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Lucius Pitkin, Inc.

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GRAND JUNCTION, COLORADO

GEOCHEMICAL INVESTIGATIONS OF PLUTONIC ROCKS IN THE WESTERN UNITED STATES FOR THE PURPOSE OF DETERMINING FAVORABILITY FOR VEIN-TYPE URANIUM DEPOSITS

MASTER

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GEOCHEMICAL INVESTIGATIONS OF PLUTONIC ROCKS IN THE WESTERN UNITED STATES FOR THE PURPOSE OF DETERMINING FAVORABILITY FOR VEIN-TYPE URANIUM DEPOSITS

Prepared For

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ABSTRACT

Reconnaissance geochemical investigations of plutonic rocks in the western United States were undertaken for the purpose of determining geochemical guides and favorable areas for vein-type uranium deposits. Gamma ray spectrometric analyses for uranium, thorium, and potassium and semiquantitative emission spectrographic analyses were obtained on approximately 500 samples collected from throughout the western U. S. Quantitative major-element analyses were obtained on selected samples.

The regional variations of uranium, thorium, and potassium concentrations in plutonic rocks were investigated on the basis of average values for one-degree latitude-longitude quadrilaterals and average values and frequency distributions for geologic subdivisions. The results in both cases indicate a general decrease in the concentrations of the three elements from the continental interior to the continental margin. Geologic subdivisions with the highest average uranium content are (a) the Northern Rocky Mountain batholiths of eastern Washington and northern Idaho, (b) the Idaho-Boulder batholiths, (c) the Southern Rocky Mountains of Colorado, and (d) the Mexican Highland of southeastern Arizona and southwestern New Mexico. Geologic subdivisions with the lowest average uranium values are the Columbia Plateau and the Colorado Plateau. Subdivisions containing major known vein-type uranium deposits are not necessarily characterized by high average uranium content.

Possible geochemical guides for vein-type uranium deposits were determined from comparisons of chemical data for (a) samples from plutonic bodies associated with known deposits and (b) all samples from the western U. S. or selected groups of samples. The results indicate that plutonic bodies associated with known vein deposits are characterized by (a) very high silicon, (b) high aluminum, potassium, rubidium and Nockolds-Allen differentiation index, (c) a limited range of values of the ferric to total iron ratio, (d) low sodium, calcium, titanium, manganese, and phosphorus, (e) very low iron and vanadium, and (f) a high range of values of the uranium-potassium ratio. Uranium and thorium concentrations and the uranium-thorium ratio are commonly but not always higher in the plutonic bodies associated with vein deposits.

Of the various chemical elements and indices considered the best possible indicators are the Nockolds-Allen index, potassium, silicon, the ferric-total iron ratio, and the uranium-potassium ratio. Uranium content is not useful as an indicator on a continental scale but it may be useful on a local or regional (geologic province) scale.

More work is required to further evaluate the possible indicators and to determine quantitative limiting values or relationships which may be used in exploration. The results do, however, indicate that plutonic bodies associated with known vein-type uranium deposits are characterized by unique geochemical abundances and relationships and that the determination of geochemical guides and favorable areas for vein-type uranium deposits is possible.

INTRODUCTION

This is a report on the first phase of the Metallogenic Project, a project conducted by the Geology Division of Lucius Pitkin, Inc. for the Resource Division of the U. S. Atomic Energy Commission, Grand Junction, Colorado.

The Metallogenic Project involves studies related to vein-type uranium ore deposits in the western United States. The objectives of the project, as stated in the work request to Lucius Pitkin, Inc. (LPI), are (a) to define "regional belts of favorability for vein- and contact-type uranium deposits in the Basin and Range province and in the Mesozoic batholithic provinces", and (b) "to attempt to establish geochemical guides for defining portions of these belts that are most favorable for the discovery of additional uranium resources".

The term "vein-type deposit", as used in this report, includes the "contact-type" deposit referred to in the work request. This more general definition of vein-type deposits follows that of Walker (1963, p. 2-3).

The Metallogenic Project, as assigned, is to be completed in two phases. The first phase involves: (a) the collection and analysis of samples from Mesozoic and Cenozoic intrusives in the western U. S., and (b) an analysis of the data to determine if the plutons associated with known uranium deposits are characterized by geochemical abundances or relationships which may be used as guides for vein-type uranium deposits. The second phase involves a more detailed study of plutons considered favorable for uranium deposits.

The project was started by personnel of the Geologic Branch of the U. S. Atomic Energy Commission in August, 1970 (Figure 1). Roger Malan was the project geologist for the AEC work on the project. Approximately 40 percent of the field work and about 25 percent of the analytical work were completed prior to LPI involvement in the project in March, 1971.

The take-over of project responsibility by LPI staff involved (a) the identification of areas in which field work was completed and areas in which field work remained, (b) the identification of samples collected, (c) the collection of location and identification data for the samples, (d) the determination of the status of laboratory work on the samples, (e) the collection of all available field and laboratory data for the samples, and (f) the identification of field methods and procedures (accomplished through a joint AEC-LPI field trip).

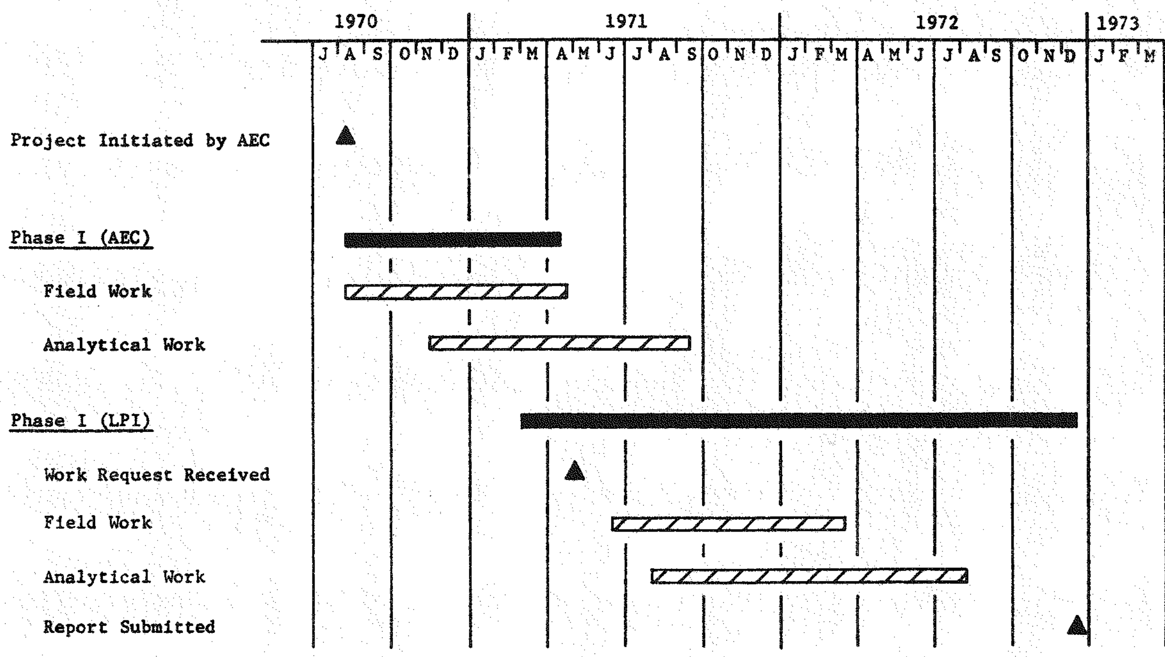


Figure 1. Basic schedule for Phase I of Metallogenic Project

METHODS OF INVESTIGATION AND APPROACH

The methods of investigation and and general approach followed in the project are described in terms of the following task areas (Figure 2): (1) project administration, (2) theoretical considerations, (3) field operations, (4) analytical considerations, (5) compilation of geologic data, (6) compilation of data on uranium deposits, (7) design and analysis of the data processing system, (8) evaluation and interpretation, and (9) report preparation. The areas of project administration and report preparation involved the usual tasks in projects of this type and are not discussed further.

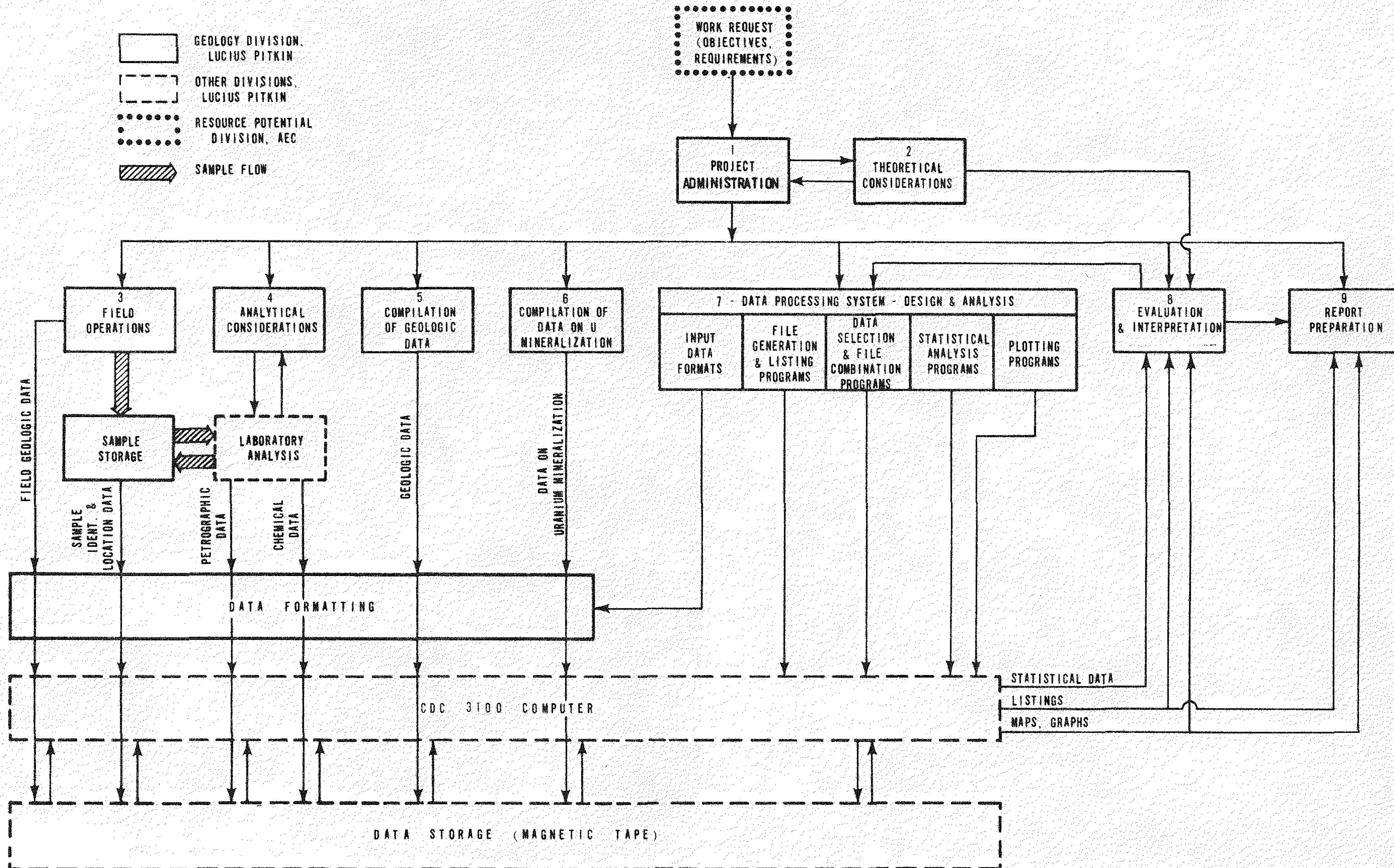


Figure 2. Operational flow diagram for Phase I of Metallogenic Project

Theoretical Considerations

Theoretical investigations consisted of literature reviews of the following: (a) the effect of weathering on the chemical composition of plutonic rocks, (b) the geochemistry and petrology of magmatic processes, with emphasis on uranium, (c) published uranium analyses and their possible use in the project, and (d) the nature and distribution of vein-type uranium deposits.

Weathering

Although a comprehensive review of literature relating to weathering of granitic rocks was beyond the scope of the project, the following considerations led to the conclusion that the effect of weathering had to be seriously considered.

Firstly, regarding the effect of weathering on uranium concentration in granitic rocks, while some studies have indicated that the effect is minimal, studies such as that of Pliler and Adams (1962) have indicated that up to half or more of the uranium can be removed in the first stages of weathering. Also, numerous published leaching studies on granitic rocks have indicated that a very high percentage of the uranium can be removed just by the action of ground water. Secondly, general geochemical studies of the weathering of granitic rocks (see, for example, Harriss and Adams, 1966; and Goldich, 1938) indicate that major and minor elements are affected to varying degrees in the process of weathering and that certain elements may be depleted or enriched up to 100 percent or more with a moderate degree of weathering.

Based on these considerations it was decided that the general degree of weathering of each sample would be determined and that an upper limit corresponding to the maximum acceptable degree of weathering would be established. Samples for which the weathering exceeded this upper limit would be excluded from further analysis.

Geochemistry and Petrology of Magmatic Processes

Based on a general understanding of magmatic processes it was realized early in the project that, while the objective was to identify geochemical guides (hence "distinctive geochemical parameters" or "anomalies") for plutons associated with vein-type uranium deposits, the chemical characteristics of plutonic rocks are to a large degree relative, being dependent on factors such as rock type (or rock composition), geologic environment, etc. An uranium content of 4 ppm in a granite, for example, is not necessarily anomalous while the same concentration in a gabbro would normally be highly anomalous. Likewise, it is not expected that the chemical composition of a quartz monzonite from the Front Range of Colorado would be the same as that of a quartz monzonite from the Southern California batholith.

This reasoning led to an attempt in this project to take into account what were considered to be the most important factors affecting the chemistry of plutonic rocks: overall composition and the geologic environment. It was decided that, to the extent possible, samples would be classified according to these factors and that any or all of these factors would be taken into consideration, as required, in the final analysis of the data to determine possible geochemical guides.

Two possible bases for the compositional classification were considered: petrographic and chemical. The latter was selected primarily because of the need for quantitative data which could be rapidly obtained.

Since it was not known at the outset which chemical parameter could be used as the basis for such a compositional classification, a "pilot study" involving a select group of samples was undertaken. The pilot study samples (hereinafter referred to as the Pilot Group) were submitted for quantitative analyses of major elements and selected trace elements. After completion of the pilot study the plan was to submit all remaining project samples for the analyses of interest. In actuality, however, due to problems with regard to analytical precision, the pilot study was not completed until the writing of this report. The results of the pilot study and the analytical data obtained in the pilot study were, nevertheless, very significant in the determination of possible geochemical guides.

Samples in the Pilot Group are identified in a later section of this report.

The classification or grouping of samples on the basis of geologic environment was undertaken at two levels: the regional level - leading to the geologic province concept; and the mountain range or pluton level - leading to the intrusive center concept. The bases for these classifications will be discussed in detail in the section on compilation of geologic data.

Published Analyses

A brief review of the literature was made to determine (a) the availability of published analyses for uranium in Mesozoic and Cenozoic plutonic rocks in the western U. S. and (b) if this data could be used in the project. Some 639 published analyses were identified. It was found that only about half of these were accompanied by thorium and potassium analyses and that the number with any additional chemical or petrographic data was small. For this reason, in view of the broad geochemical objectives of the project, the data were used only in a comparison of project and published data for uranium, thorium, and potassium in certain geographic subdivisions of the western U. S. These data are presented later in the report.

Vein-Type Uranium Deposits

A brief review of available literature on vein-type uranium deposits was made. Knowledge of the locations and general characteristics of the major known vein deposits was needed in the analysis and interpretive phases of the project.

Field Operations

Preparation for the field consisted of: (a) the identification of general areas from which samples were desired, using state geologic maps and other available data, (b) the review of pertinent geologic reports on the areas of interest, and (c) the review of USGS topographic maps, U. S. Forest Service maps, and county highway maps, as available, to determine accessibility and tentative itinerary.

A total of 520 bulk samples (average weight 8-10 pounds) were collected. Sampling was generally limited to large plutonic bodies; small stocks (less than a few square miles in size), dikes, and sills were not sampled.

The sampling density ranged from an estimated one sample per 100 square miles of outcrop (ie., outcropping of both Mesozoic and Cenozoic plutonic rocks) in the Basin and Range to an estimated one sample per 1000 square miles of outcrop in the Mesozoic batholiths; the difference being due to the interest in sampling as many separate intrusive bodies as possible. A slightly higher sampling density was achieved in intrusive phases associated with vein-type uranium deposits; this was for the purpose of establishing reference geochemical relations.

The selection of sample sites in the field was strongly influenced by accessibility and the availability of fresh rock. Road cuts and draws proved to be the best for obtaining fresh samples. In some areas, however, the freshest samples which could be obtained were still noticeably decomposed.

Prior to the collection of a sample in the field, the prospective sample site was reconnoitered to determine its acceptability in terms of (a) overall lithologic uniformity of the rock unit, (b) radiometric uniformity as determined with a portable scintillometer, and (c) lack of evidence of post-crystallization alteration due to nearby intrusions or regional metamorphism.

Each sample is actually a composite of several rock chips from the outcrop area. Weathered and fracture surfaces on the chips were removed by trimming.

The data recorded at each sample site included: (1) geographic location, (2) political location (state, county, nearest town), (3) information regarding sample control (eg., outcrop, talus, etc.), (4) degree of weathering and fracturing, (5) evidence of possible alteration, if any, (6) presence of foreign rock fragments, (7) gross count recorded with a scintillometer, and (8) degree of variation in the gross count.

Analytical Considerations

Petrographic Analyses

Petrographic work in the project consisted of (a) a weathering analysis and (b) a rock description.

The weathering analysis involved the microscopic examination of the sample to determine the degree of decomposition (ie., total percentage of weathering products, including clay, sericite, and calcite). The analysis was semiquantitative and involved only a few minutes per sample. Each sample was classified into one of three groups based on the degree of weathering: (1) slightly weathered - less than 25 percent, (2) moderately weathered - between 25 and 35 percent, and (3) highly weathered - greater than 35 percent.

A 25 percent weathering cut-off was adopted and all samples (47 in number) which fell in the moderately weathered and highly weathered classes were excluded from further consideration in the project (Figure 3). The cut-off value was based on (a) an estimate of the maximum degree of chemical bias due to weathering which could be tolerated, considering the project objectives, and (b) practical considerations of the number of samples collected versus the number rejected. Further investigation of the affect of weathering on the particular geochemical parameters of interest (as identified in the "pilot study") was planned but time did not permit it.

The rock description involved the microscopic and/or macroscopic examination of the sample to determine rock type (eg., granite, quartz monzonite, etc.), granularity, and gross mineralogic composition. This analysis was discontinued by LPI because of (a) the qualitative nature of the analysis and (b) the use of chemical parameters in place of rock type for the compositional classification of samples. The data of this type which accumulated prior to LPI involvement in the project was retained, however, and a brief analysis of the variation of uranium, thorium, and potassium with rock type and granularity is provided in this report.

Rejection of Samples

Of the 520 samples collected, data for only 460 were used in the final analysis of the data (determination of geochemical indicators). The location and identification data for these samples are given in Appendix A. The sample localities are shown on Plate 1. The rejected samples are identified in Appendix B.

The largest number of samples, 47 in number, were rejected because of their high degree of decomposition due to weathering. In some cases the high degree of weathering was apparent when the sample was collected but fresher samples simply could not be obtained. In other cases, although the sample appeared to be acceptable based on a megascopic examination in the field, later petrographic analysis indicated an unacceptable degree of decomposition.

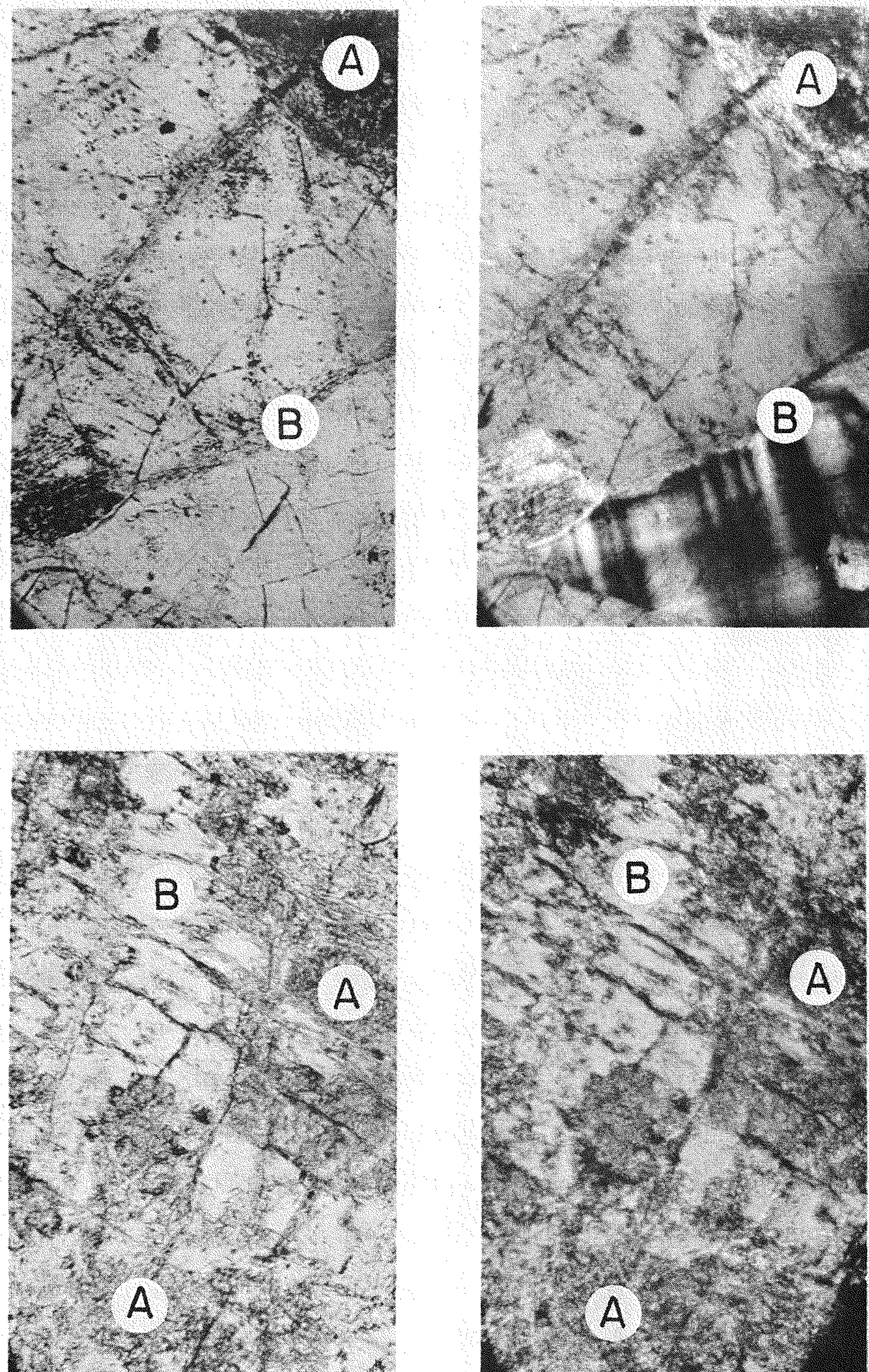


Figure 3. Photomicrographs showing degree of decomposition of accepted and rejected samples. Nicols uncrossed on left, crossed on right. 150X. Upper pair, accepted sample, number 1269, showing incipient kaolin-type clay and minor sericite replacing plagioclase (A) and along grain boundary (B). Lower pair, rejected sample, number 1301, showing plagioclase remnants (B) and sericite, calcite, and kaolin-type clay (A) replacing plagioclase.

Ten samples were rejected because of their fine-grained texture (Figure 4); all other project samples are medium to coarse-grained. In some cases, while the rock unit sampled was mapped as granite on the published geologic map, field relations and laboratory data indicated an extrusive origin.

Five of the rejected fine-grained samples are from the Lakeview area of Oregon, an area which contains known uranium deposits. A separate analysis of the data on these samples, in light of conclusions drawn from the study, is provided in Appendix F.

One sample was rejected because of visible sulfide mineralization and two additional ones were rejected for being distant surface float. In both cases time did not permit the location of fresh outcrop samples and these samples were collected only for "backup" or special study.

Chemical Analyses

The routine chemical analysis of each sample, decided on prior to LPI involvement in the project, consisted of the following:

1. semiquantitative emission spectrographic analysis

2. gamma-ray spectrometric analysis for uranium, thorium, and potassium

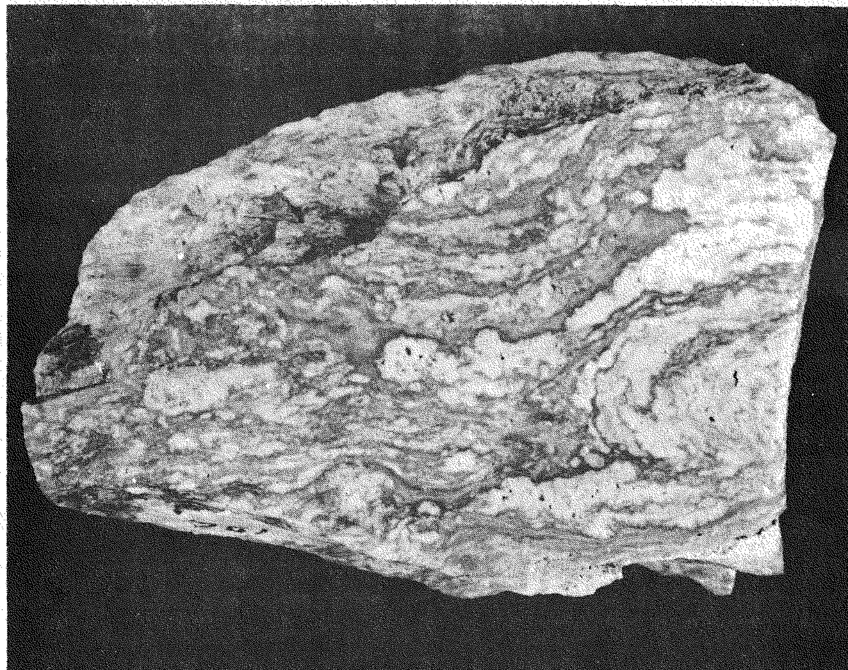
3. quantitative analyses for zirconium, molybdenum, tungsten, and uranium in zircon

The tungsten analysis was discontinued when it was found that most of the samples were below the analytical detection limit. The uranium-in-zircon analysis was discontinued due to the absence of a sufficient amount of zircon in most of the samples.

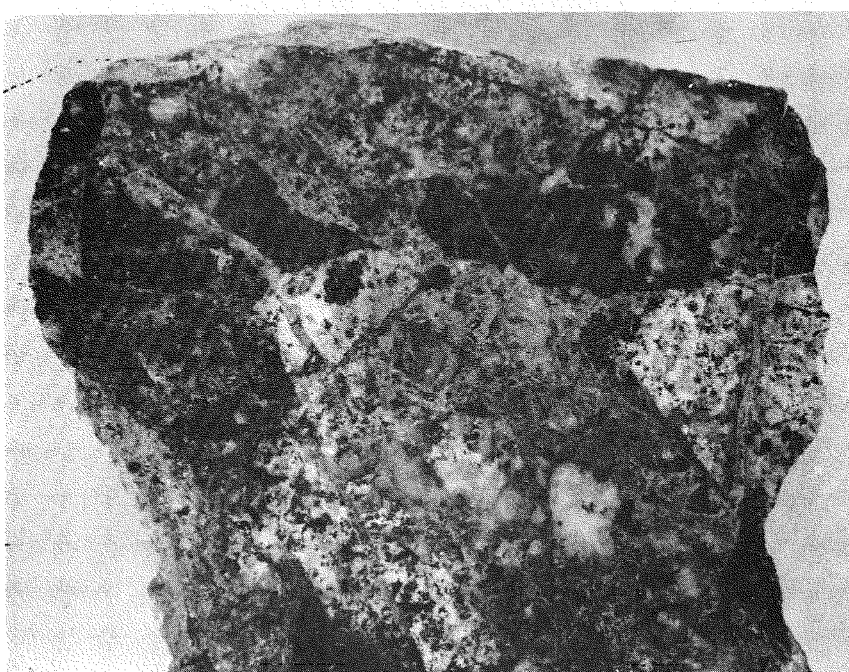
Rapid rock analyses were obtained on the approximately 70 samples which comprise the Pilot Group. Also, quantitative rubidium analyses were obtained on selected samples in the Pilot Group.

Special investigations were undertaken to determine the precision of the various chemical analyses obtained in the project. The results of these investigations are summarized in Appendix E.

All analytical results were used as received from the laboratory. Zero and negative values reported for uranium and thorium reflect the relatively large analytical error (largely due to variations in the radiation background) at the low concentration levels.



A



B

Figure 4. Hand specimen photographs of fine-grained samples not considered in the analysis. A, sample 1222 showing lamination. B, sample 1324 showing brecciation.

Compilation of Geologic Data

The compilation phase involved (a) the classification and coding of samples according to geologic province and intrusive center and (b) the compilation of published data relative to the geologic age of the samples.

Geologic Subdivision of the Western U. S.

The geologic subdivision of the Western U. S. used in this project is based strongly on the distribution of samples collected and outcrops of Mesozoic and Cenozoic intrusive rocks, as well as factors such as geologic age, structure, and rock type which would normally be the bases for such a subdivision. The geologic subdivisions are outlined in Figure 5. Numeric codes and names used for the provinces are listed in Table 1.

The boundaries of the geologic provinces generally follow boundaries of Fenneman's (1931) physiographic provinces or sections with the following major exceptions: (1) some of Fenneman's provinces and/or sections are combined, (2) Jahns' (1954) subdivision of southern California is used and (3) the Northern Rocky Mountains province of Fenneman is subdivided for purposes of this study into the Northern Rocky Mountain Batholiths, the Idaho-Boulder Batholiths and the Beltian Section. Additional changes include: (1) the incorporation of the Mountain City and Contact localities or northeastern Nevada into the Great Basin, (2) a slight expansion of the Sierra Nevada province to include localities north of Reno, Nevada, and (3) a modification of the Southern Rocky Mountains to include the Spanish Peaks of south-central Colorado.

The Intrusive Center Approach

The intrusive center approach involved the grouping of samples where there is reason to believe they may be genetically related (Figure 6). Most commonly this "reason" is that the samples were collected from the same continuous area of granitic rock as mapped on a state geologic map. Although obviously limited, this approach was taken to allow the treatment of one mass of granitic rock on a par with another. The reasoning was that a group of samples might provide information such as variability or range of a chemical parameter that a single sample could not.

A simple numeric identification system for the intrusive centers, subservient to the geologic province codes, was used.

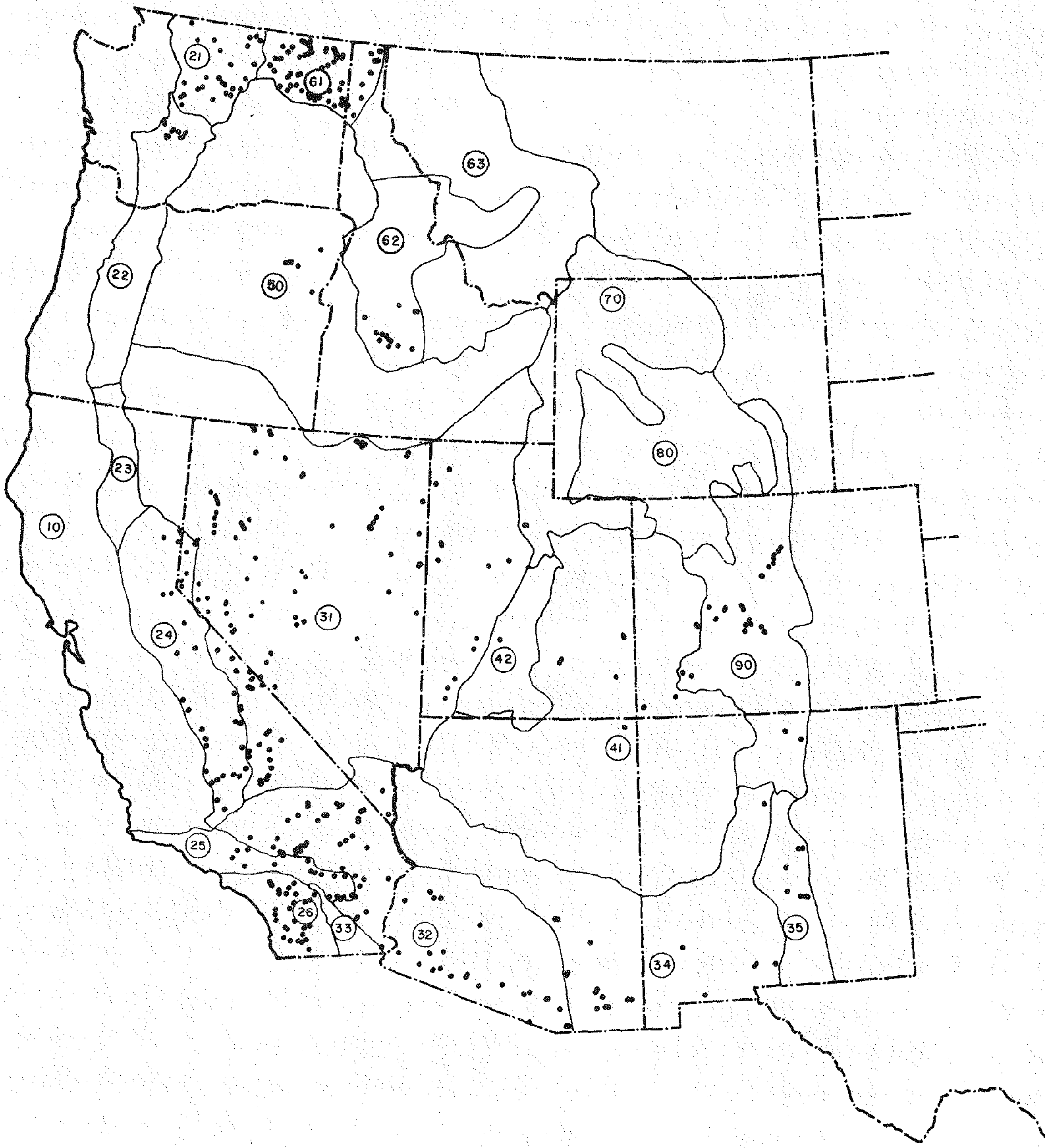


Figure 5. Map showing subdivisions of western U.S. into geologic provinces. Dots indicate sample locations. Circled numbers are geologic province codes.

