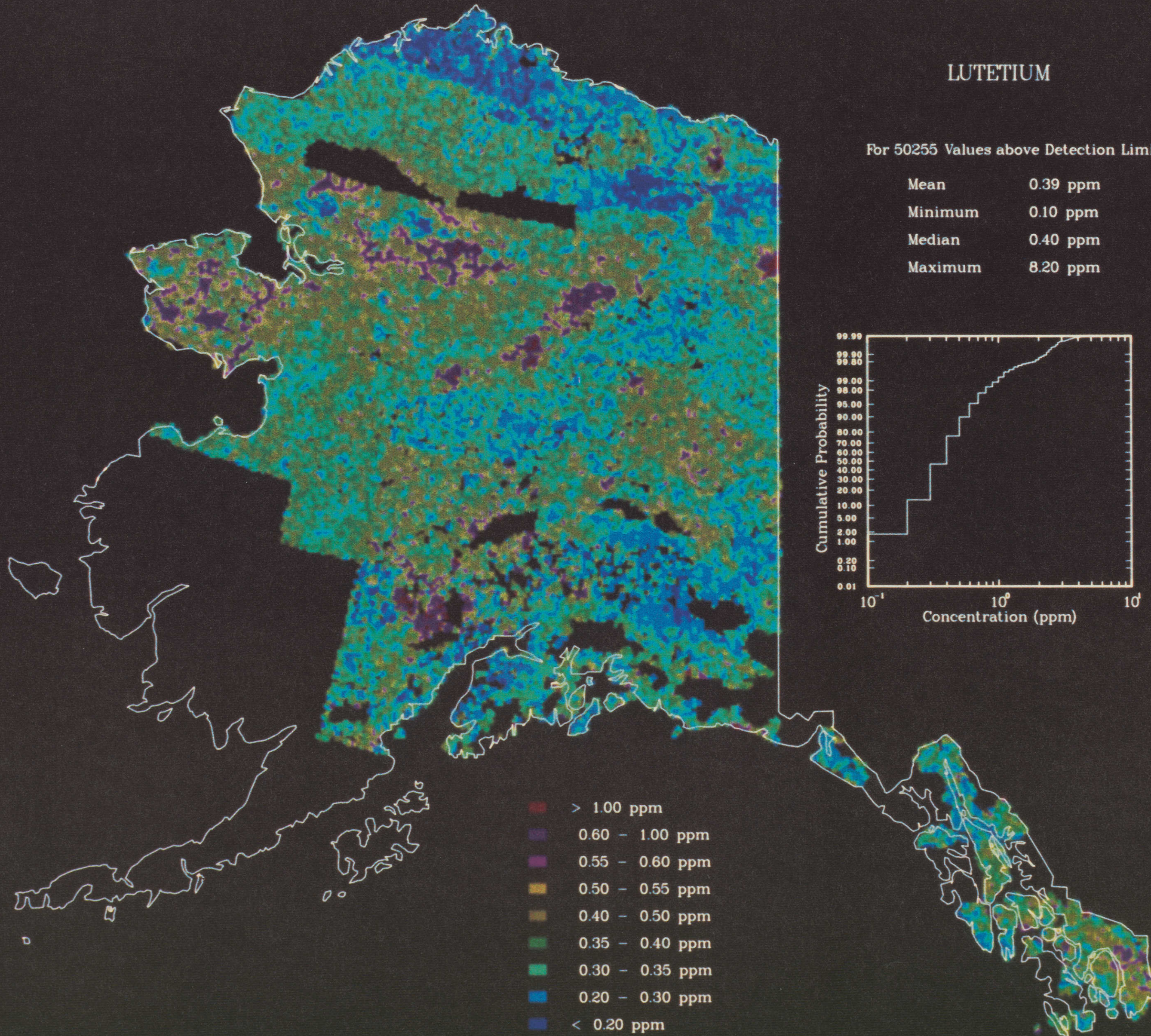
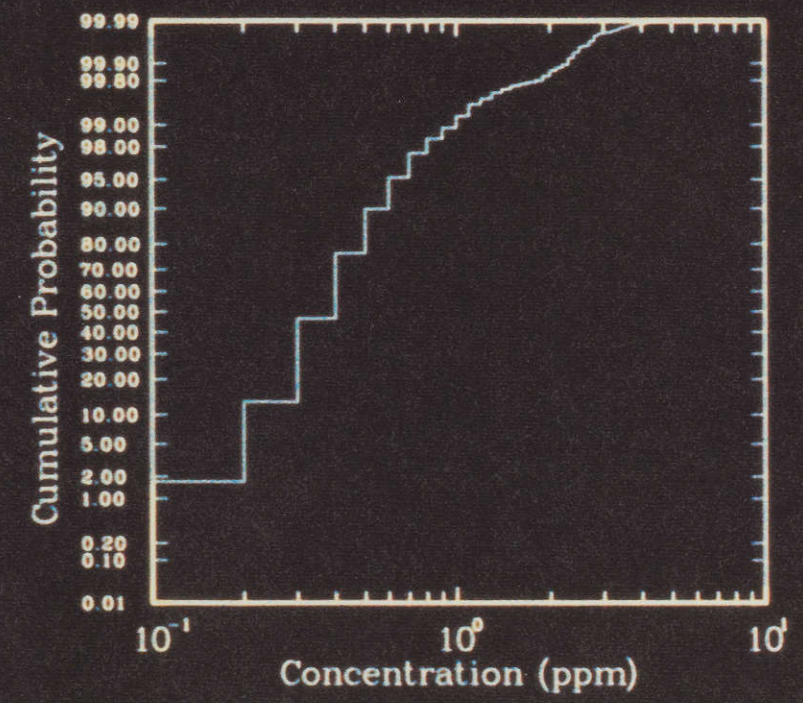
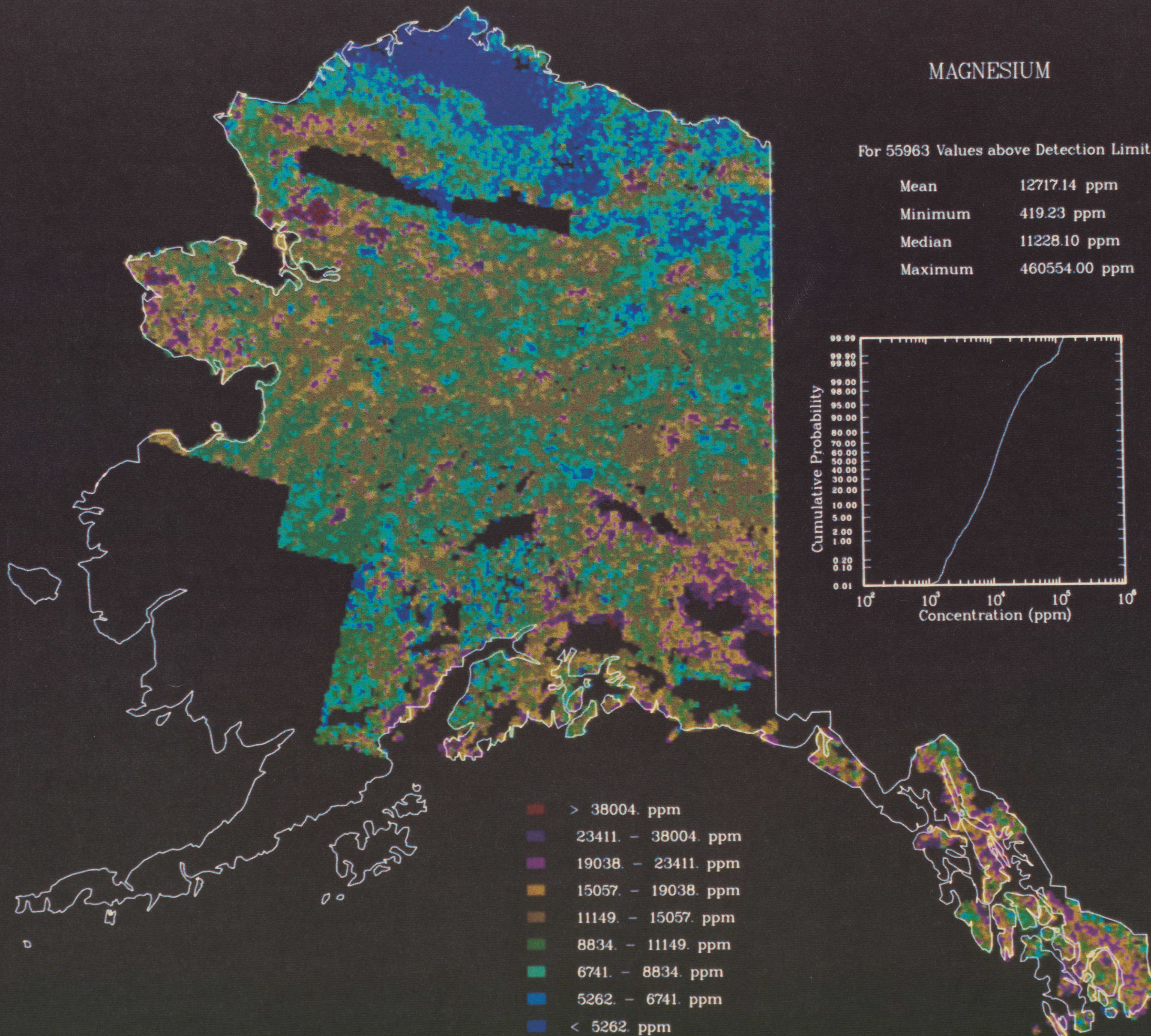
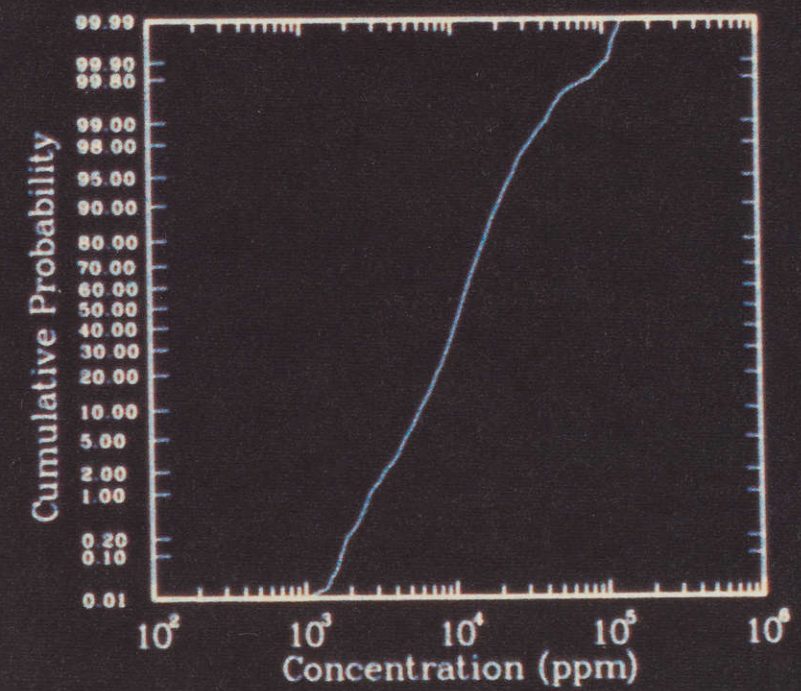


PLATE 23

MAGNESIUM

For 55963 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 12717.14 ppm |
| Minimum | 419.23 ppm |
| Median | 11228.10 ppm |
| Maximum | 460554.00 ppm |



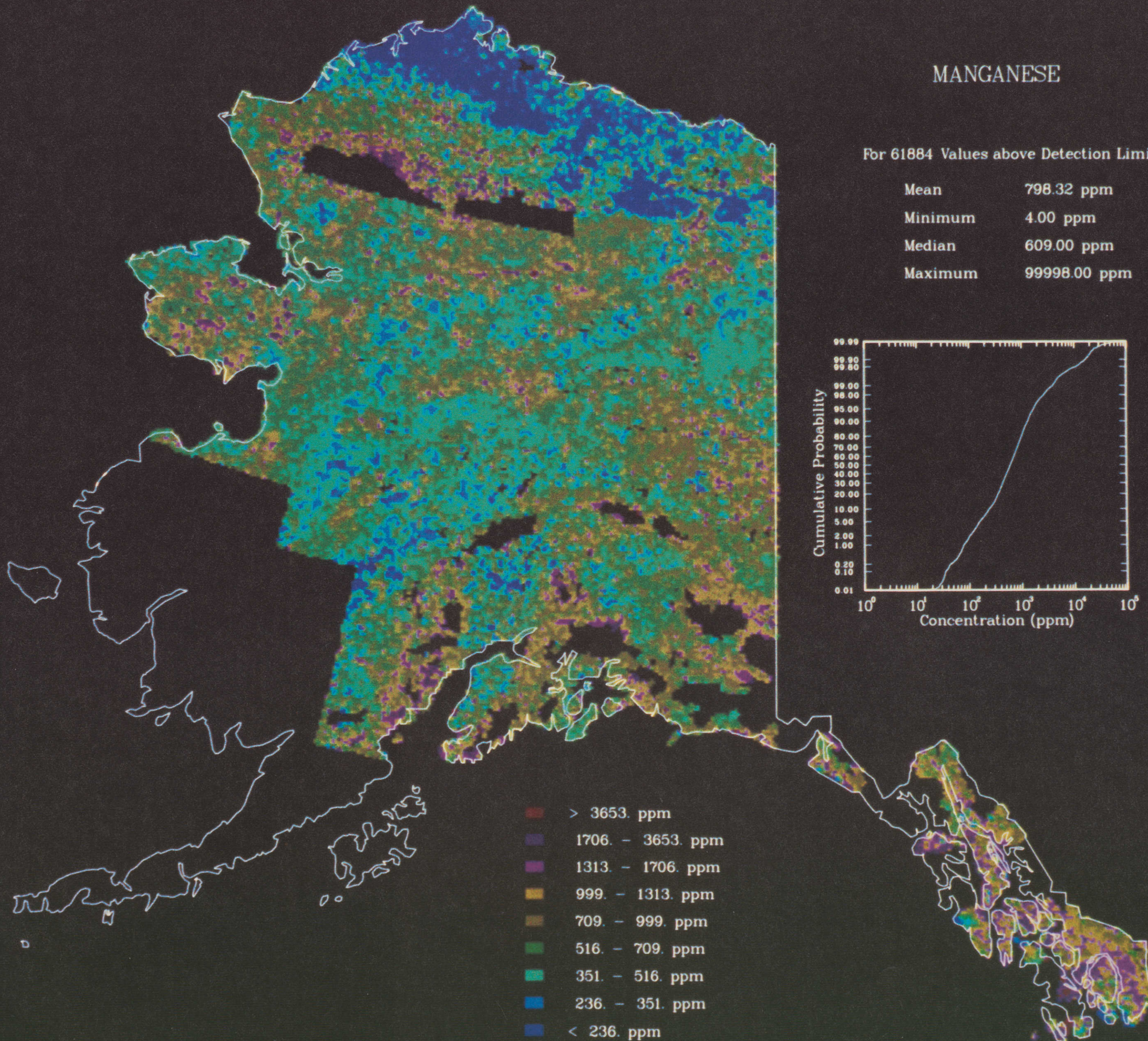
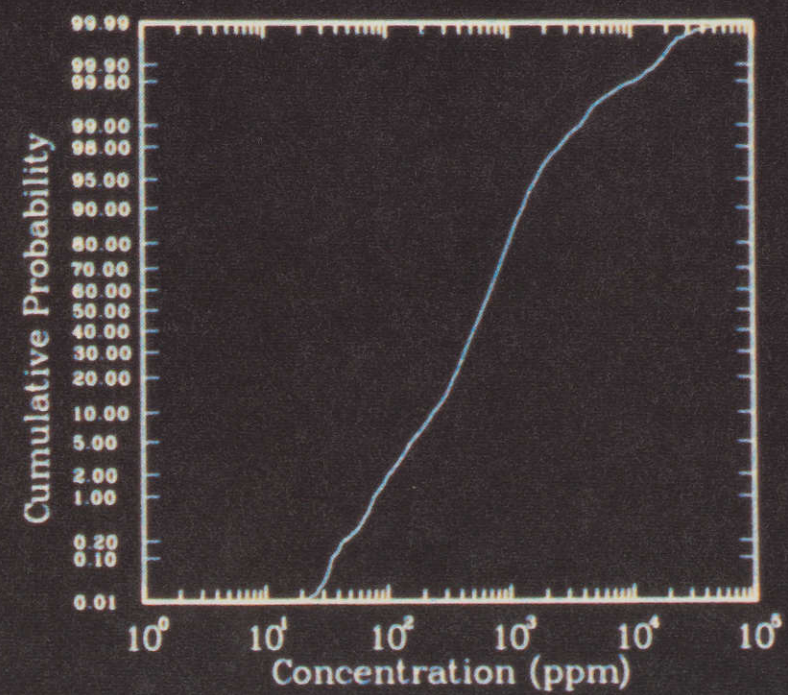
- > 38004. ppm
- 23411. - 38004. ppm
- 19038. - 23411. ppm
- 15057. - 19038. ppm
- 11149. - 15057. ppm
- 8834. - 11149. ppm
- 6741. - 8834. ppm
- 5262. - 6741. ppm
- < 5262. ppm

PLATE 24

MANGANESE

For 61884 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 798.32 ppm |
| Minimum | 4.00 ppm |
| Median | 609.00 ppm |
| Maximum | 99998.00 ppm |



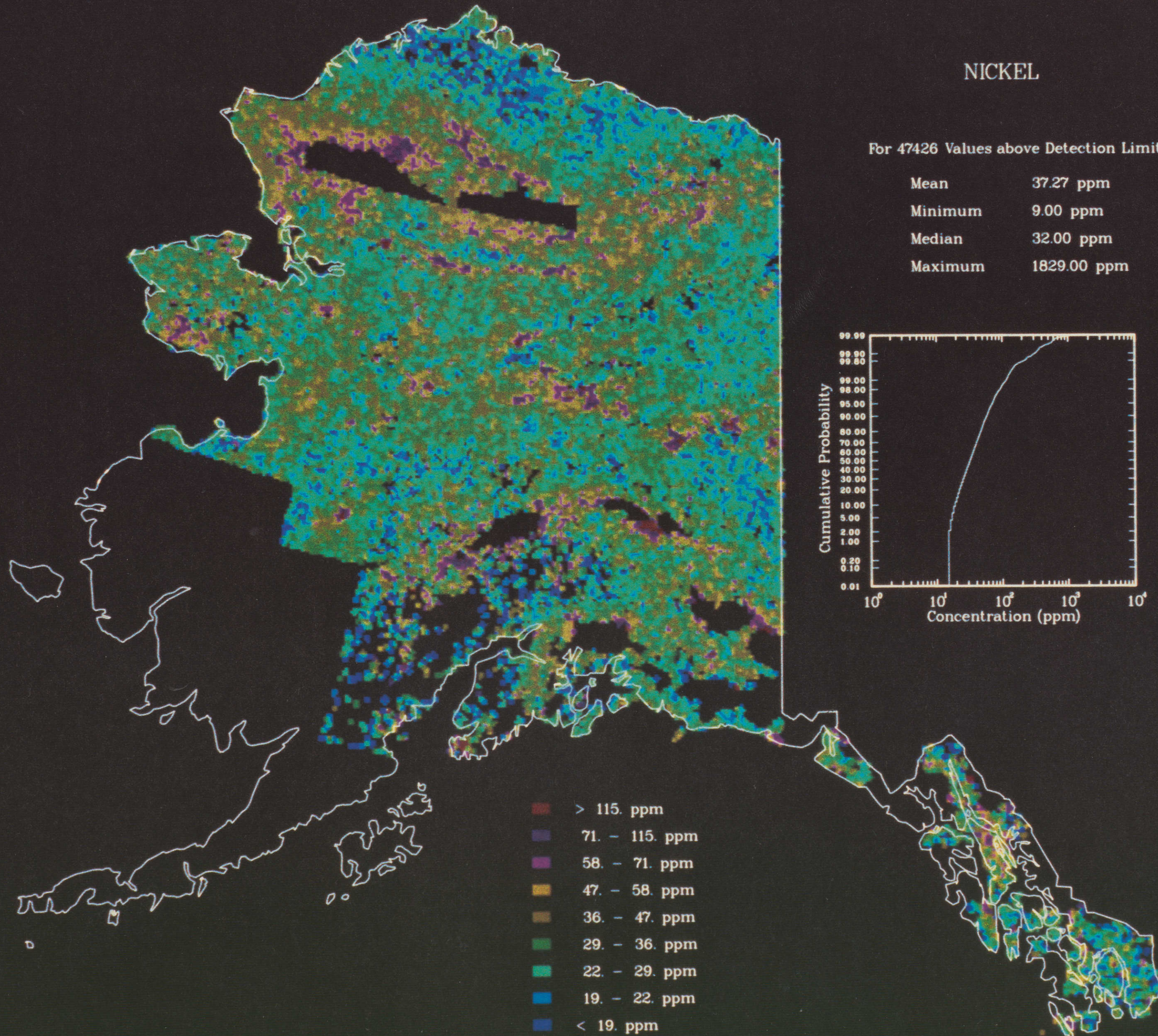
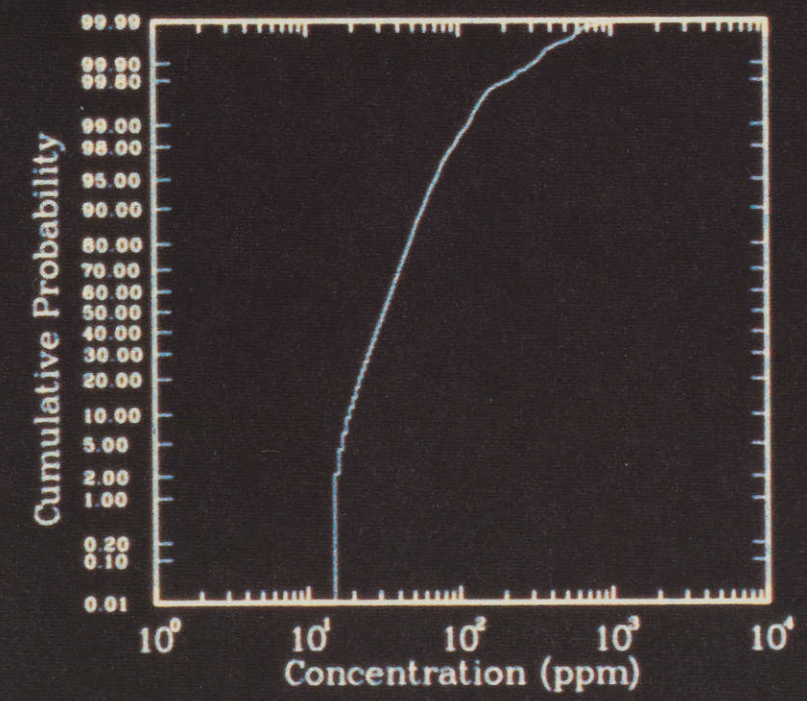
- > 3653. ppm
- 1706. - 3653. ppm
- 1313. - 1706. ppm
- 999. - 1313. ppm
- 709. - 999. ppm
- 516. - 709. ppm
- 351. - 516. ppm
- 236. - 351. ppm
- < 236. ppm

PLATE 25

NICKEL

For 47426 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 37.27 ppm |
| Minimum | 9.00 ppm |
| Median | 32.00 ppm |
| Maximum | 1829.00 ppm |



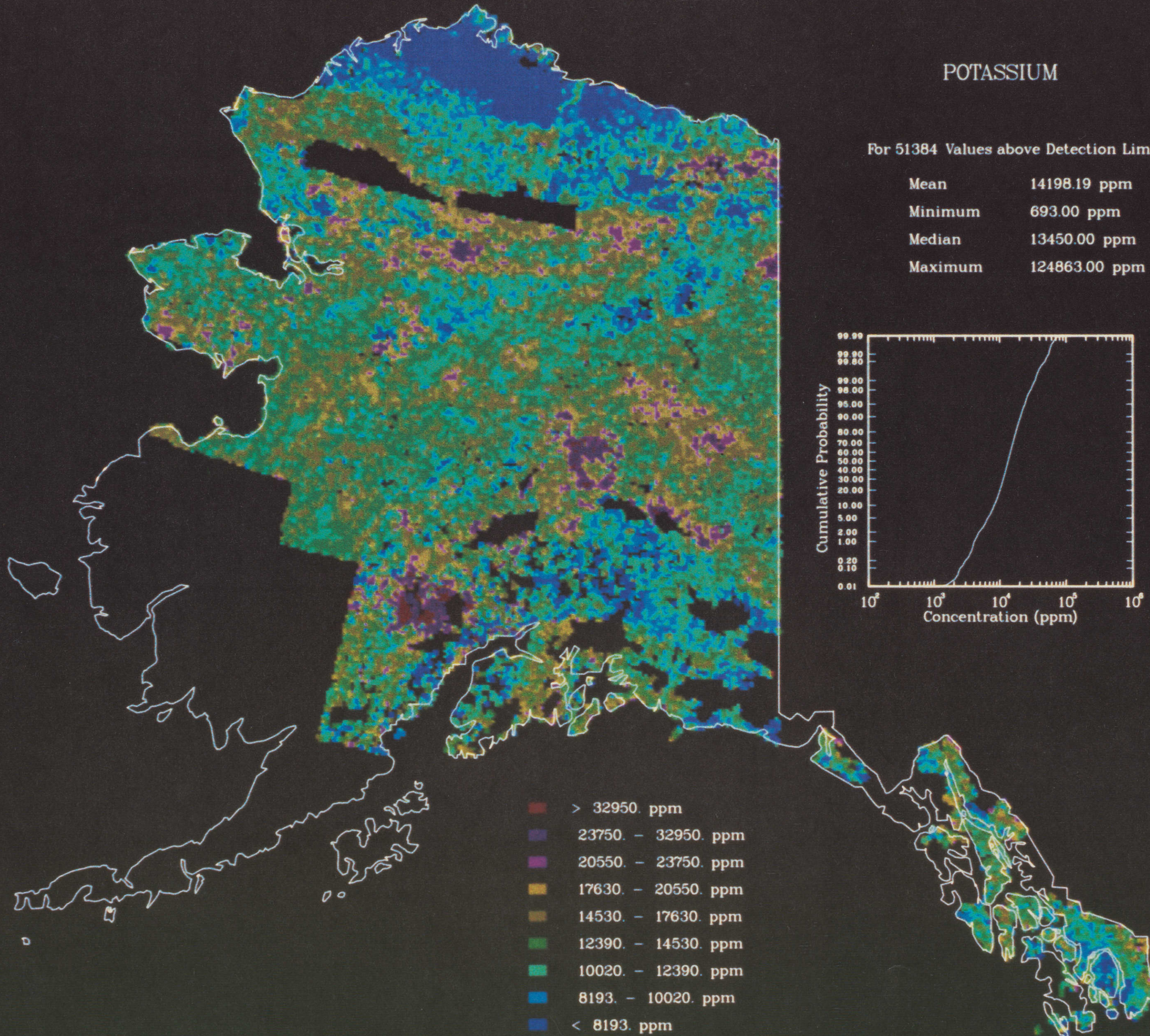
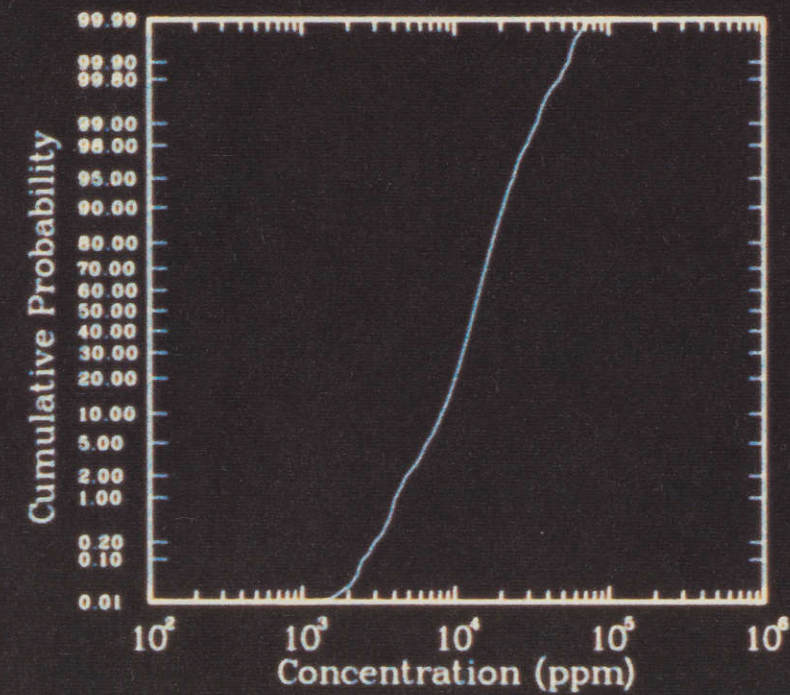
- > 115. ppm
- 71. - 115. ppm
- 58. - 71. ppm
- 47. - 58. ppm
- 36. - 47. ppm
- 29. - 36. ppm
- 22. - 29. ppm
- 19. - 22. ppm
- < 19. ppm

PLATE 26

POTASSIUM

For 51384 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 14198.19 ppm |
| Minimum | 693.00 ppm |
| Median | 13450.00 ppm |
| Maximum | 124863.00 ppm |



- > 32950. ppm
- 23750. - 32950. ppm
- 20550. - 23750. ppm
- 17630. - 20550. ppm
- 14530. - 17630. ppm
- 12390. - 14530. ppm
- 10020. - 12390. ppm
- 8193. - 10020. ppm
- < 8193. ppm

PLATE 27

SCANDIUM

For 61603 Values above Detection Limit

| | |
|---------|------------|
| Mean | 13.56 ppm |
| Minimum | 0.10 ppm |
| Median | 13.50 ppm |
| Maximum | 128.60 ppm |

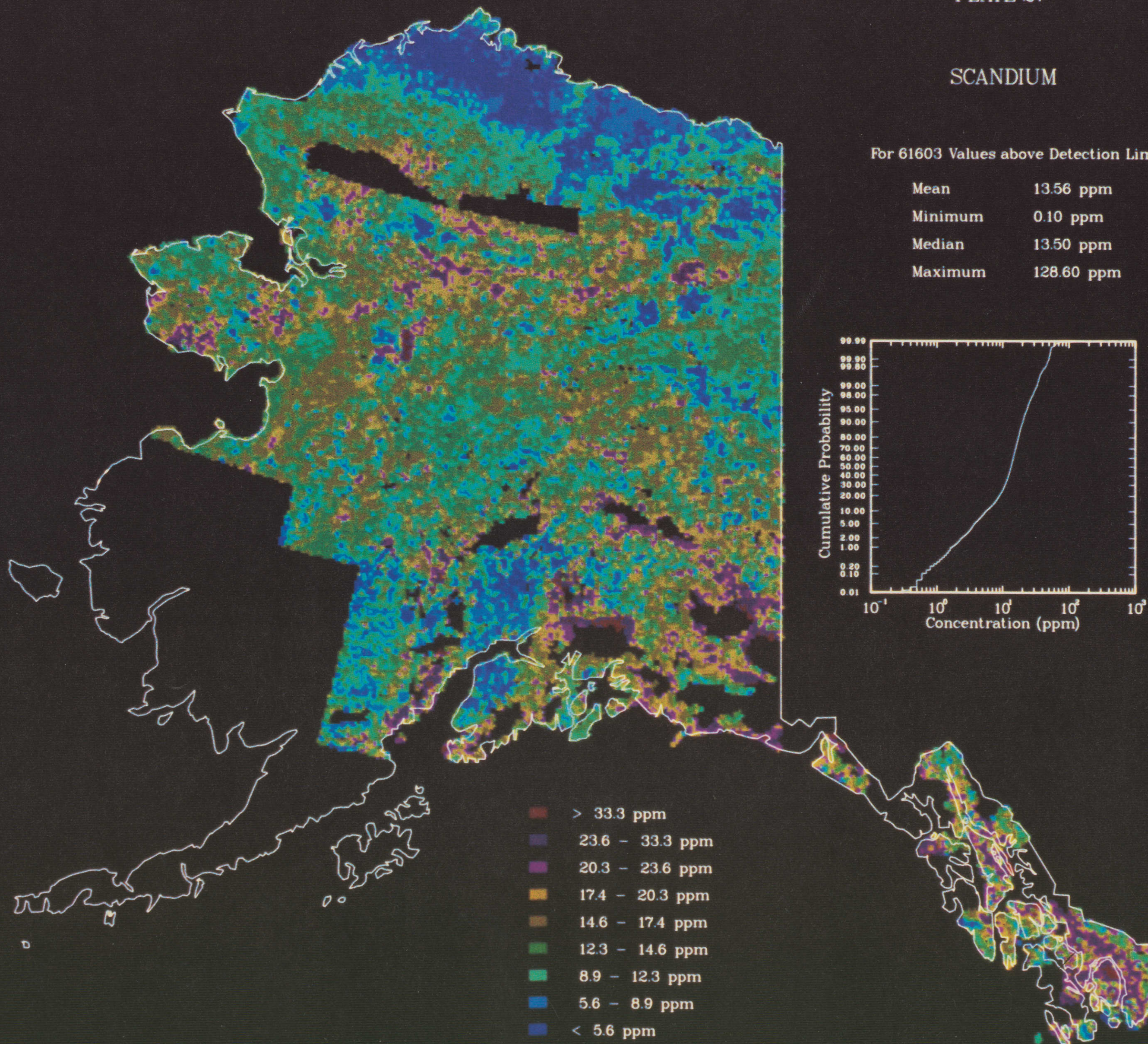
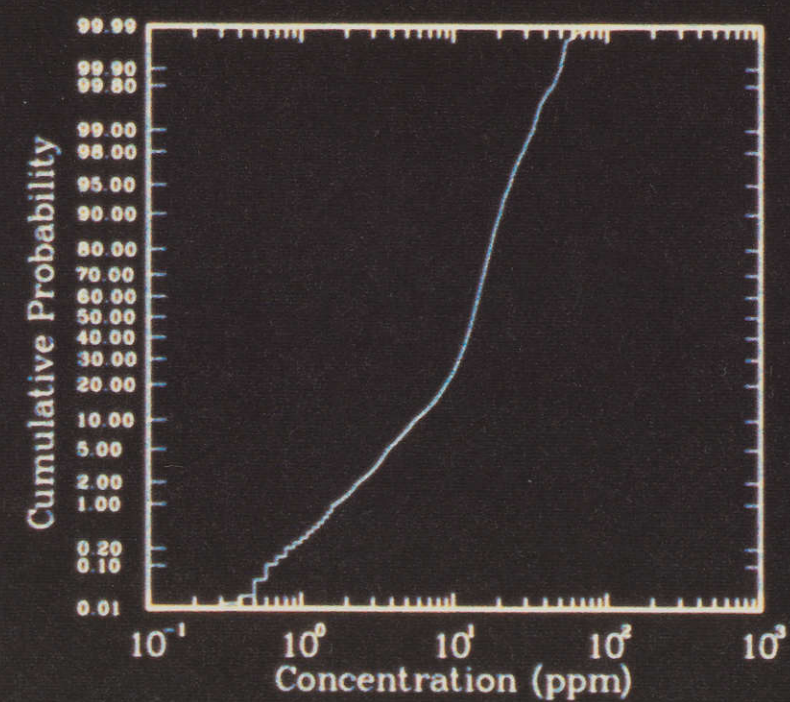
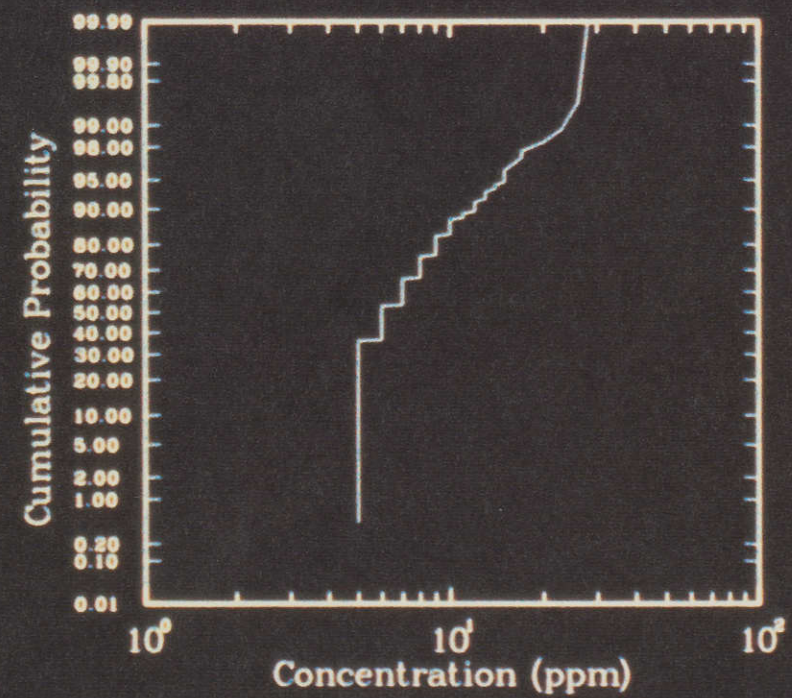


PLATE 28

SELENIUM

For 171 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 7.57 ppm |
| Minimum | 5.00 ppm |
| Median | 6.00 ppm |
| Maximum | 28.00 ppm |



Numeric averaging, instead of kriging, was used for this element (see p. 4).

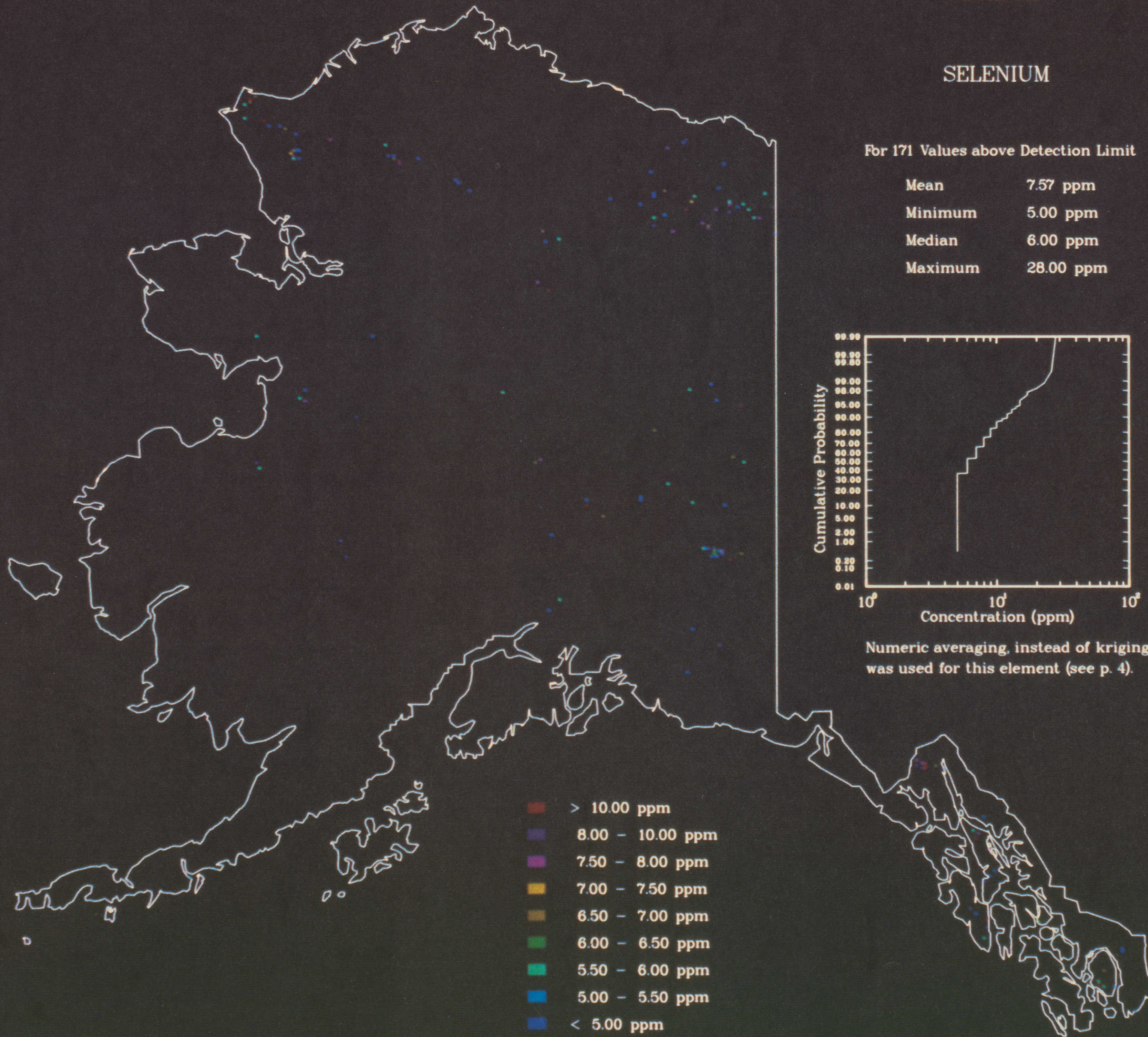
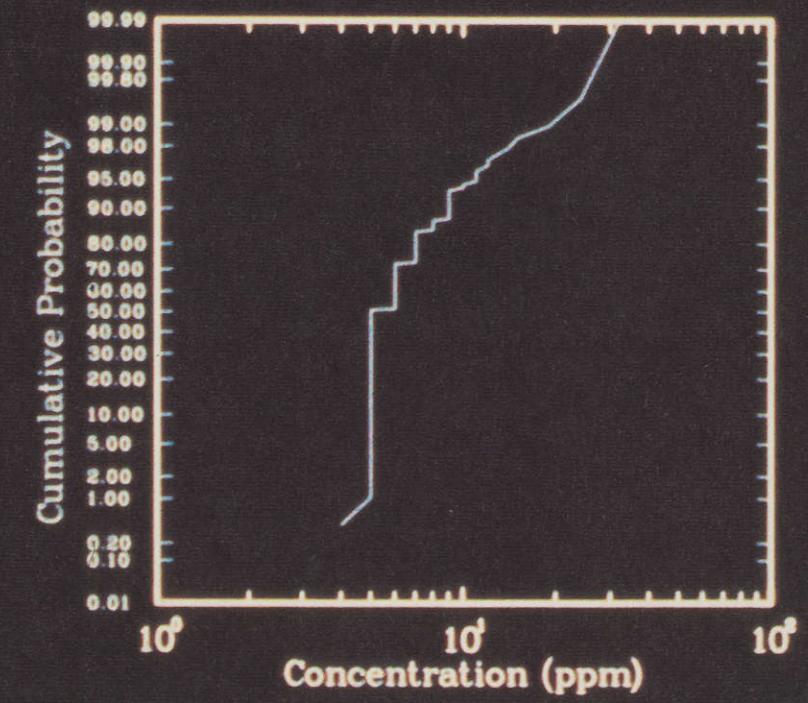


PLATE 29

SILVER

For 187 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 6.48 ppm |
| Minimum | 4.00 ppm |
| Median | 5.00 ppm |
| Maximum | 32.00 ppm |



Numeric averaging, instead of kriging, was used for this element (see p. 4).