Table 1

GEOLOGIC PROVINCE CODES
AND NAMES USED IN THIS REPORT

Geologic Province Code	Geologic Province Name
10	Pacific Border
21	Northern Cascade Mountains
22	Middle Cascade Mountains
23	Southern Cascade Mountains
24	Sierra Nevada
25	Transverse Ranges
26	Peninsular Ranges
31	Great Basin
32	Sonoran Desert
33	Colorado Desert
34	Mexican Highland
35	Sacramento Mountains
41	Colorado Plateau
42	High Plateaus of Utah
50	Columbia Plateau
61	Northern Rocky Mountain Batholiths
62	Idaho-Boulder Batholiths
63	Beltian Section
70	Middle Rocky Mountains
80	Wyoming Basin
90	Southern Rocky Mountains

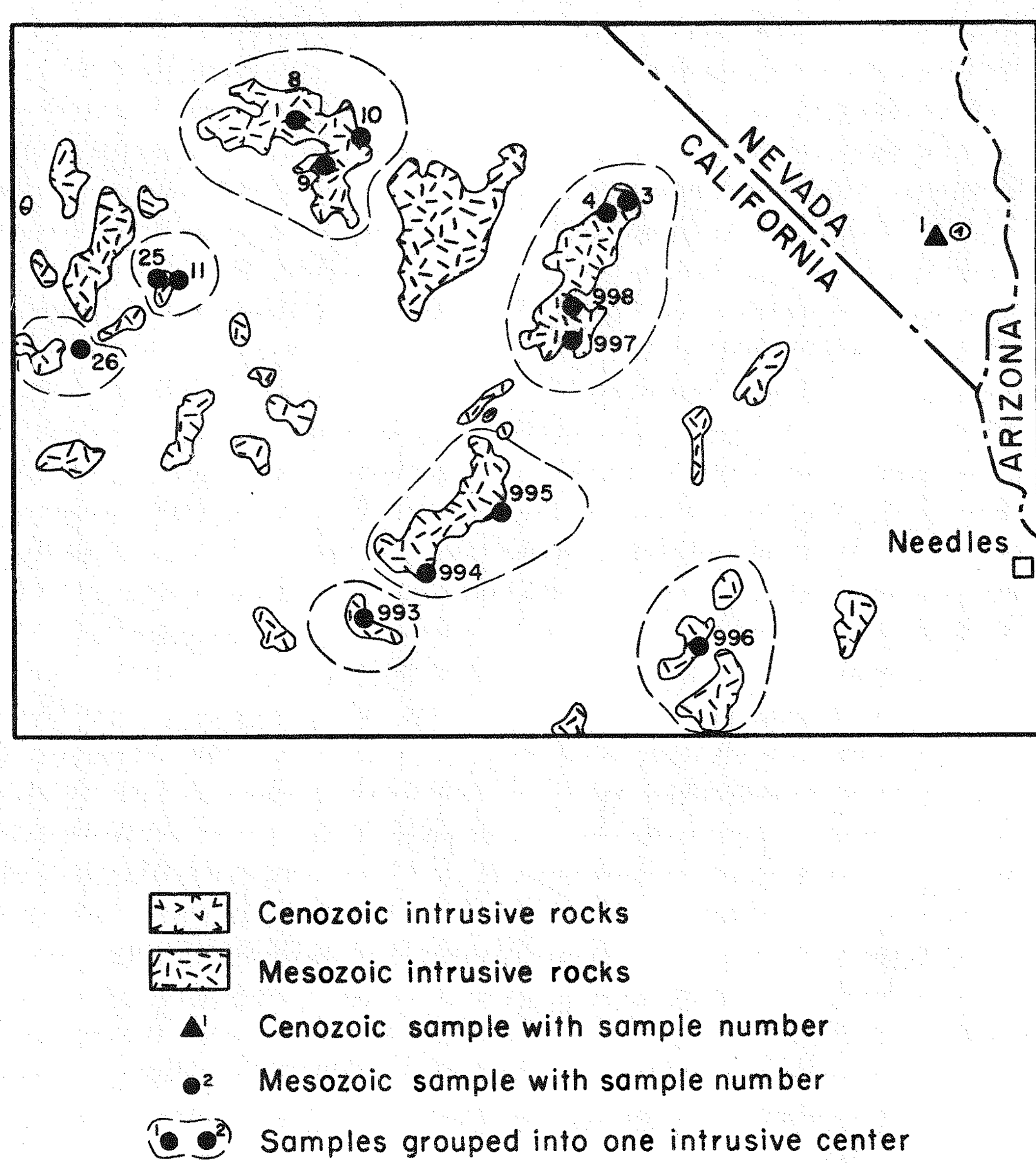


Figure 6. Map illustrating intrusive center concept for grouping samples. Dots indicate sample locations. Circled numbers are geologic province codes.

Geologic Age

The general age (Mesozoic or Cenozoic) of each sample was obtained from published sources, primarily state geologic maps.

A brief survey of the literature was made for the purpose of obtaining radiometric age dates on the areas sampled. The number of such dates obtained was too small to permit an investigation of possible correlations between chemical parameters and age.

Compilation of Data on Uranium Mineralization

One objective of the project was to compare the distribution of chemical parameters with the distribution of known vein-type uranium deposits. Three possible sources of data on the latter were investigated: (1) AEC files on properties with production and/or reserves, (2) AEC Preliminary Reconnaissance Reports on uranium, and (3) Walker (1963). The first was eliminated because of the lack of location data beyond the state and county level. The second was eliminated because of the amount of work required for compilation. The third source was used as the basis for studies described in this report.

Data Processing System - Design and Analysis

The data processing system developed for the project was based on the use of the CDC 3100 computer with existing auxiliary equipment. The computer programs were designed simply to meet the data processing requirements of the project.

Approximately 25 computer programs were developed for use in the project. These included programs for (a) file generation and listing, (b) file combination, (c) data selection, (d) data grouping and statistical calculations (averaging), (e) plotting scatter diagrams (X-Y plots), (f) plotting histograms, and (g) plotting cumulative frequency plots.

Two existing LPI programs were used - one for filing and listing sample identification and location data and the other for Lambert coordinate conversion. One program (weighted regression analysis program, WRAP) and subroutines for making linear correlation plots and for making statistical calculations were obtained from AEC personnel. ACI programs for mapping and Calcomp plotter subroutines were used wherever possible.

An estimated 40,000 data values were stored on magnetic tape. Each value was checked, via computer listings and plots, against the original sources of data (eg., laboratory reports). Also, the processing of the data at various levels was checked manually.

The development of the data processing system for the project involved several stages, as the results from one stage dictated new requirements for the next. The first stage involved the development of programs for statistical processing (ie., averaging data on the basis of geologic province, intrusive center, one-degree latitude-longitude quadrilaterals, presence or absence of vein-deposits, geologic age, etc.). This stage did not lead to positive geochemical results because of the strong affect of individual anomalous samples on the statistical parameters. Subsequent stages led to the development of programs for generating scatter diagrams, frequency diagrams, and cumulative frequency diagrams.

Evaluation and Interpretation

The evaluation and interpretation of the data, leading up to the results presented in this report, involved the review of some 1300 scatter diagrams, histograms, and other plots. By means of these plots the dependence of selected chemical parameters (especially uranium) on the other chemical parameters for various groupings of the samples (eg., geographic, geologic, and economic groupings) were investigated.

THE VARIATIONS OF URANIUM, THORIUM, AND POTASSIUM CONTENTS WITH PETROGRAPHIC, GEOGRAPHIC, AND GEOLOGIC SUBDIVISIONS

The variations of uranium, thorium, and potassium with (a) rock type and granularity, (b) latitude and longitude and (c) geologic province, were considered. Also, the possible correlation of anomalous uranium content with the metal provinces of Noble (1970) was investigated.

Variations with Rock Type and Granularity

Petrographic data used in this analysis are, as noted earlier, qualitative in nature.

Data on uranium, thorium, and potassium concentrations in six different groups of rock types (Figures 7, 8, and 9) indicate noticeable increases in the average concentrations of these elements from the basic to the more acidic types, as expected. This is observed in both the quartz-bearing (eg. quartz monzonite) and quartz-free (eg. monzonite) series. Data for the syenite group should be disqualified since only one sample is involved. For uranium it is further noted that the distribution of values is broader in the more acidic groups (eg. granite and quartz monzonite).

Data on uranium, thorium, and potassium contents as functions of granularity (Table 2) suggest a bimodal distribution for uranium (highs in the aphanitic and medium- to coarse-grained classes) and a general decrease in thorium and potassium content with increasing grain size.

Variations with Latitude and Longitude

Average concentrations of uranium, thorium, and potassium in one-degree latitude-longitude quadrilaterals are indicated in Figures 10, 11, and 12. A general westward decrease in average uranium, thorium, and potassium content is noted, particularly in northern Washington and Nevada. Quadrilaterals with the highest average uranium content are found in eastern Washington, western and southwestern Utah, central Colorado, northcentral New Mexico, and southeastern Arizona.

The analysis of the one-degree average data was not pursued further for the following reasons: (1) the number of samples in the quadrilaterals is uneven and the data are strongly affected by individual anomalous samples; three of the areas in the highest uranium range, for example, include less than four samples, (2) there is no firm evidence, either from theoretical considerations or from field geochemical investigations, that data on uranium, thorium, or potassium concentration in plutonic rocks can be used on a regional scale to indicate favorability for vein-type uranium deposits.

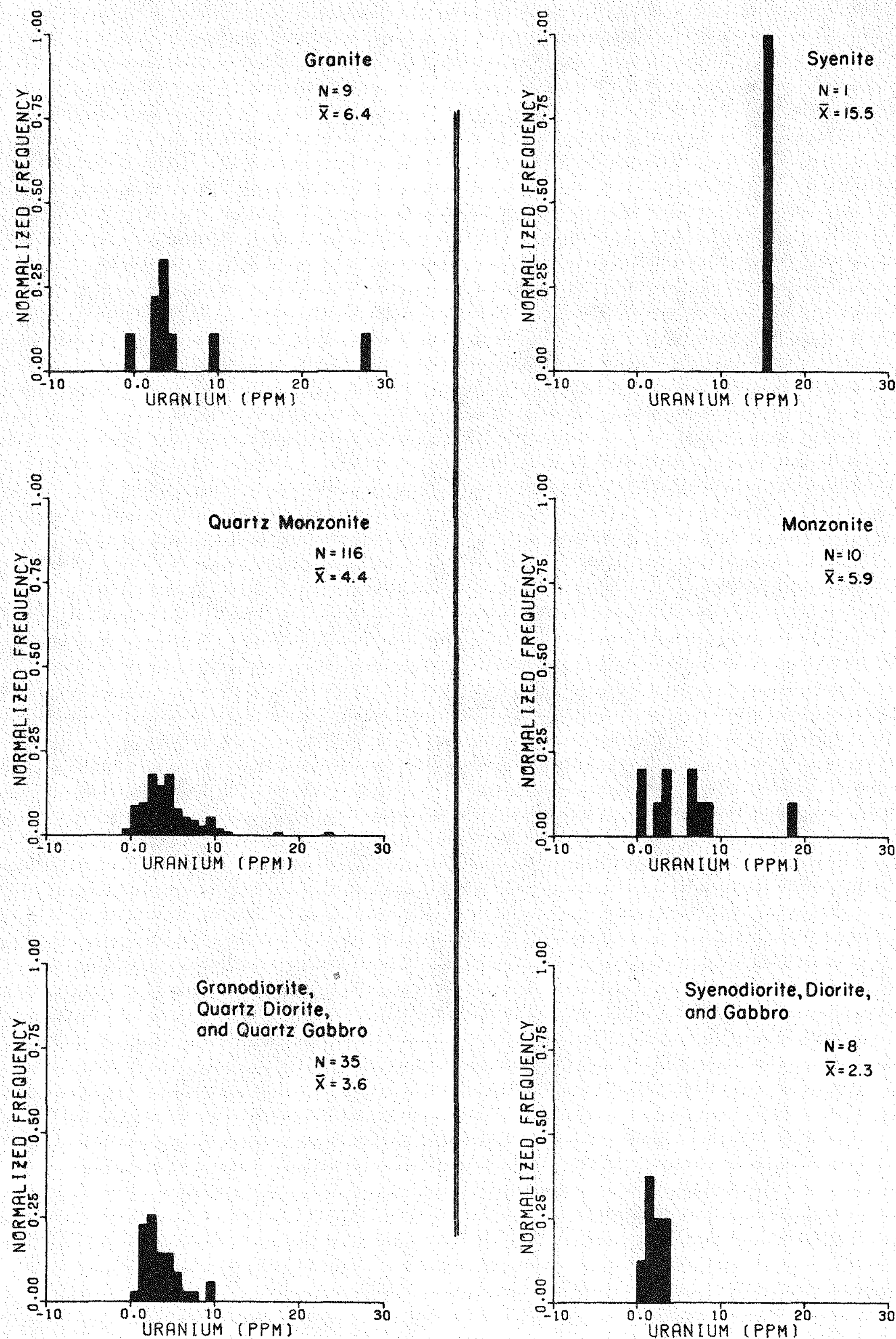


Figure 7. Histograms showing frequency distributions of uranium in different rock types. N = number of samples; $\bar{x}$ = mean.

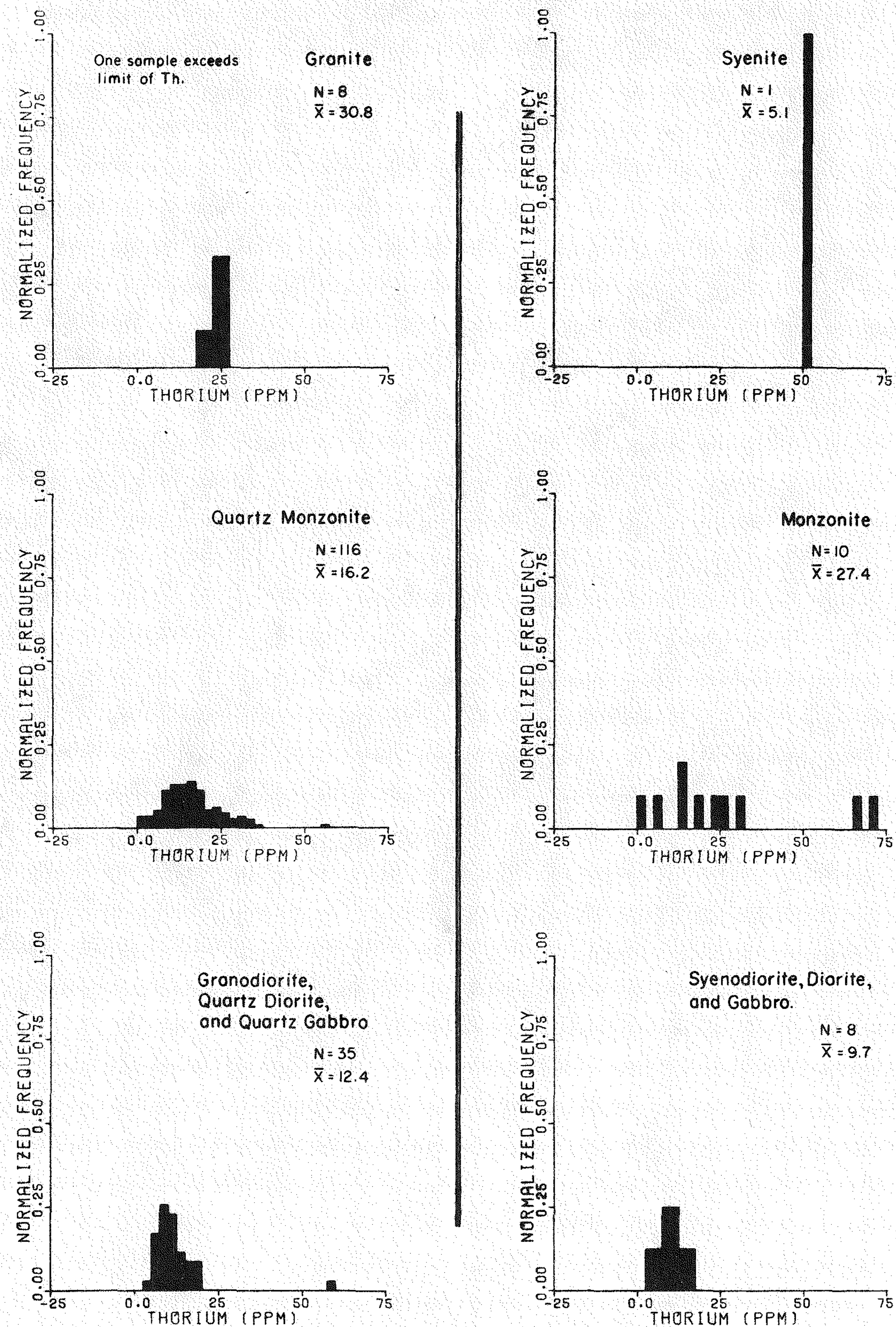


Figure 8. Histograms showing frequency distributions of thorium in different rock types. N = number of samples; $\bar{x}$ = mean.

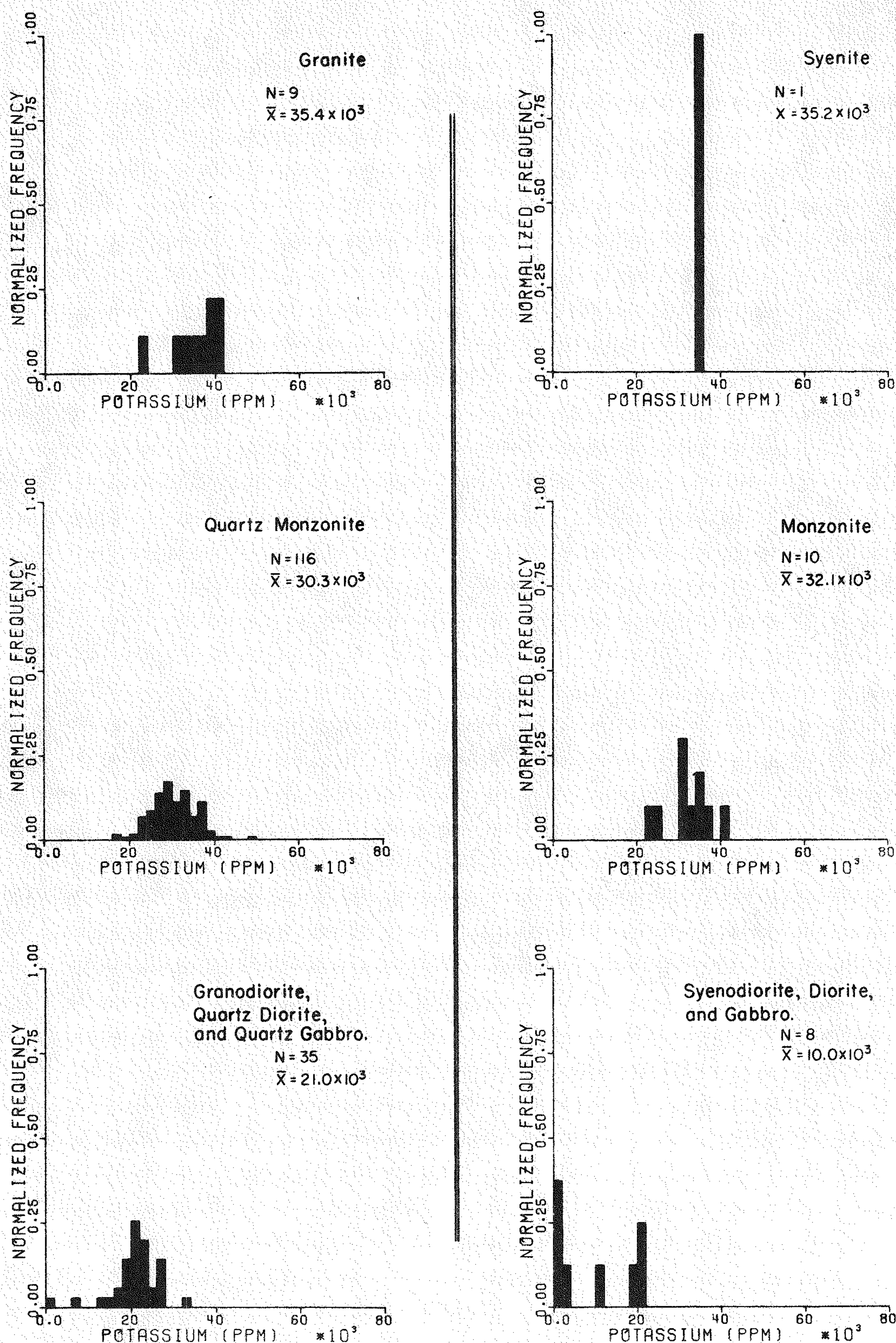


Figure 9. Histograms showing frequency distributions of potassium in different rock types. N = number of samples; $\bar{x}$ = mean.

Table 2

AVERAGE URANIUM, THORIUM, AND POTASSIUM CONTENTS AS FUNCTIONS OF GRANULARITY[1]

Granularity	Number of Samples	Uranium (ppm)	Thorium (ppm)	Potassium (percent)
aphanitic	4	4.4	25.2	3.31
fine grained	18	3.8	16.1	3.21
medium grained	79	4.6	16.2	3.04
coarse grained	15	4.3	14.0	3.07

[1]Quartz monzonite, Mesozoic and Cenozoic

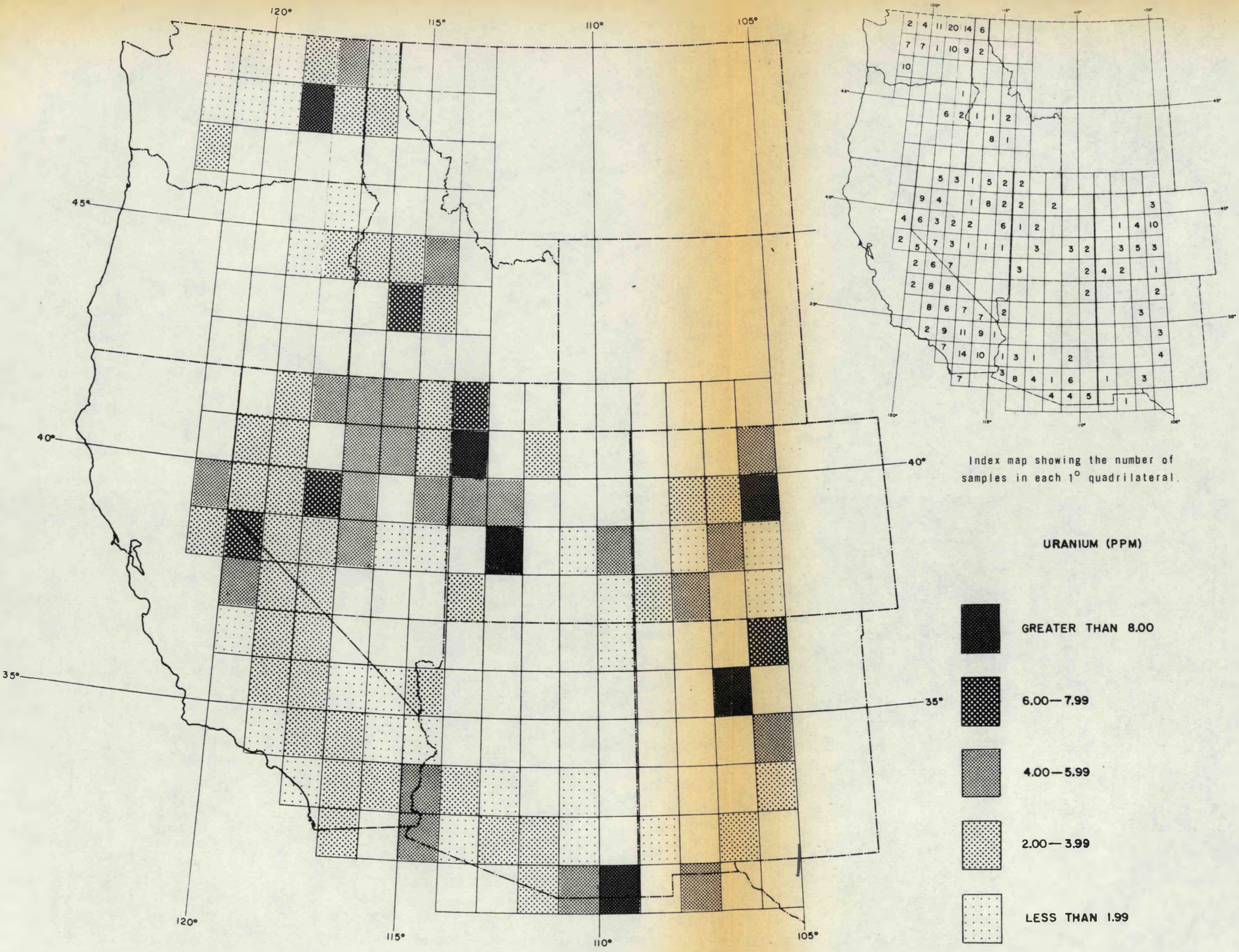
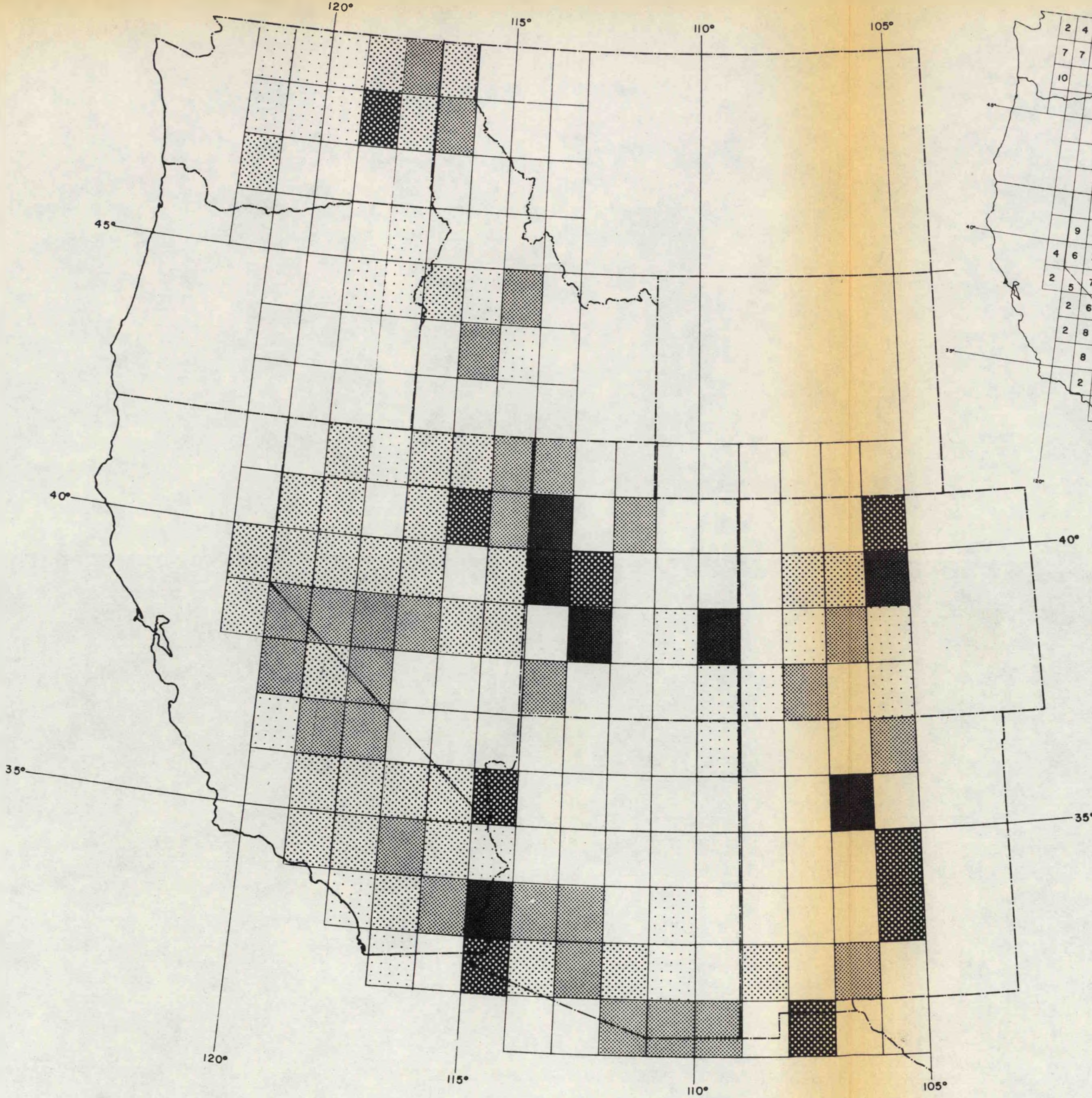
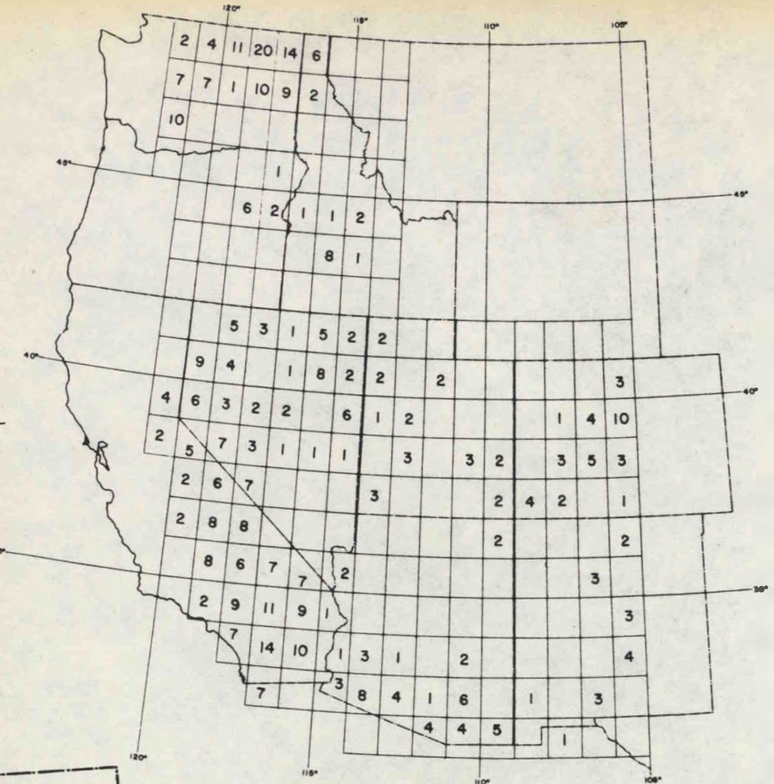


Figure 10. Map showing average concentration of uranium in one-degree quadrilaterals. N = number of samples; $\bar{x}$ = mean.





Index map showing the number of samples in each 1° quadrilateral.

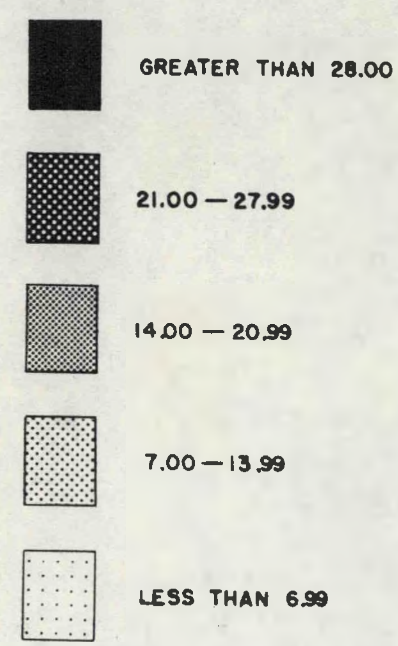


Figure 11. Map showing average concentration of thorium in one-degree quadrilaterals. N = number of samples; $\bar{x}$ = mean.