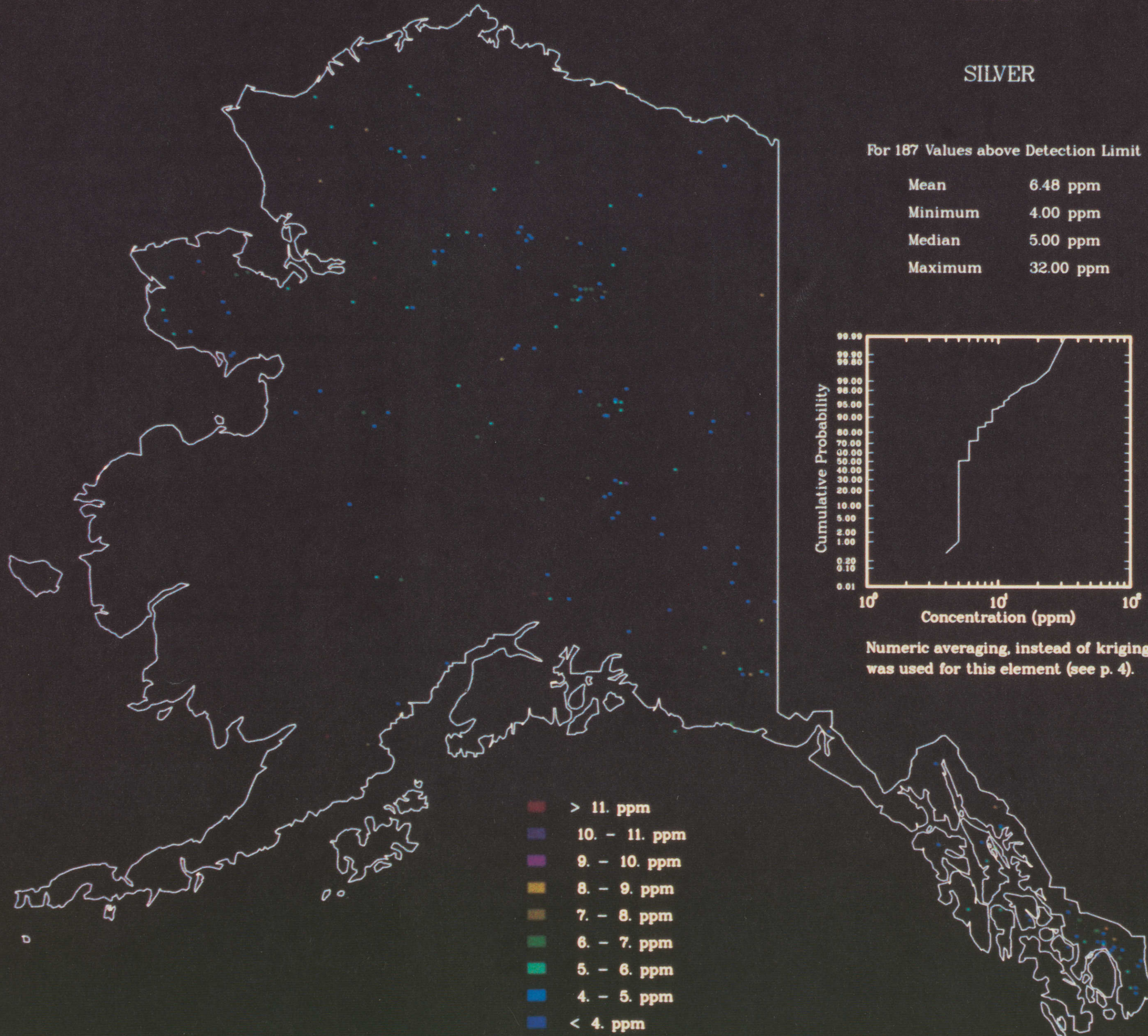
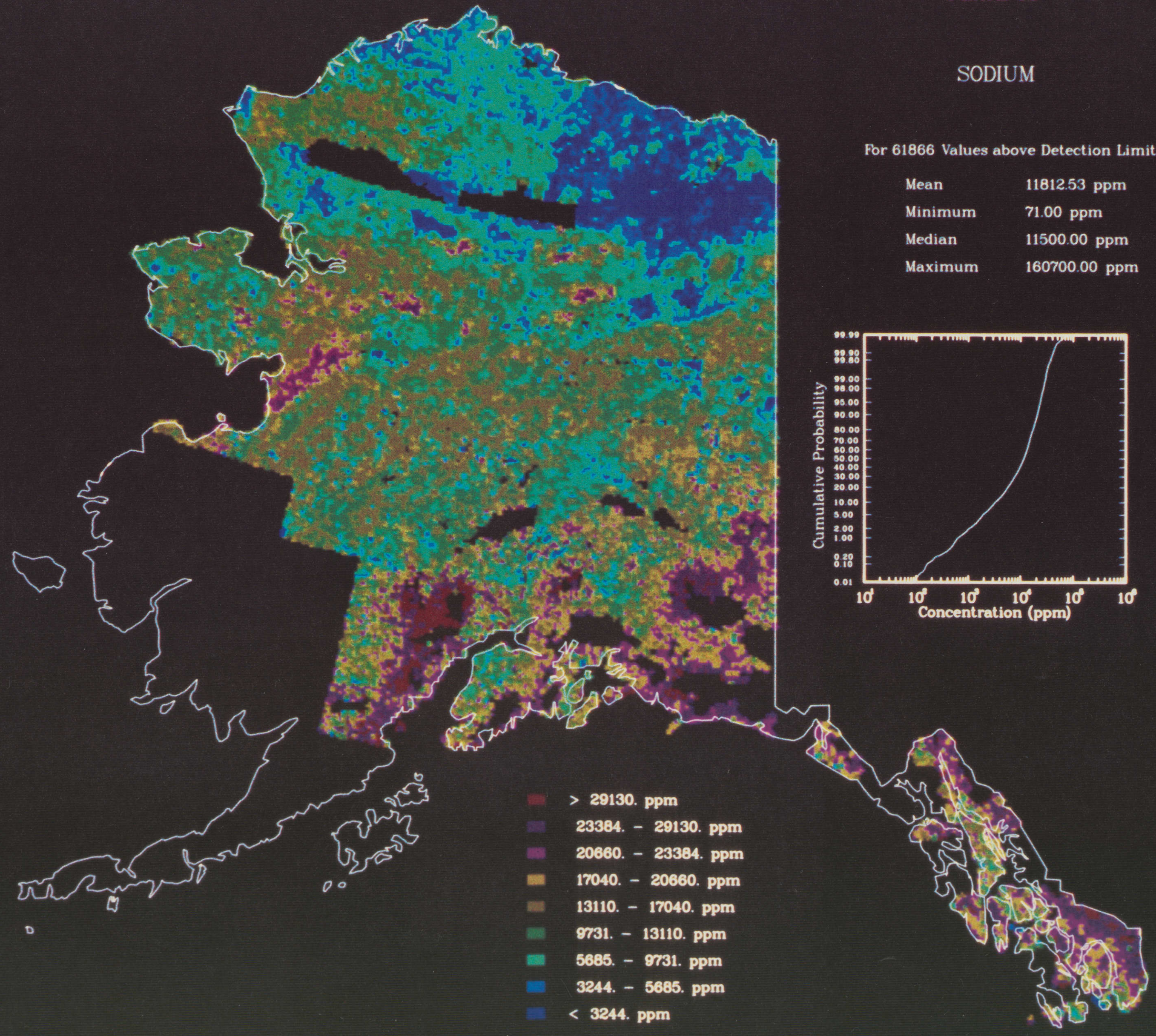
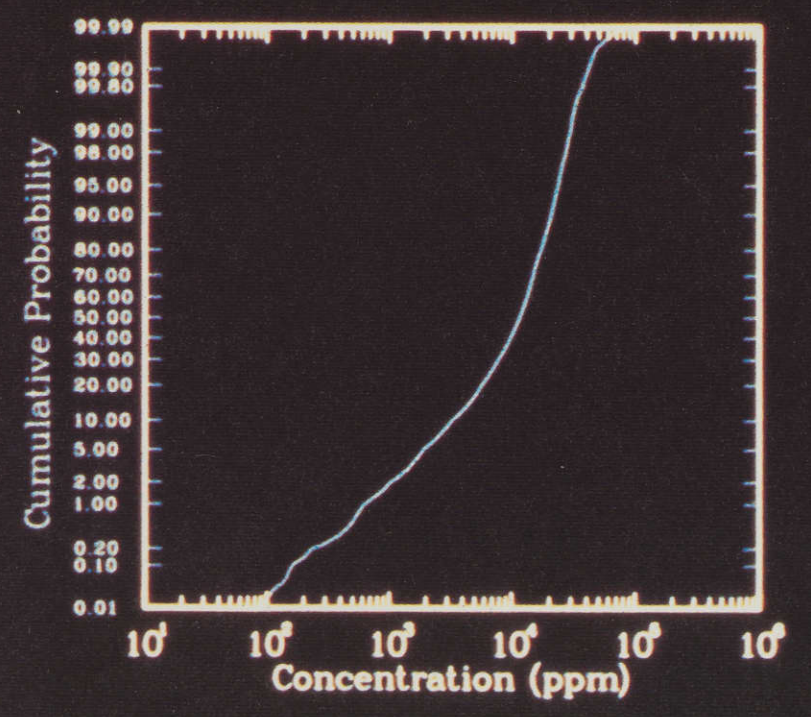


PLATE 30

SODIUM

For 61866 Values above Detection Limit

| | |
|---------|---------------|
| Mean | 11812.53 ppm |
| Minimum | 71.00 ppm |
| Median | 11500.00 ppm |
| Maximum | 160700.00 ppm |



- > 29130. ppm
- 23384. - 29130. ppm
- 20660. - 23384. ppm
- 17040. - 20660. ppm
- 13110. - 17040. ppm
- 9731. - 13110. ppm
- 5685. - 9731. ppm
- 3244. - 5685. ppm
- < 3244. ppm

PLATE 31

STRONTIUM

For 3598 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 489.31 ppm |
| Minimum | 40.00 ppm |
| Median | 455.00 ppm |
| Maximum | 5478.00 ppm |

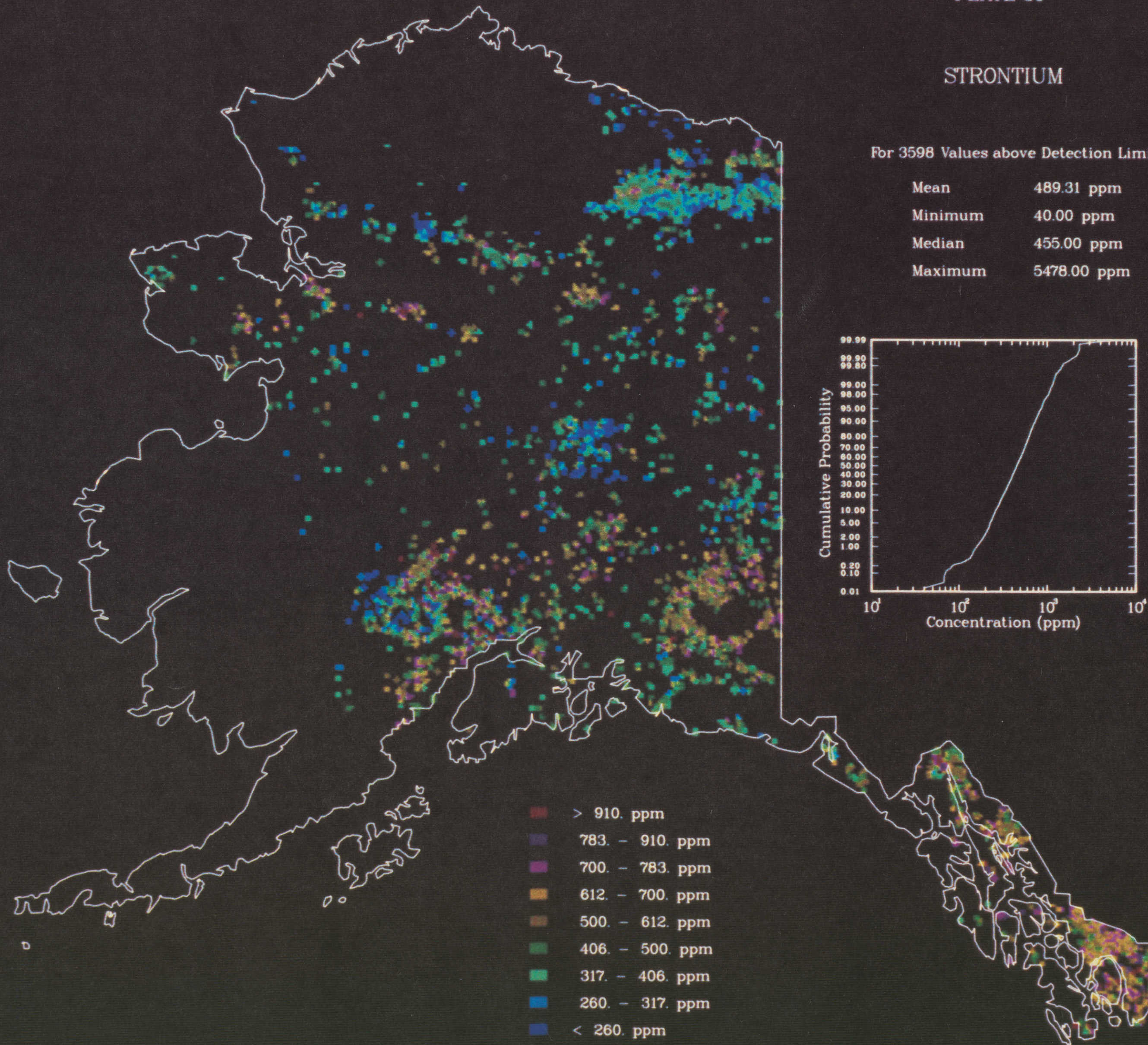
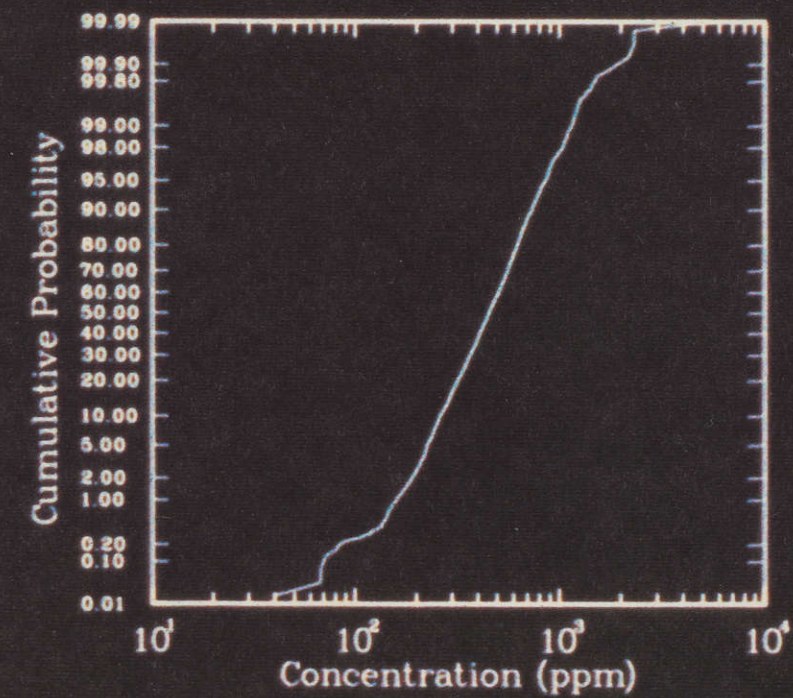
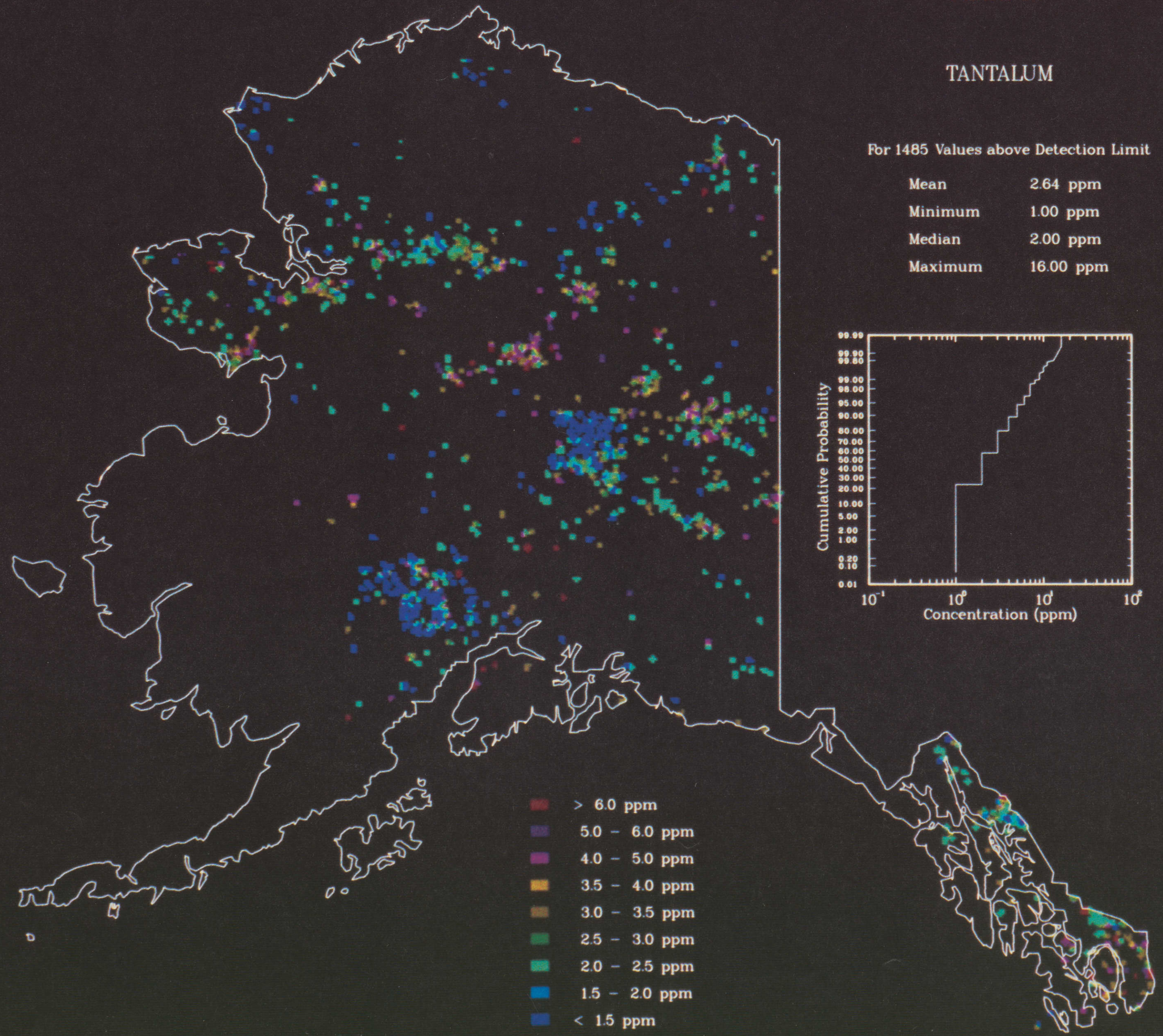
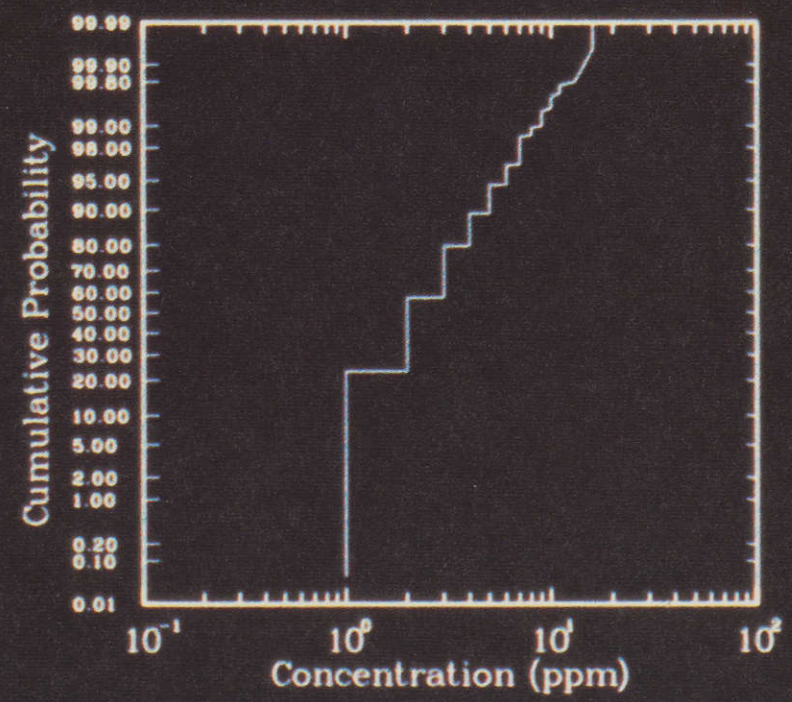


PLATE 32

TANTALUM

For 1485 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 2.64 ppm |
| Minimum | 1.00 ppm |
| Median | 2.00 ppm |
| Maximum | 16.00 ppm |



- > 6.0 ppm
- 5.0 - 6.0 ppm
- 4.0 - 5.0 ppm
- 3.5 - 4.0 ppm
- 3.0 - 3.5 ppm
- 2.5 - 3.0 ppm
- 2.0 - 2.5 ppm
- 1.5 - 2.0 ppm
- < 1.5 ppm

PLATE 33

TERBIUM

For 2952 Values above Detection Limit

| | |
|---------|-----------|
| Mean | 1.36 ppm |
| Minimum | 1.00 ppm |
| Median | 1.00 ppm |
| Maximum | 12.00 ppm |

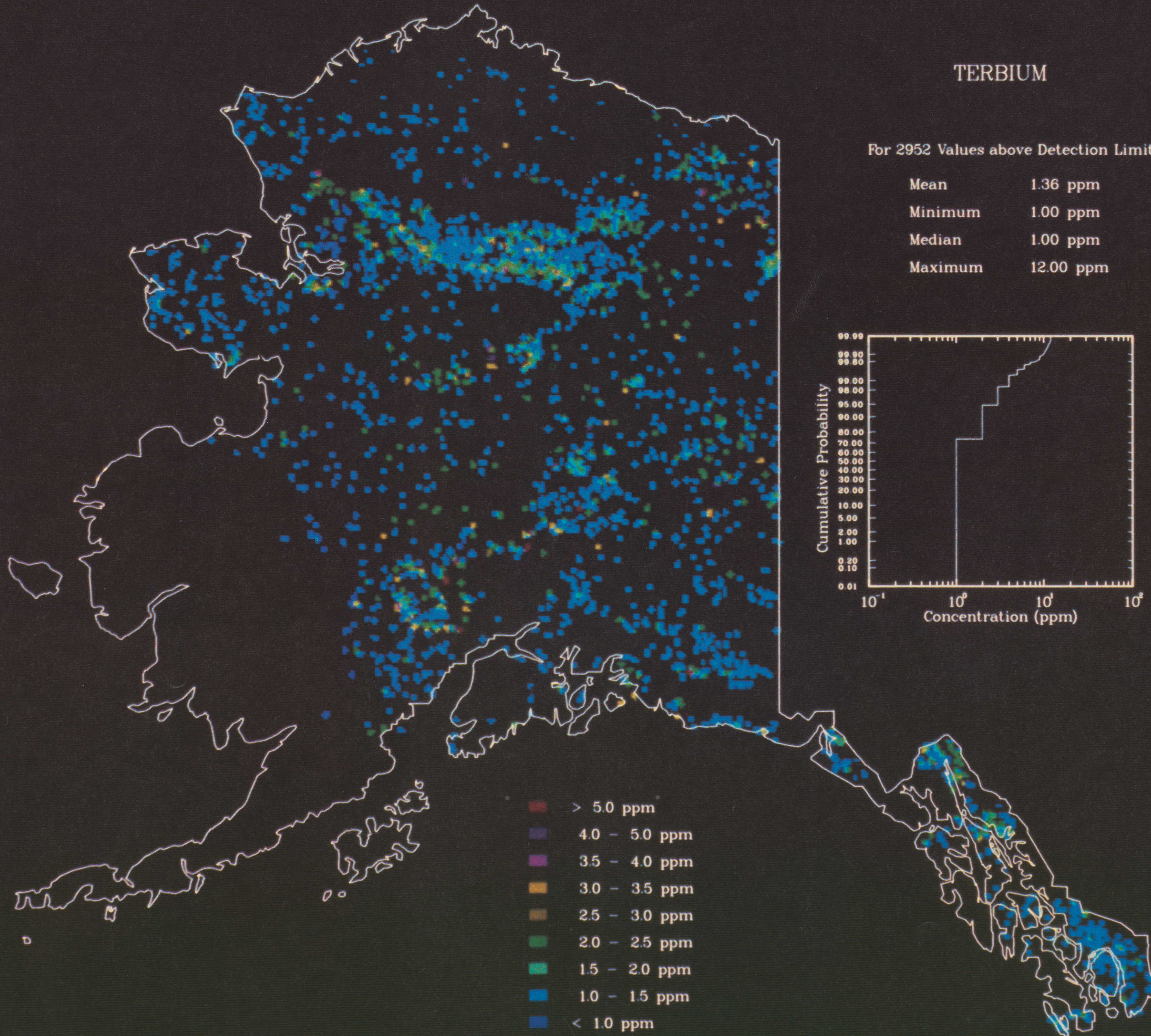
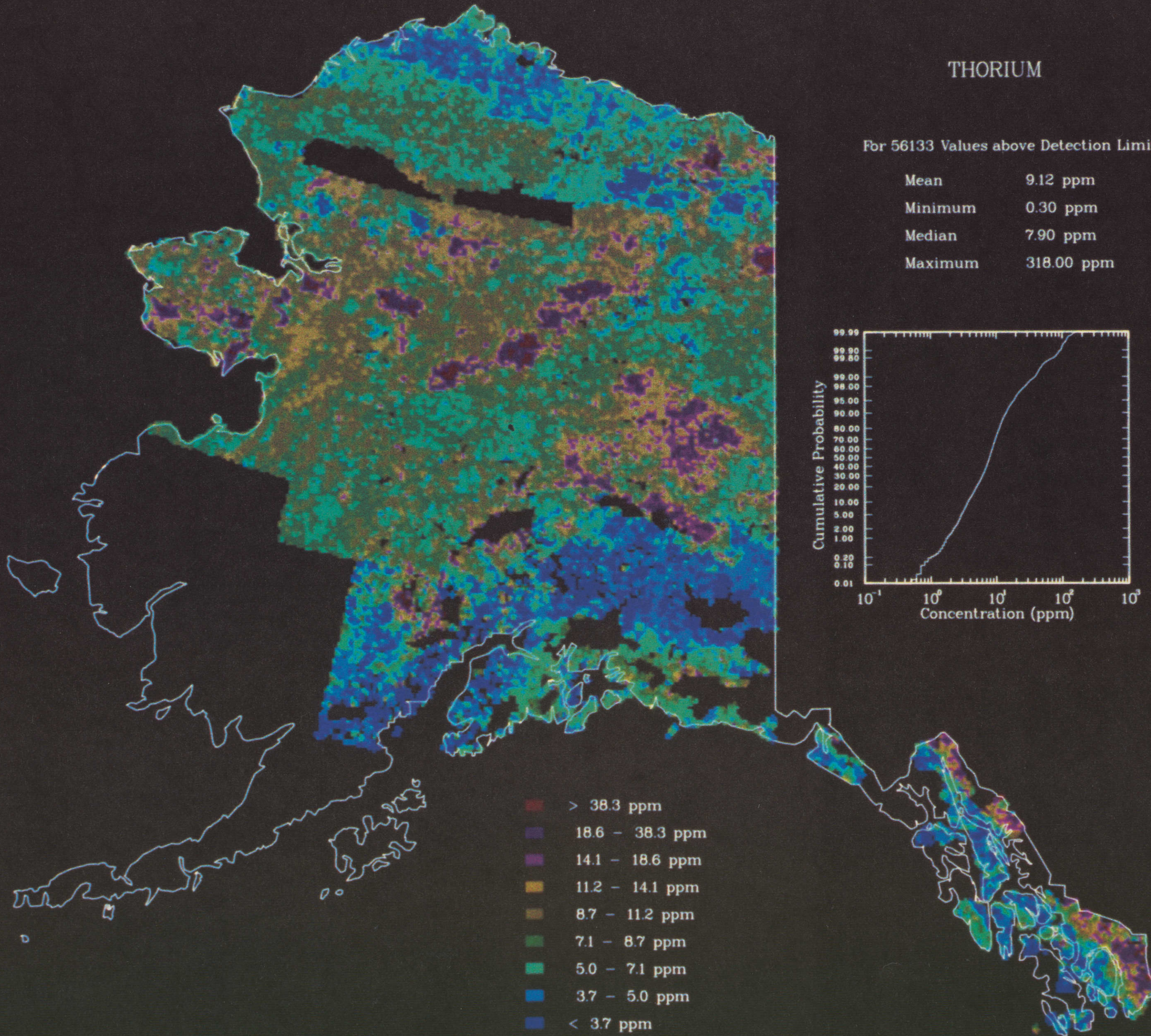
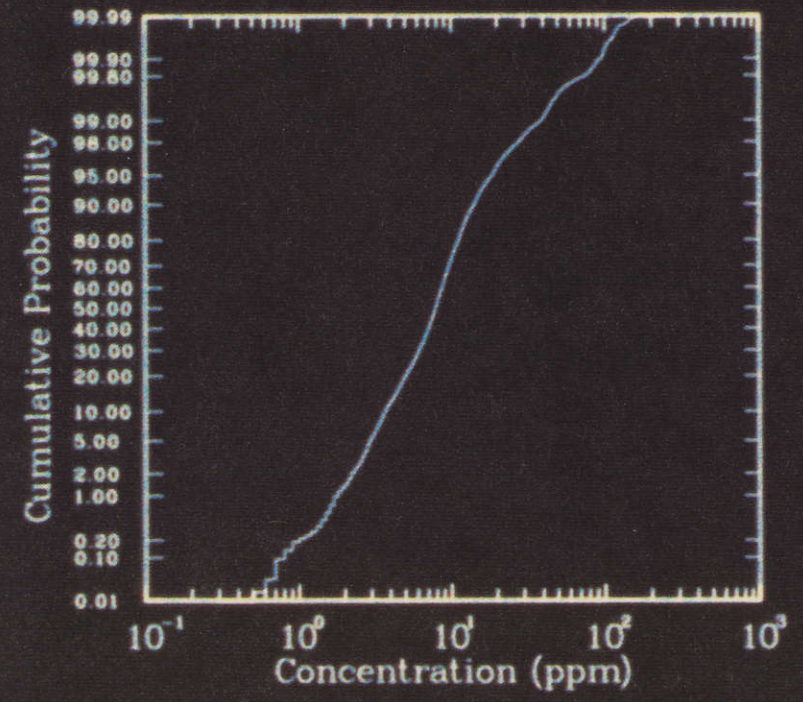


PLATE 34

THORIUM

For 56133 Values above Detection Limit

| | |
|---------|------------|
| Mean | 9.12 ppm |
| Minimum | 0.30 ppm |
| Median | 7.90 ppm |
| Maximum | 318.00 ppm |



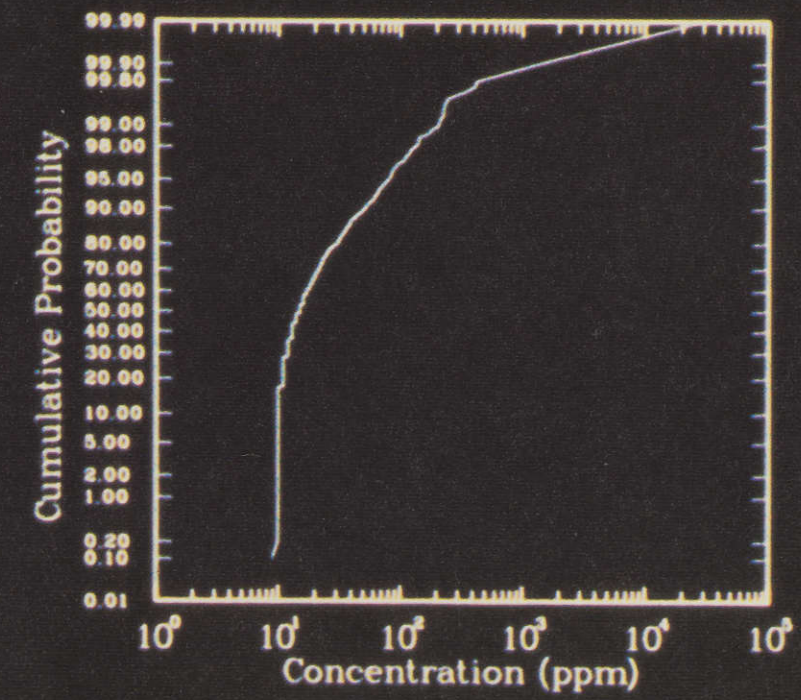
- > 38.3 ppm
- 18.6 - 38.3 ppm
- 14.1 - 18.6 ppm
- 11.2 - 14.1 ppm
- 8.7 - 11.2 ppm
- 7.1 - 8.7 ppm
- 5.0 - 7.1 ppm
- 3.7 - 5.0 ppm
- < 3.7 ppm

PLATE 35

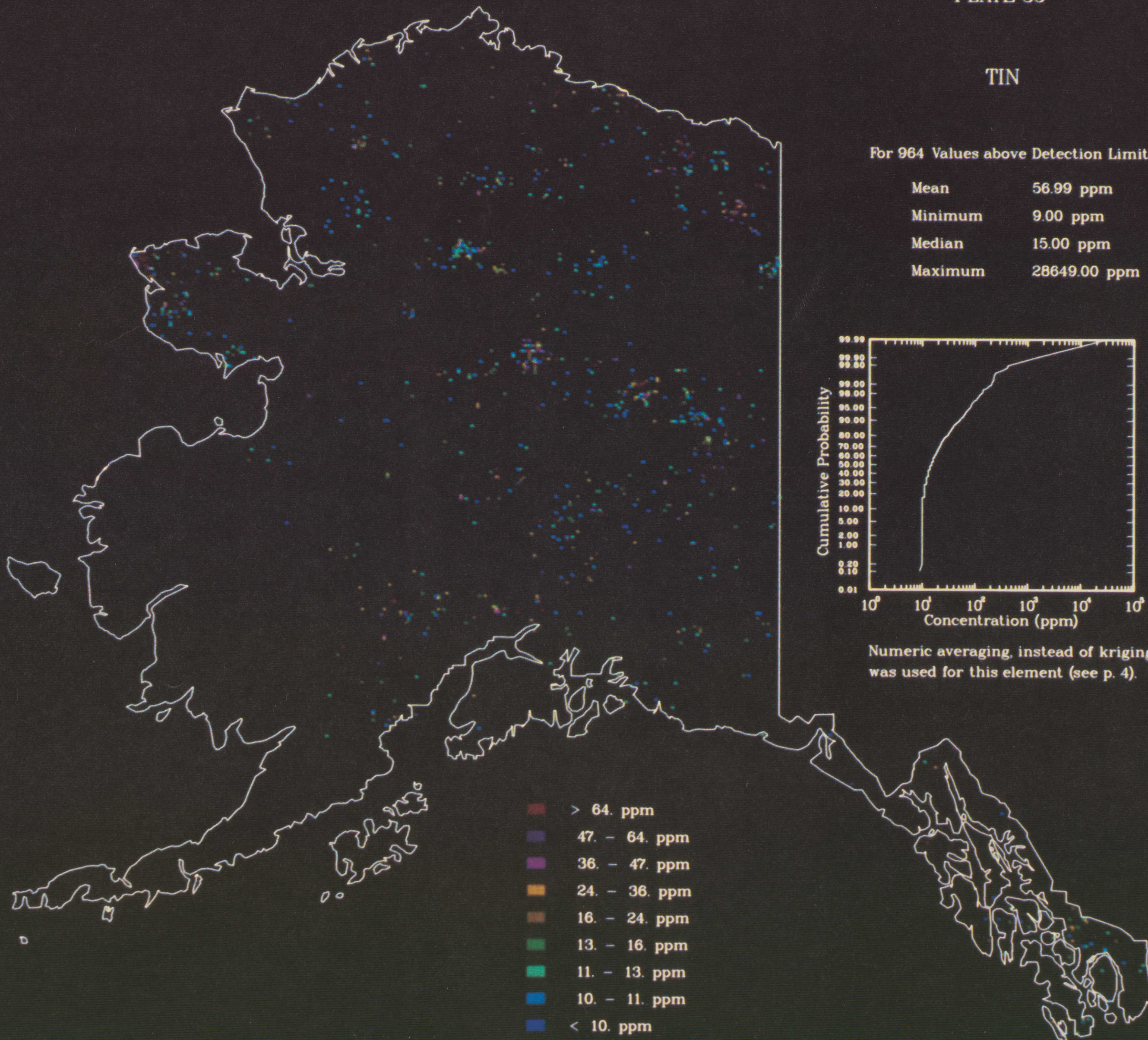
TIN

For 964 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 56.99 ppm |
| Minimum | 9.00 ppm |
| Median | 15.00 ppm |
| Maximum | 28649.00 ppm |



Numeric averaging, instead of kriging, was used for this element (see p. 4).



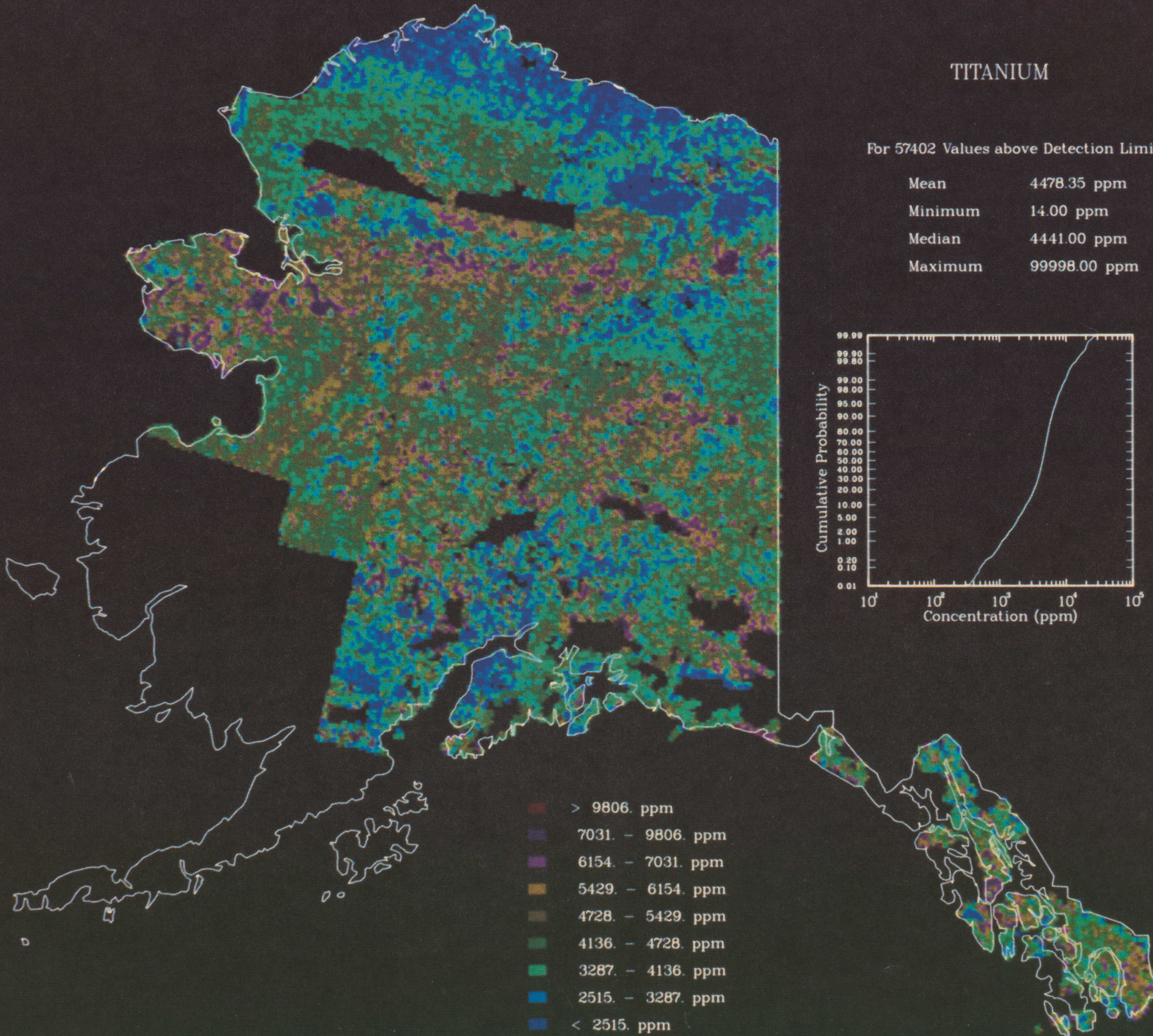
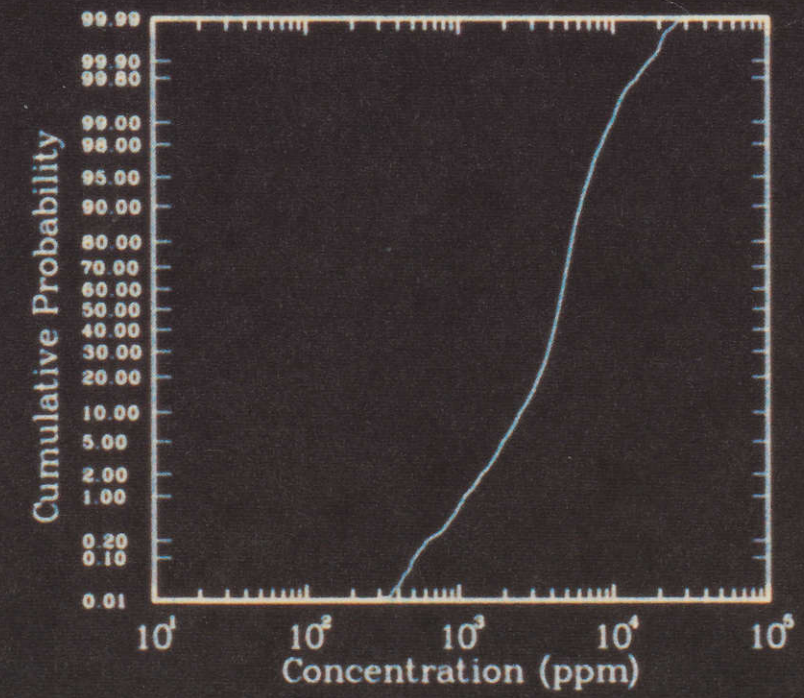
- > 64. ppm
- 47. - 64. ppm
- 36. - 47. ppm
- 24. - 36. ppm
- 16. - 24. ppm
- 13. - 16. ppm
- 11. - 13. ppm
- 10. - 11. ppm
- < 10. ppm

PLATE 36

TITANIUM

For 57402 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 4478.35 ppm |
| Minimum | 14.00 ppm |
| Median | 4441.00 ppm |
| Maximum | 99998.00 ppm |



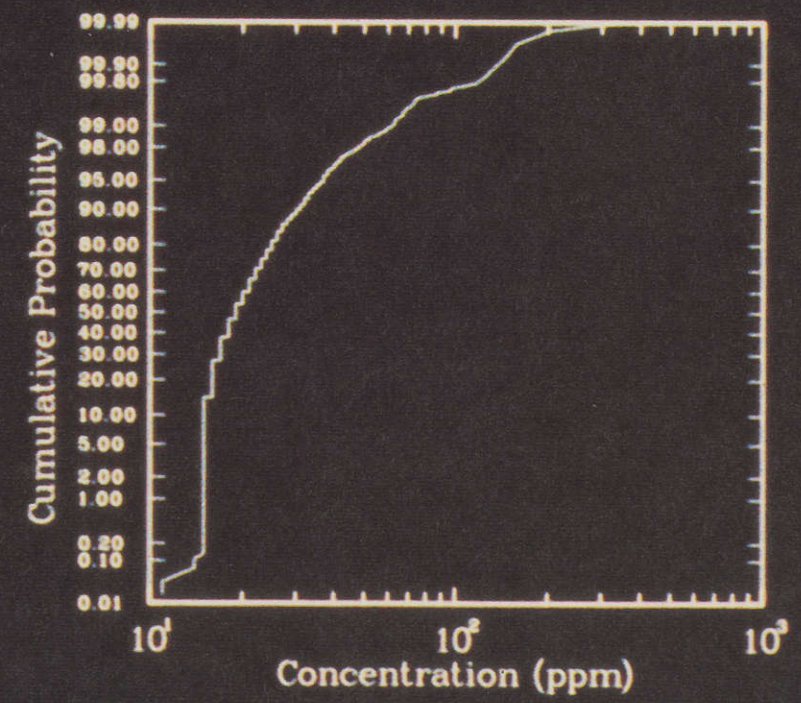
- > 9806. ppm
- 7031. - 9806. ppm
- 6154. - 7031. ppm
- 5429. - 6154. ppm
- 4728. - 5429. ppm
- 4136. - 4728. ppm
- 3287. - 4136. ppm
- 2515. - 3287. ppm
- < 2515. ppm

PLATE 37

TUNGSTEN

For 3569 Values above Detection Limit

| | |
|---------|------------|
| Mean | 21.84 ppm |
| Minimum | 11.00 ppm |
| Median | 19.00 ppm |
| Maximum | 338.00 ppm |



Numeric averaging, instead of kriging, was used for this element (see p. 4).