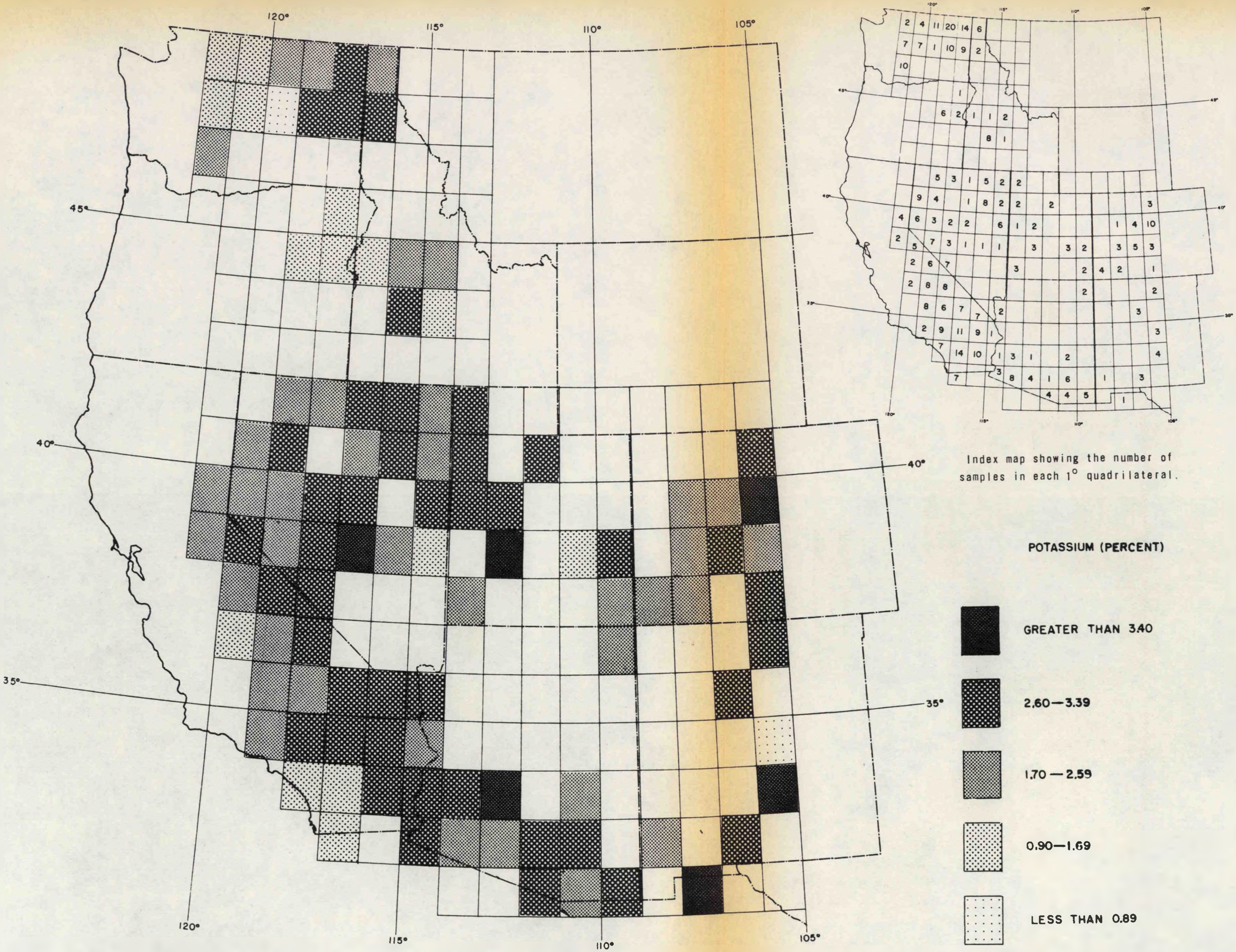


Figure 12. Map showing average concentration of potassium in one-degree quadrilaterals. N = number of samples; $\bar{x}$ = mean.

Variations with Geologic Province

Frequency distributions and mean values of uranium, thorium, and potassium in the various geologic provinces are presented in Figures 13, 14, and 15. The data are not given for provinces with less than 5 samples. As with the one-degree averages, these data indicate a general decrease in all three elements from the continental interior toward the continental margin.

Uranium frequency distributions are narrow and mean values consistently low for provinces nearest the continental margin (provinces 21, 22, 24, 25, 26, and 32). The lowest mean values are found in the Columbia Plateau (province 50) and Colorado Plateau (province 41). The highest mean values and the broadest distributions are found in the Northern Rocky Mountain Batholiths (province 61), Idaho-Boulder Batholiths (province 62), Southern Rocky Mountains (province 90) and Mexican Highland (province 34).

The major known vein-type uranium deposits are found in provinces 61 and 31. Although mean uranium, thorium and potassium concentrations are higher than the average in these provinces, there is no definite correlation between high concentrations of these elements on a province basis and the presence of vein-type uranium deposits. Provinces with the highest mean concentrations of uranium (ie., provinces 62, 90 and 34) do not contain known major vein-type uranium deposits.

Variations with Geologic Province and Age

Data from three provinces, each containing appreciable numbers of both Mesozoic and Cenozoic samples, were used to evaluate the effect of general age on the concentrations of uranium, thorium, and potassium in plutonic rocks (Figures 16, 17, and 18). The mean values of uranium, thorium, and the uranium-thorium ratio (Figures 16, 17 and 19, respectively) are consistently higher in the Cenozoic compared with the Mesozoic. The mean potassium concentrations (Figure 18) are the same in both the Mesozoic and Cenozoic for province 21 but potassium is higher in the Cenozoic than in the Mesozoic for provinces 31 and 32.

Comparison with Published Data

Data on the average concentrations of uranium, thorium, and potassium in various parts of the western U. S. agree favorably with published data (Table 3) without regard to method or precision of analysis. The greatest difference in the uranium data are for the Idaho batholith and for Central Colorado.

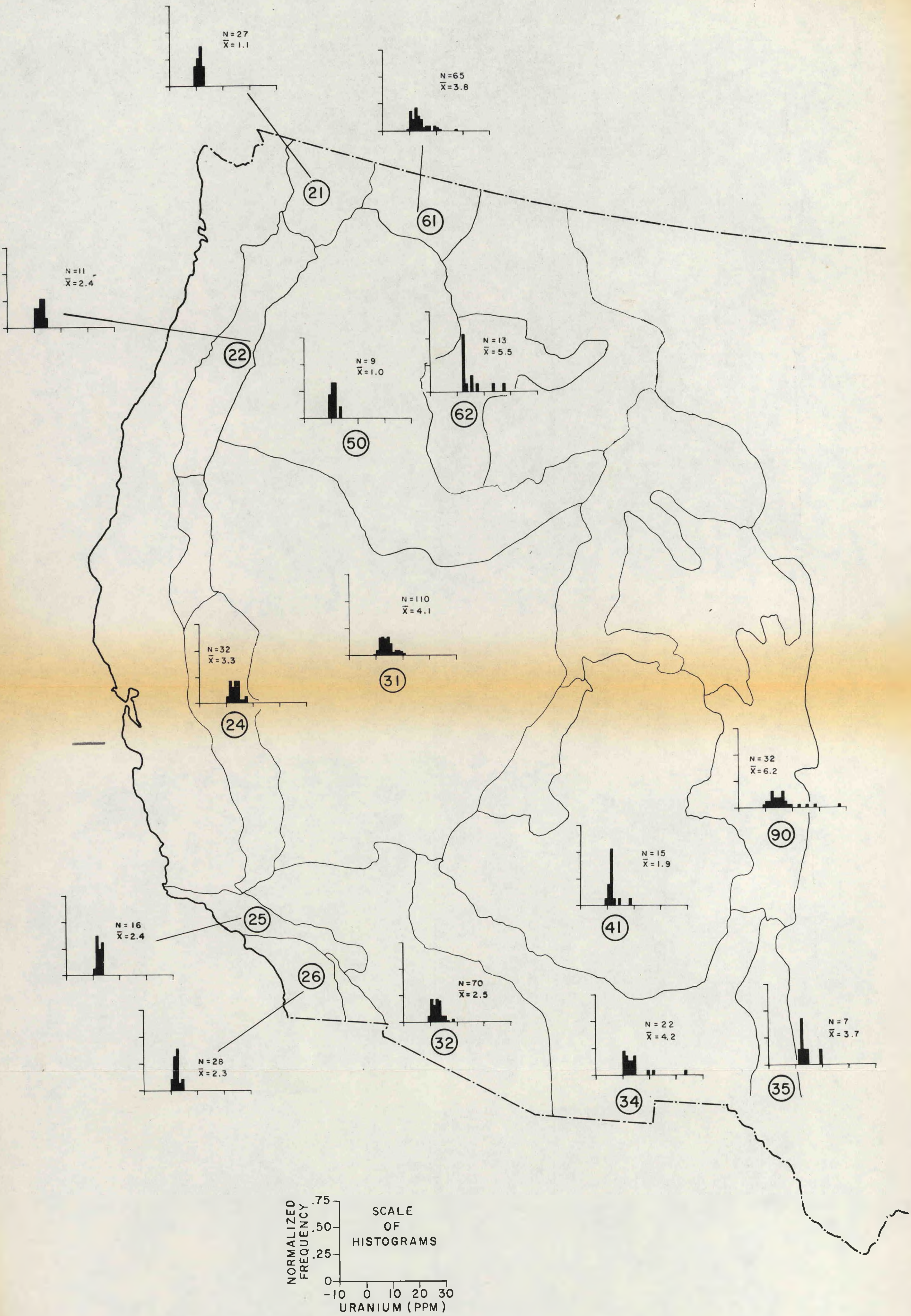


Figure 13. Histograms showing frequency distribution of uranium in geologic provinces. N = number of samples; $\bar{x}$ = mean.

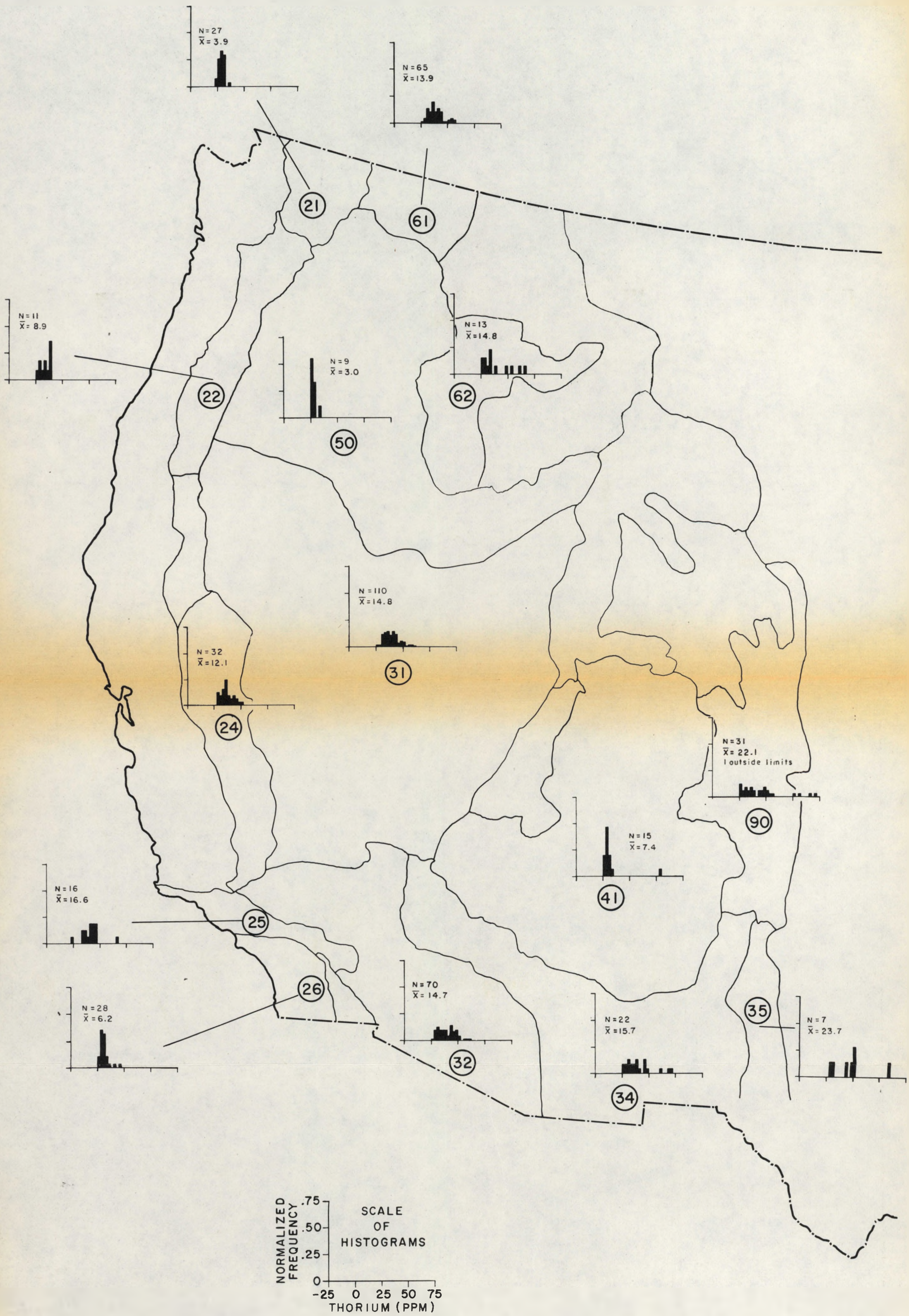


Figure 14. Histograms showing frequency distributions of thorium in geologic provinces. N = number of samples exclusive of samples beyond concentration limit; x = mean.

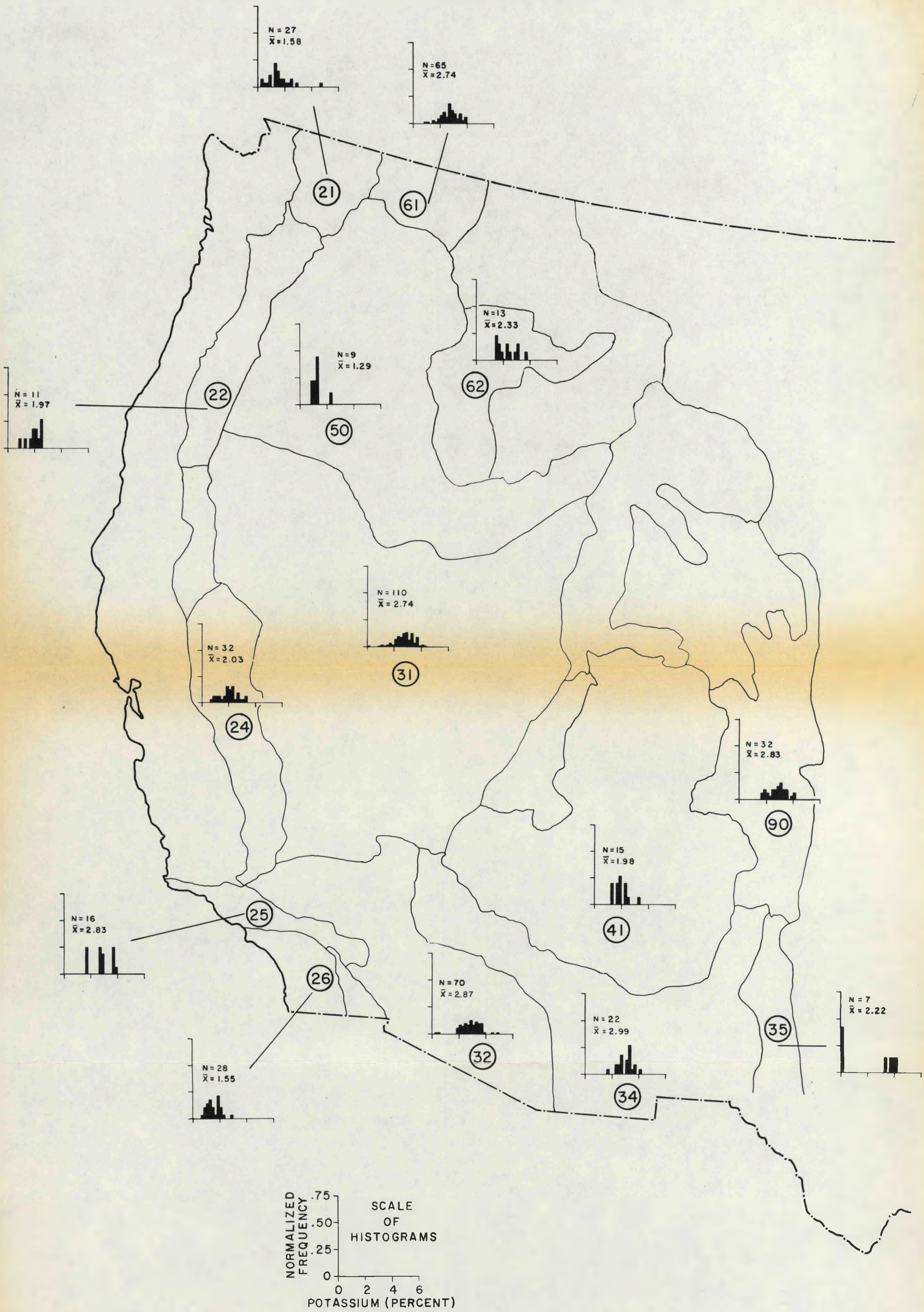


Figure 15. Histograms showing frequency distributions of potassium in geologic provinces. N = number of samples; $\bar{x}$ = mean.

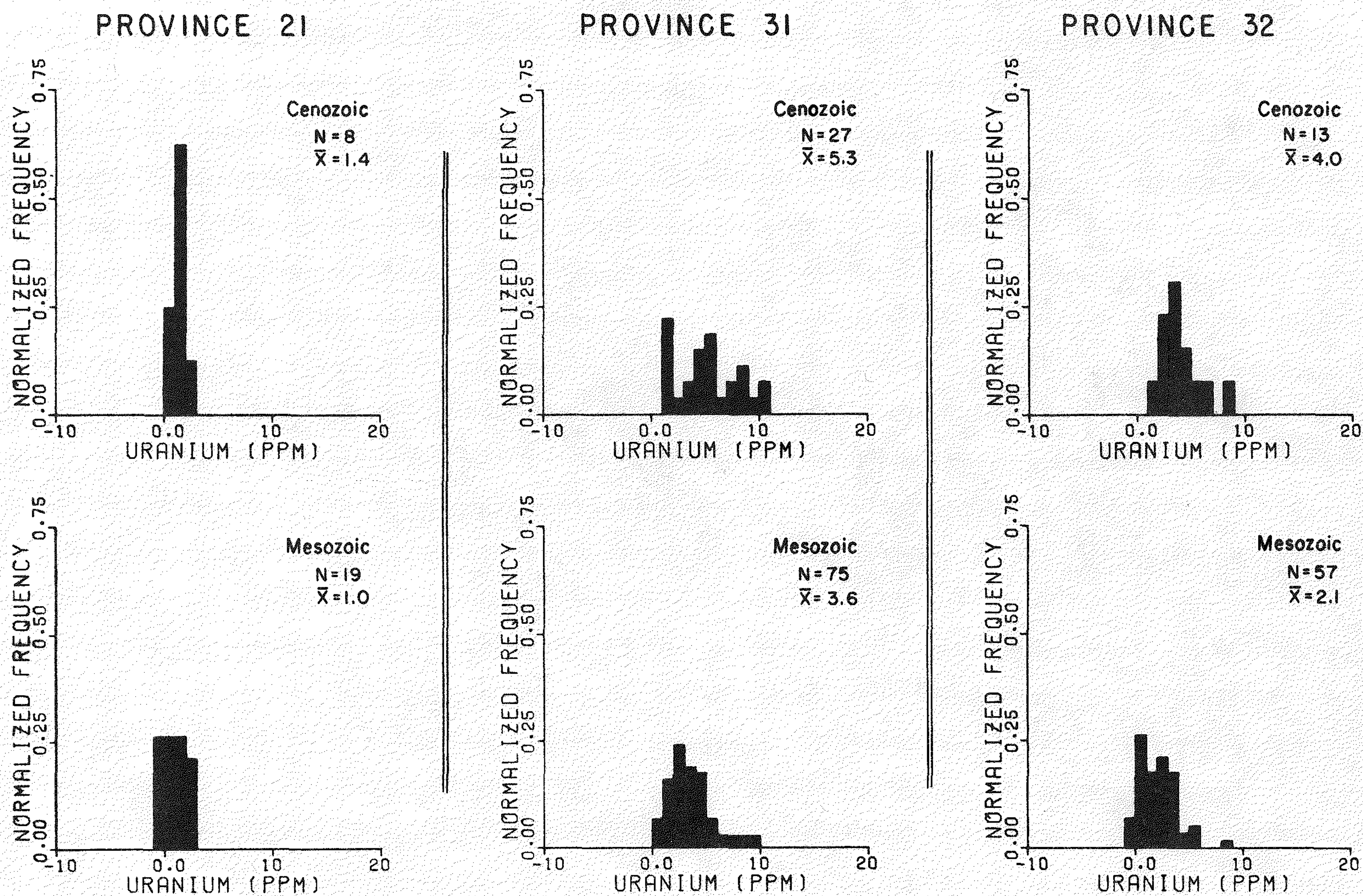


Figure 16. Histograms showing frequency distributions of uranium as a function of age in three provinces. N = number of samples; $\bar{x}$ = mean.

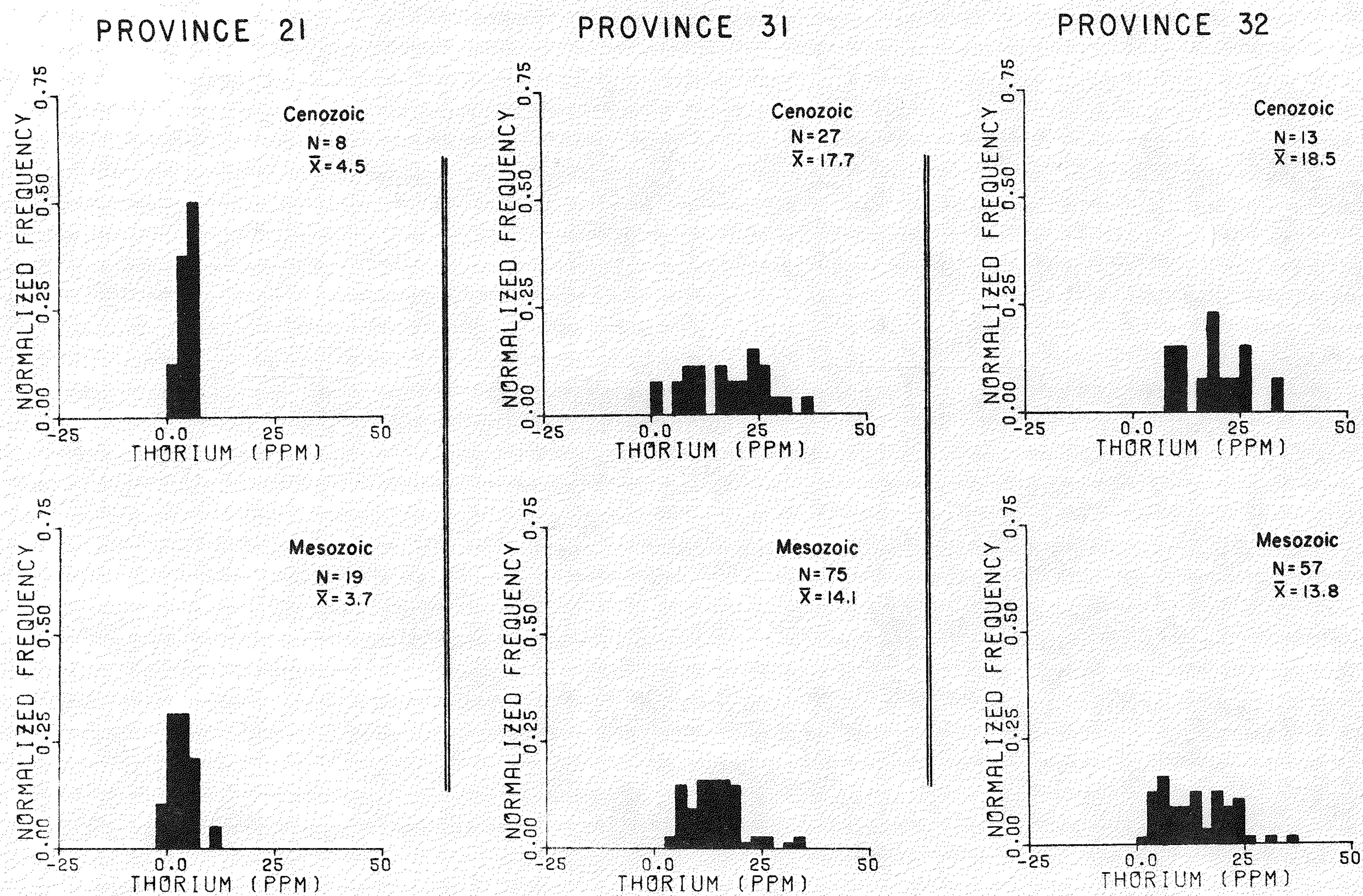


Figure 17. Histograms showing frequency of distributions of thorium as a function of age in three provinces. N = number of samples; $\bar{x}$ = mean.

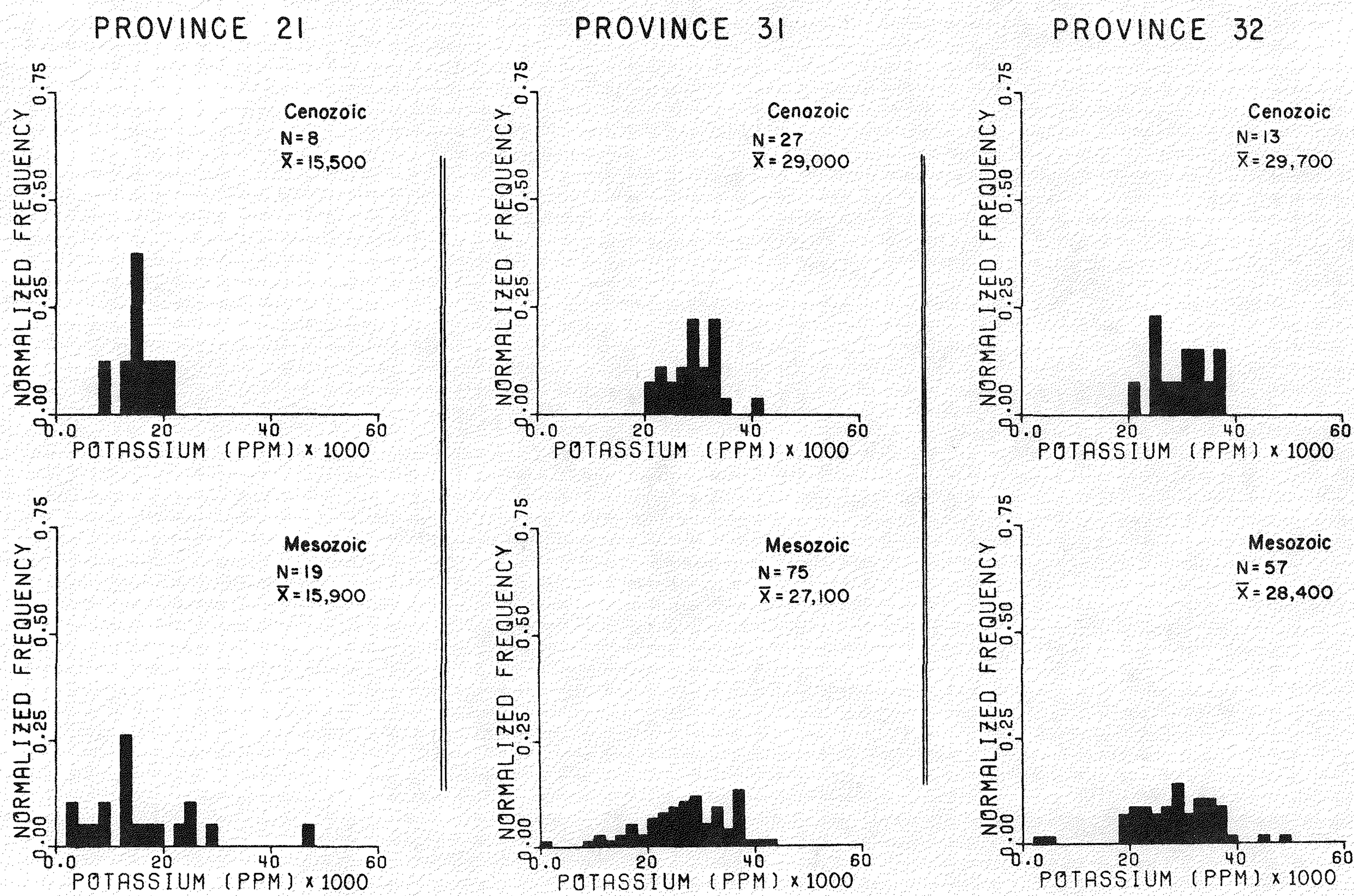


Figure 18. Histograms showing frequency distributions of potassium as a function of age in three provinces. N = number of samples; $\bar{x}$ = mean.

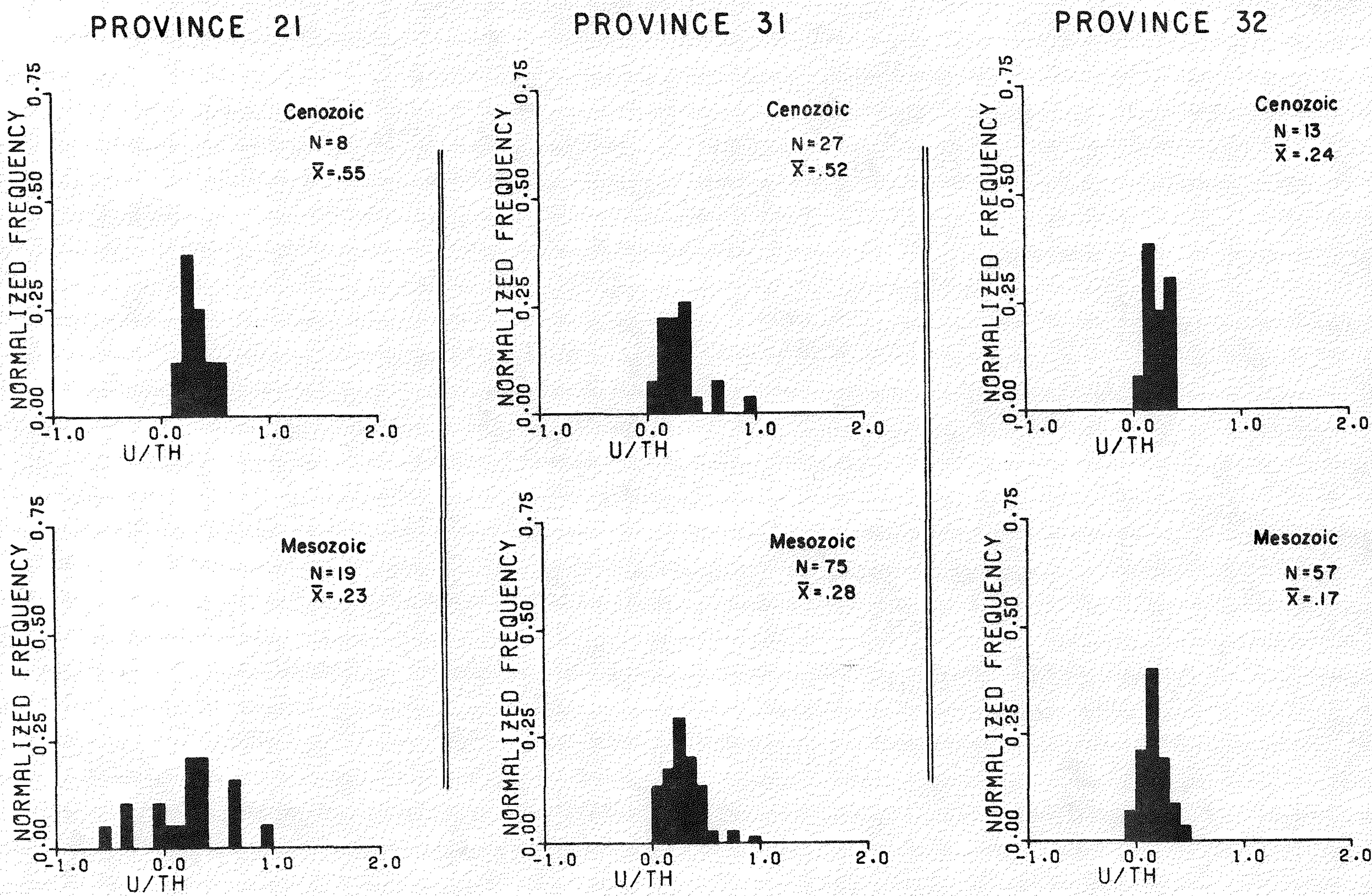


Figure 19. Histograms showing frequency distributions of uranium/thorium ratio as a function of age in three provinces. N = number of samples; $\bar{x}$ = mean.