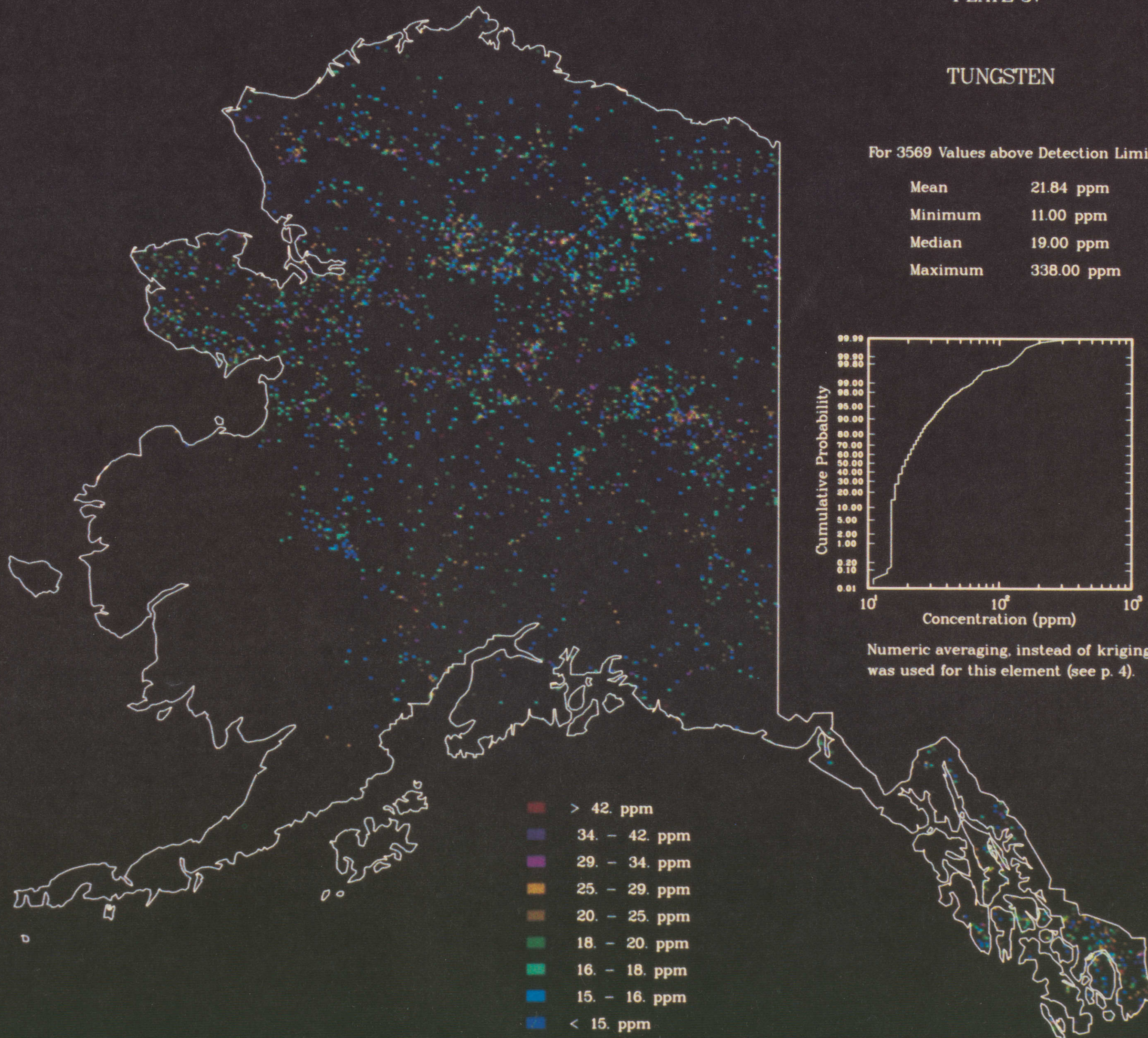
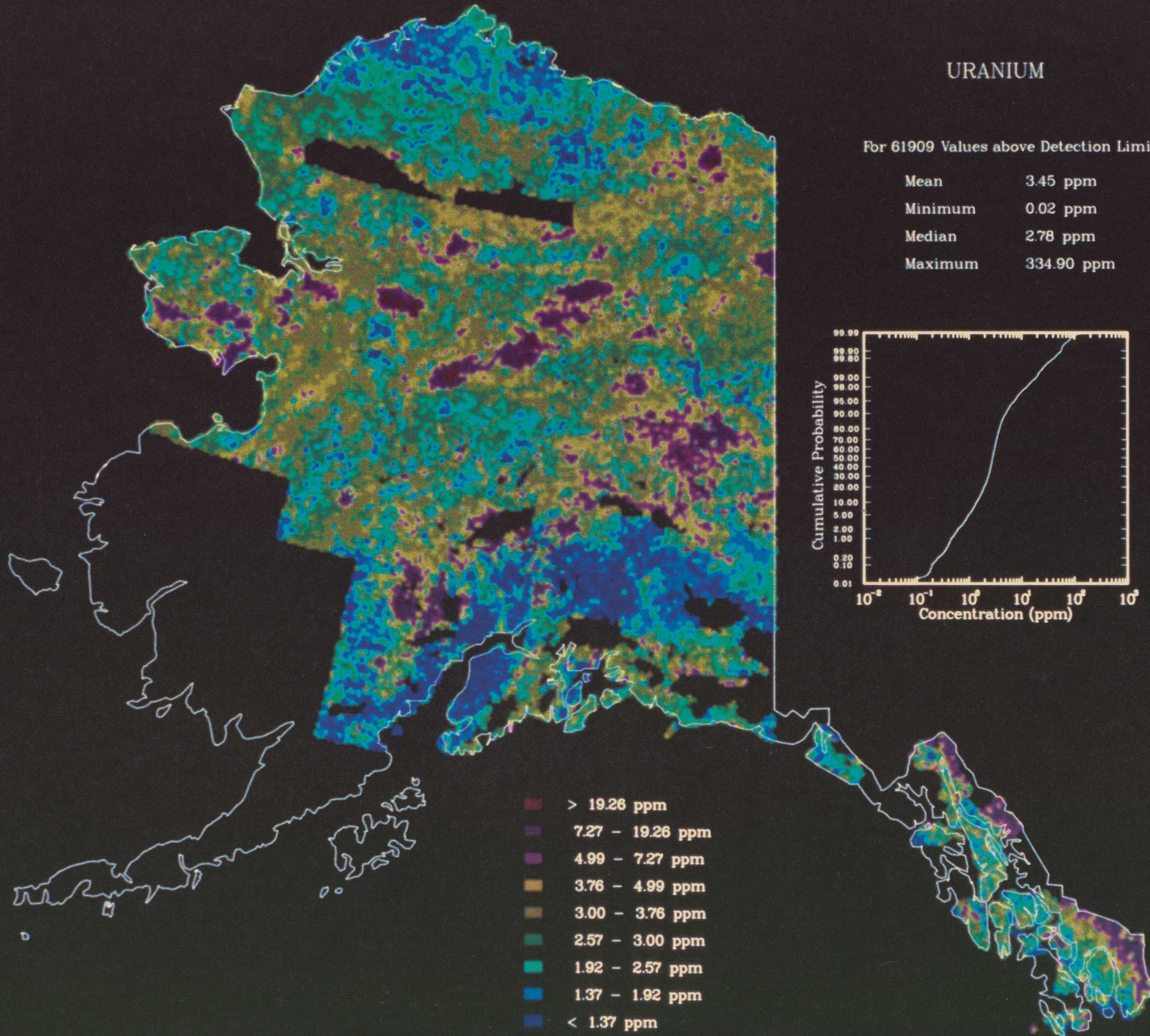
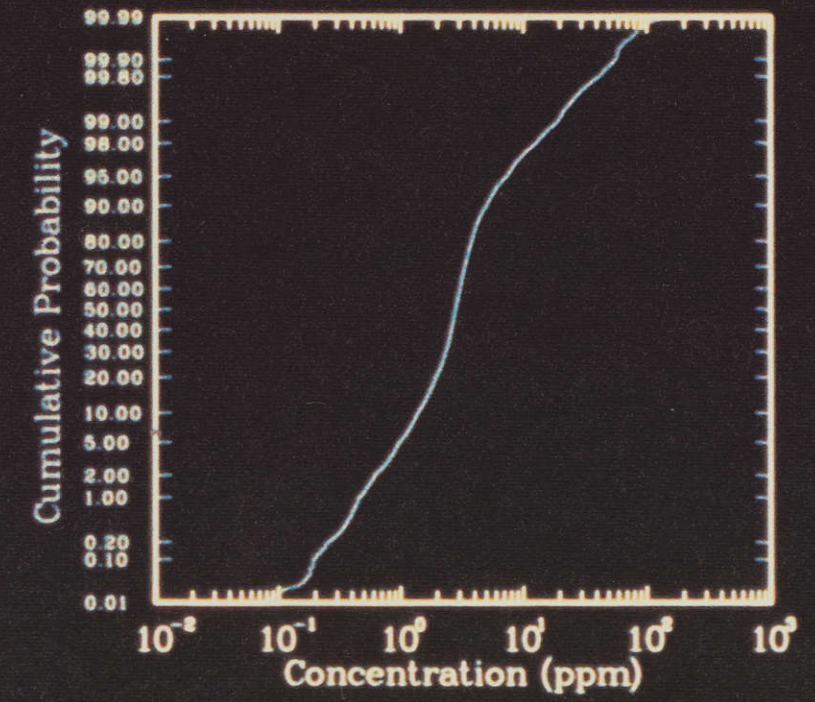


PLATE 38

URANIUM

For 61909 Values above Detection Limit

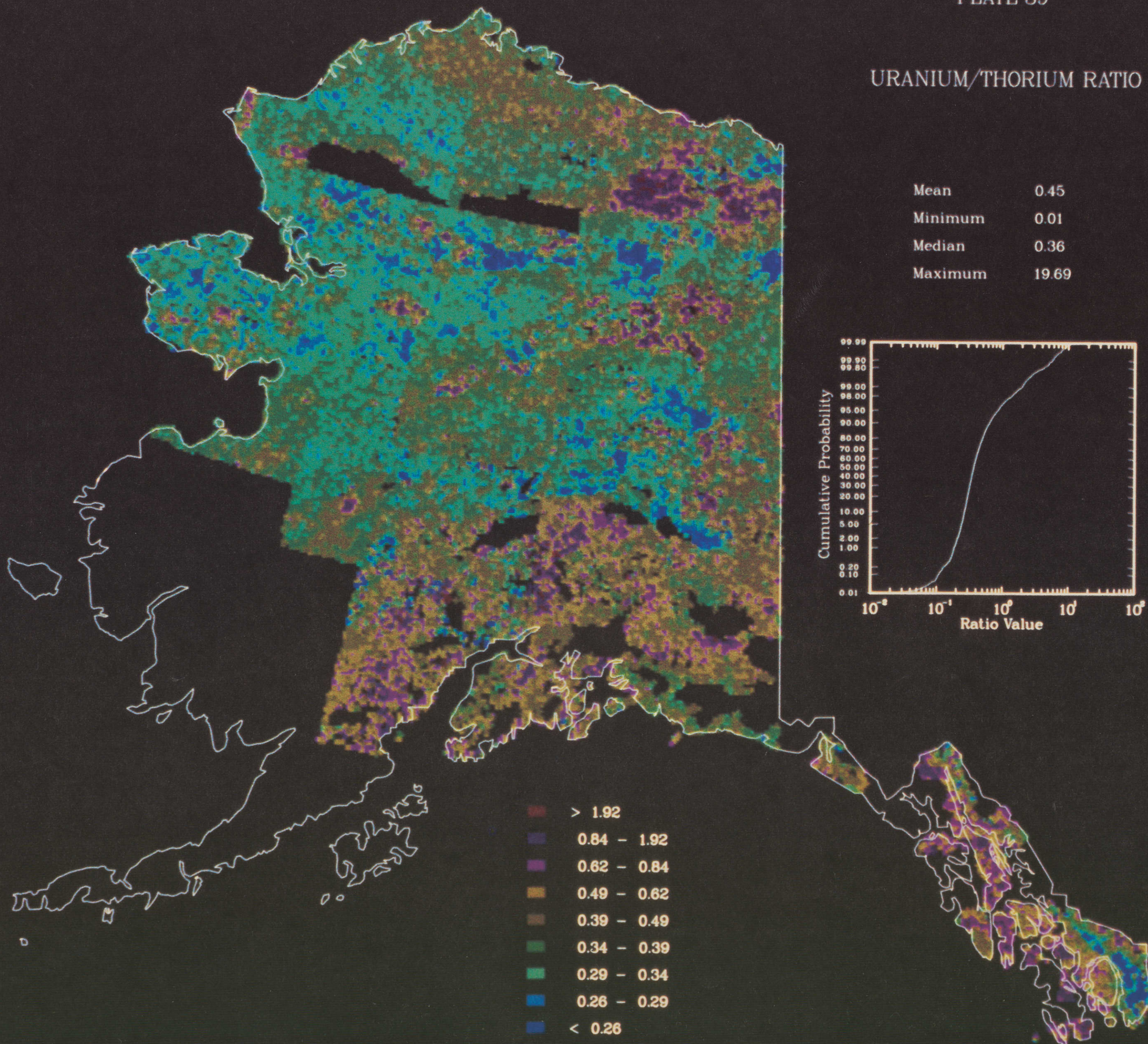
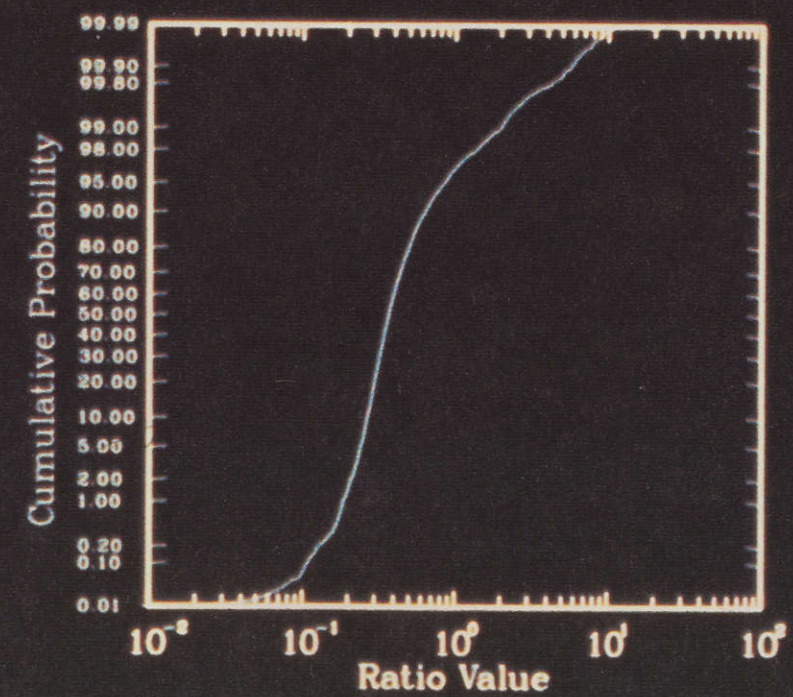
| | |
|---------|------------|
| Mean | 3.45 ppm |
| Minimum | 0.02 ppm |
| Median | 2.78 ppm |
| Maximum | 334.90 ppm |



- > 19.26 ppm
- 7.27 - 19.26 ppm
- 4.99 - 7.27 ppm
- 3.76 - 4.99 ppm
- 3.00 - 3.76 ppm
- 2.57 - 3.00 ppm
- 1.92 - 2.57 ppm
- 1.37 - 1.92 ppm
- < 1.37 ppm

URANIUM/THORIUM RATIO

| | |
|---------|-------|
| Mean | 0.45 |
| Minimum | 0.01 |
| Median | 0.36 |
| Maximum | 19.69 |



- > 1.92
- 0.84 - 1.92
- 0.62 - 0.84
- 0.49 - 0.62
- 0.39 - 0.49
- 0.34 - 0.39
- 0.29 - 0.34
- 0.26 - 0.29
- < 0.26

PLATE 40

VANADIUM

For 60750 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 120.48 ppm |
| Minimum | 2.00 ppm |
| Median | 119.00 ppm |
| Maximum | 2003.00 ppm |

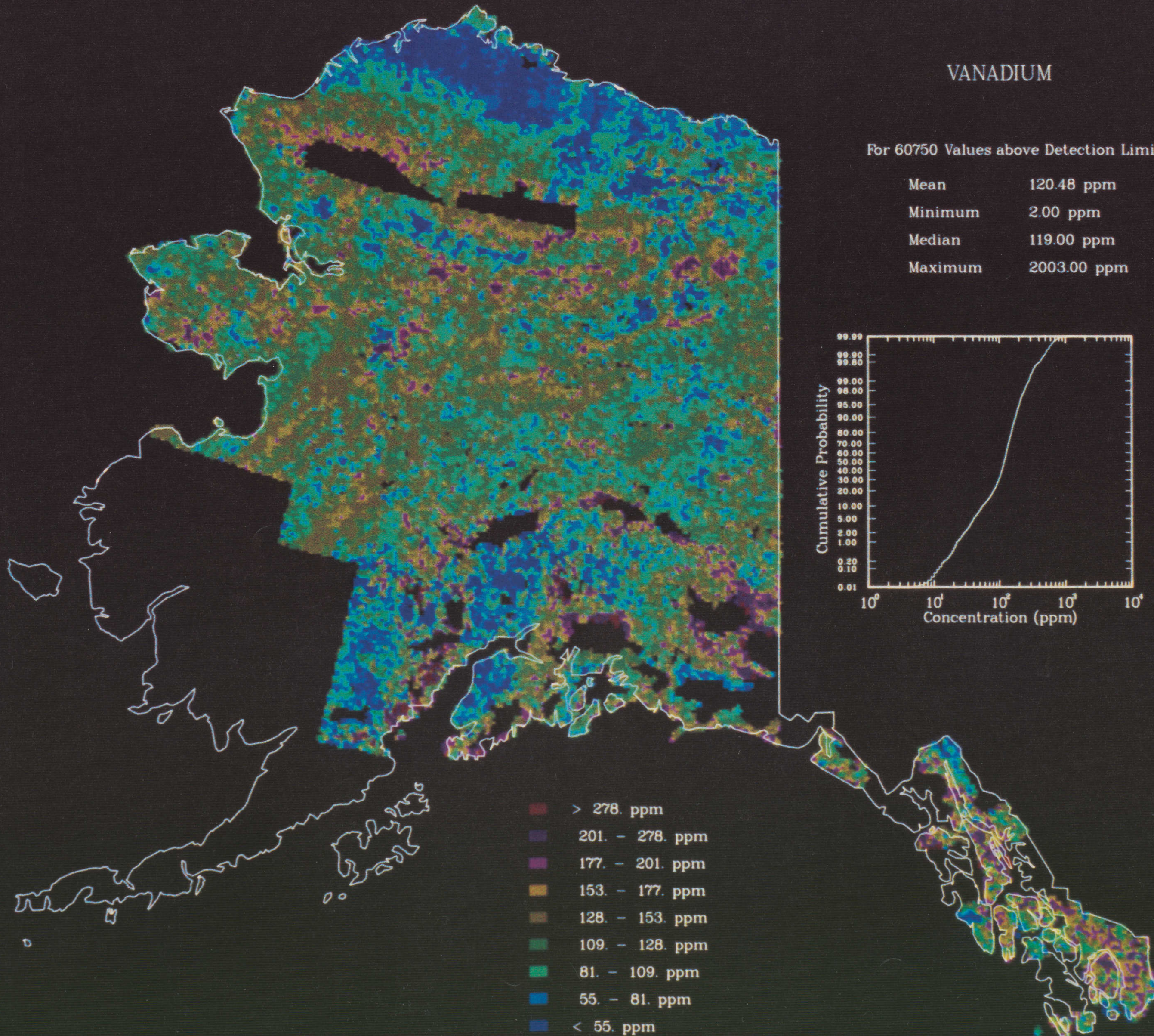
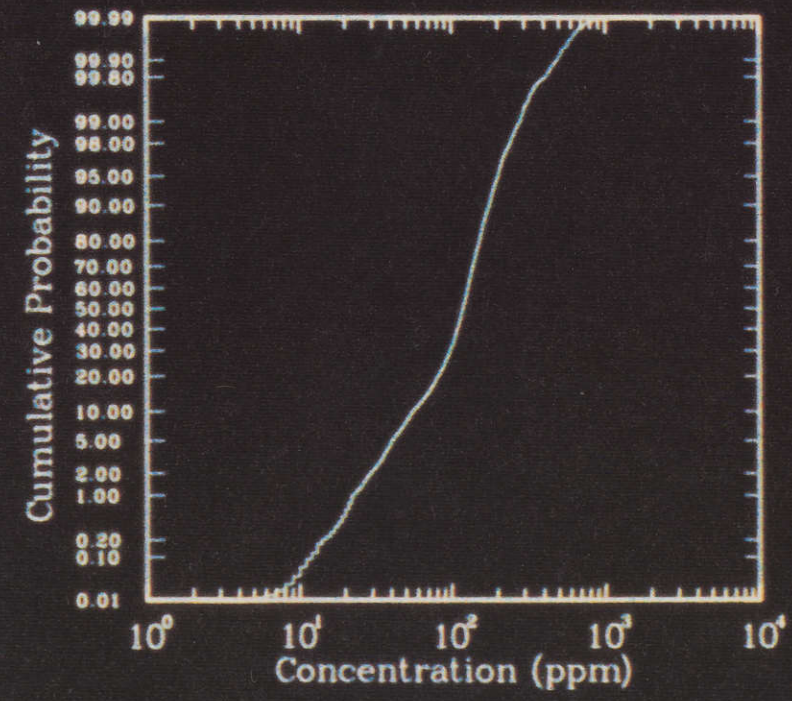
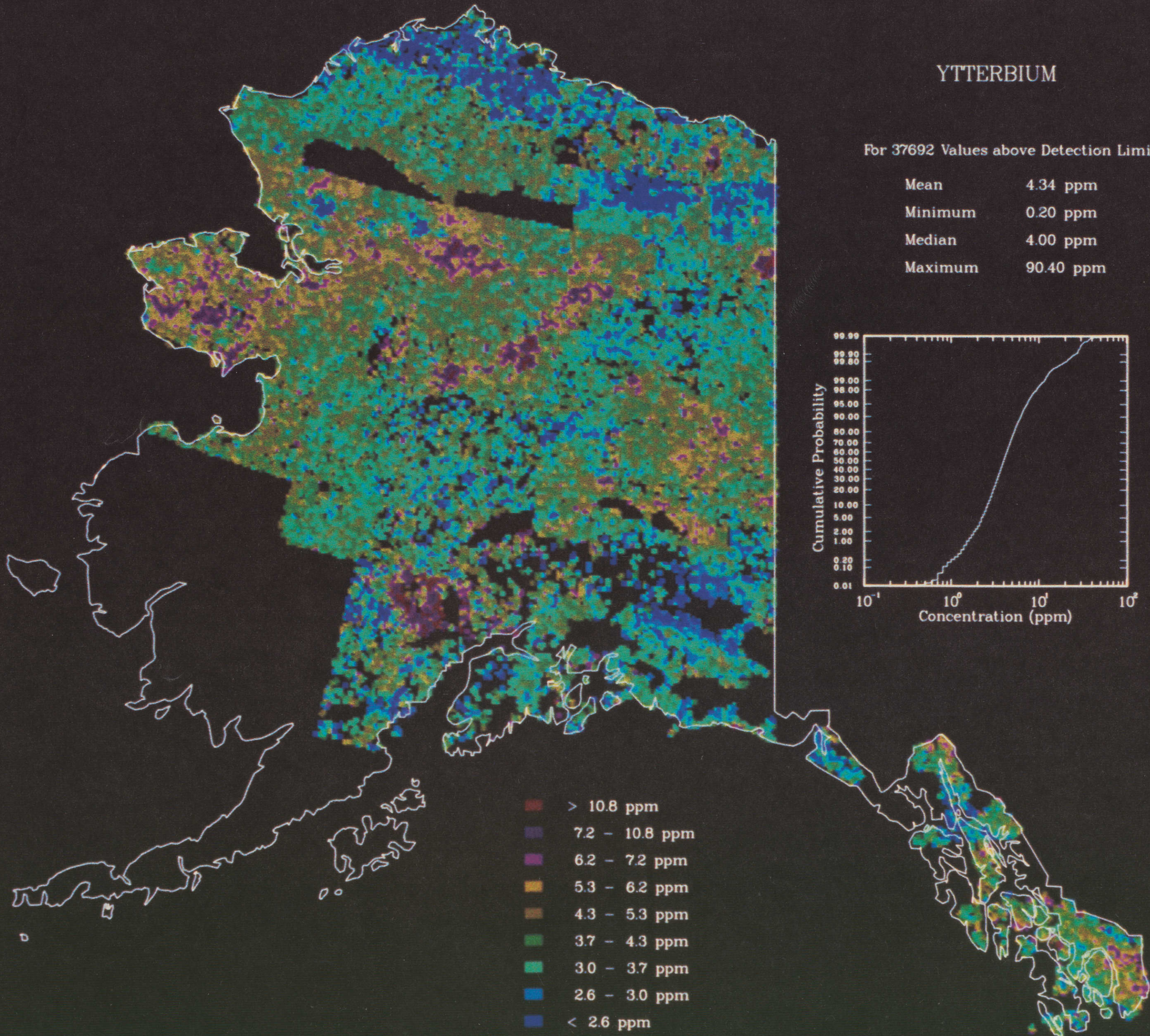