Table 3

COMPARISON OF RESULTS OBTAINED IN THIS STUDY WITH PUBLISHED DATA ON URANIUM, THORIUM, AND POTASSIUM CONCENTRATIONS IN PLUTONIC ROCKS

Area	This Report				Previously Published Data				References
		Average Values				Average Values			
	Number of Samples	Uranium (ppm)	Thorium (ppm)	Potassium (percent)	Number of Samples	Uranium (ppm)	Thorium (ppm)	Potassium (percent)	
Southern California batholith	28	2.3	6.2	1.6	45	1.7[a]	5.5[a]	1.7[a]	calculated by Tilling and Gottfried (1969) from data of Larsen, Jr., and Gottfried (1961)
Central Sierra Nevada	4	4.2	17.0	2.4	278	4.46	15.5	2.86	Wollenberg and Smith, 1968
Idaho batholith	18	5.3	14.8	2.3	44/29[b]	2.5[a]	12.0[a]	--	Larsen, Jr., and Gottfried, 1961; Larsen, 3d, and Gottfried, 1960
Boulder batholith	--	--	--	--	60	3.9[a]	15.4[a]	3.3[a]	Tilling and Gottfried, 1969
Colorado Front Range	11	10.5	39.9	3.4	27/23[b]	7.6[a]	30.0[a]	--	Phair and Gottfried, 1964
Central Colorado (exclusive of Front Range)	13	4.3	13.7	2.5	25	2.2	9.7	--	Phair and Gottfried, 1964

[a] Average weighted according to areal abundance of rock types or constituent plutons.

[b] First figure is number of samples analyzed for uranium; second figure is number analyzed for thorium.

Investigation of the Possible Correlation Between
Anomalous Uranium Content and Metallization

The possibility of a correlation between the uranium content of plutonic rocks and associated metallization was investigated by means of a comparison between the relative percentages of all versus anomalous (ie., average uranium content greater than 5 ppm; Plate 2) intrusive centers occurring within the various metal provinces of Noble (Figures 3, 4, 5, 6, 9 and 10 of Noble, 1970). This was done for both the total area of study and for the Great Basin (Table 4). Other geologic provinces contained too few anomalous intrusive centers for a valid comparison. Also, one of the metals considered by Noble, tungsten, was omitted from the comparison because the small and widely scattered tungsten provinces do not contain any of the intrusive centers sampled in the project.

The data (Table 4) indicate that the percentage of anomalous intrusive centers occurring within a particular metal province is greater than the percentage of all intrusive centers occurring within the same province. This is true for both the total area of study and for the Great Basin, except for the "Large Concentrations of Metals" in the Great Basin where relatively few data points are involved. This effect is most pronounced for copper, where, in the total area of study, the percentage of anomalous intrusive centers occurring within the copper province (43 percent fall within the province) is twice the percentage of all intrusive centers together (21percent fall within the province).

It also noteworthy, in reference to Plate 2, that in several areas the anomalous intrusive centers tend to occur in clusters, the most obvious being in west central Nevada, southern Arizona and in the Colorado Front Range.

Table 4

COMPARISON OF THE RELATIVE PERCENTAGES OF ALL AND OF ANOMALOUS INTRUSIVE CENTERS FALLING WITHIN METAL PROVINCES

	Gold (Figure 4 Noble, 1970)	Silver (Figure 5 Noble, 1970)	Copper (Figure 3 Noble, 1970)	Lead-Zinc (Figure 6 Noble, 1970)	Combined Metals (Figure 10 Noble, 1970)	Large Concentrations of Metals (Figure 9 Noble, 1970)
1. Total Area of Study						
Percentages of all[1] intrusive centers located within province	55	58	21	30	73	11
Percentage of anomalous[2] intrusive centers located within province	74	77	43	54	89	20
2. Great Basin						
Percentage of all[1] intrusive centers located within province	57	98	13	43	97	2
Percentage of anomalous[2] intrusive centers located within province	80	100	27	53	100	0

[1]All intrusive centers (210 in number) sampled in the project.

[2]Anomalous intrusive centers (40 in number) are those with an average uranium content greater than 5 ppm.

AN ANALYSIS OF THE DATA TO DETERMINE POSSIBLE GEOCHEMICAL INDICATORS

The approach taken in this analysis consists of a comparison of chemical data for samples from areas of known vein-type uranium mineralization (referred to as "reference areas") with data for select groups of samples (eg., all samples in a particular geologic province, the Pilot Group). Frequency distributions, cumulative frequency distributions and X-Y plots (scatter diagrams) are used.

The "reference areas" are areas containing important vein-type uranium deposits (Figure 20). The samples associated with uranium deposits in these areas are collectively referred to as the Reference Group (Table 5). A sample is considered to be associated with a particular deposit if the sample is from an intrusive phase which has a probable or possible genetic relation to the uranium deposit (Table 6). All samples from the reference areas are unmineralized and are intended to represent the intrusive phase of interest.

The genetic relationship between uranium mineralization and the intrusive phase in each of the reference areas is not certain (Table 6). Geologic data available on the various areas, however, indicate the highest possibility of a genetic relationship in the Midnight Boyd and Austin areas. Although each of the five reference areas[1] are considered in this analysis, the results obtained for the Midnight Boyd and Austin areas are weighed the heaviest.

In the discussion that follows, several elements for which semiquantitative emission spectrographic data were received are not considered because of either (a) analytical difficulties or (b) the small percentage of samples in which the element was detected.

Major elements are considered first since the concentrations of most minor elements are dependent to some degree on the concentrations of one or more of the major elements. Also, uranium is considered last because of the interest in its possible relationships to the other elements.

In general, only significant correlations are considered, except for the uranium-zirconium, thorium-zirconium, uranium-molybdenum, and thorium-molybdenum correlations which were identified as of specific interest to the AEC.

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[1]The data from Marysvale are not considered in the analyses that follows because only one sample from the area was accepted; other samples collected were rejected because of weathering (Appendix B).

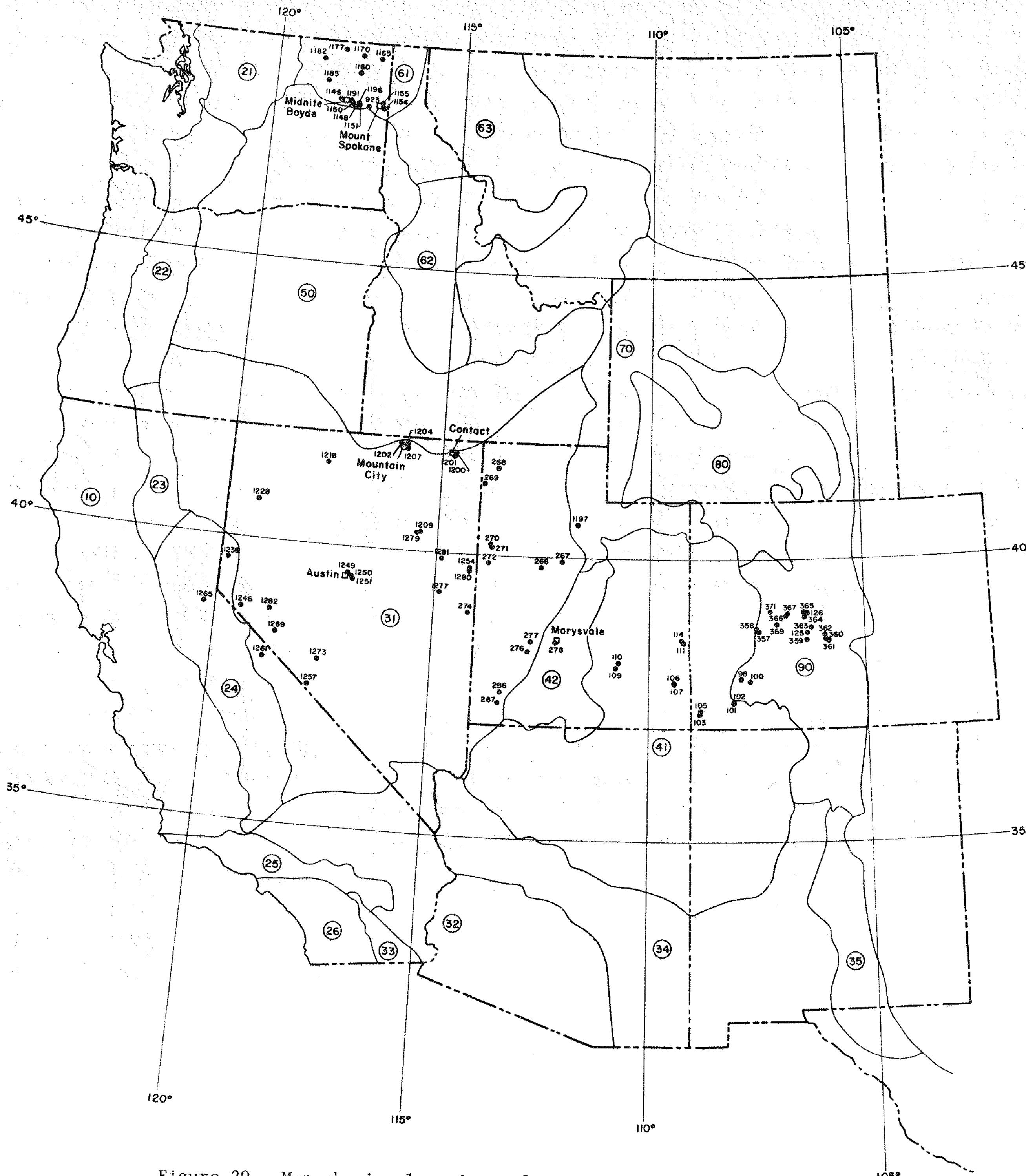

Figure 20. Map showing locations of samples in Pilot Group and locations of reference areas. Reference areas are indicated by name. Numbers with dots are sample numbers.

Table 5

IDENTIFICATION OF SAMPLES FROM REFERENCE AREAS

Reference Area	General Analysis: Number of Samples	General Analysis: Sample Numbers	Pilot Study: Number of Samples	Pilot Study: Sample Numbers
Midnight Boyd	5	1191-1195	1	1191
Austin	3	1249-1251	3	1249-1251
Mt. Spokane	3	1153-1155	2	1154,1155
Marysvale	1	278	1	278
Mountain City	6	1202-1207	3	1202,1204, 1207
Contact	2	1200,1201	2	1200,1201
Total	20		12	

TABLE 6

NATURE OF URANIUM DEPOSITS IN REFERENCE AREAS

Reference Area	Relationship Between Uranium Deposit and Intrusive	Reference
Midnight Boyd	probable genetic relationship	Barrington, J. and P. F. Kerr, 1961
Austin	probable genetic relationship	Sharp, B. J. and D. L. Hetland, 1954
Mount Spokane	possible genetic relationship; veins are in the intrusive	Norman, W. H., 1957
Marysvale	possible genetic relationship; veins are in the intrusive but appear to be related to a later volcanic phase	Kerr, P. F. and others, 1957
Mountain City	possible genetic relationship; mineralization may be associated with a later, volcanic phase	Sharp, B. J. and R. C. Malan, 1972 oral communication
Contact	possible genetic relationship; mineralization may be associated with a later, volcanic phase	Sharp, B. J. and R. C. Malan, 1972 oral communication

9

Major Elements

Quantitative analyses for the major elements were obtained only for samples comprising the Pilot Group (Figure 20). The analysis of the data that follows is based primarily on these data and on the gamma spectrometric analyses for potassium in all of the samples. Semiquantitative analyses of the elements in all of the samples are also considered.

Several compositional indices, including potassium, silicon, the alkali-lime index (Peacock, 1931), the Larsen Index (Larsen, 1938), and the Nockolds-Allen Index (Nockolds and Allen, 1953) were investigated. The best correlations were obtained with the Nockolds-Allen Index and it is used throughout the remainder of the report to indicate the compositional dependence of chemical parameters.

Differentiation indices such as the Larsen Index and the Nockolds-Allen Index have been widely used in petrographic studies, but primarily on a local scale where related rock units are involved. Although its use on a regional or continental scale, as in this project, is not theoretically based it does serve the purpose of an overall "compositional index".

Nockolds-Allen Index

The frequency distribution[1] of the Nockolds-Allen Index for the Pilot Group is relatively flat (Figure 21) indicating a broad compositional range. The reference areas are characterized by generally higher than average values. No sample in the Reference Group has an index less than 8.0 while approximately 30 percent of the samples in the Pilot Group are below this value (Figure 22).

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[1]All frequency distributions and cumulative frequency distributions in this report are normalized to the total number of samples represented in the plot; samples whose data values exceed the limit of the x-axis are not considered in the normalization.

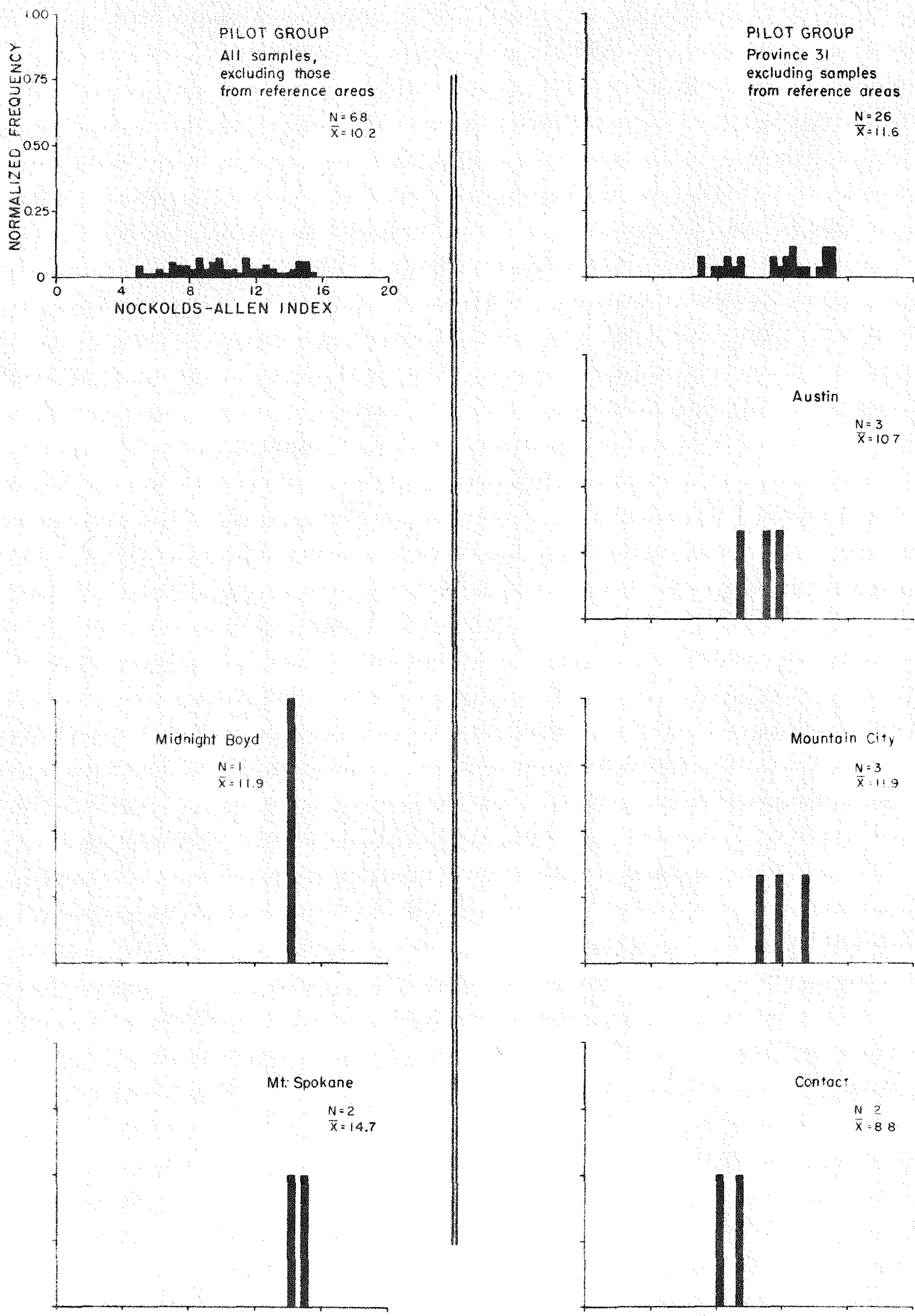


Figure 21. Frequency distribution of the Nockolds-Allen Index for the Pilot Group. Index equals 1/3 Si + K - Ca - Mg; based on quantitative analyses. N = number of samples; $\overline{X}$ = mean.

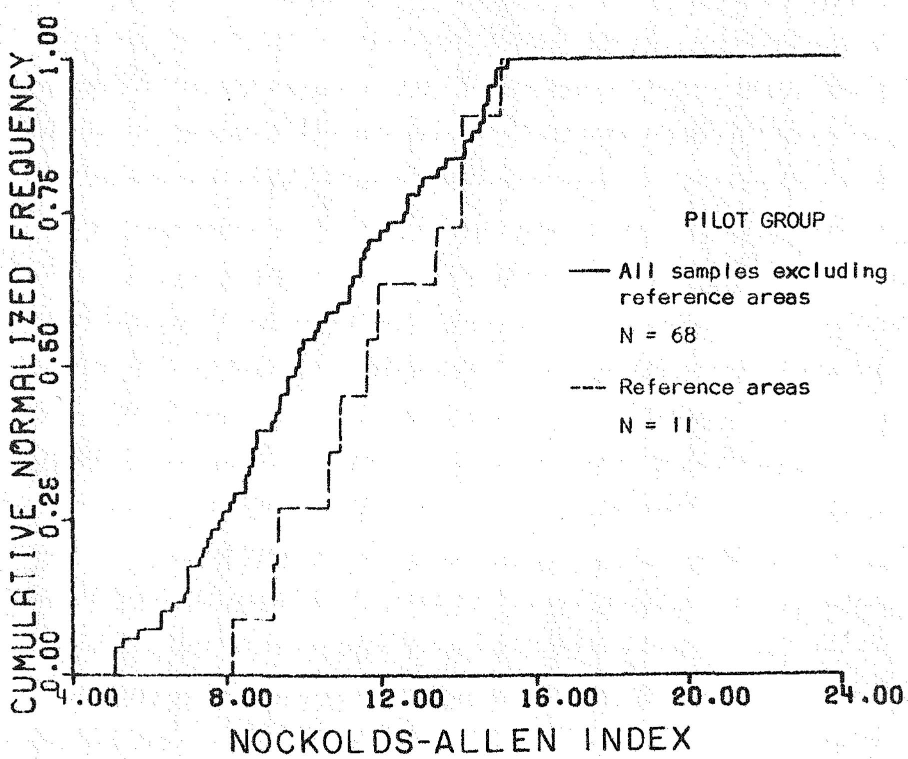


Figure 22. Cumulative frequency distribution of the Nockolds-Allen Index for the Pilot Group. Quantitative analyses. Index equals 1/3 Si + K - Ca - Mg.

Sodium

A comparison of quantitative data for sodium in the Reference and Pilot Groups (Figures 23 and 24A) leads to the conclusion that the former may be characterized by an absence of very low values (ie., below 2.3 percent) and an absence of high values (ie., above 3.2 percent). In the Pilot Group, excluding the reference areas, approximately 10 percent of the samples are below the lower cut-off and about 25 percent are above the upper cut-off (Figure 24A). This conclusion is supported in principal by the semiquantitative data for the Reference Group and for all of the project samples (Figure 24B).

Within the Reference Groups, three of the areas - Austin, Mountain City, and Midnight Boyd - are significantly low in sodium when compared with the average for all other samples in the Pilot Group (Figure 23).

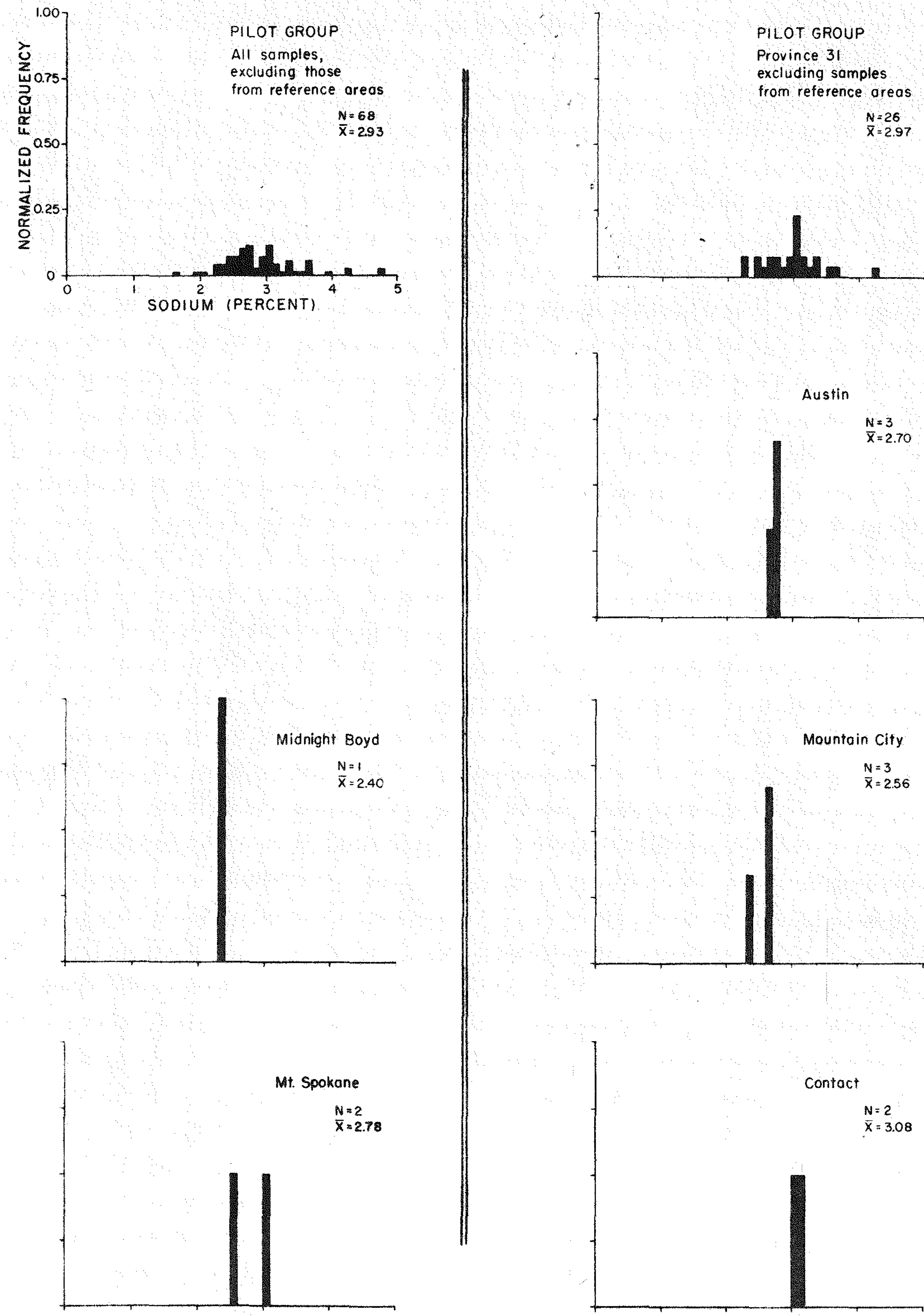
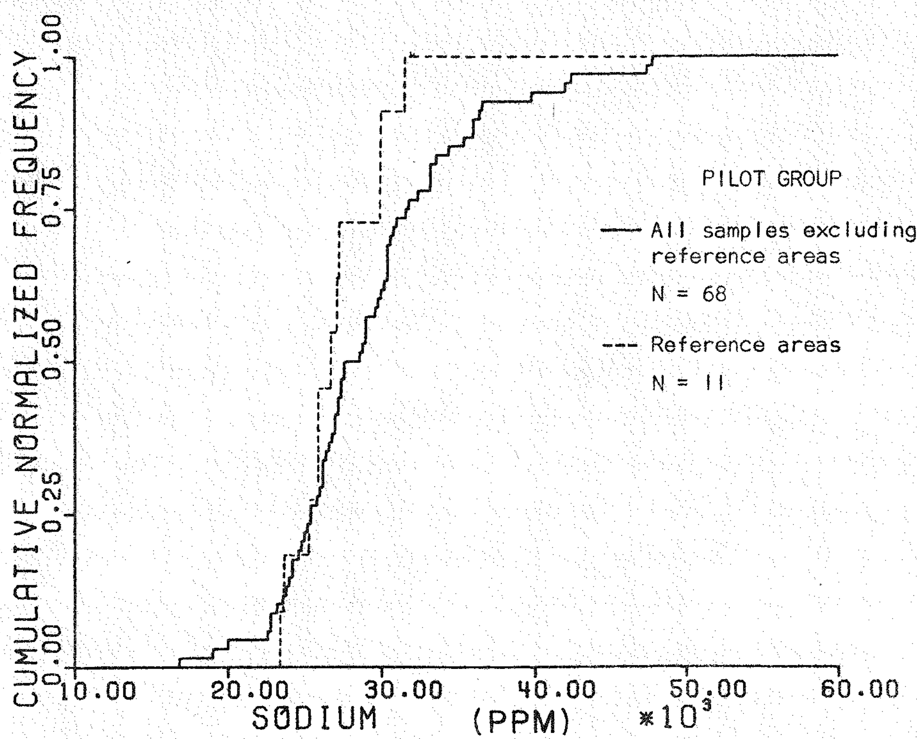
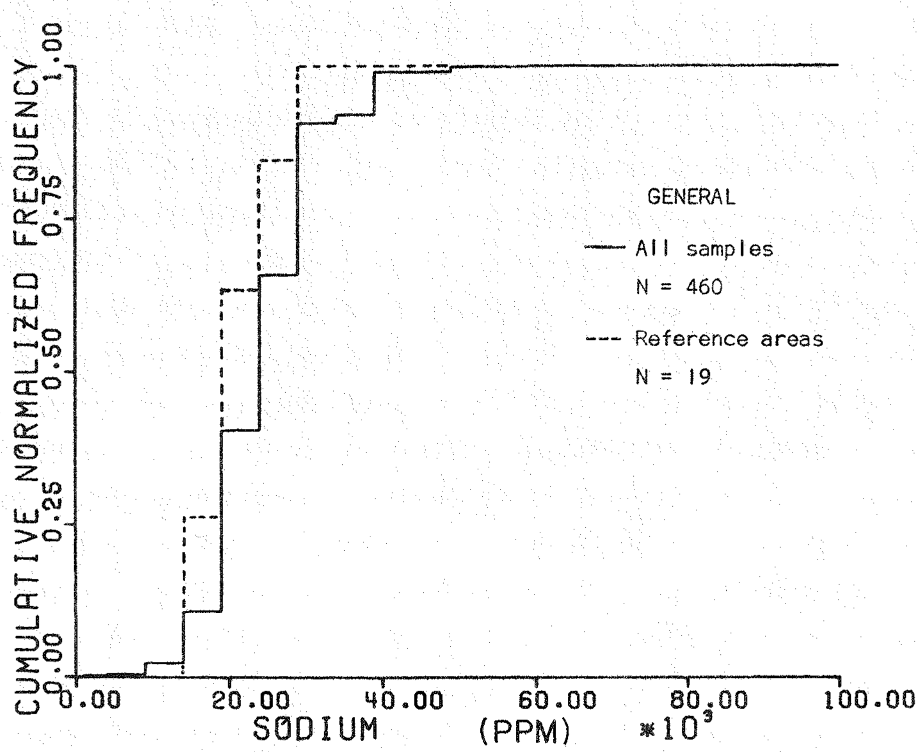


Figure 23. Frequency distribution of sodium for the Pilot Group. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.



A



B

Figure 24. Cumulative frequency distributions of sodium for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

Potassium

A comparison of quantitative data for potassium in the Reference Group and in all samples (Figures 25 and 26) leads to the conclusion that the former may be characterized by a broad range of values but an exclusion of low values (ie., below 2 percent). An estimated 30 percent of all project samples are below this cut-off value.

In determining anomalous potassium abundance in the reference areas, the dependence of potassium on the rock composition, using the Nockolds-Allen Index (Figure 27), must be taken into consideration. Taking into consideration also the levels of analytical precision for both potassium and the Nockolds-Allen Index, no anomalies are noted in the reference areas when compared with the least squares best straight line for the Pilot Group as a whole. The effect of the interdependence of the two variables in this analysis must be noted since the one variable - potassium - is also an element in the other variable - the Nockolds-Allen Index.

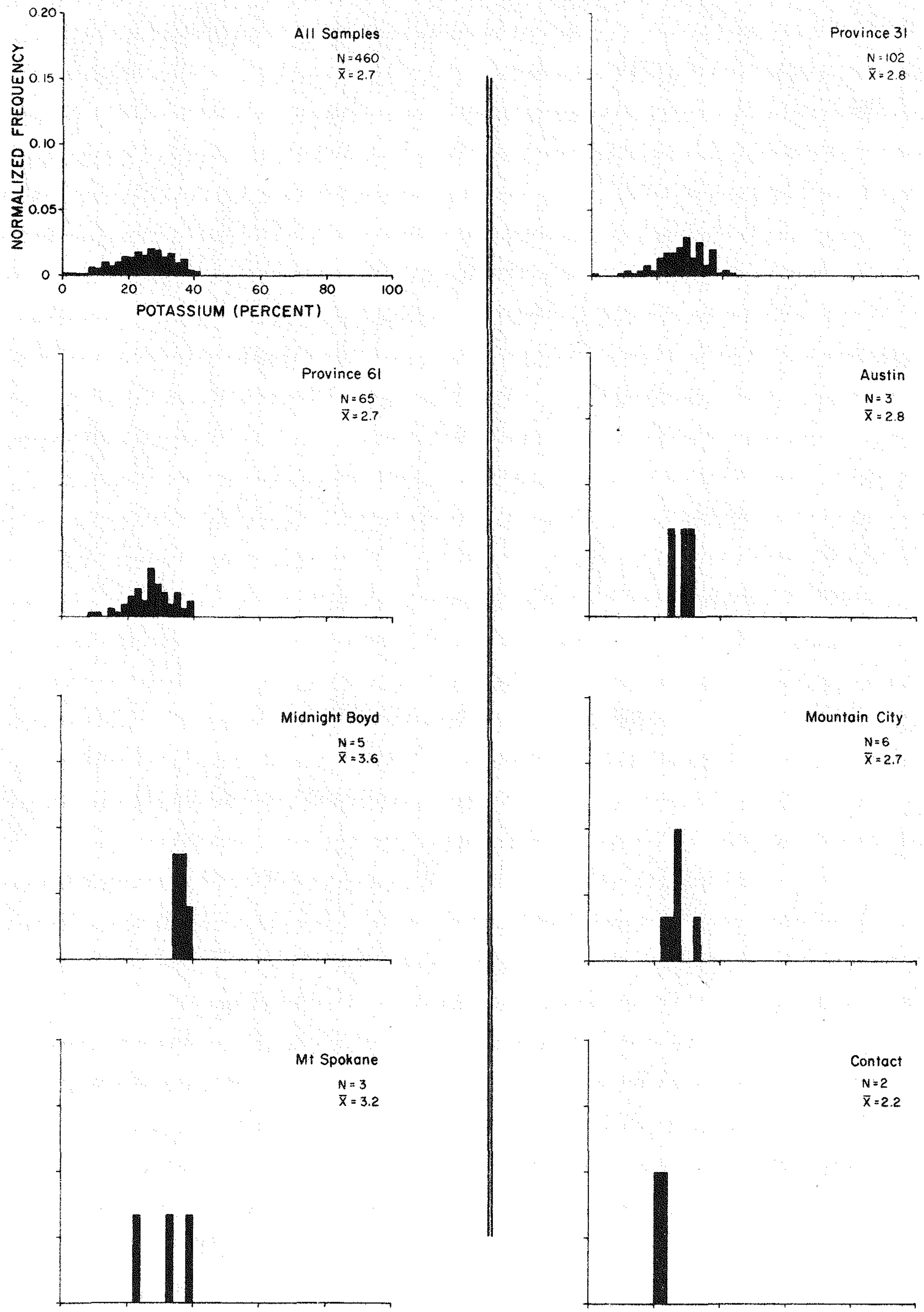


Figure 25. Frequency distribution of potassium for all samples. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.

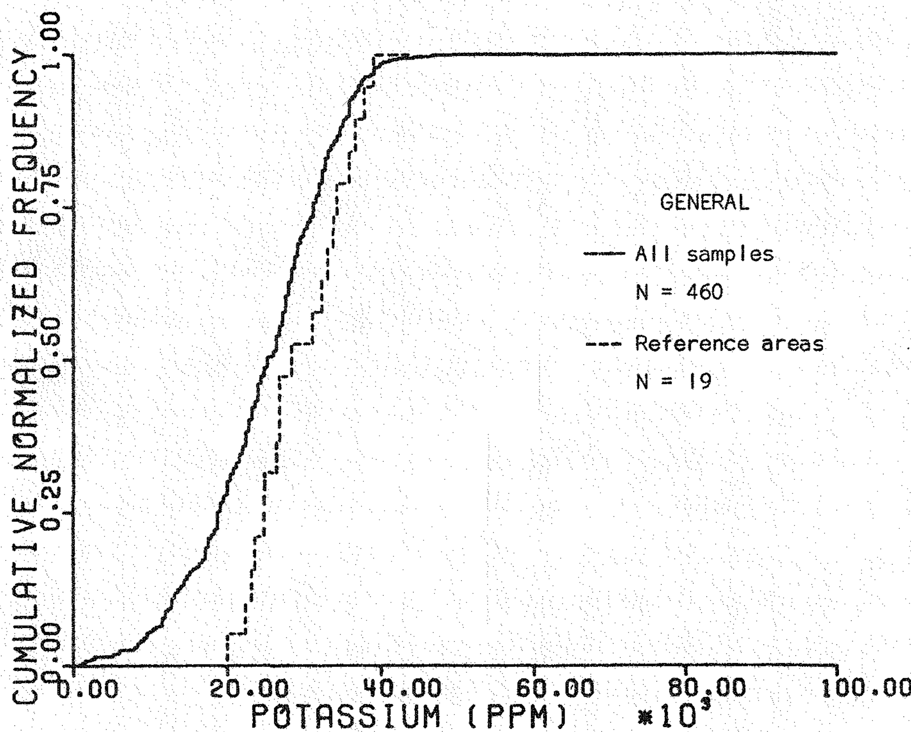
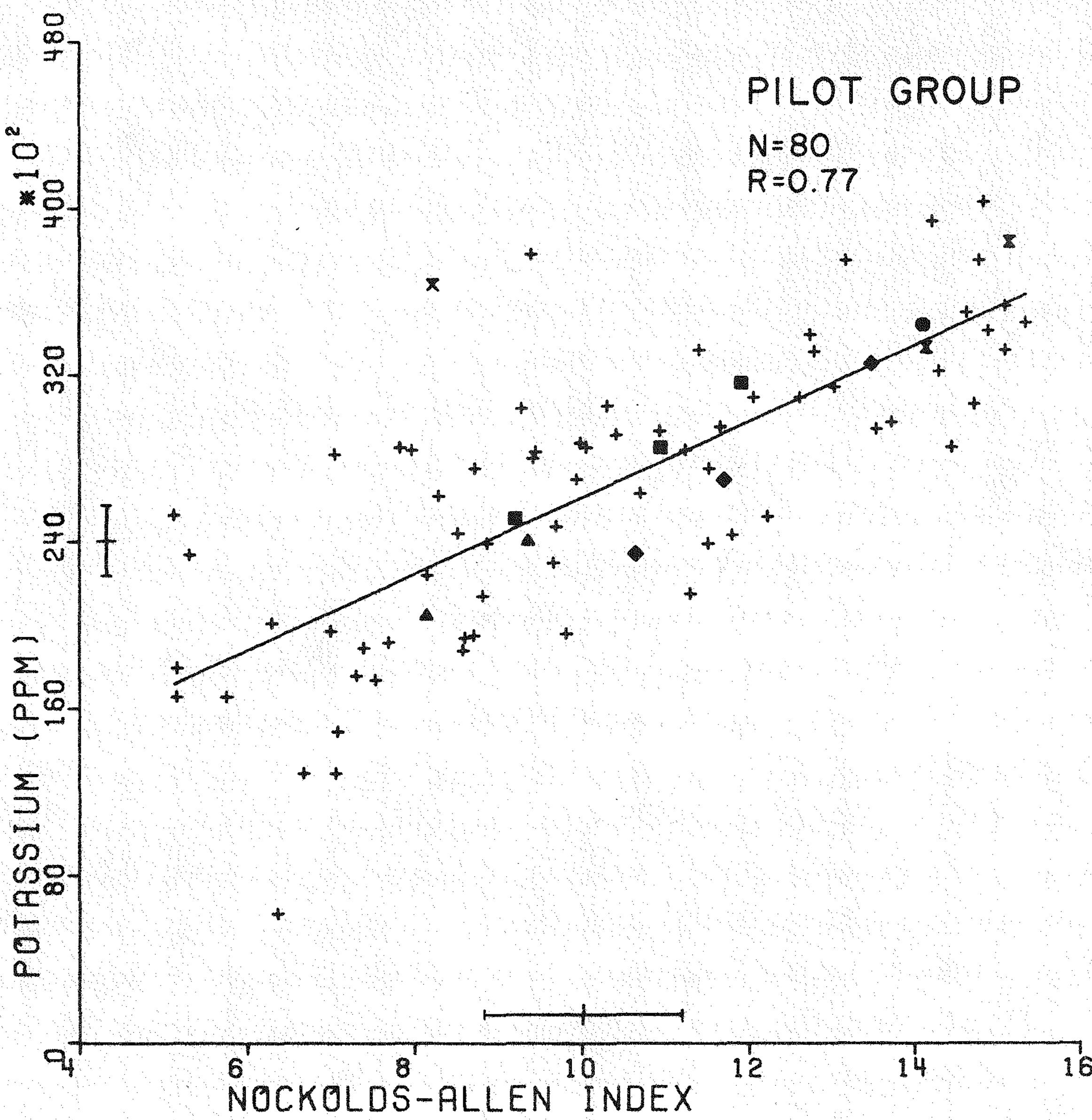


Figure 26. Cumulative frequency distribution of potassium for all samples. Quantitative analyses.



KEY TO REFERENCE AREAS

● Midnight Boyd	x Marysvale
■ Austin	◆ Mountain City
⧗ Mt. Spokane	▲ Contact

Figure 27. Plot of potassium versus Nockolds-Allen Index for the Pilot Group. Quantitative Analyses for potassium. Showing best straight line fit; N = number of samples plotted; R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

Magnesium

No unique characteristic of the Reference Group with respect to magnesium concentrations can be identified from a comparison of (a) quantitative data for the Reference and Pilot Groups (Figures 28 and 29A) and (b) semiquantitative data for the Reference Group and for all samples (Figure 29B).

Magnesium correlates well with the differentiation index (Figure 28). From this plot, taking into consideration the levels of analytical precision, it is noted that samples from Contact and Austin are significantly high when compared with the best straight line fit. Again, however, there is an unknown interdependence of the two variables plotted since magnesium is also a component of the index.

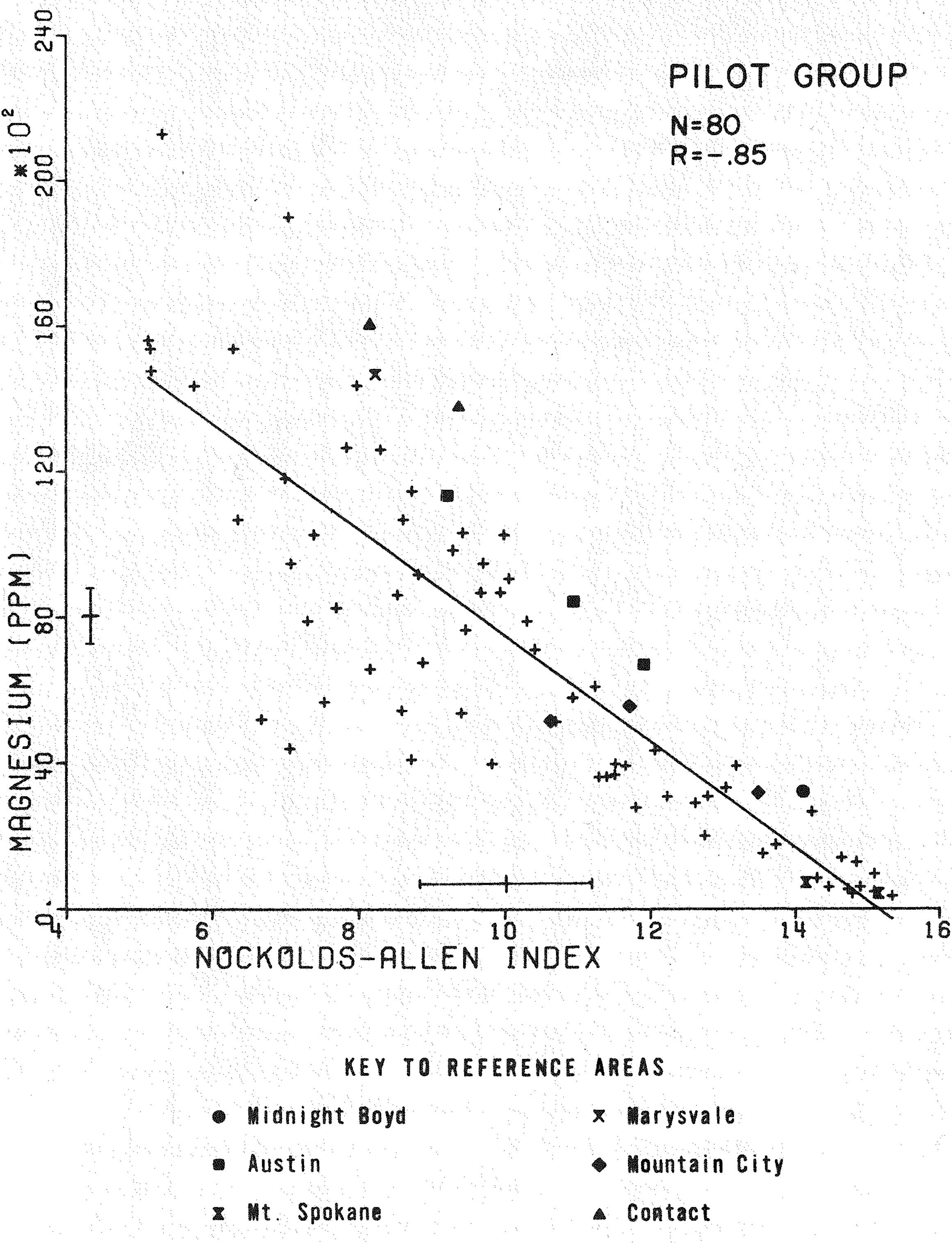
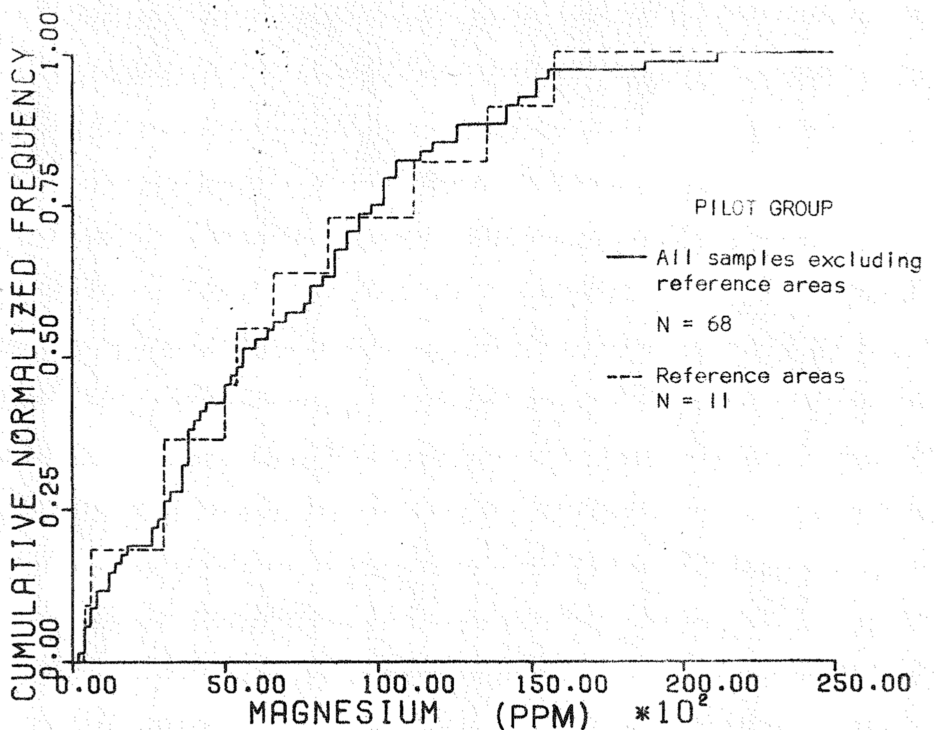


Figure 28. Plot of magnesium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for magnesium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



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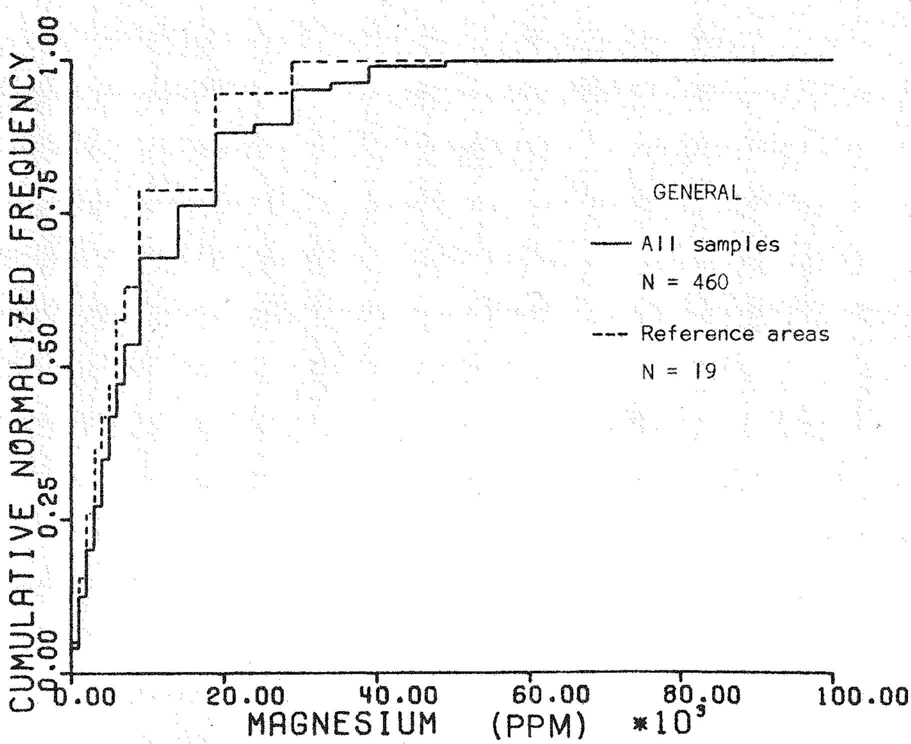


B

Figure 29. Cumulative frequency distributions of magnesium for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

Calcium

A comparison of quantitative data for calcium in the Reference and Pilot Groups (Figures 30 and 31A) leads to the conclusion that the former may be characterized by an absence of very low values (below 0.5 percent) and an absence of high values (above 2.8 percent). Approximately 10 percent of the samples in the Pilot Group (excluding the reference areas) are below the lower cut-off and about 27 percent are above the upper cut-off. These results parallel those noted earlier for sodium. The semiquantitative data for the Reference Group and for all project samples (Figure 31B) do not support this conclusion (in terms of upper and lower cut-offs) but they do indicate that generally lower concentrations of calcium are found in the Reference Group.

Calcium correlates very well with the differentiation index (Figure 30). No significant anomalies are noted in the reference areas when compared with the best fit correlation line for the Pilot Group as a whole. The interdependence of calcium and the index must be noted, however.

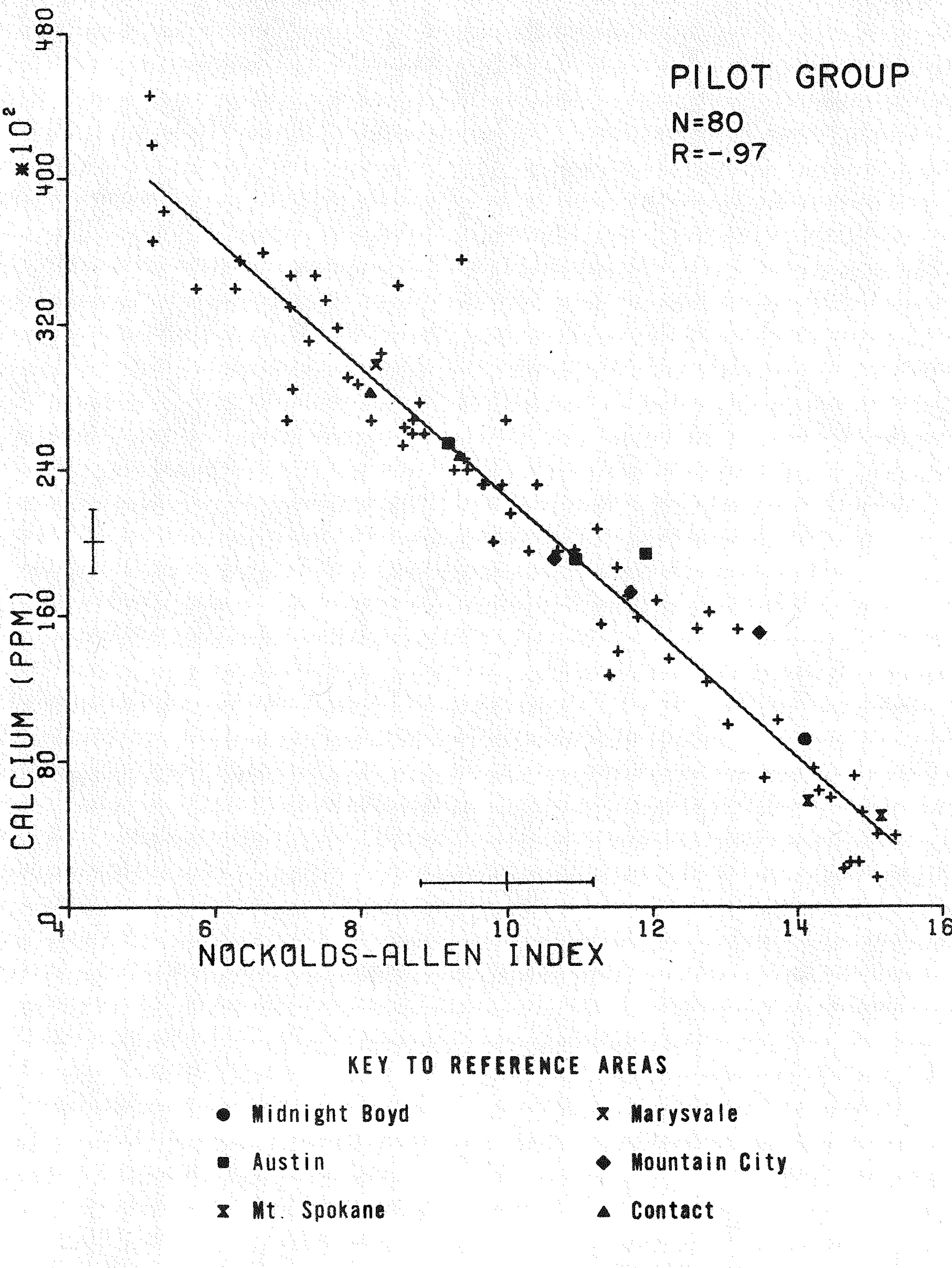
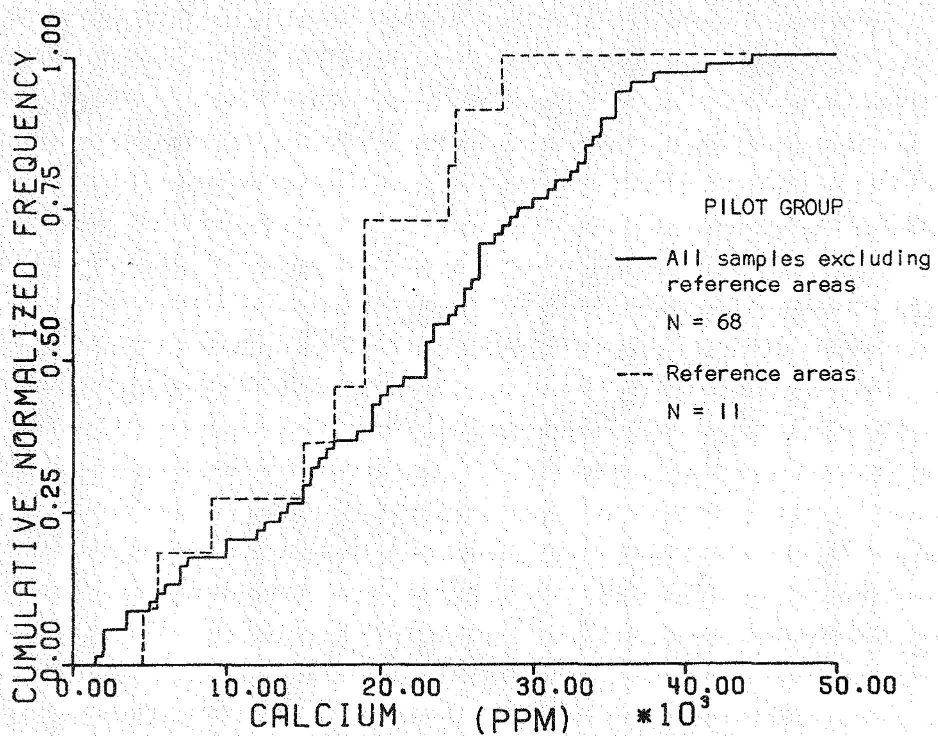
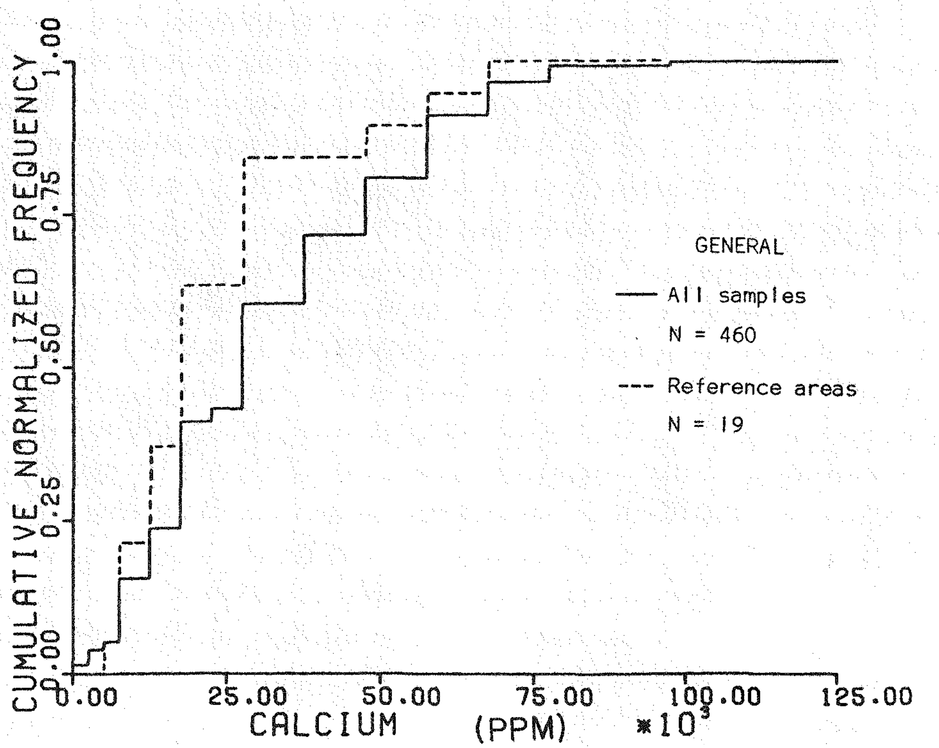


Figure 30. Plot of calcium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for calcium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



A



B

Figure 31. Cumulative frequency distributions of calcium for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

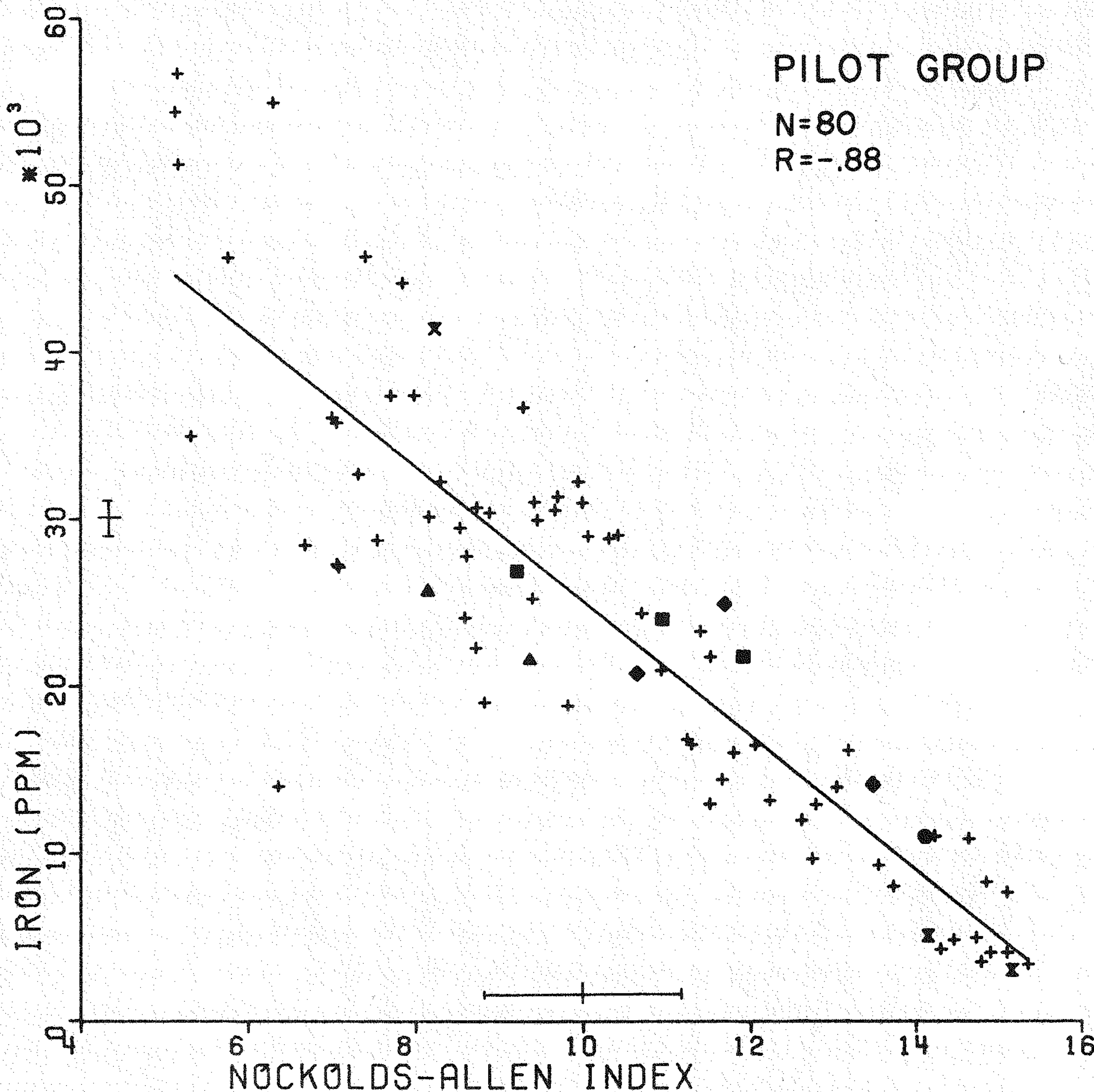
Iron

A comparison of quantitative data for iron in the Reference and Pilot Groups (Figures 32 and 33A) leads to the conclusion that the reference areas may be characterized by generally lower values and an absence of high values (ie., above 2.7 percent). Approximately 50 percent of the samples in the Pilot Group, excluding the reference area samples, exceed this cut-off value. Semiquantitative data for the reference areas and for all of the project samples (Figure 33B) also indicate an absence of high values in the reference areas.

Samples from the Contact area are anomalously low in iron when the Nockolds-Allen Index is used to correct for composition (Figure 32).

A comparison of quantitative data on the ferrous and ferric oxide contents in the Reference and Pilot Groups (Figure 34 and 35) leads to the conclusion that the former may be characterized by a relatively narrow range of values of the ratio Fe_2O_3/total Fe. Values below 0.35 and above 0.55 are not found in the Reference Group, whereas approximately 25 percent of the samples in the Pilot Group (excluding reference area samples) are below the lower cut-off and about 26 percent are above the upper cut-off.

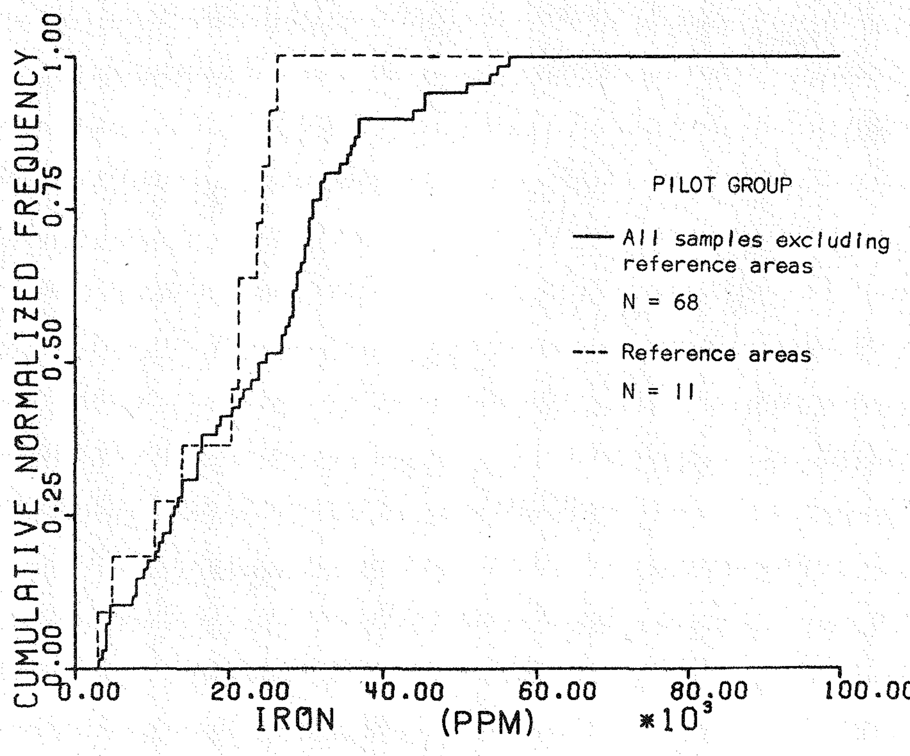
Samples from the Austin and Midnight Boyd areas are characterized by significantly low values of this ratio when compared with the average for all other samples in the Pilot Group (Figure 34). Also, samples from the Mountain City area are higher than the average.