PLATE 41

YTTERBIUM

For 37692 Values above Detection Limit

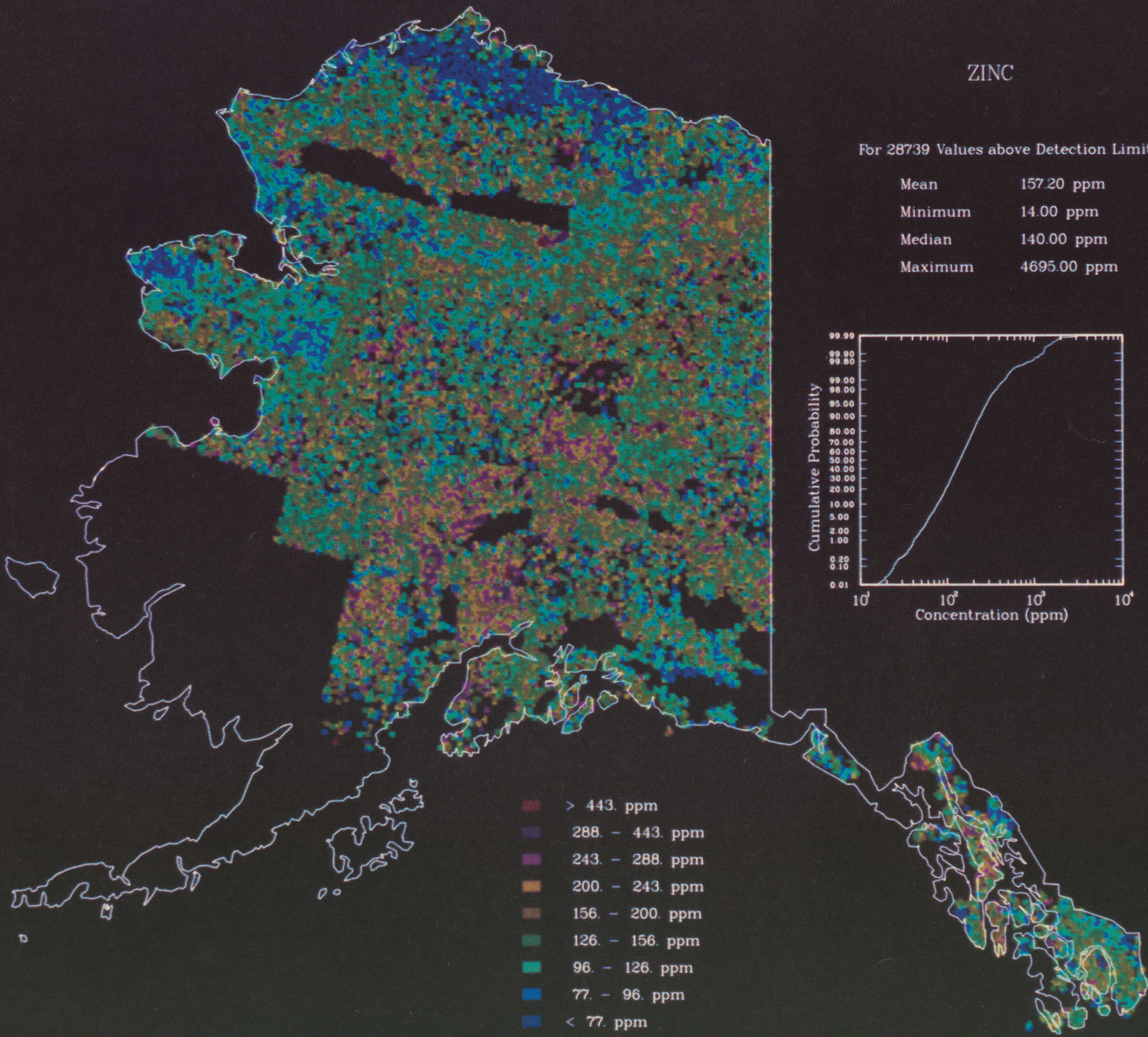
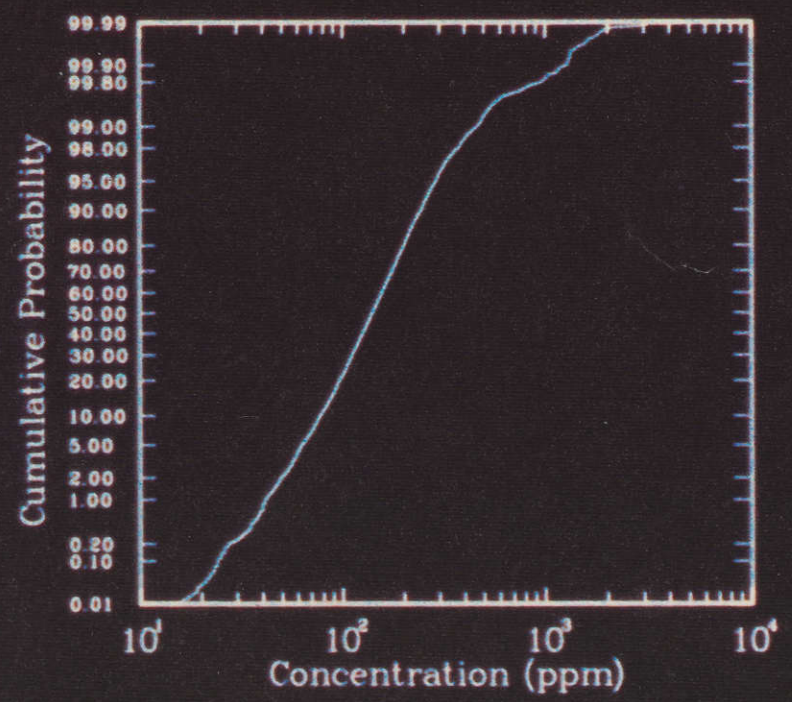
| | |
|---------|-----------|
| Mean | 4.34 ppm |
| Minimum | 0.20 ppm |
| Median | 4.00 ppm |
| Maximum | 90.40 ppm |



ZINC

For 28739 Values above Detection Limit

| | |
|---------|-------------|
| Mean | 157.20 ppm |
| Minimum | 14.00 ppm |
| Median | 140.00 ppm |
| Maximum | 4695.00 ppm |



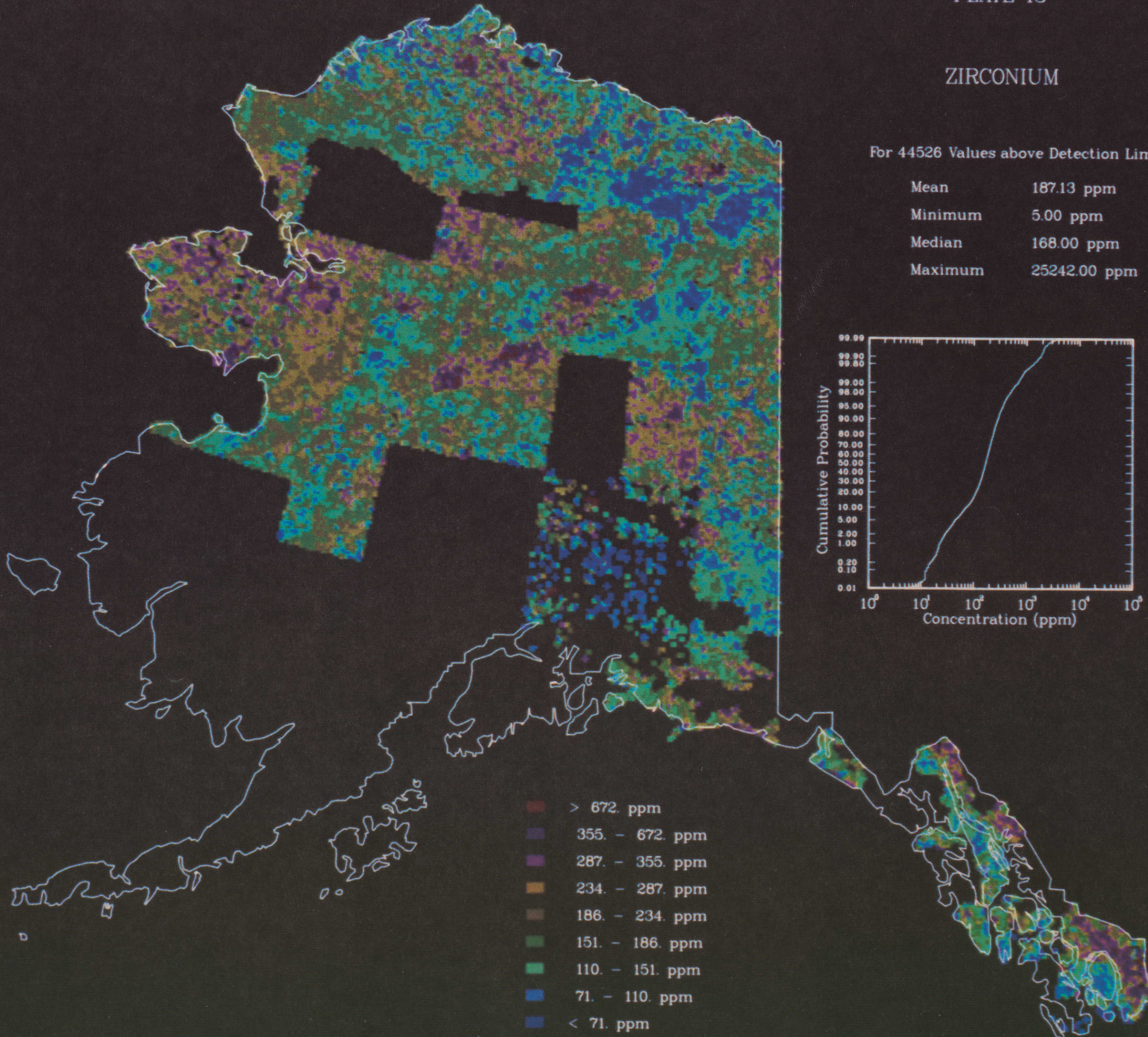
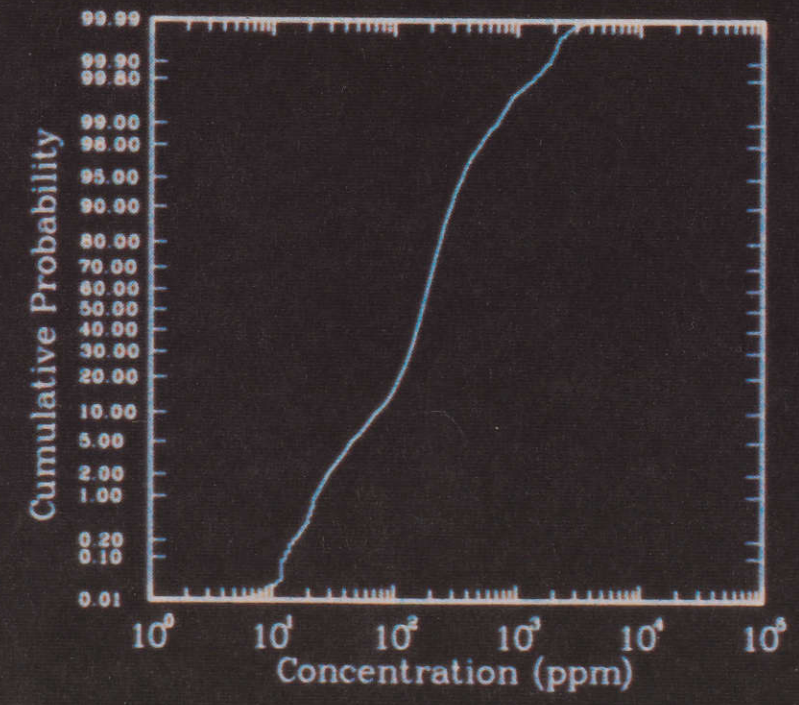
- > 443. ppm
- 288. - 443. ppm
- 243. - 288. ppm
- 200. - 243. ppm
- 156. - 200. ppm
- 126. - 156. ppm
- 96. - 126. ppm
- 77. - 96. ppm
- < 77. ppm

PLATE 43

ZIRCONIUM

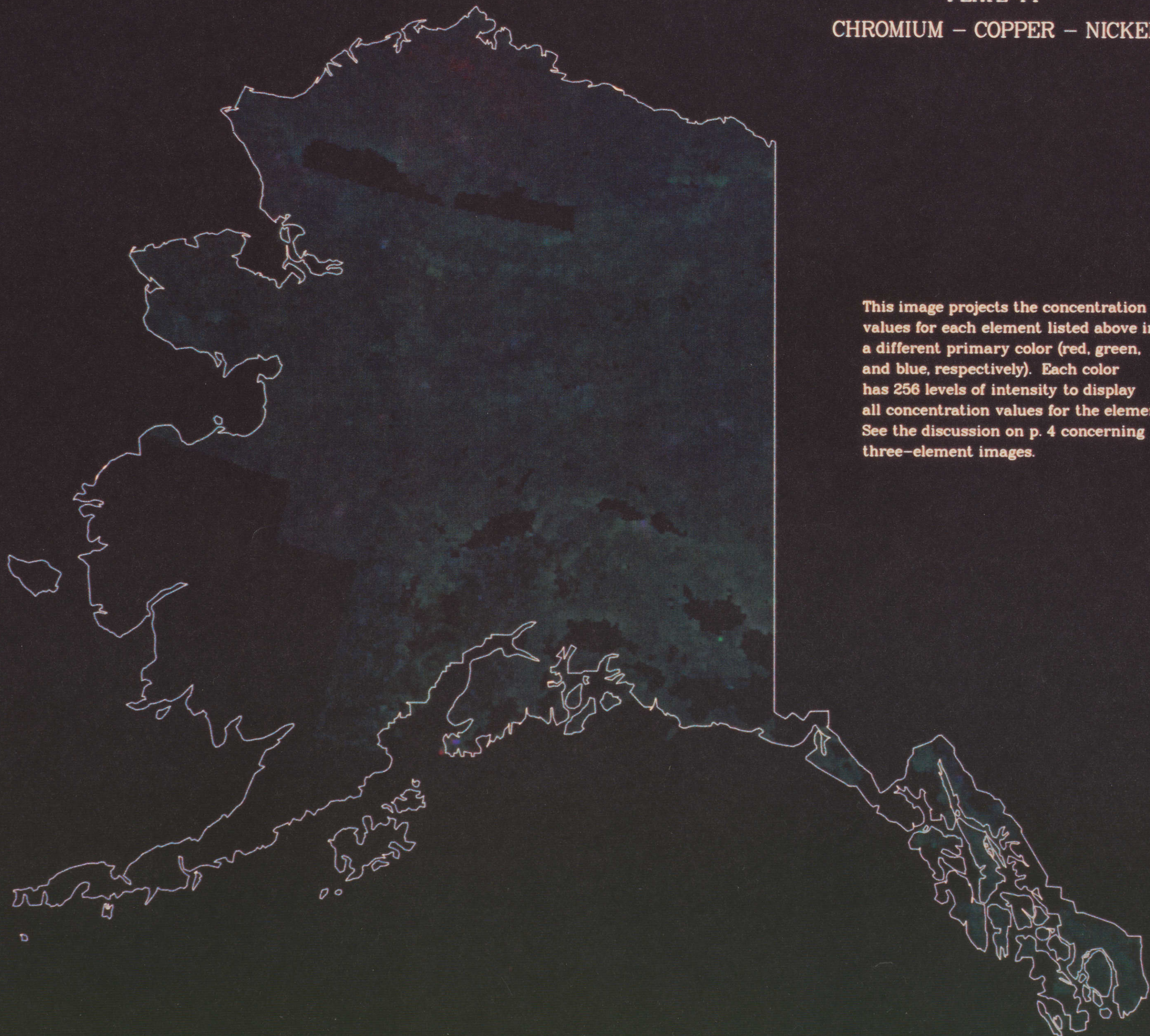
For 44526 Values above Detection Limit

| | |
|---------|--------------|
| Mean | 187.13 ppm |
| Minimum | 5.00 ppm |
| Median | 168.00 ppm |
| Maximum | 25242.00 ppm |



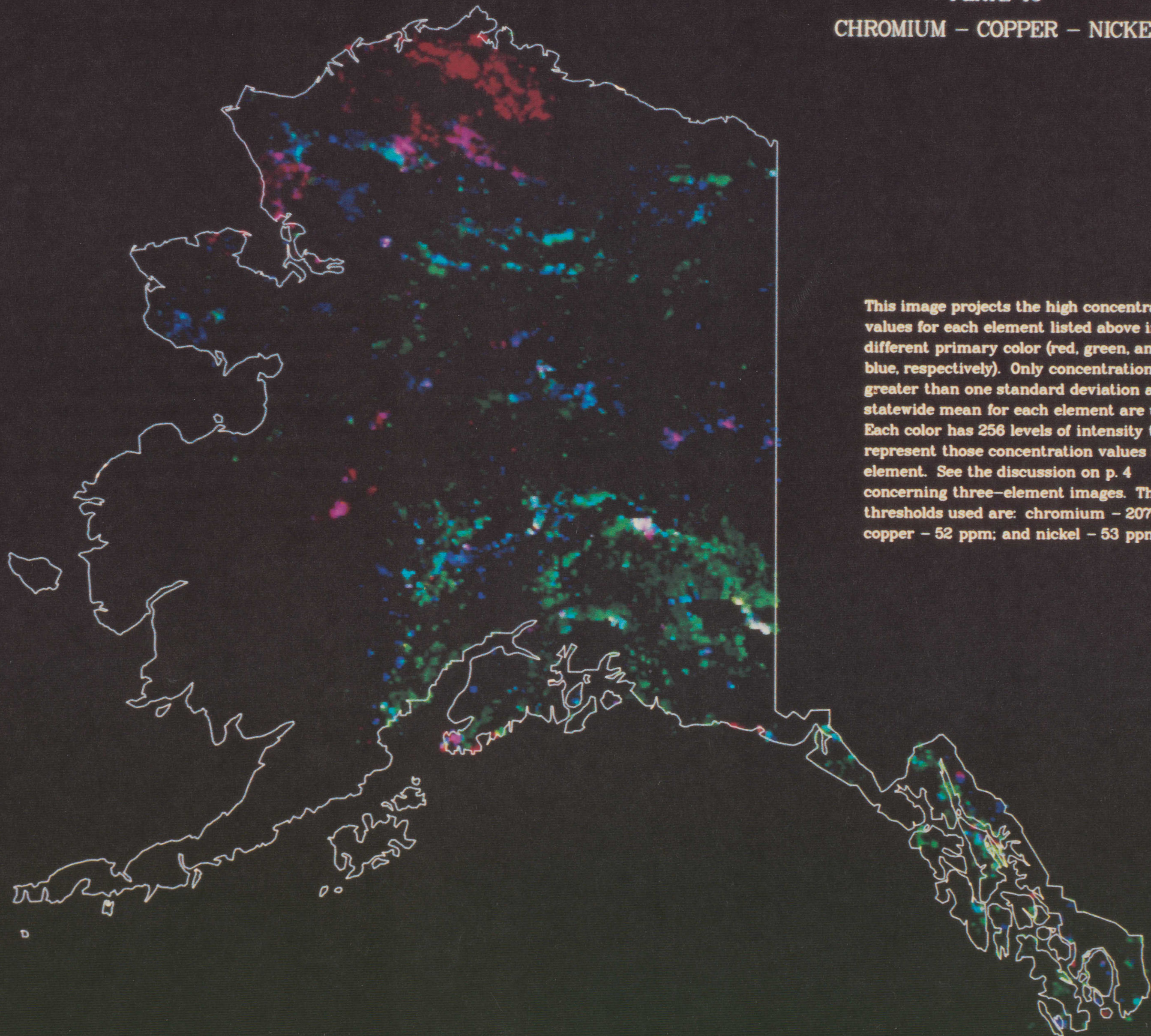
- > 672. ppm
- 355. - 672. ppm
- 287. - 355. ppm
- 234. - 287. ppm
- 186. - 234. ppm
- 151. - 186. ppm
- 110. - 151. ppm
- 71. - 110. ppm
- < 71. ppm