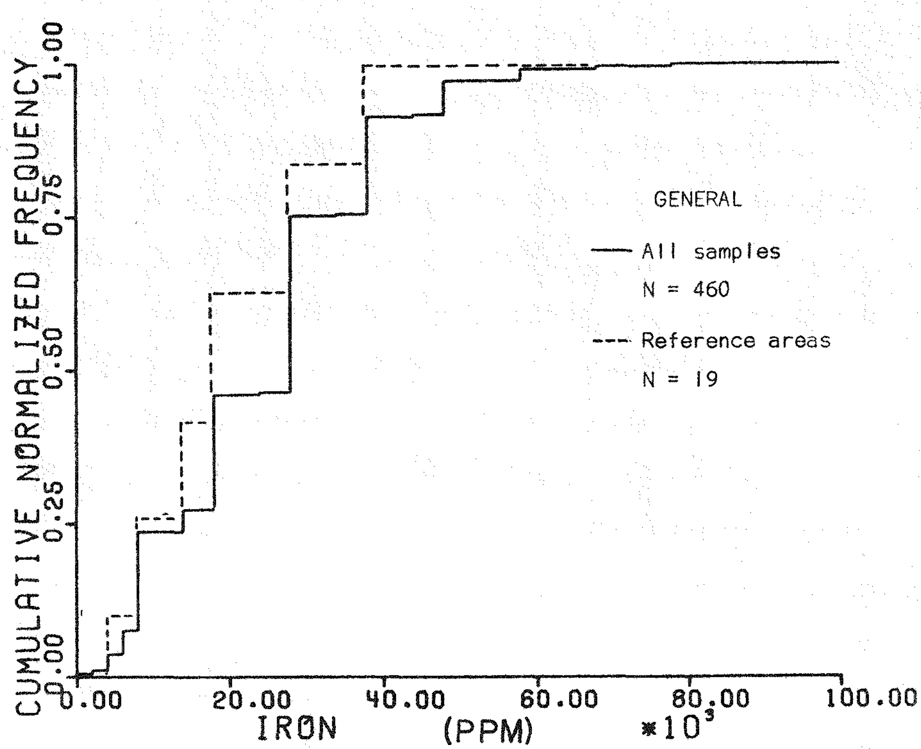
KEY TO REFERENCE AREAS

● Midnight Boyd ■ Austin ⧗ Mt. Spokane ✕ Marysvale ◆ Mountain City ▲ Contact

Figure 32. Plot of iron versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for iron. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



A



B

Figure 33. Cumulative frequency distributions of iron for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

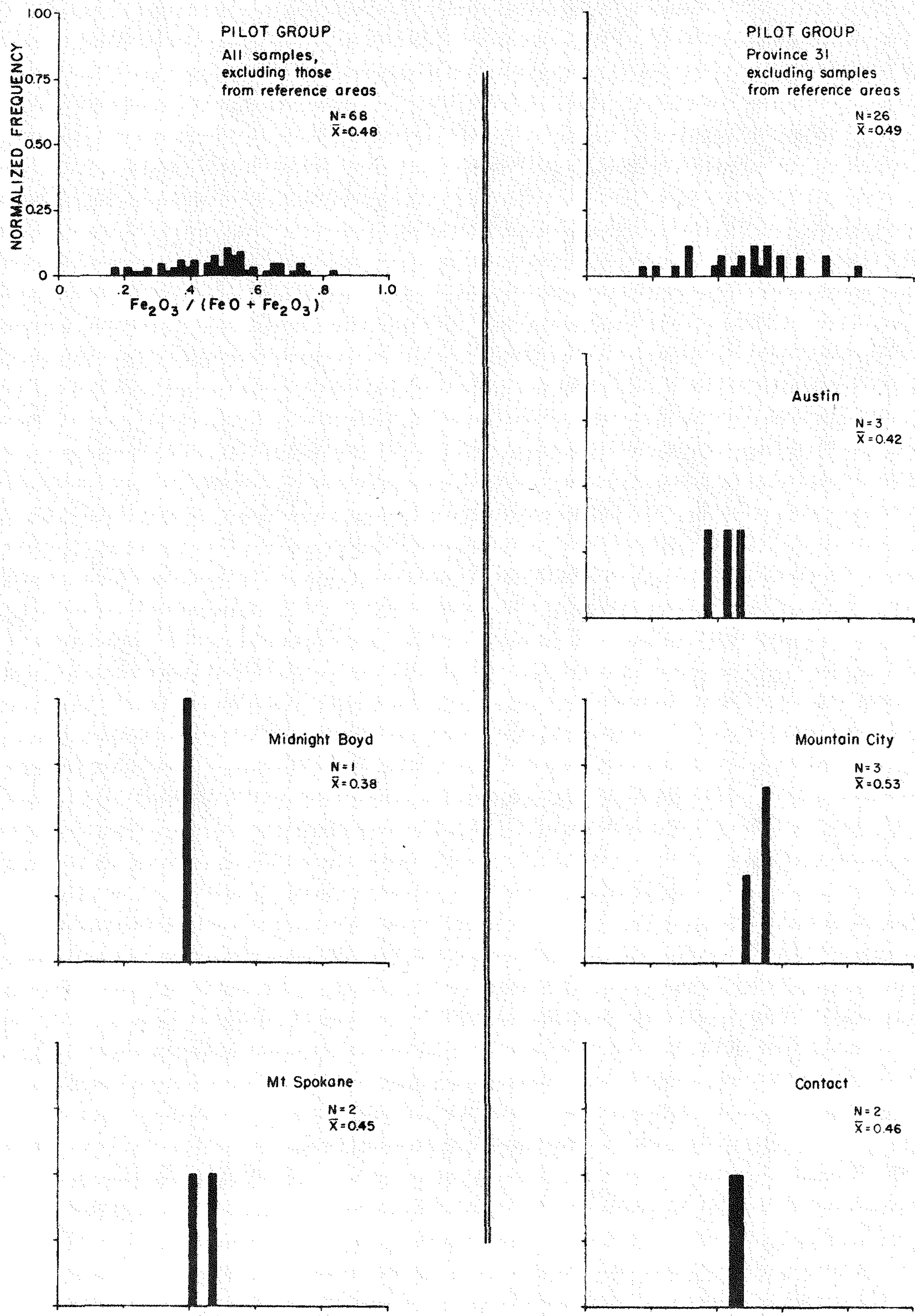


Figure 34. Frequency distribution of the ratio $Fe_2O_3/FeO + Fe_2O_3$ for the Pilot Group. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.

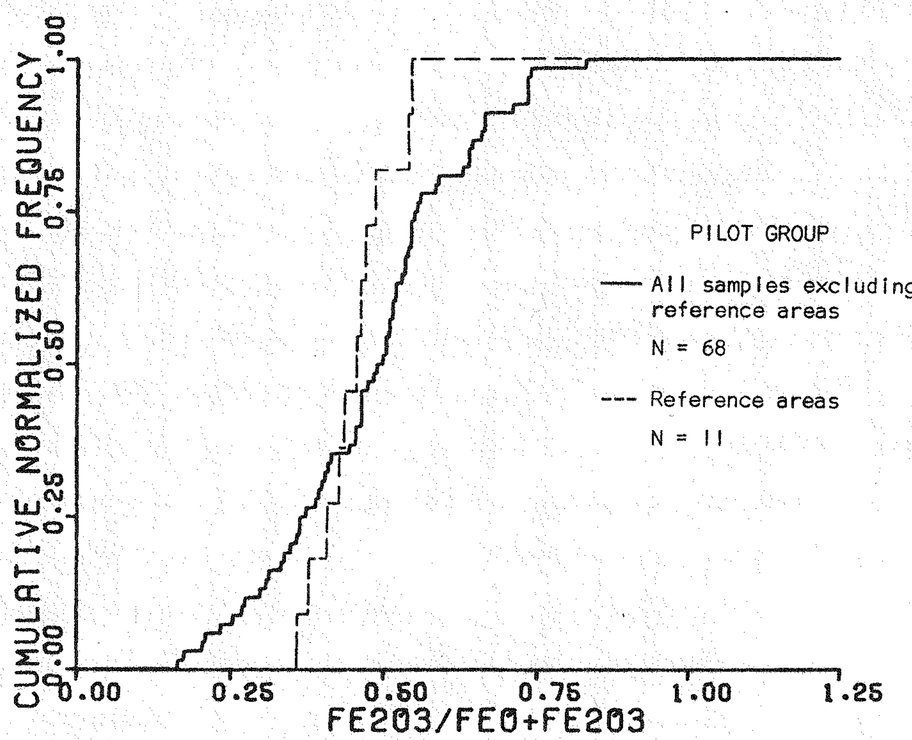


Figure 35. Cumulative frequency distribution of the ratio $Fe_2O_3/FeO + Fe_2O_3$ for the Pilot Group. Quantitative analyses.

Titanium

A comparison of quantitative data for titanium in the Reference and Pilot Groups (Figures 36 and 37A) leads to the conclusion that the former may be characterized by generally lower values. Also, there is an absence of high values (ie., above 0.35 percent). Approximately 22 percent of the samples in the Pilot Group (excluding the reference area samples) exceed this upper cut-off. Semiquantitative data for the Reference Group and for all of the project samples (Figure 37B) support this conclusion in principle.

Samples from the Austin area are anomalously high in titanium when compared with other samples in the Pilot Group (Figure 36).

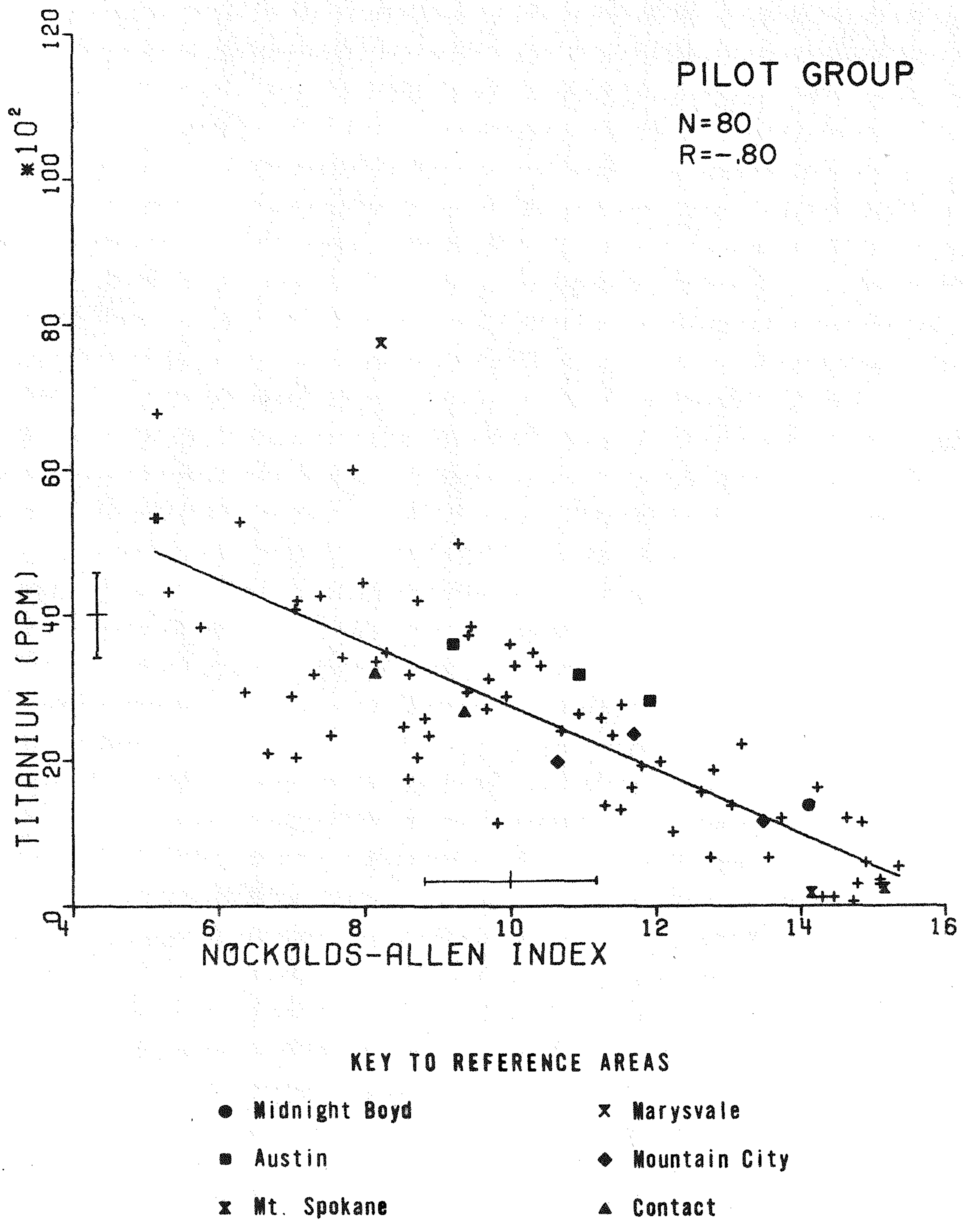
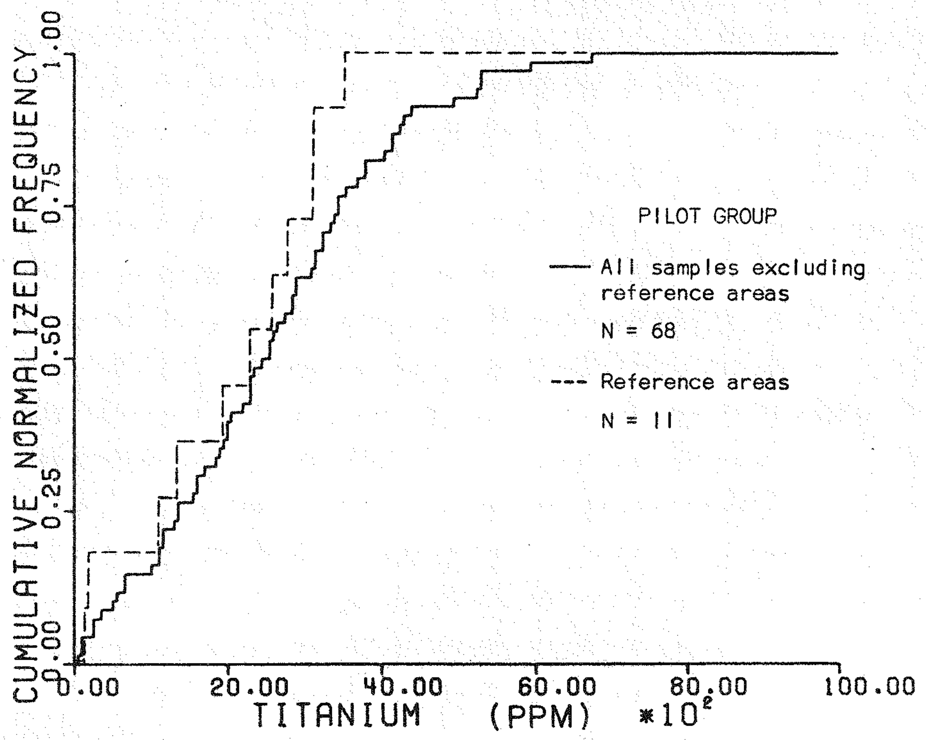
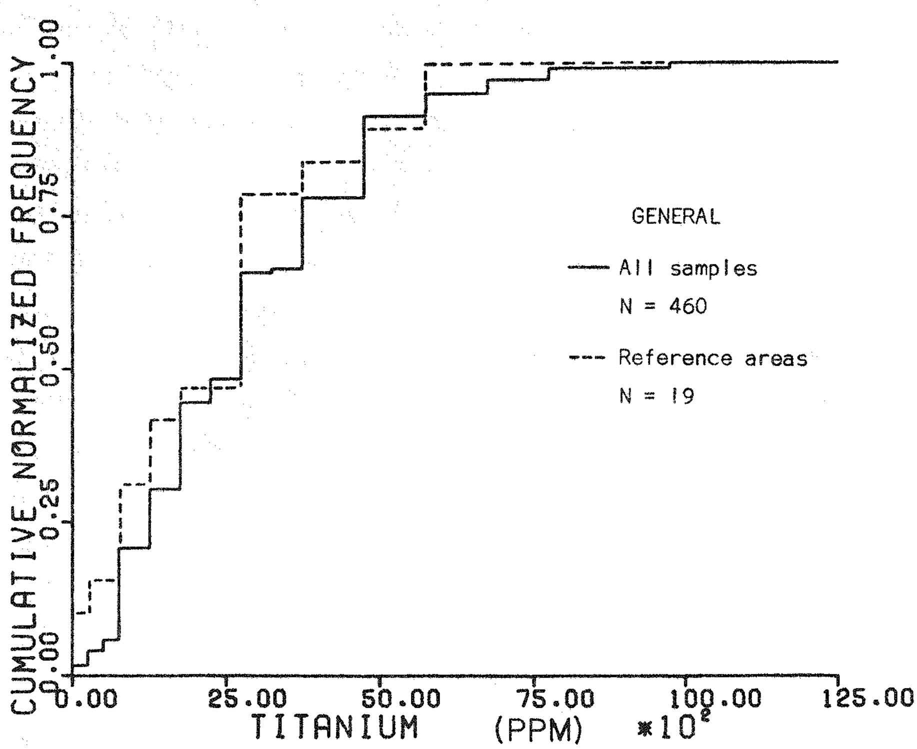


Figure 36. Plot titanium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for titanium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



A



B

Figure 37. Cumulative frequency distributions of titanium for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

Manganese

A comparison of quantitative data for manganese in the Reference and Pilot Groups (Figures 38 and 39A) leads to the conclusion that the former may be characterized by generally lower values and an absence of high values (ie., above 600 ppm). Approximately 28 percent of the samples in the Pilot Group (excluding the reference area samples) exceed this upper cut-off. Semiquantitative data for the Reference Group and for all project samples (Figure 39B) indicate generally lower values in the former but do not indicate an upper cut-off.

Taking into consideration the dependence of manganese on the differentiation index (Figure 38) and the level of analytical precision, samples from the Contact and Austin areas are anomalously low when compared with other samples in the Pilot Group.

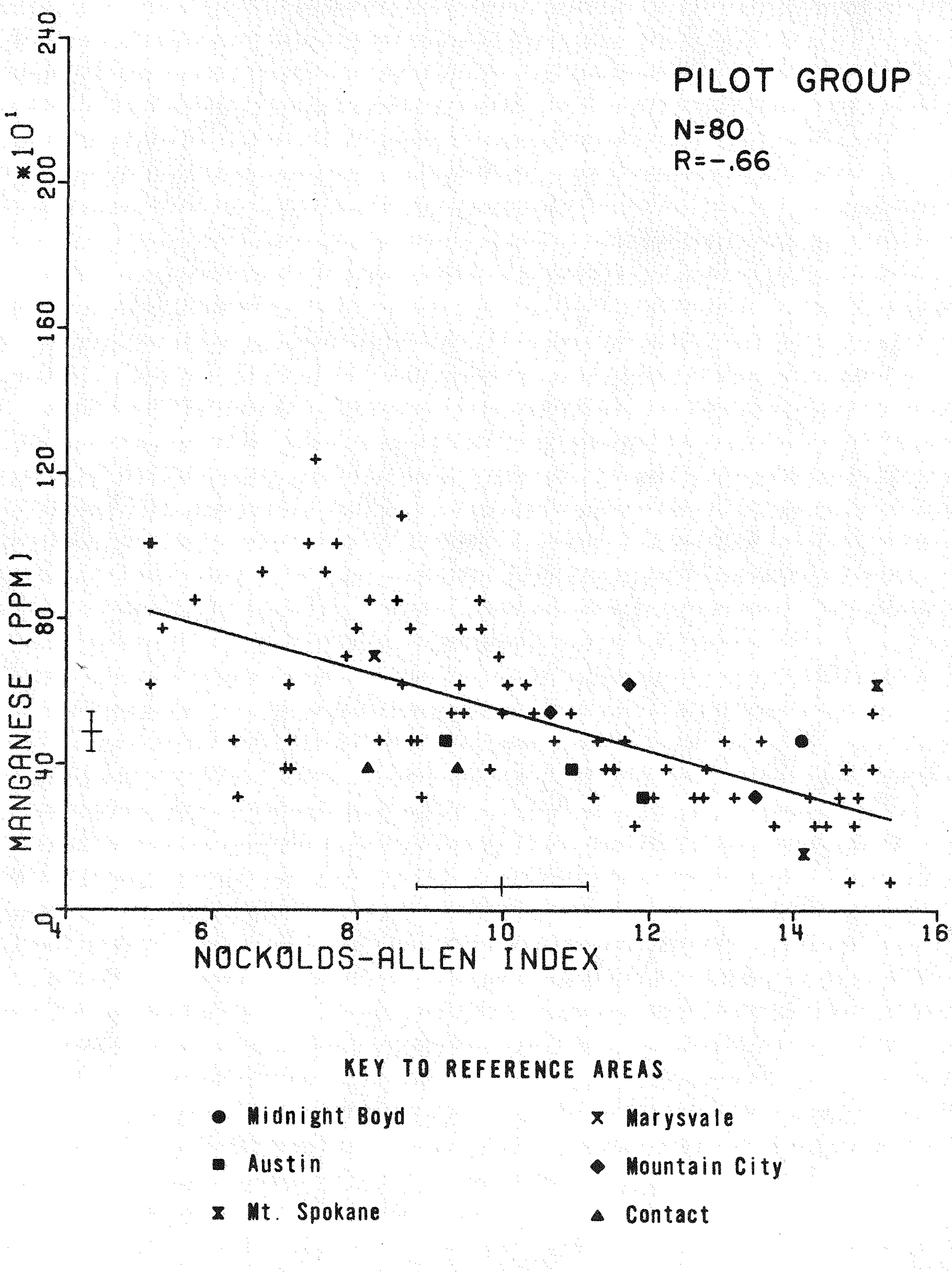
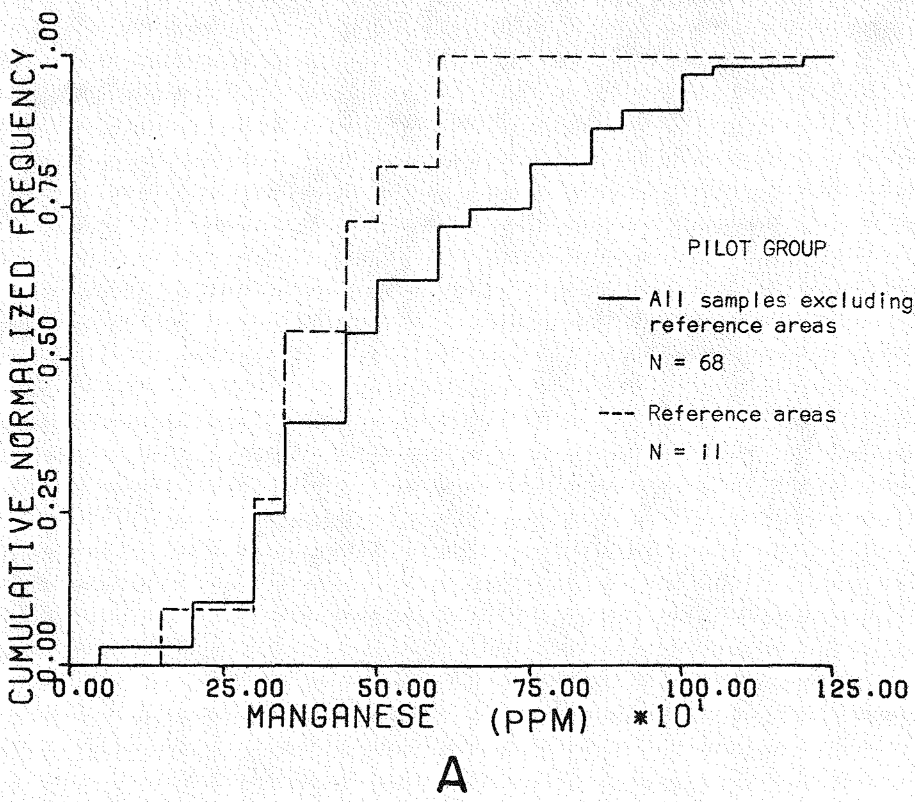


Figure 38. Plot of manganese versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for manganese. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



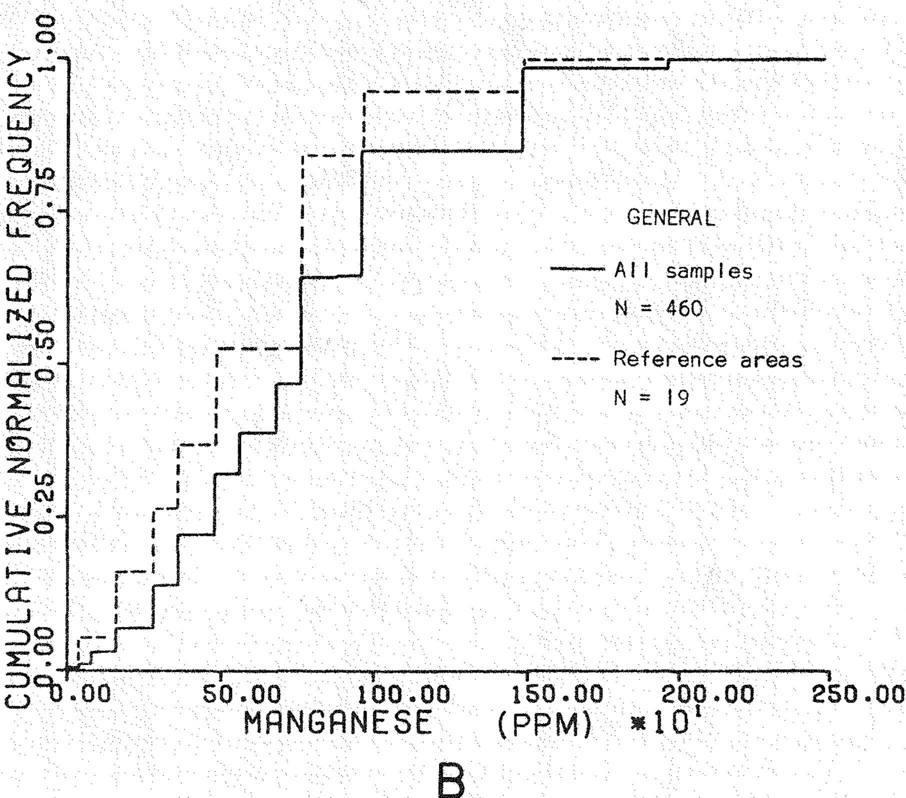


Figure 39. Cumulative frequency distributions of manganese for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

Aluminum

A comparison of quantitative data for aluminum in the Reference and Pilot Groups (Figures 40 and 41) lead to the conclusion that the former may be characterized by generally higher values and an absence of low values (ie., below 7.9 percent). Approximately 37 percent of the samples in the Pilot Group are below this cut-off. No semiquantitative data is available for use in the further evaluation of this conclusion.

The correlation between aluminum and the differentiation index is relatively poor. It is noted, however, that the highest values of aluminum are found in samples with the lowest differentiation index, ie., samples from the Contact, Austin, and Mountain City, areas.

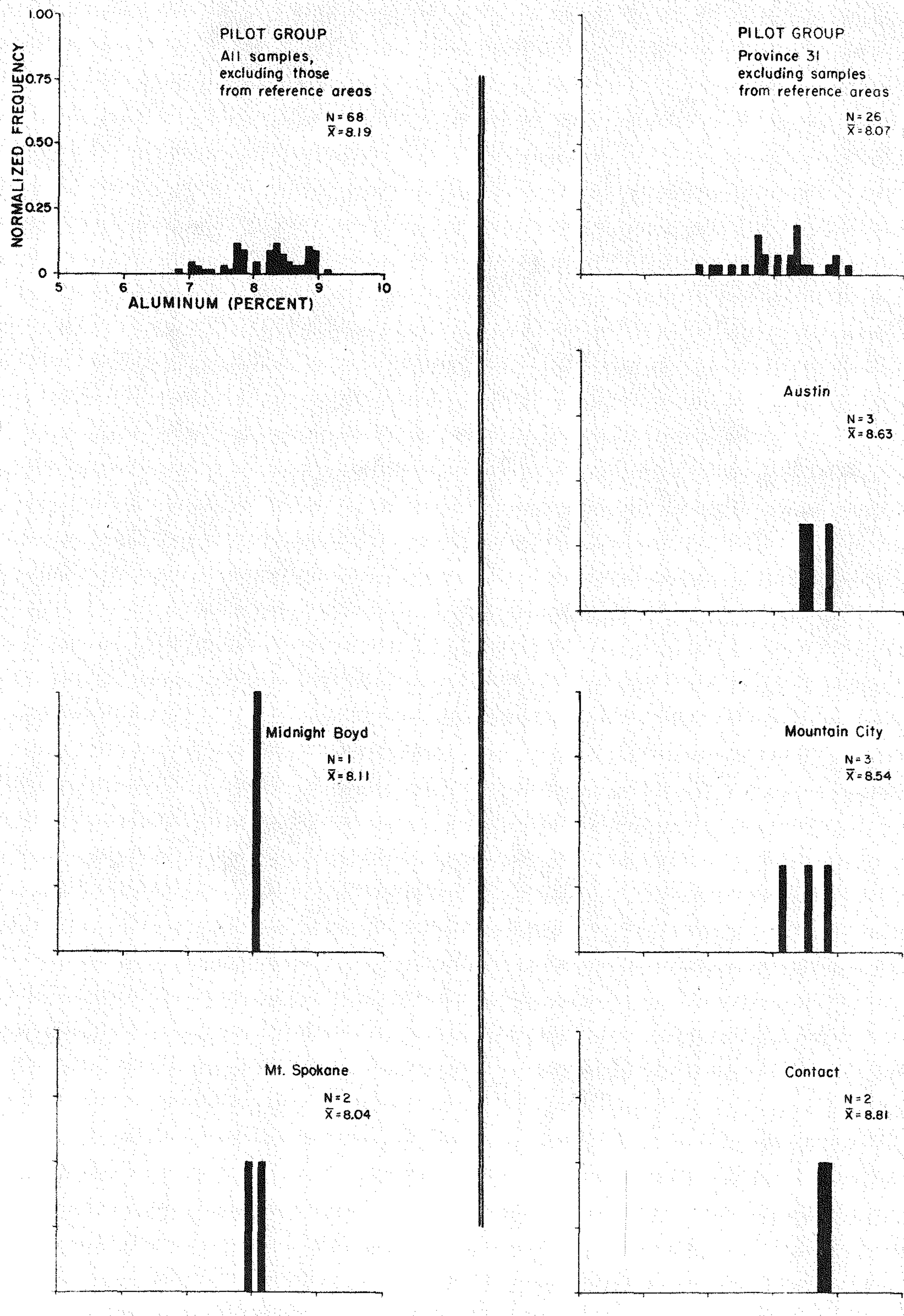


Figure 40. Frequency distribution of aluminum for the Pilot Group. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.

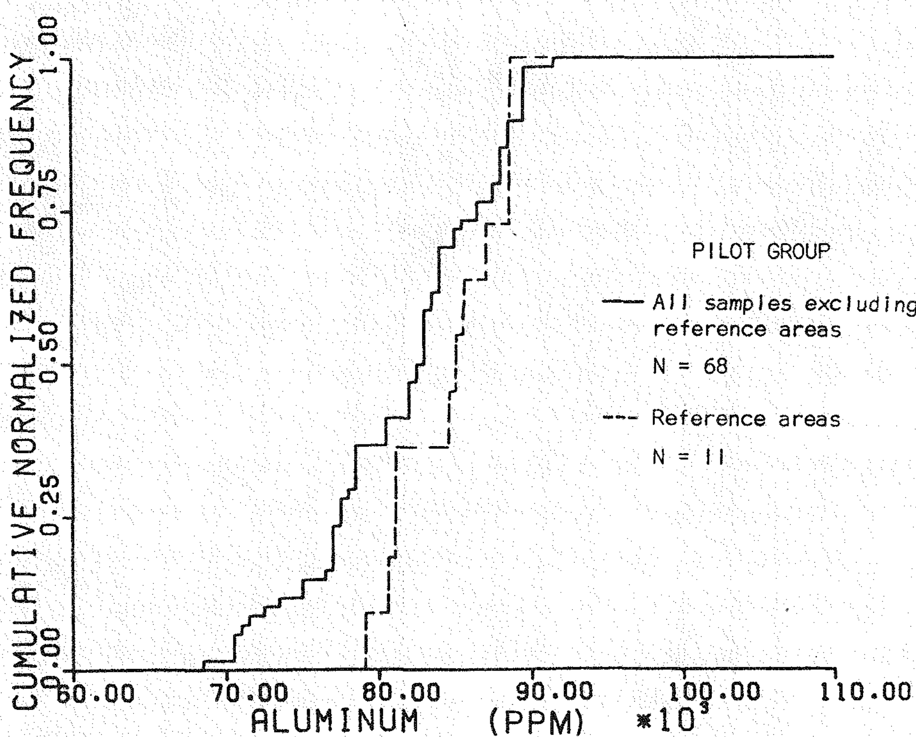


Figure 41. Cumulative frequency distributions of aluminum for the Pilot Group. Quantitative analyses.

Silicon

A comparison of quantitative data for silicon in the Reference and Pilot Groups (Figures 42 and 43) leads to the conclusion that the former may be characterized by high values. No values below 31 percent are found in the Reference Group while approximately 46 percent of the remainder of the samples in the Pilot Group fall below this value (Figures 42 and 43).

Considering the level of precision of the silicon analyses, no anomalies with respect to silicon in the Reference Group (Figure 42) can be identified. It must be noted, however, that silicon is a dominant factor in the Nockolds-Allen Index against which it is plotted.

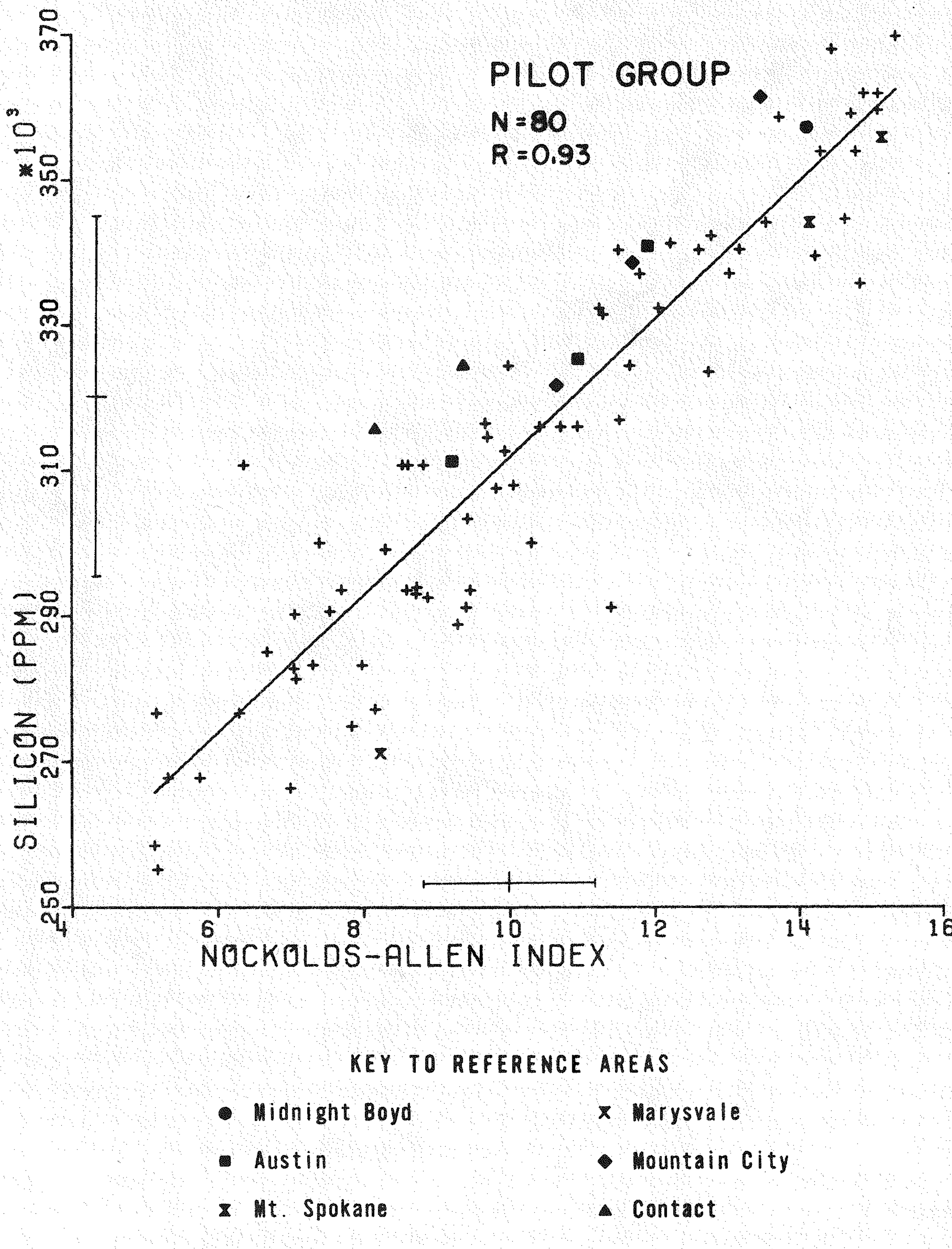


Figure 42. Plot of silicon versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for silicon. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

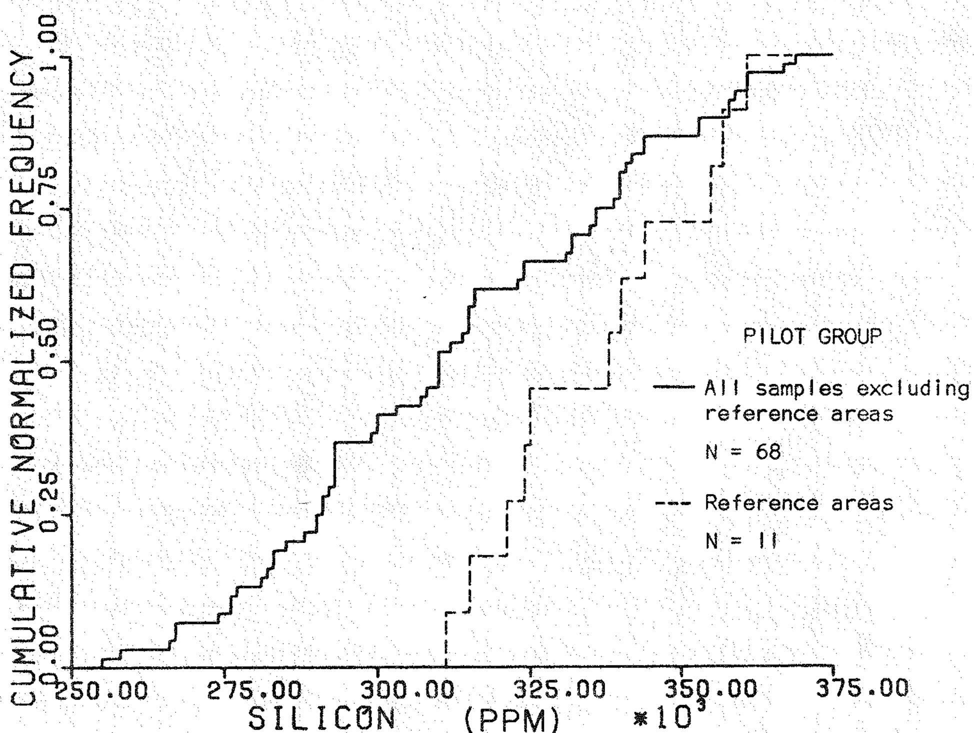
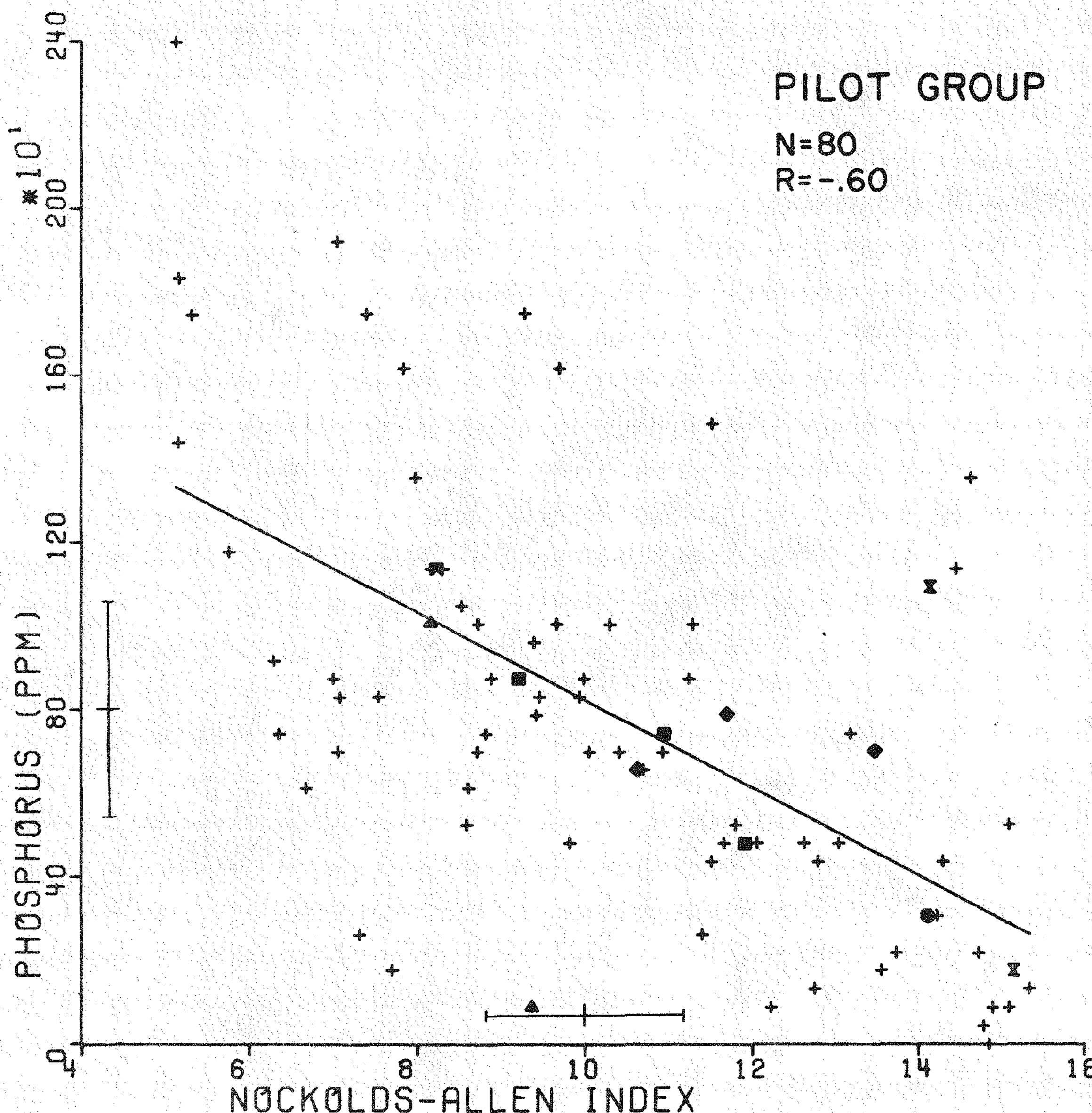


Figure 43. Cumulative frequency distributions of silicon for the Pilot Group. Quantitative analyses.

Phosphorus

A comparison of quantitative data for phosphorus in the Reference and Pilot Groups (Figures 44 and 45A) leads to the conclusion that the former may be characterized by an absence of high values (ie., above 1100 ppm). Approximately 24 percent of the samples in the Pilot Group (excluding the reference areas) exceed the upper cut-off. This conclusion is generally supported by the semiquantitative data for the Reference Group and for all samples (Figure 45B).

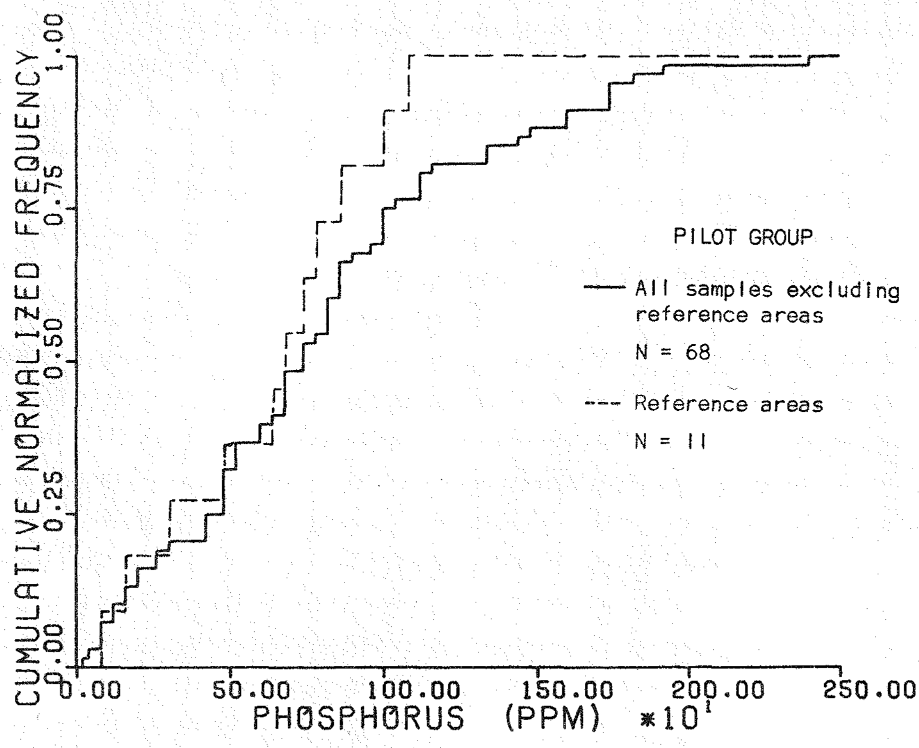
There is a suggestion of a correlation between phosphorus and the differentiation index in the Pilot Group (Figure 44). Taking this possible relationship into consideration and the level of analytical precision it is noted that individual samples from Contact and Mount Spokane may be anomalously low and high, respectively.



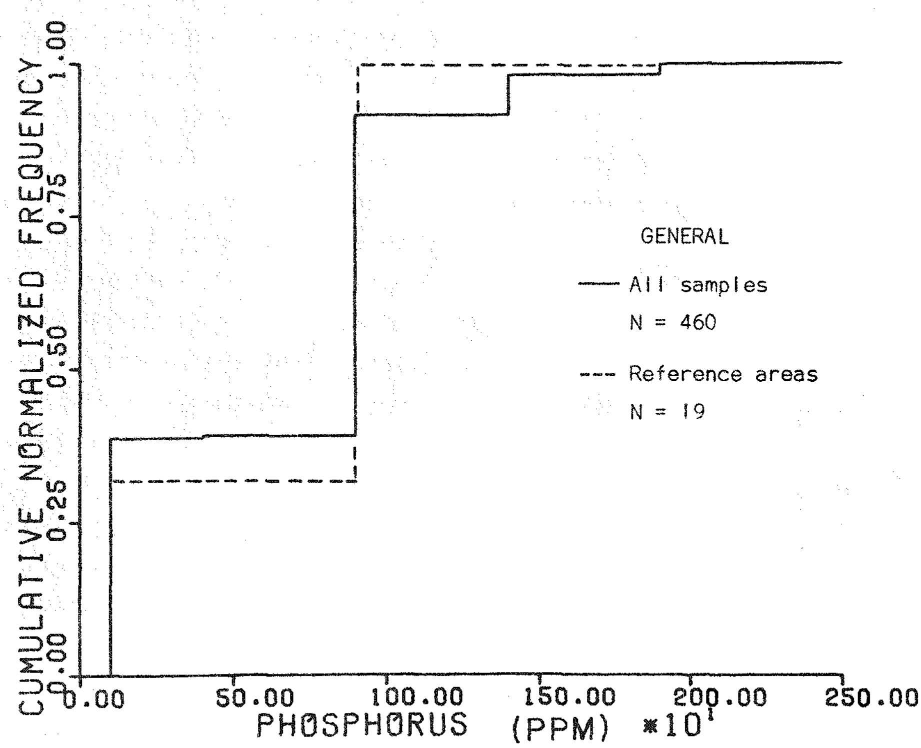
KEY TO REFERENCE AREAS

● Midnight Boyd
■ Austin
⧗ Mt. Spokane
⨯ Marysvale
◆ Mountain City
▲ Contact

Figure 44. Plot of phosphorus versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for phosphorus. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



A



B

Figure 45. Cumulative frequency distribution of phosphorus for the Pilot Group and for all samples. A, quantitative analyses for Pilot Group; B, semiquantitative analyses for all samples.

Minor Elements

Quantitative analyses for zirconium, thorium, and uranium were obtained on all samples. Quantitative analyses for rubidium were obtained on a select group of samples. All other analyses for the minor elements are semiquantitative.

Lithium

A comparison of semiquantitative data for lithium in the Reference Group and in all samples (Figures 46 and 47) leads to the conclusion that there may be generally higher values in the reference areas.

Multiple samples from the Austin and Mountain City areas are higher than the average (Figure 46) but it is not certain that the anomalously high values are significant in view of the semiquantitative nature of the data and the low concentration level. Replicate analyses of a standard sample indicate an analytical precision (95 percent confidence level) of ±120% at 17 ppm (Table E2, Appendix E).

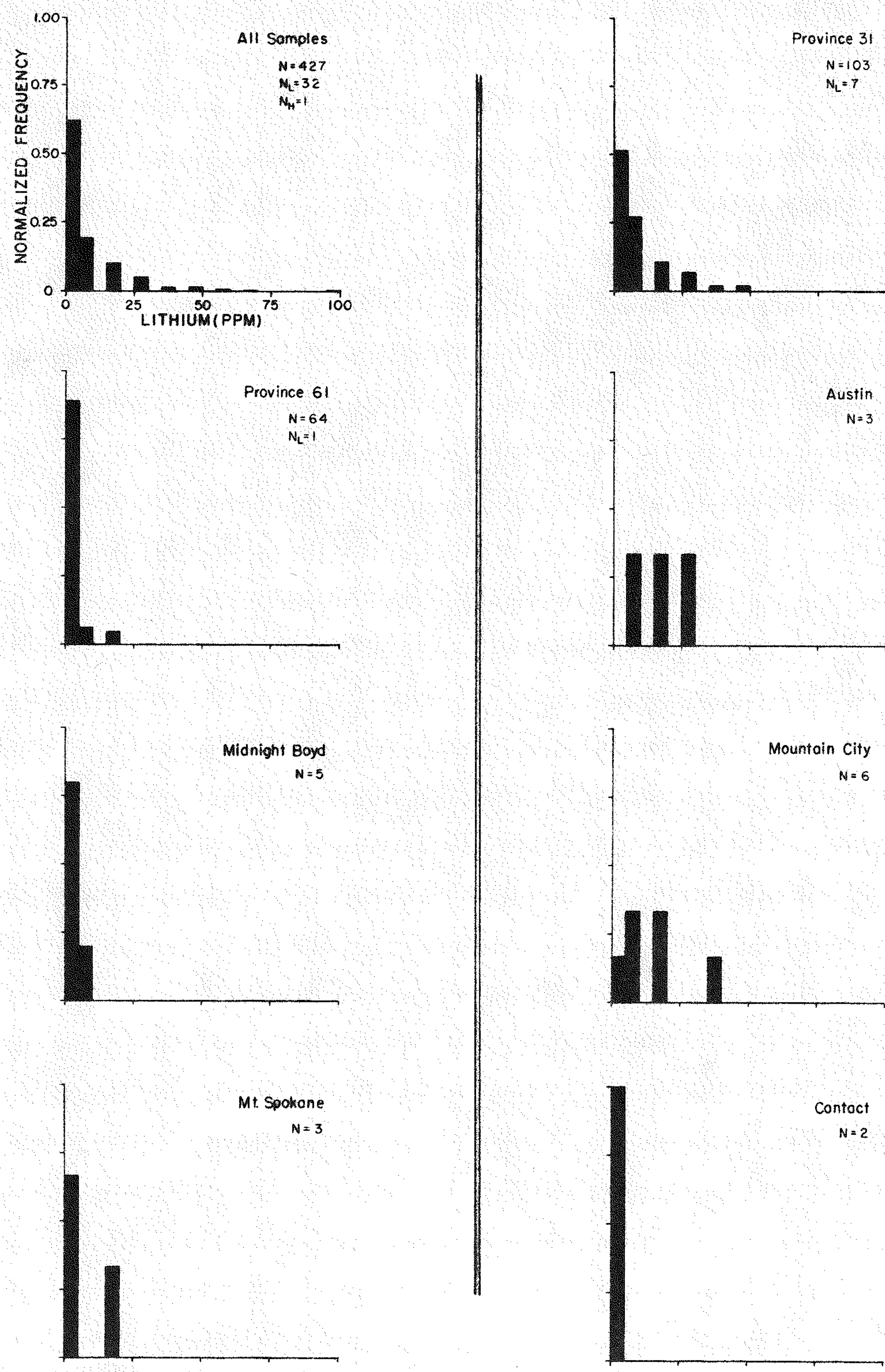


Figure 46. Frequency distribution of lithium for all samples. Semiquantitative analyses. N = number of samples; N_L = number of samples below detection limit (not considered in histogram or N); N_H = number of samples above limit of histogram (not considered in N).

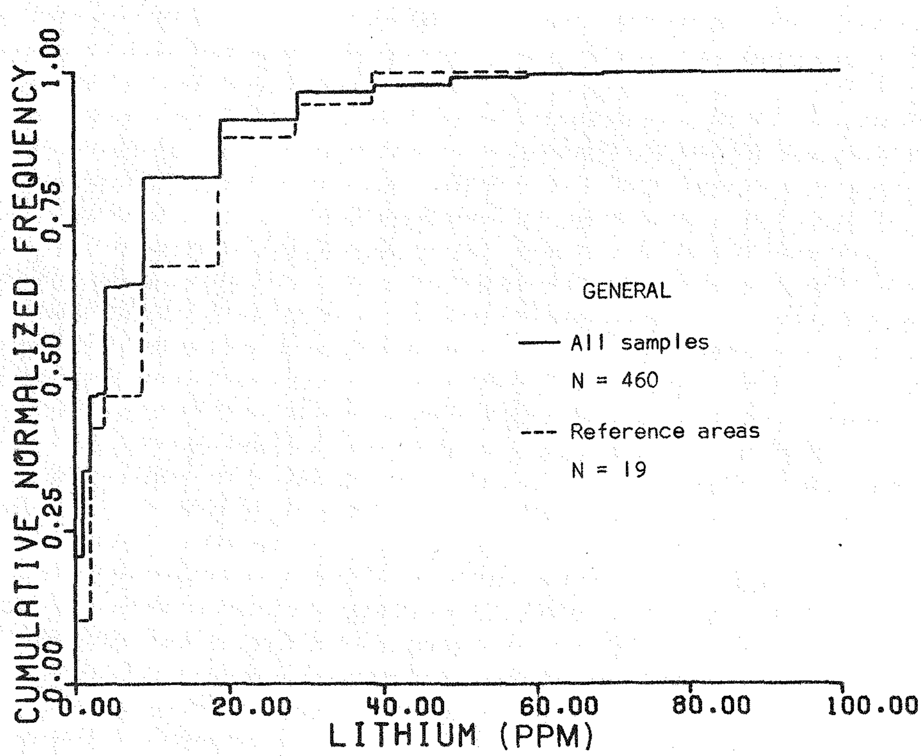


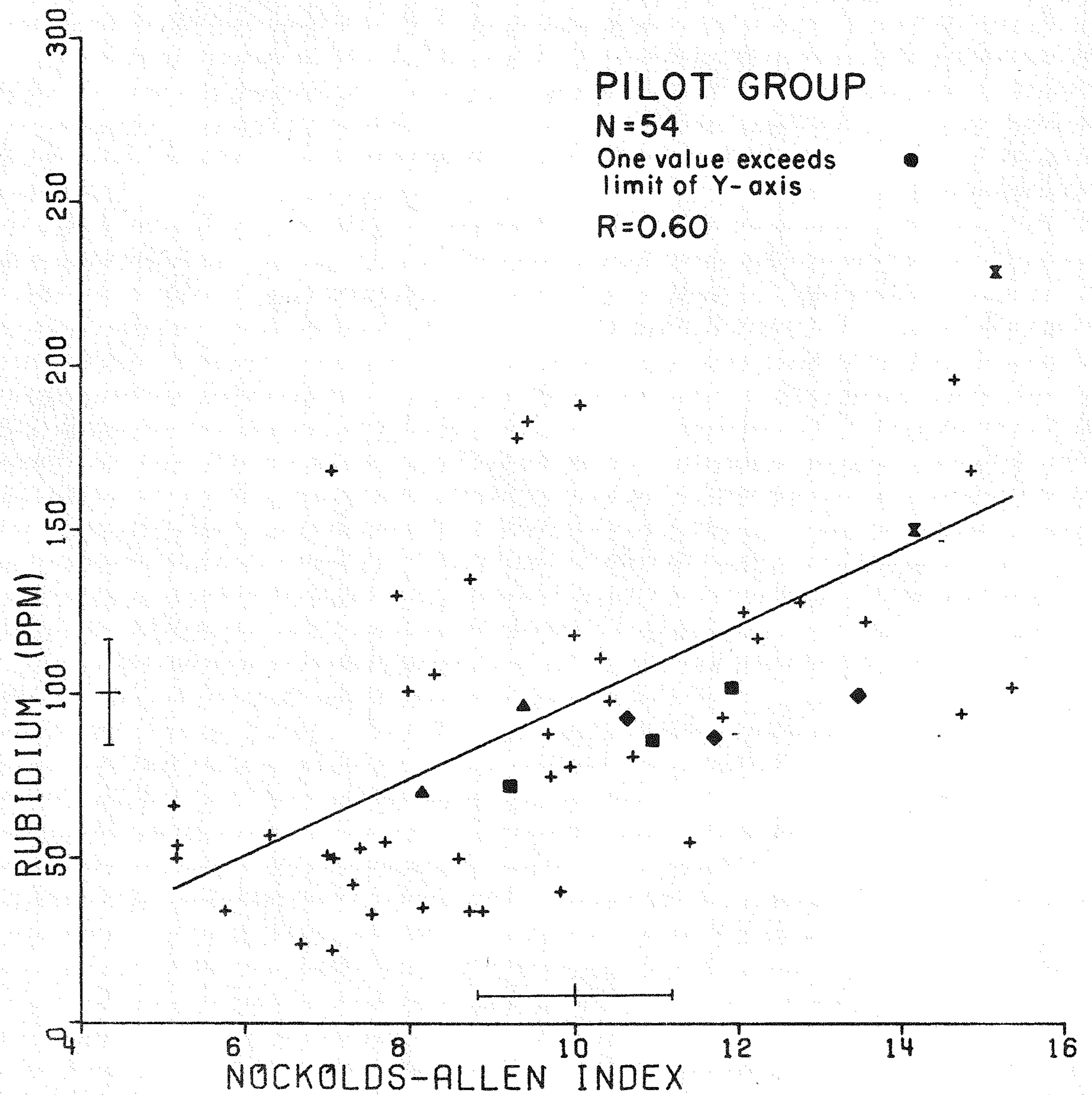
Figure 47. Cumulative frequency distribution of lithium for all samples. Semiquantitative analyses.

Rubidium

A comparison of quantitative data for rubidium in the Reference and Pilot Groups (Figures 48, 49 and 50A) leads to the conclusion that the former may be characterized by higher values. No values below 60 ppm are found in the Reference Group whereas approximately 41 percent of the samples in the Pilot Group (excluding the reference areas) are below this value.

The dependence of rubidium on the differentiation index is indicated in Figure 48. Also, the well-known association between potassium and rubidium in the Pilot Group samples is indicated in Figure 49. On both diagrams, it is noted that individual samples from the Mountain City, Midnight Boyd, and Mount Spokane areas are high. These apparent anomalies can be explained by the progressive enrichment of rubidium relative to potassium with differentiation, a relationship which has been previously observed and reported in the literature (Taylor, 1965, p. 144).

The Rb/K ratio appears to enhance the differences between the two groups of samples (Figure 50B) and may be more diagnostic of the reference areas.



KEY TO REFERENCE AREAS

- ● Midnight Boyd
- ■ Austin
- ⧗ Mt. Spokane
- ✕ Marysvale
- ◆ Mountain City
- ▲ Contact

Figure 48. Plot of rubidium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for rubidium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

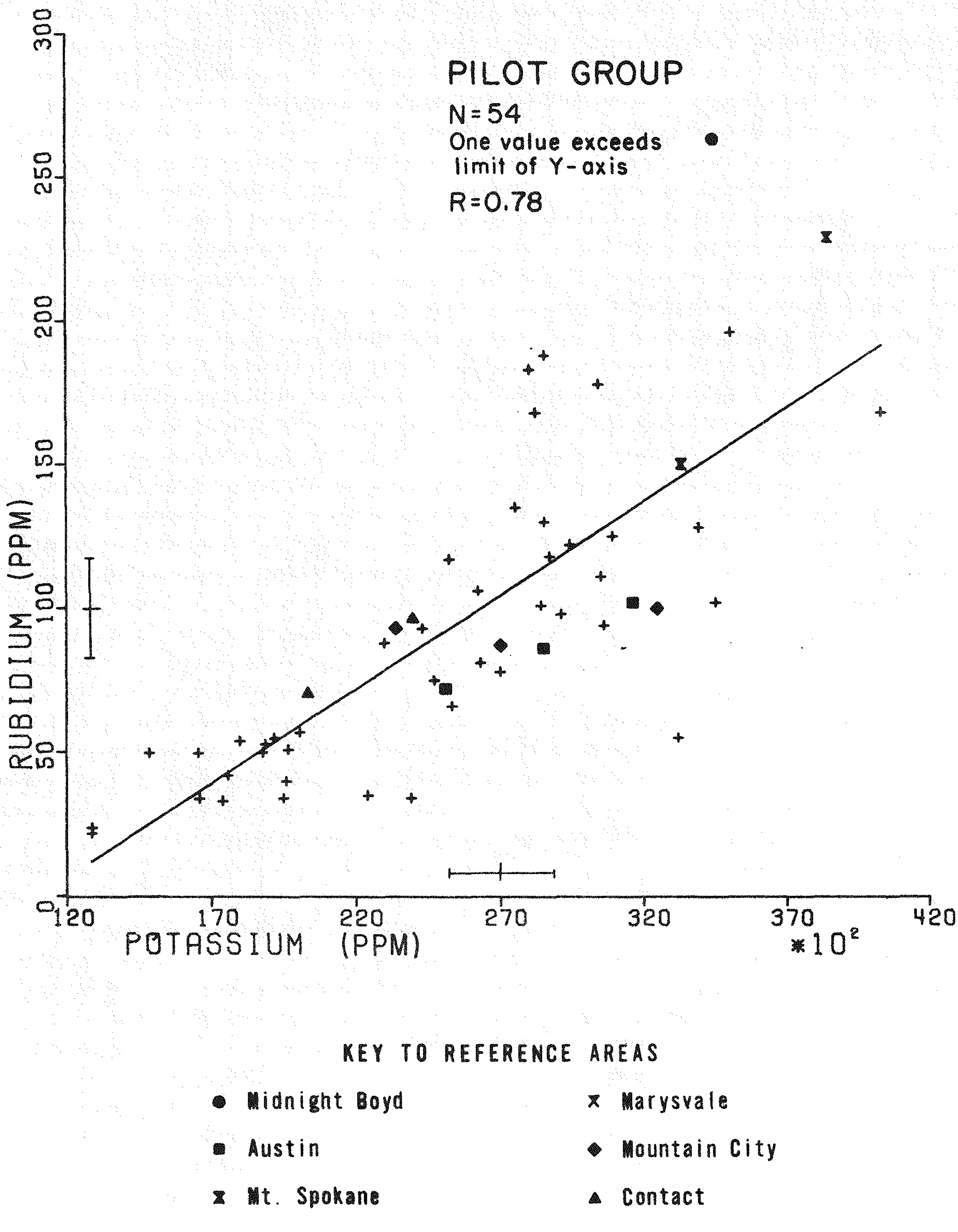


Figure 49. Plot of rubidium versus potassium for the Pilot Group. Quantitative analyses for potassium and rubidium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

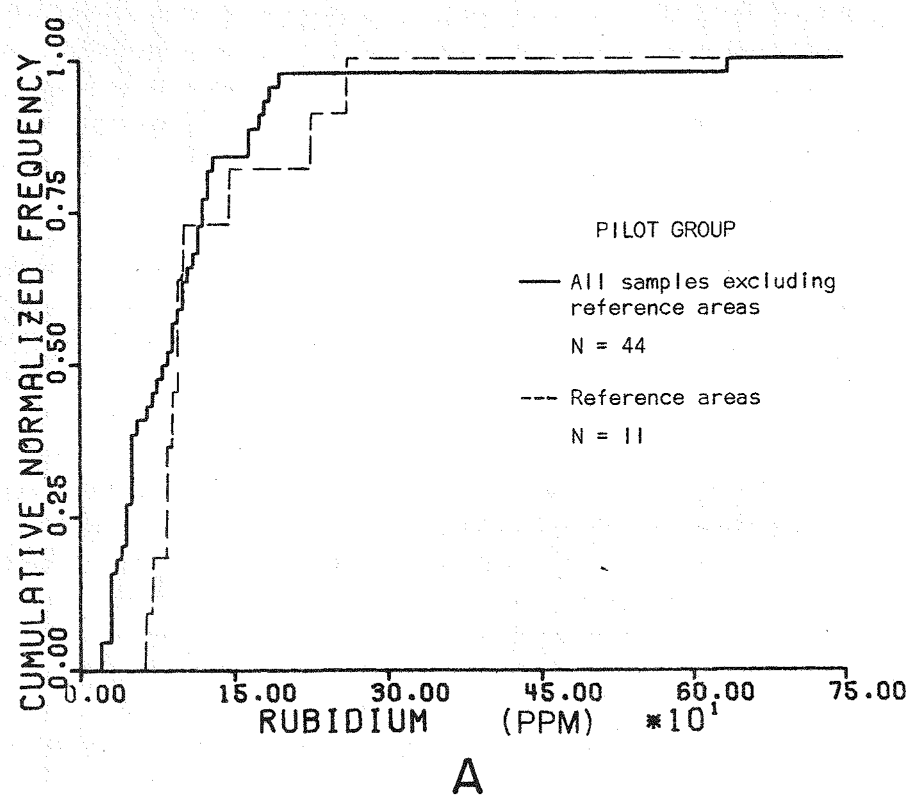


Figure 50. Cumulative frequency distributions of rubidium and the ratio Rb/K for the Pilot Group. A, quantitative analyses for rubidium; B, the ratio Rb/K based on quantitative analyses.

Beryllium

A comparison of semiquantitative data for beryllium in the Reference Group and in all samples (Figures 51 and 52) leads to the conclusion that the former may be characterized by higher values.

Multiple samples with higher than average concentrations of beryllium are found in the Contact and Midnight Boyd areas (Figure 51).