PLATE 44
CHROMIUM - COPPER - NICKEL



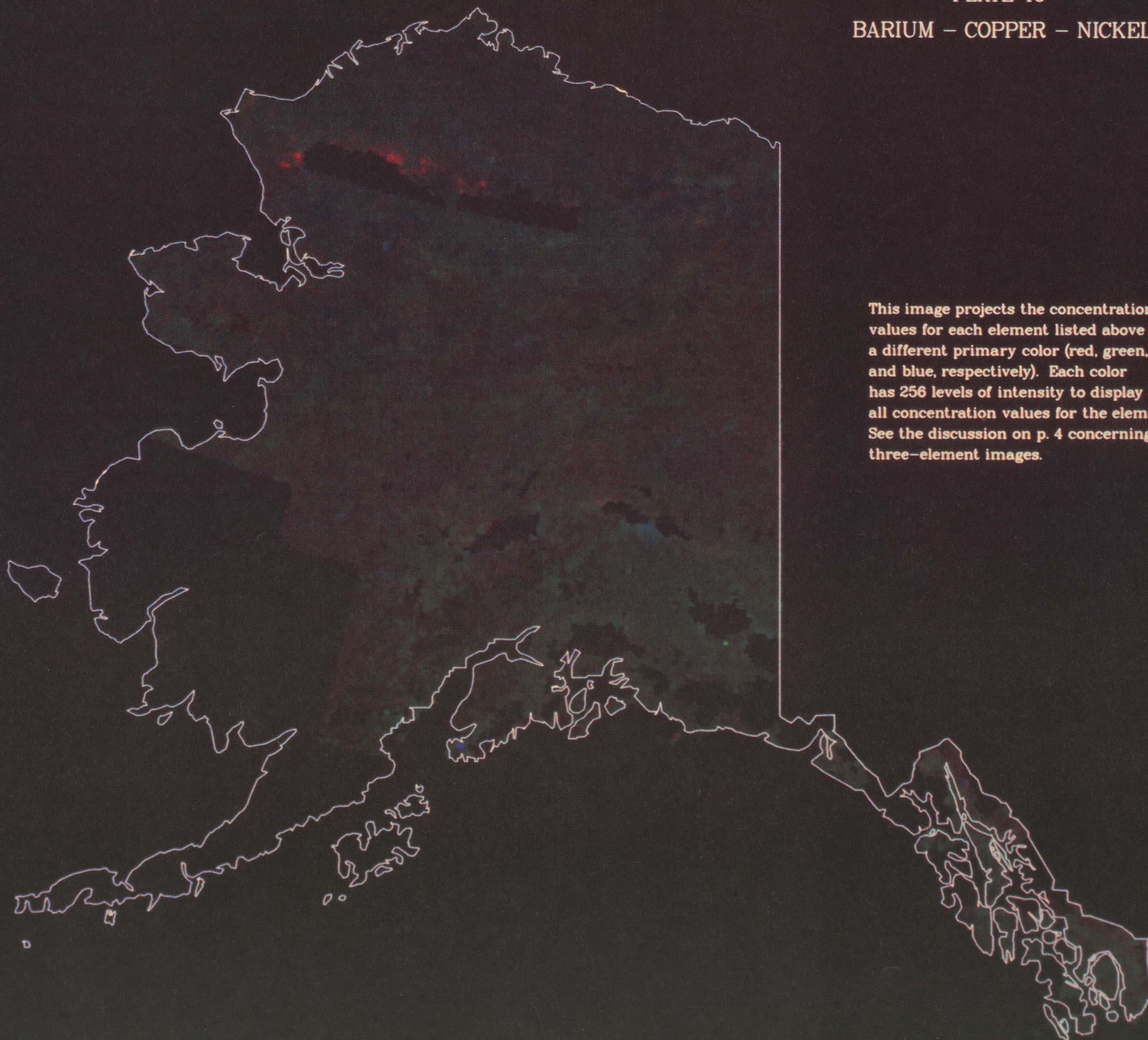
This image projects the concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Each color has 256 levels of intensity to display all concentration values for the element. See the discussion on p. 4 concerning three-element images.

PLATE 45
CHROMIUM - COPPER - NICKEL



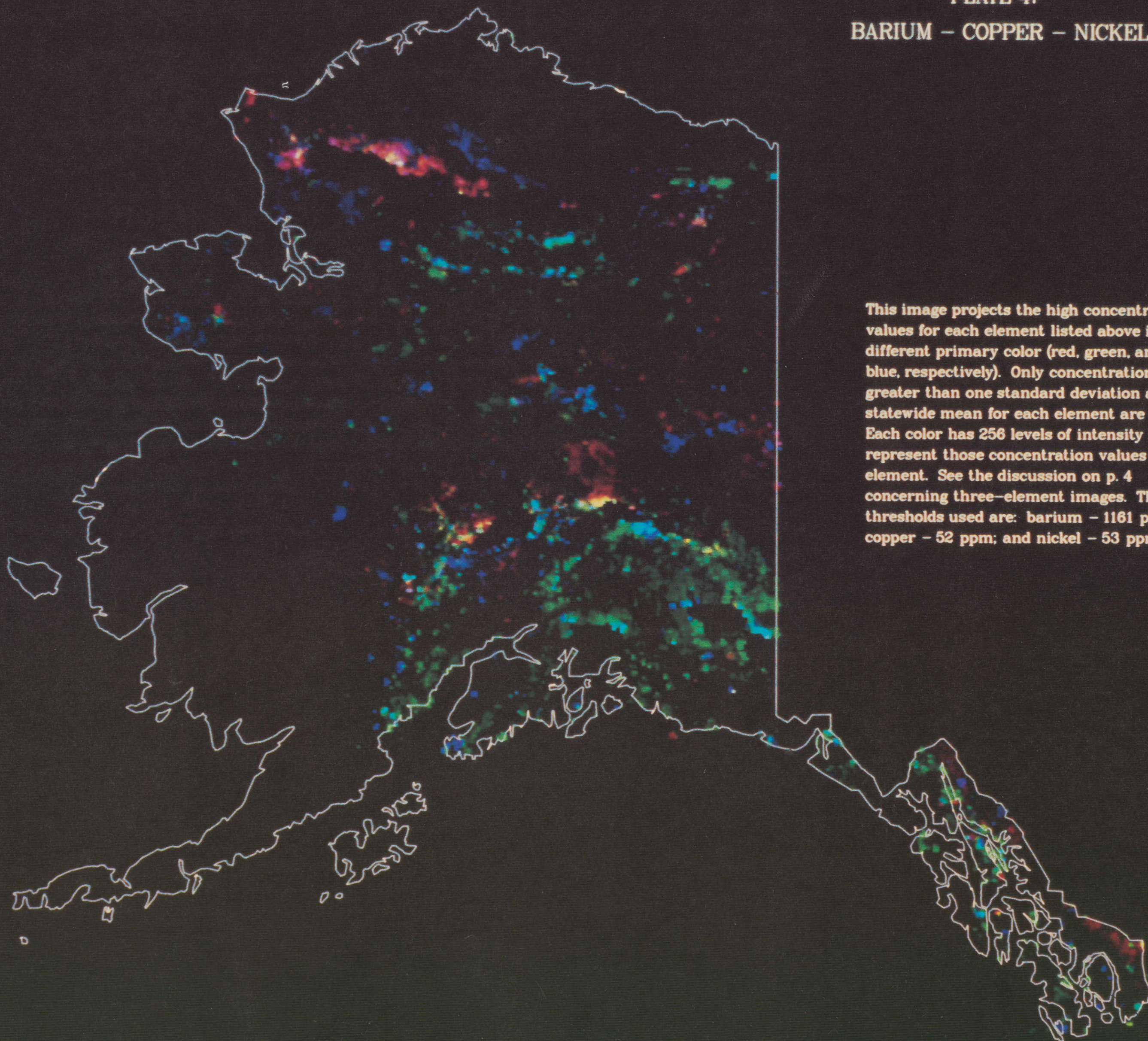
This image projects the high concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Only concentrations greater than one standard deviation above the statewide mean for each element are used. Each color has 256 levels of intensity to represent those concentration values for the element. See the discussion on p. 4 concerning three-element images. The lower thresholds used are: chromium - 207 ppm; copper - 52 ppm; and nickel - 53 ppm.

PLATE 46
BARIUM - COPPER - NICKEL



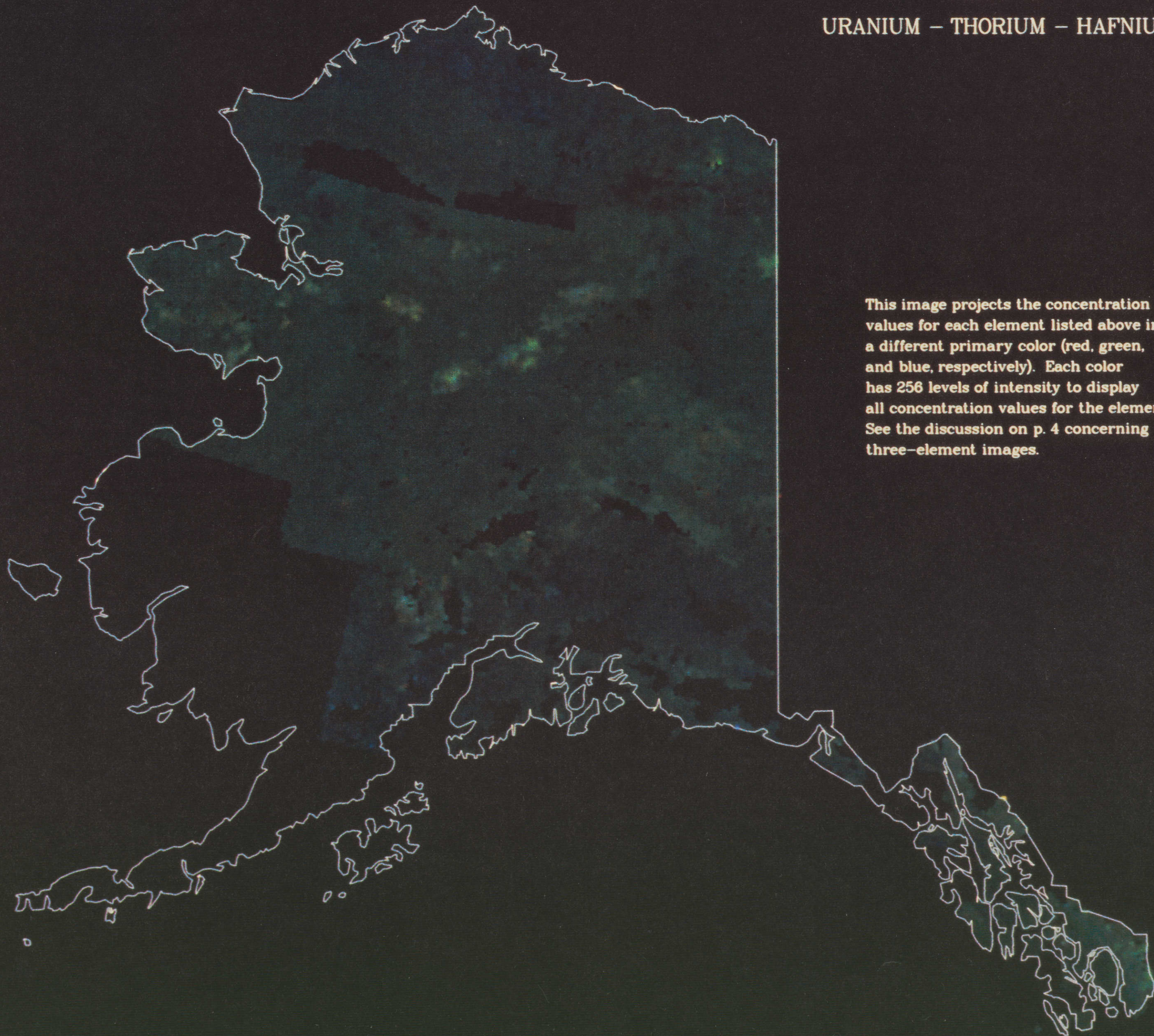
This image projects the concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Each color has 256 levels of intensity to display all concentration values for the element. See the discussion on p. 4 concerning three-element images.

PLATE 47
BARIUM - COPPER - NICKEL



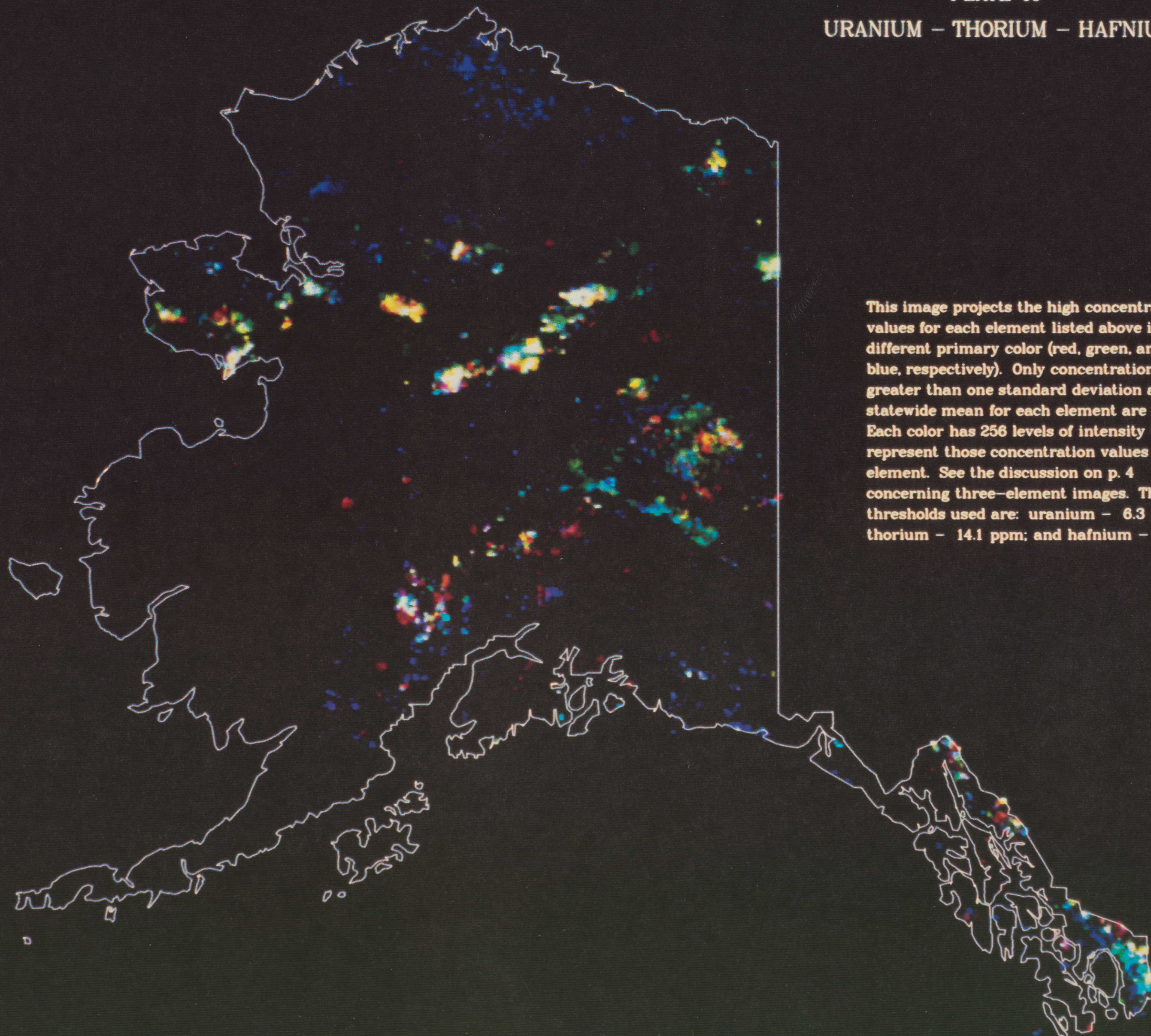
This image projects the high concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Only concentrations greater than one standard deviation above the statewide mean for each element are used. Each color has 256 levels of intensity to represent those concentration values for the element. See the discussion on p. 4 concerning three-element images. The lower thresholds used are: barium - 1161 ppm; copper - 52 ppm; and nickel - 53 ppm.

PLATE 48
URANIUM - THORIUM - HAFNIUM



This image projects the concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Each color has 256 levels of intensity to display all concentration values for the element. See the discussion on p. 4 concerning three-element images.

PLATE 49
URANIUM - THORIUM - HAFNIUM



This image projects the high concentration values for each element listed above in a different primary color (red, green, and blue, respectively). Only concentrations greater than one standard deviation above the statewide mean for each element are used. Each color has 256 levels of intensity to represent those concentration values for the element. See the discussion on p. 4 concerning three-element images. The lower thresholds used are: uranium - 6.3 ppm; thorium - 14.1 ppm; and hafnium - 10.4 ppm.

Printed in the United States of America
 Available from
 National Technical Information Service
 US Department of Commerce
 5285 Port Royal Road
 Springfield, VA 22161

Microfiche (A01)

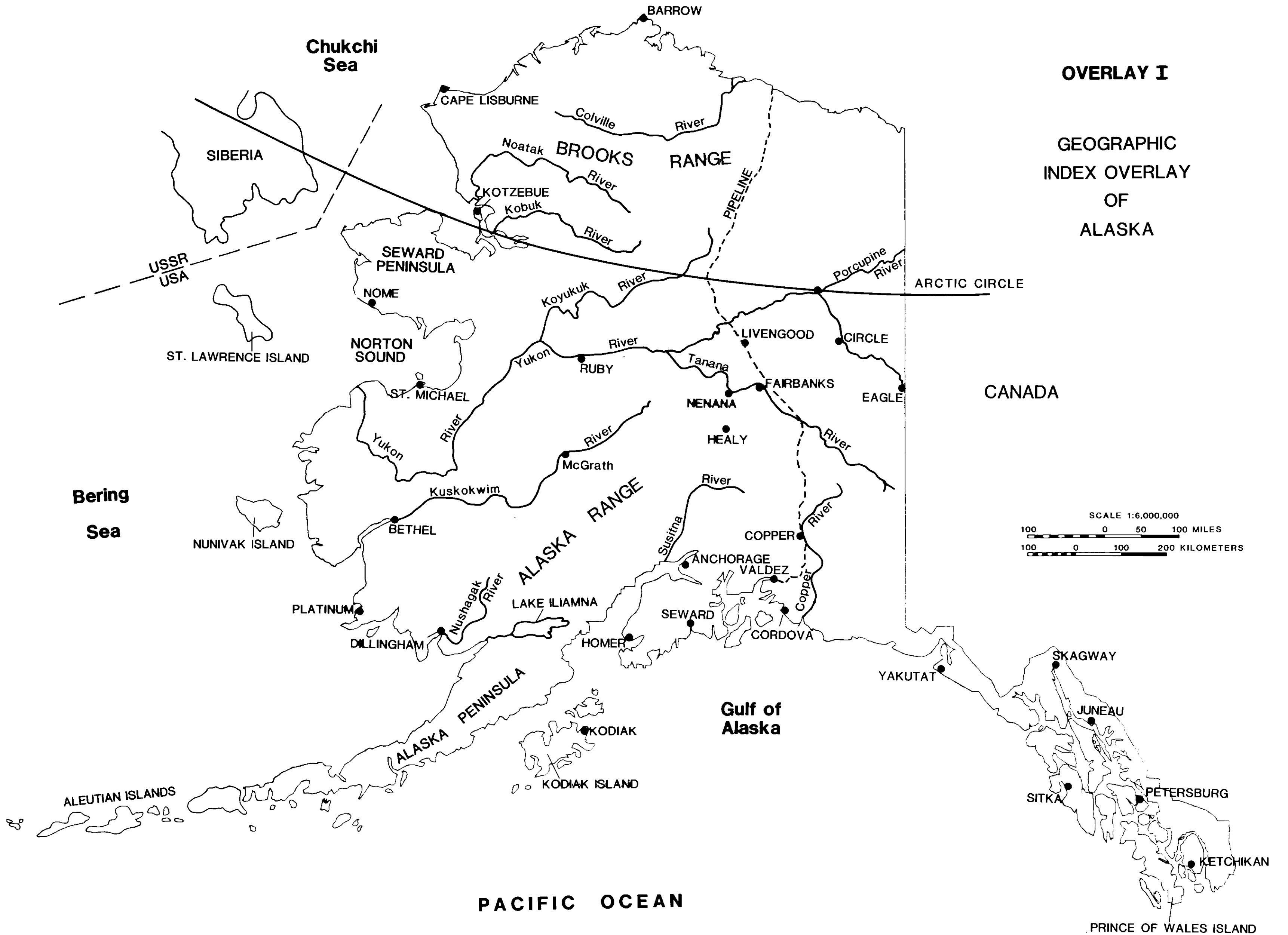
| NTIS | | NTIS | | NTIS | | NTIS | |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Page Range | Price Code | Page Range | Price Code | Page Range | Price Code | Page Range | Price Code |
| 001-025 | A02 | 151-175 | A08 | 301-325 | A14 | 451-475 | A20 |
| 026-050 | A03 | 176-200 | A09 | 326-350 | A15 | 476-500 | A21 |
| 051-075 | A04 | 201-225 | A10 | 351-375 | A16 | 501-525 | A22 |
| 076-100 | A05 | 226-250 | A11 | 376-400 | A17 | 526-550 | A23 |
| 101-125 | A06 | 251-275 | A12 | 401-425 | A18 | 551-575 | A24 |
| 126-150 | A07 | 276-300 | A13 | 426-450 | A19 | 576-600 | A25 |
| | | | | | | 601 up* | A99 |

*Contact NTIS for a price quote.

ARCTIC OCEAN

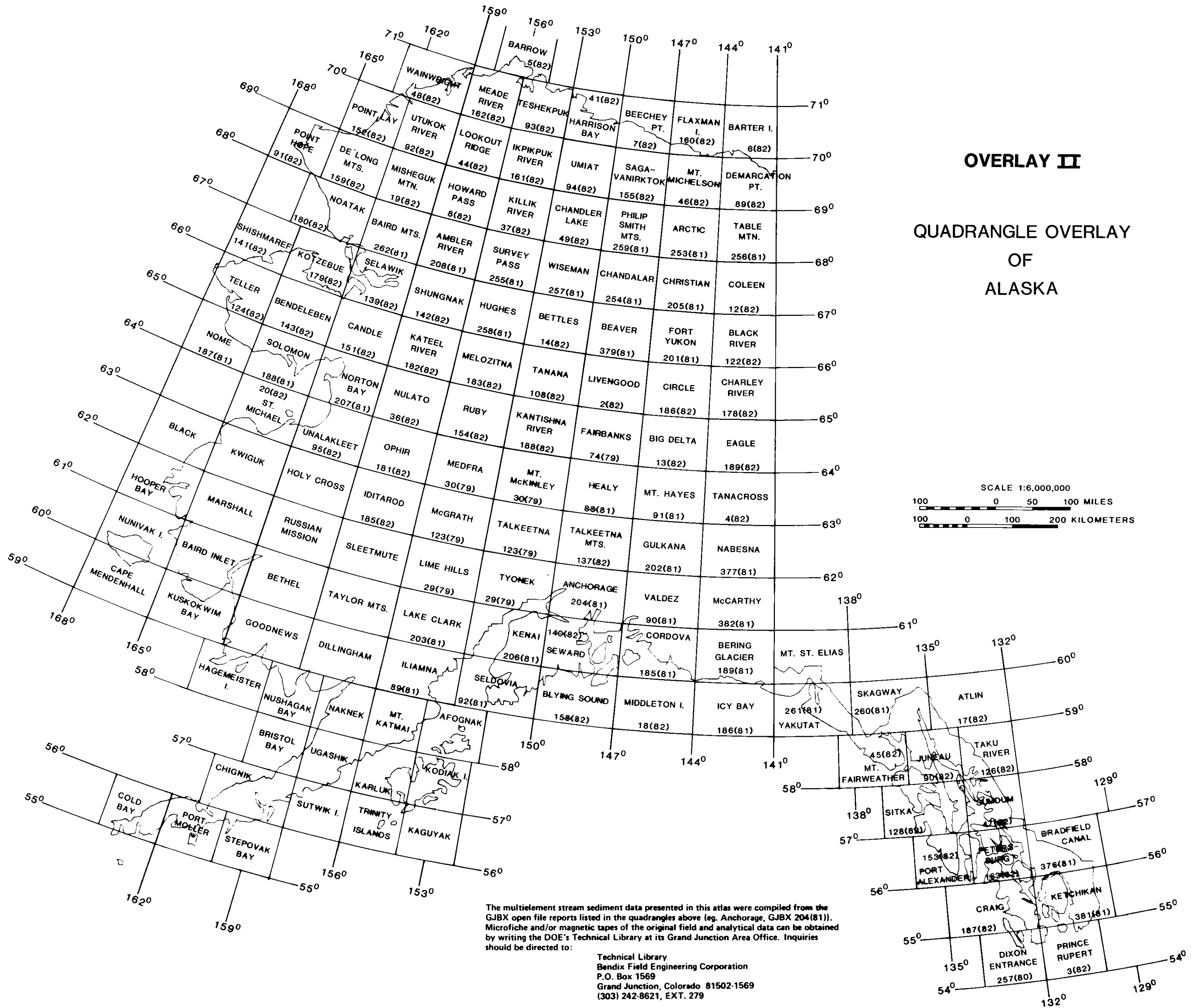
OVERLAY I

GEOGRAPHIC INDEX OVERLAY OF ALASKA



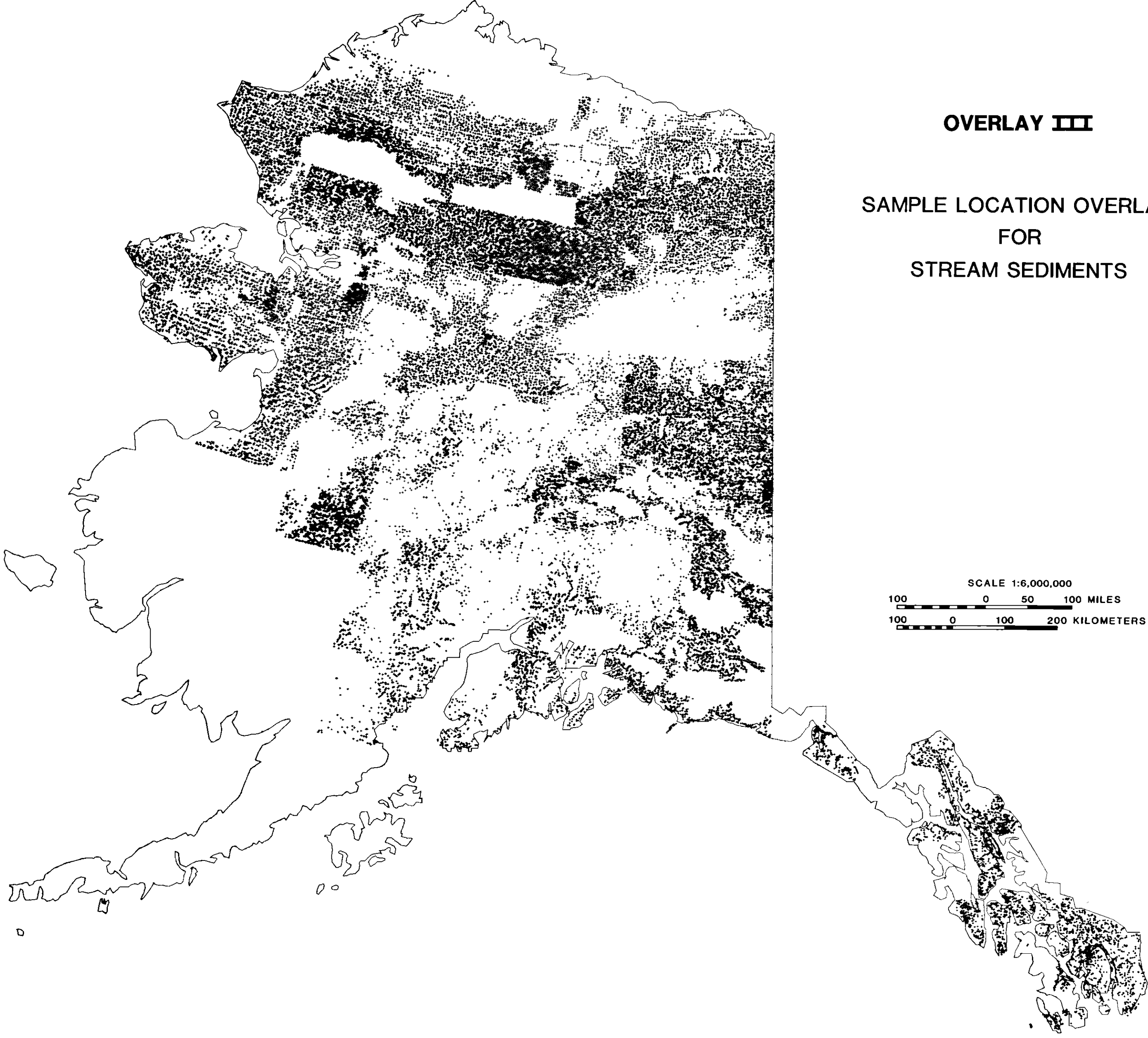
OVERLAY II

QUADRANGLE OVERLAY OF ALASKA



The multielement stream sediment data presented in this atlas were compiled from the GJBX open file reports listed in the quadrangles above (eg. Anchorage, GJBX 204(81)). Microfiche and/or magnetic tapes of the original field and analytical data can be obtained by writing the DOE's Technical Library at its Grand Junction Area Office. Inquiries should be directed to:

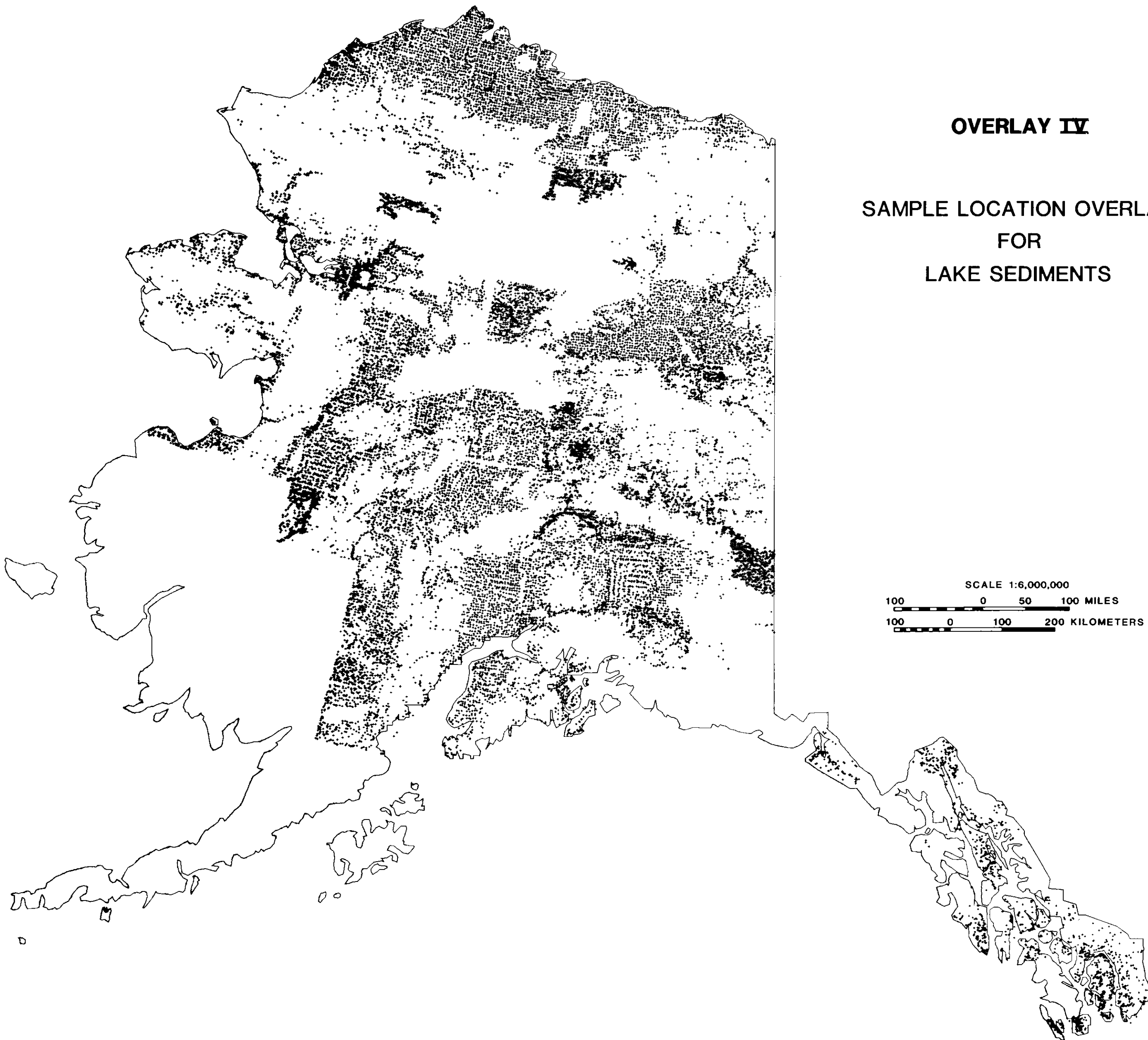
Technical Library
 Bendix Field Engineering Corporation
 P.O. Box 1569
 Grand Junction, Colorado 81502-1569
 (303) 242-8621, EXT. 279



OVERLAY III

**SAMPLE LOCATION OVERLAY
FOR
STREAM SEDIMENTS**

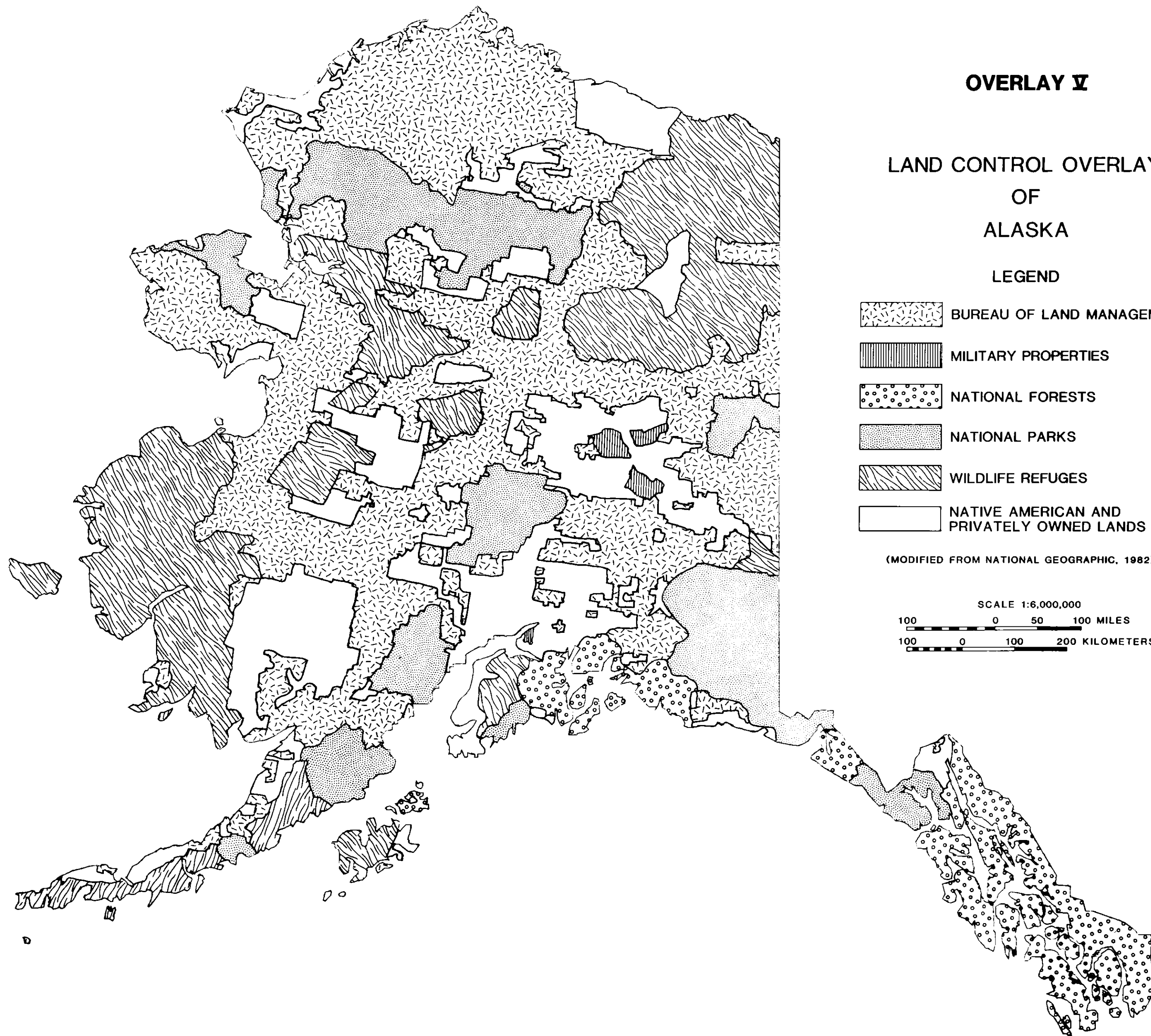
SCALE 1:6,000,000
100 0 50 100 MILES
100 0 100 200 KILOMETERS



OVERLAY IV

**SAMPLE LOCATION OVERLAY
FOR
LAKE SEDIMENTS**

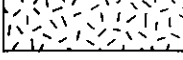

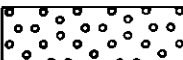

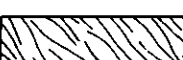
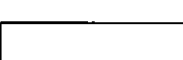
SCALE 1:6,000,000
100 0 50 100 MILES
100 0 100 200 KILOMETERS



OVERLAY V

**LAND CONTROL OVERLAY
OF
ALASKA**

LEGEND

-  BUREAU OF LAND MANAGEMENT
-  MILITARY PROPERTIES
-  NATIONAL FORESTS
-  NATIONAL PARKS
-  WILDLIFE REFUGES
-  NATIVE AMERICAN AND PRIVATELY OWNED LANDS

(MODIFIED FROM NATIONAL GEOGRAPHIC, 1982)

SCALE 1:6,000,000
100 0 50 100 MILES
100 0 100 200 KILOMETERS

OVERLAY VI

MINERAL OCCURRENCES OVERLAY OF ALASKA

LEGEND

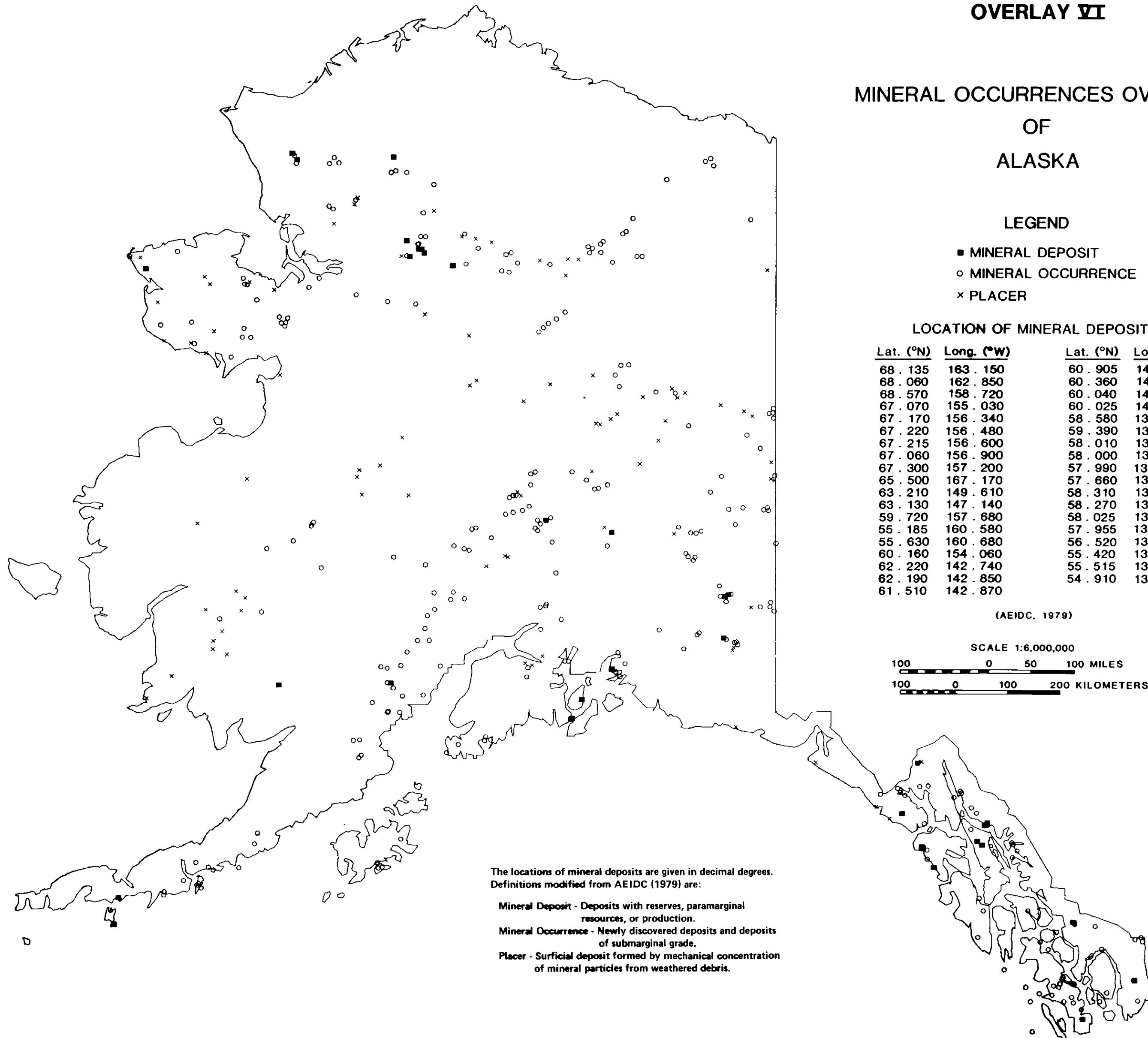
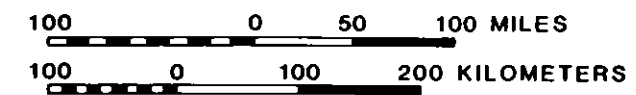
- MINERAL DEPOSIT
- MINERAL OCCURRENCE
- × PLACER

LOCATION OF MINERAL DEPOSITS

| Lat. (°N) | Long. (°W) | Lat. (°N) | Long. (°W) |
|-----------|------------|-----------|------------|
| 68.135 | 163.150 | 60.905 | 146.700 |
| 68.060 | 162.850 | 60.360 | 147.630 |
| 68.570 | 158.720 | 60.040 | 147.890 |
| 67.070 | 155.030 | 60.025 | 147.930 |
| 67.170 | 156.340 | 58.580 | 137.020 |
| 67.220 | 156.480 | 59.390 | 136.400 |
| 67.215 | 156.600 | 58.010 | 136.460 |
| 67.060 | 156.900 | 58.000 | 136.450 |
| 67.300 | 157.200 | 57.990 | 136.420 |
| 65.500 | 167.170 | 57.660 | 136.120 |
| 63.210 | 149.610 | 58.310 | 134.340 |
| 63.130 | 147.140 | 58.270 | 134.420 |
| 59.720 | 157.680 | 58.025 | 134.710 |
| 55.185 | 160.580 | 57.955 | 134.570 |
| 55.630 | 160.680 | 56.520 | 132.050 |
| 60.160 | 154.060 | 55.420 | 130.490 |
| 62.220 | 142.740 | 55.515 | 132.280 |
| 62.190 | 142.850 | 54.910 | 132.150 |
| 61.510 | 142.870 | | |

(AEIDC, 1979)

SCALE 1:6,000,000



The locations of mineral deposits are given in decimal degrees.
Definitions modified from AEIDC (1979) are:

- Mineral Deposit** - Deposits with reserves, paramarginal resources, or production.
- Mineral Occurrence** - Newly discovered deposits and deposits of submarginal grade.
- Placer** - Surficial deposit formed by mechanical concentration of mineral particles from weathered debris.

GEOLOGY