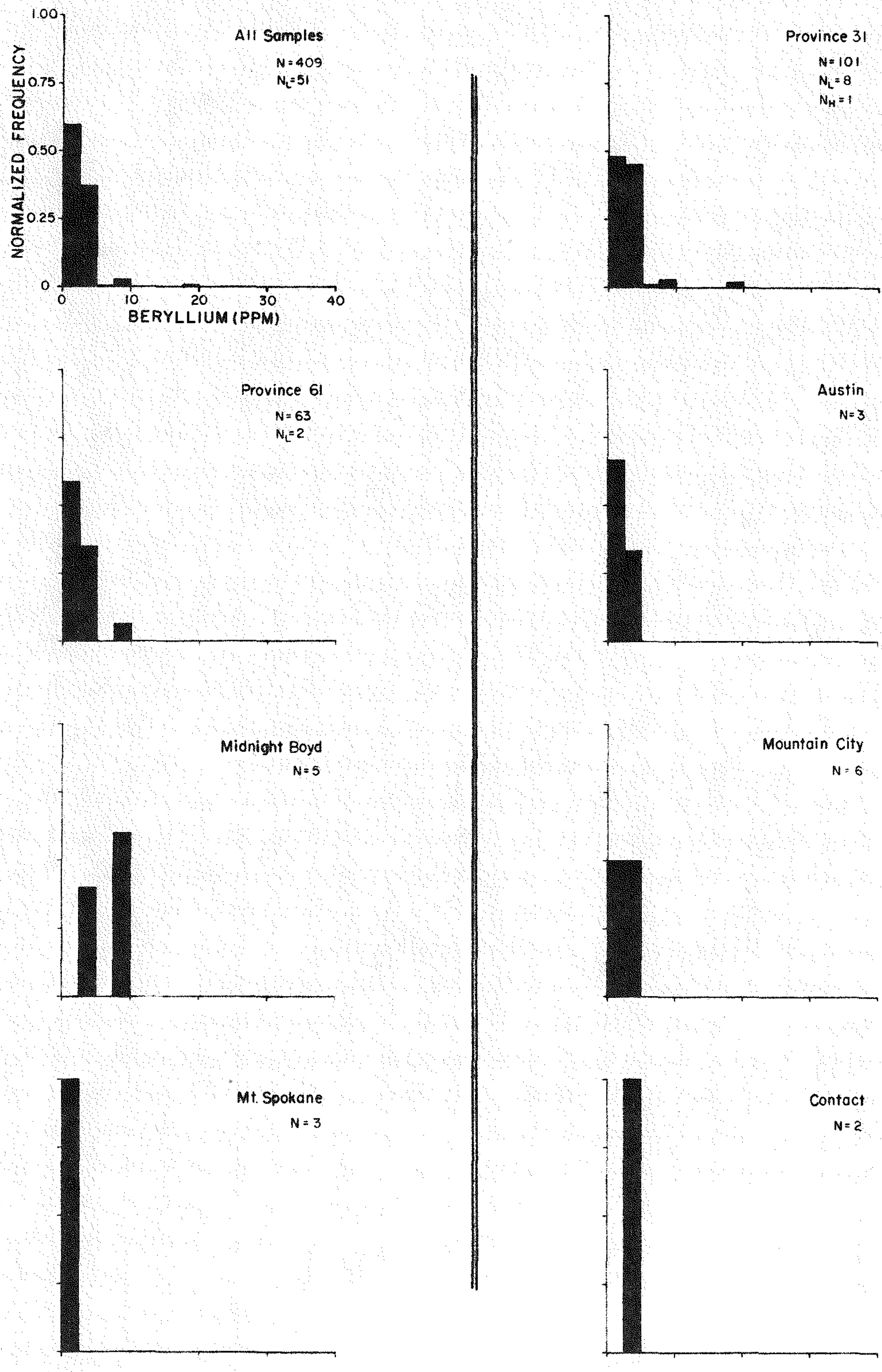


Figure 51. Frequency distribution of beryllium for all samples. Semiquantitative analyses. N = number of samples; N_L = number of samples below detection limit (not considered in histogram or N); N_H = number of samples above limit of histogram (not considered in N).

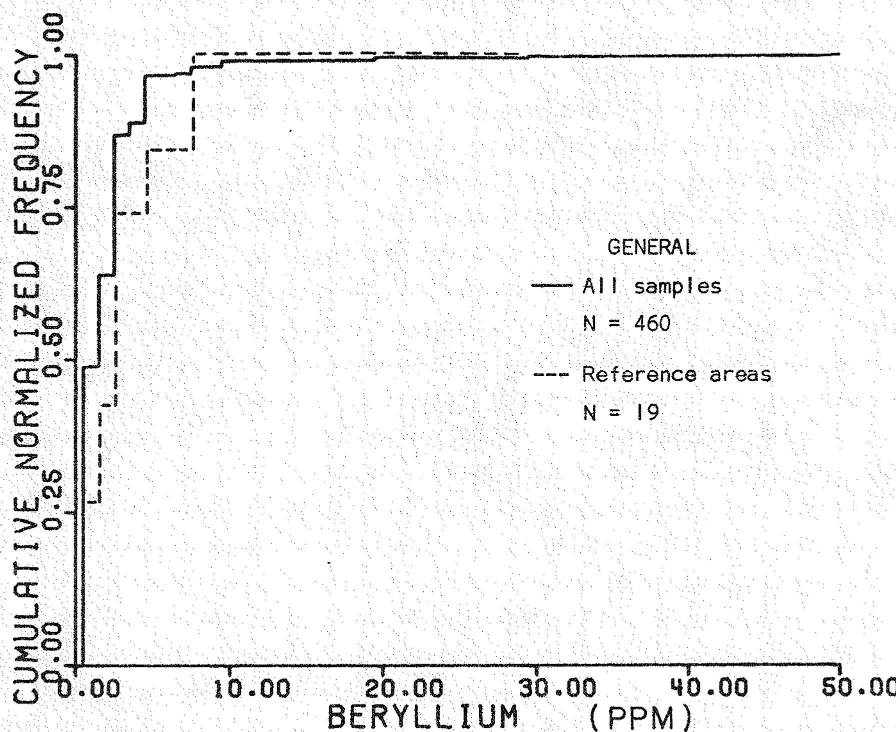


Figure 52. Cumulative frequency distribution of beryllium for all samples. Semiquantitative analyses.

Strontium

A comparison of semiquantitative data for strontium in the Reference Group and in all samples (Figure 53) leads to the conclusion that the former may be characterized by lower concentrations of the element. This is consistent with the lower abundance of calcium in the reference areas expected from the close relationship between strontium and calcium (Figure 54).

Strontium abundance decreases systematically with increasing values of the differentiation index (Figure 55), as does calcium. Assuming an analytical precision of ±50 percent (95 percent confidence level) for the semiquantitative analyses for strontium, no significant anomalies in the reference area can be detected, when compared with the Pilot Group as a whole.

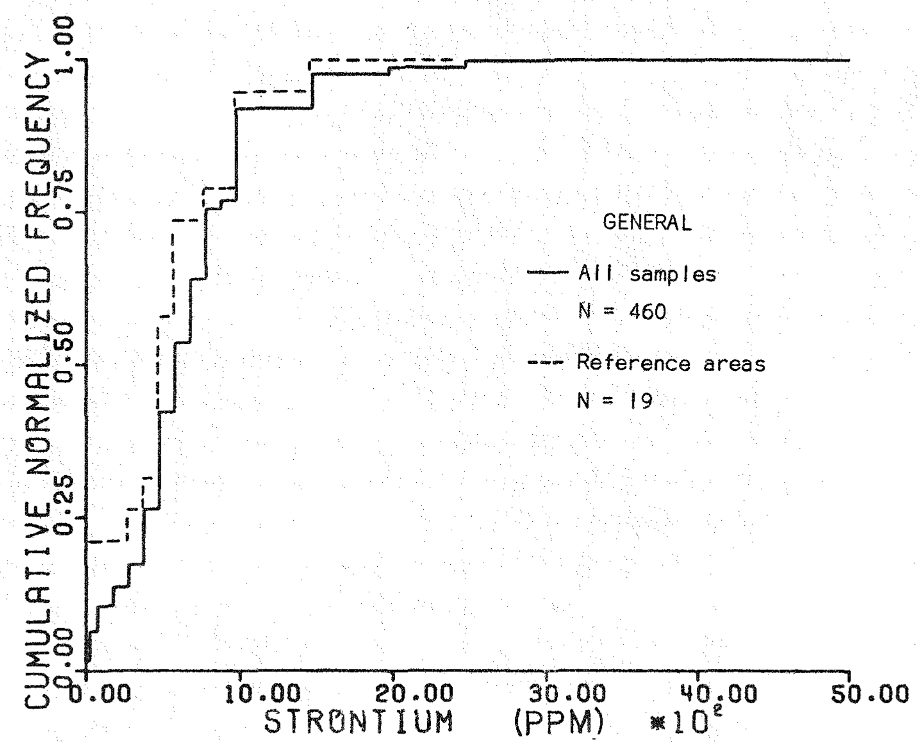


Figure 53. Cumulative frequency distribution of strontium for all samples. Semiquantitative analyses.

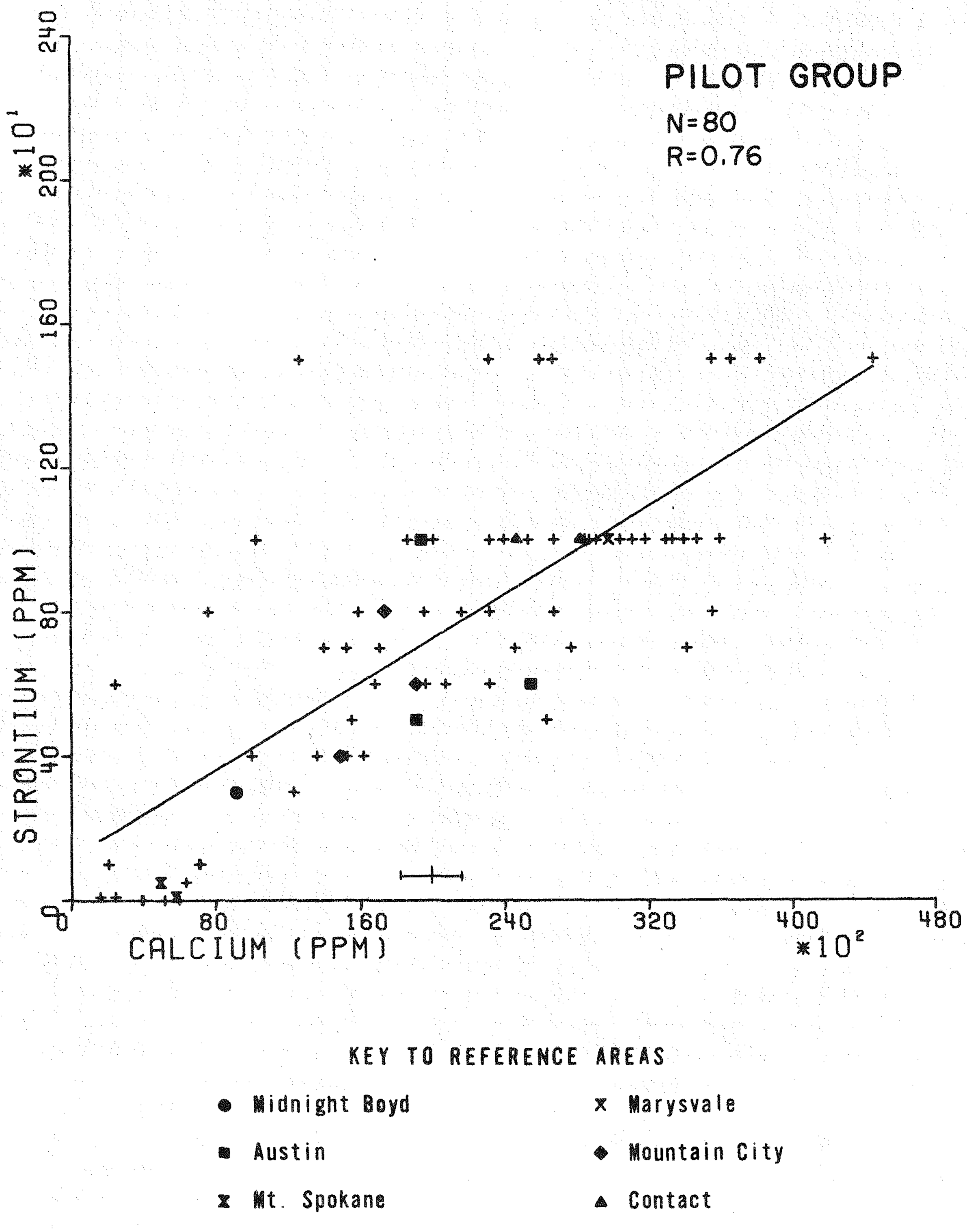


Figure 54. Plot of strontium versus calcium for the Pilot Group. Quantitative analyses for calcium; semiquantitative analyses for strontium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

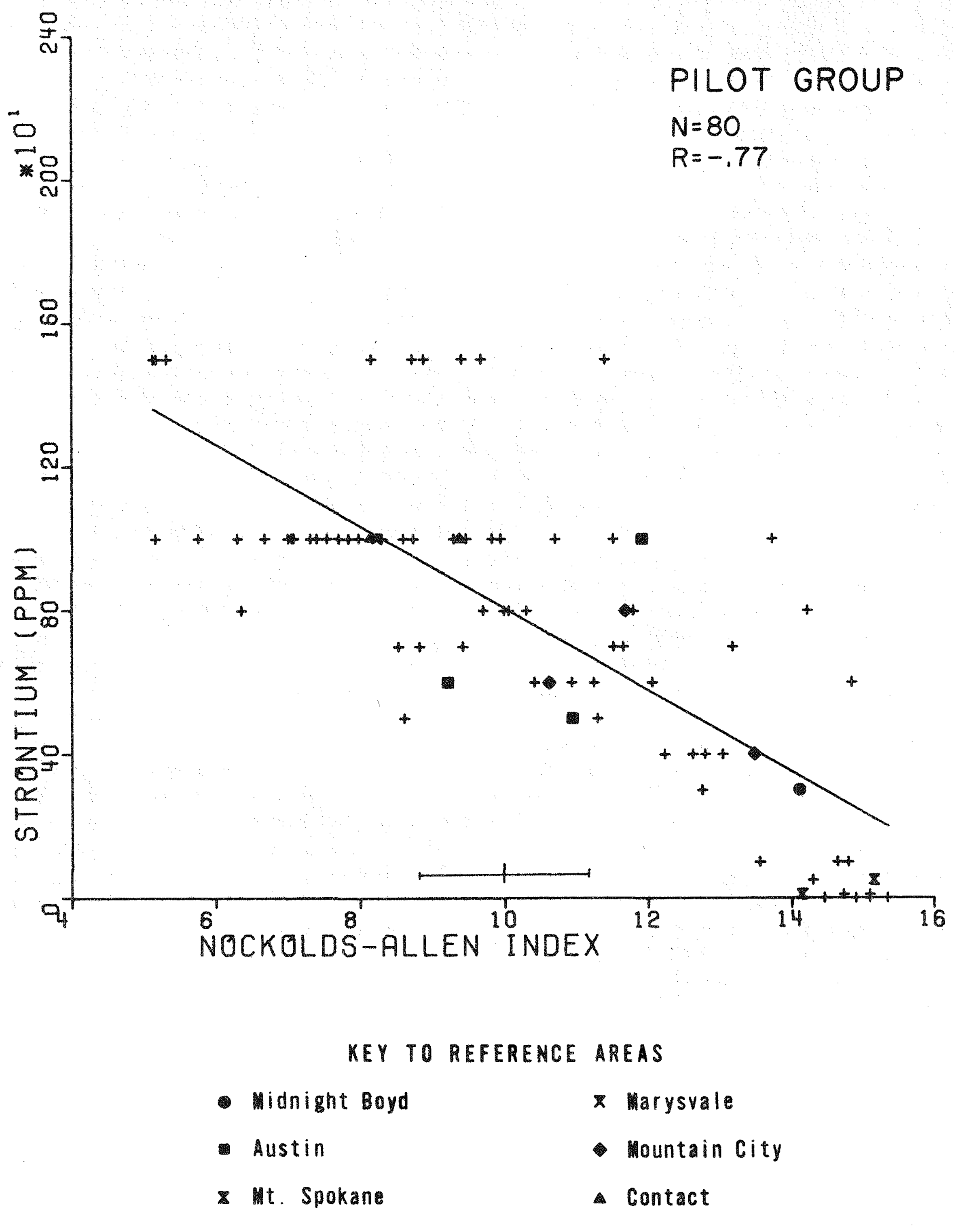


Figure 55. Plot of strontium versus Nockolds-Allen Index for the Pilot Group. Semiquantitative analyses for strontium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

Barium

A comparison of semiquantitative data for barium in the Reference Group and in all samples (Figure 56) leads to the conclusion that the former may be characterized by higher percentages of lower values (ie., below about 50 ppm) and a lower percentage of high values (ie., above 50 ppm). This result must be considered provisional in view of the effect that the analytical error on even a single sample in the Reference Group would have on the distribution for that group.

There appears to be a slight negative dependence of barium on the differentiation index in the Pilot Group (Figure 57). Also, reference areas in the Northern Rocky Mountain batholiths (Midnight Boyd and Mount Spokane areas; province 61, Figure 5) appear to be significantly lower in barium (average 100 ppm) than the reference areas in the Great Basin (Mountain City, Contact, Austin; province 31, Figure 6; average 1000 ppm). Comparison of individual data values for samples from the reference areas with average concentrations of barium in the respective provinces leads to the conclusion that in the Northern Rocky Mountain batholiths the reference areas are anomalously low in barium while in the Great Basin the reference areas are anomalously high in barium.

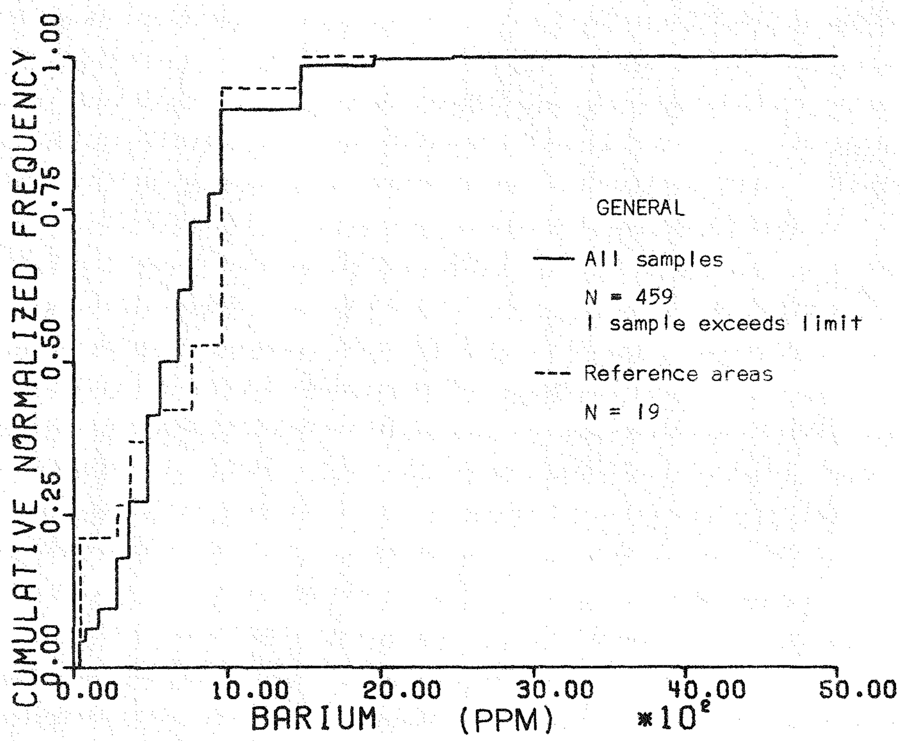


Figure 56. Cumulative frequency distribution of barium for all samples. Semiquantitative analyses.

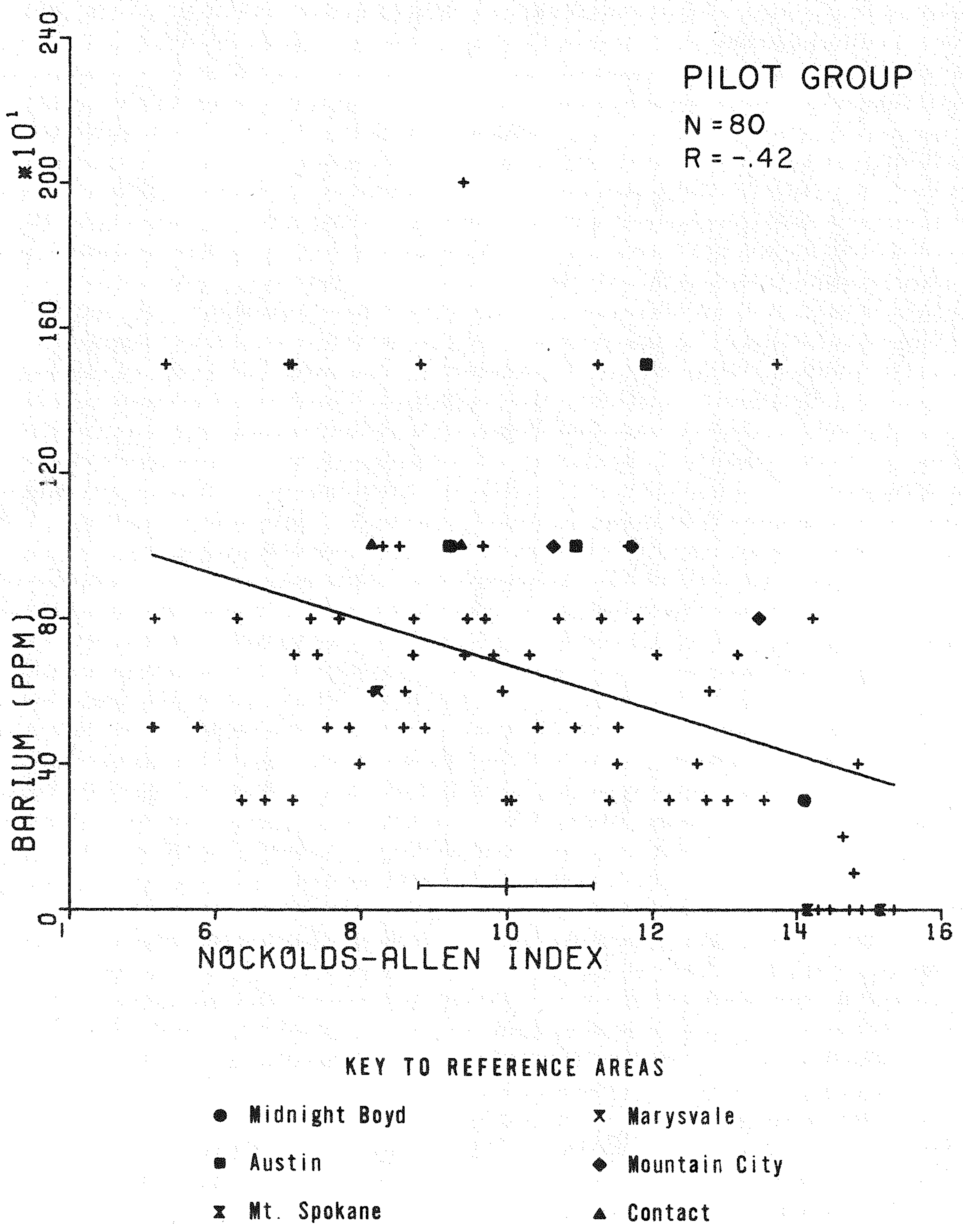


Figure 57. Plot of barium versus Nockolds-Allen Index for the Pilot Group. Semiquantitative analyses for barium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

Vanadium

A comparison of semiquantitative data for vanadium in the Reference Group and in all samples (Figure 58) leads to the conclusion that the former may be characterized by lower values and an absence of high values (ie., above 100 ppm). This is consistent with the earlier conclusion for iron, since vanadium shows a close association with iron (Figure 59).

Taking into consideration the dependence of vanadium on iron content (Figure 59) and on the Nockolds-Allen Index (Figure 60), the three samples from the Austin area are high in comparison to the other samples in the Pilot Group. Analytical errors of the order of ±50 percent on the three samples, however, would preclude that conclusion.

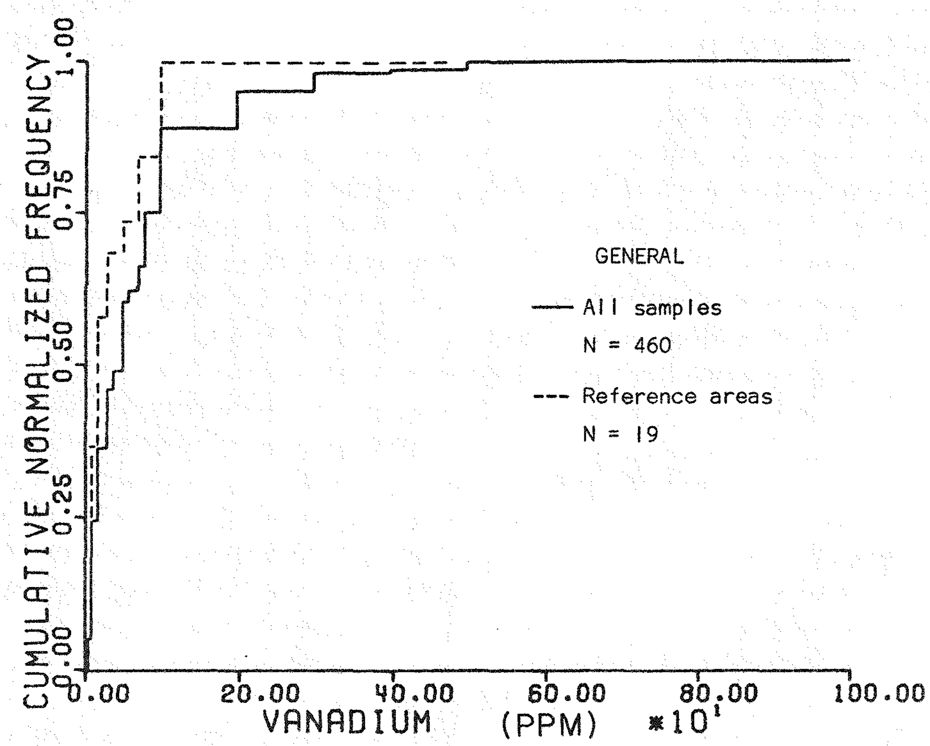
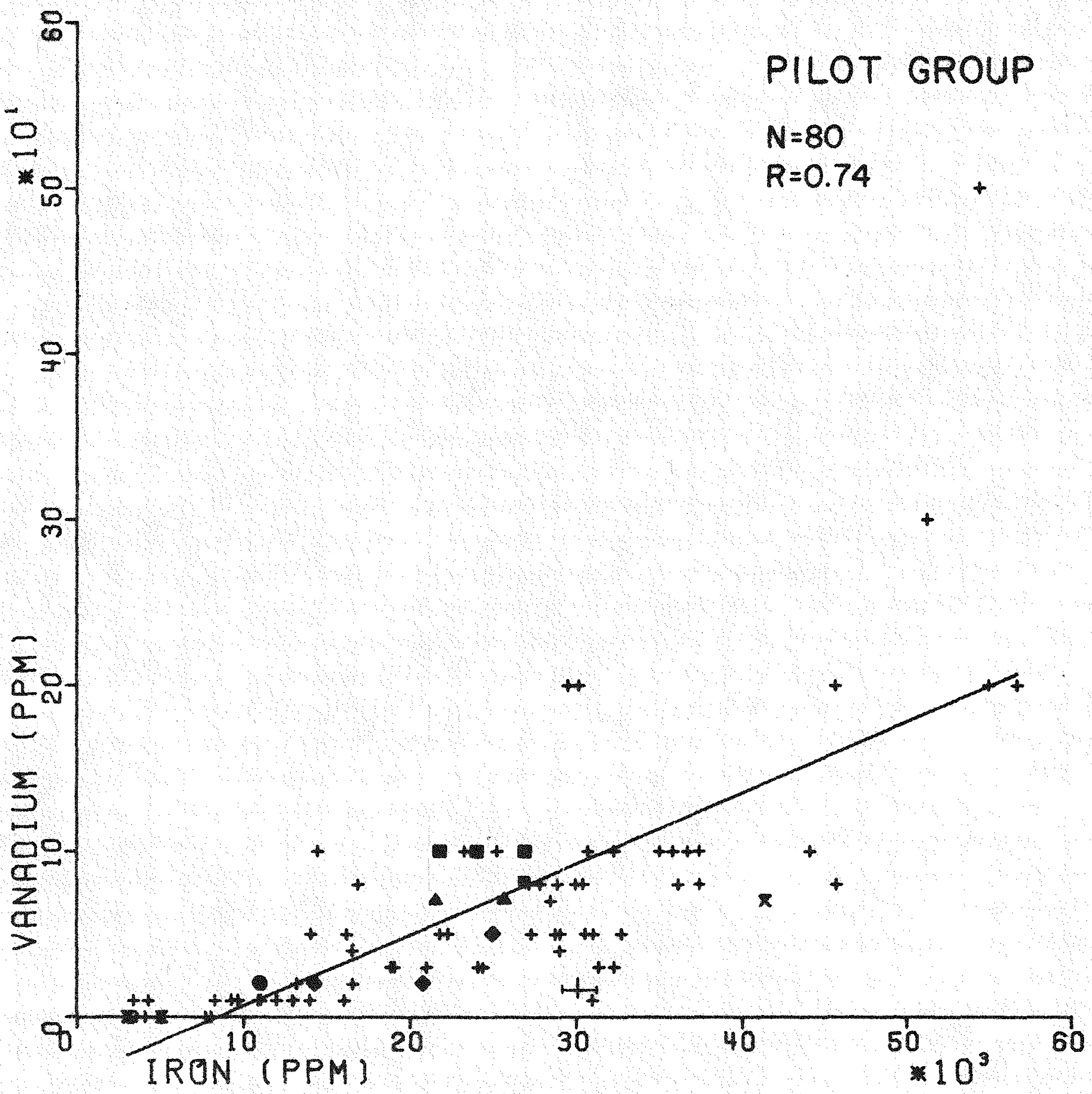


Figure 58. Cumulative frequency distribution of vanadium for all samples. Semiquantitative analyses.



KEY TO REFERENCE AREAS

● Midnight Boyd
■ Austin
⧗ Mt. Spokane
⧗ Marysvale
◆ Mountain City
▲ Contact

Figure 59. Plot of vanadium versus iron for the Pilot Group. Quantitative analyses for iron; semiquantitative analyses for vanadium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

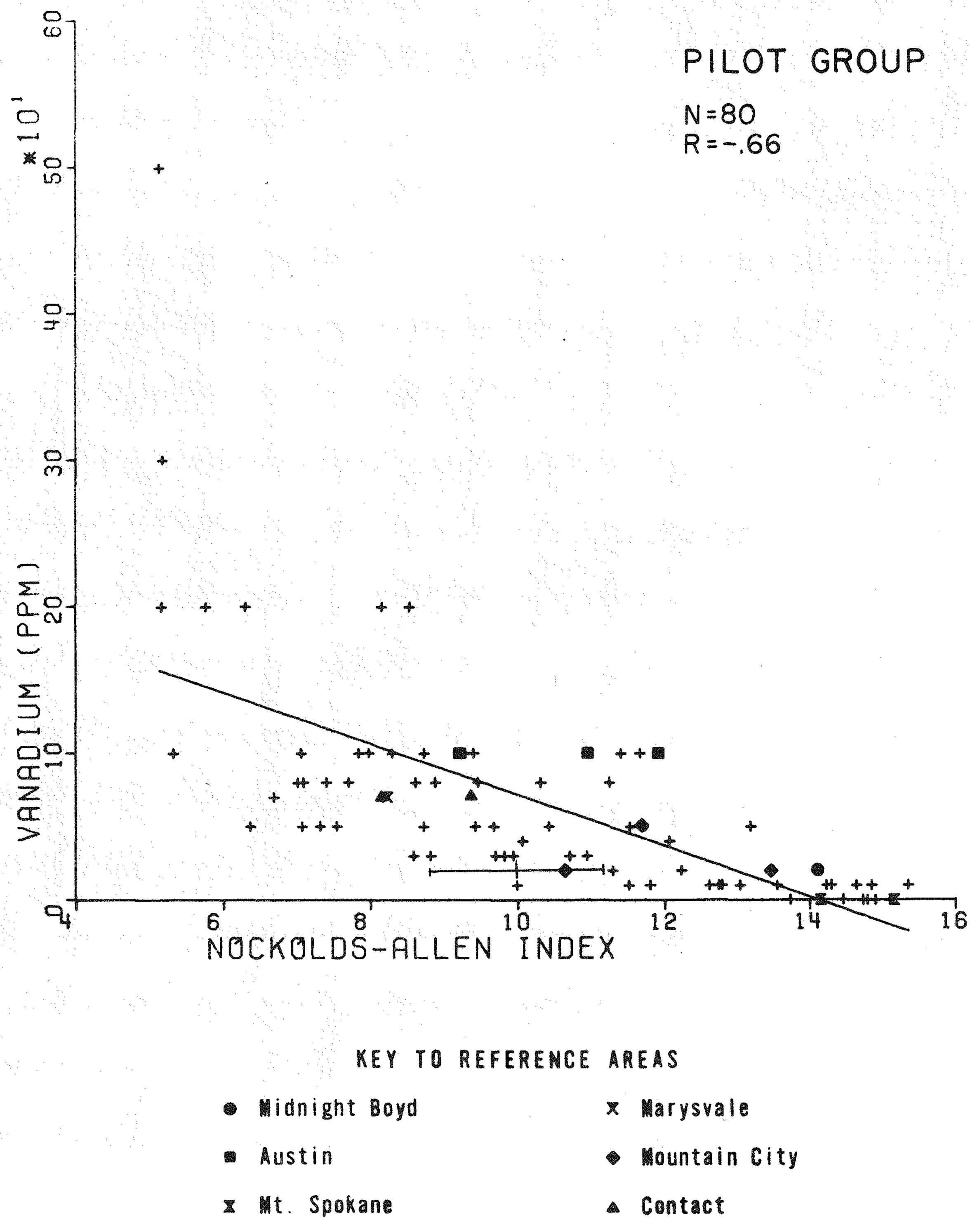


Figure 60. Plot of vanadium versus Nockolds-Allen Index for the Pilot Group. Semiquantitative analyses for vanadium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

Zirconium

A comparison of semiquantitative data for zirconium in the Reference Group and in all samples (Figures 61 and 62) leads to the conclusion that the former may be characterized by a smaller percentage of high values. Approximately 25 percent of all project samples are above 100 ppm whereas in the Pilot Group only about 5 percent (one sample from the Contact area) are above this cut-off.

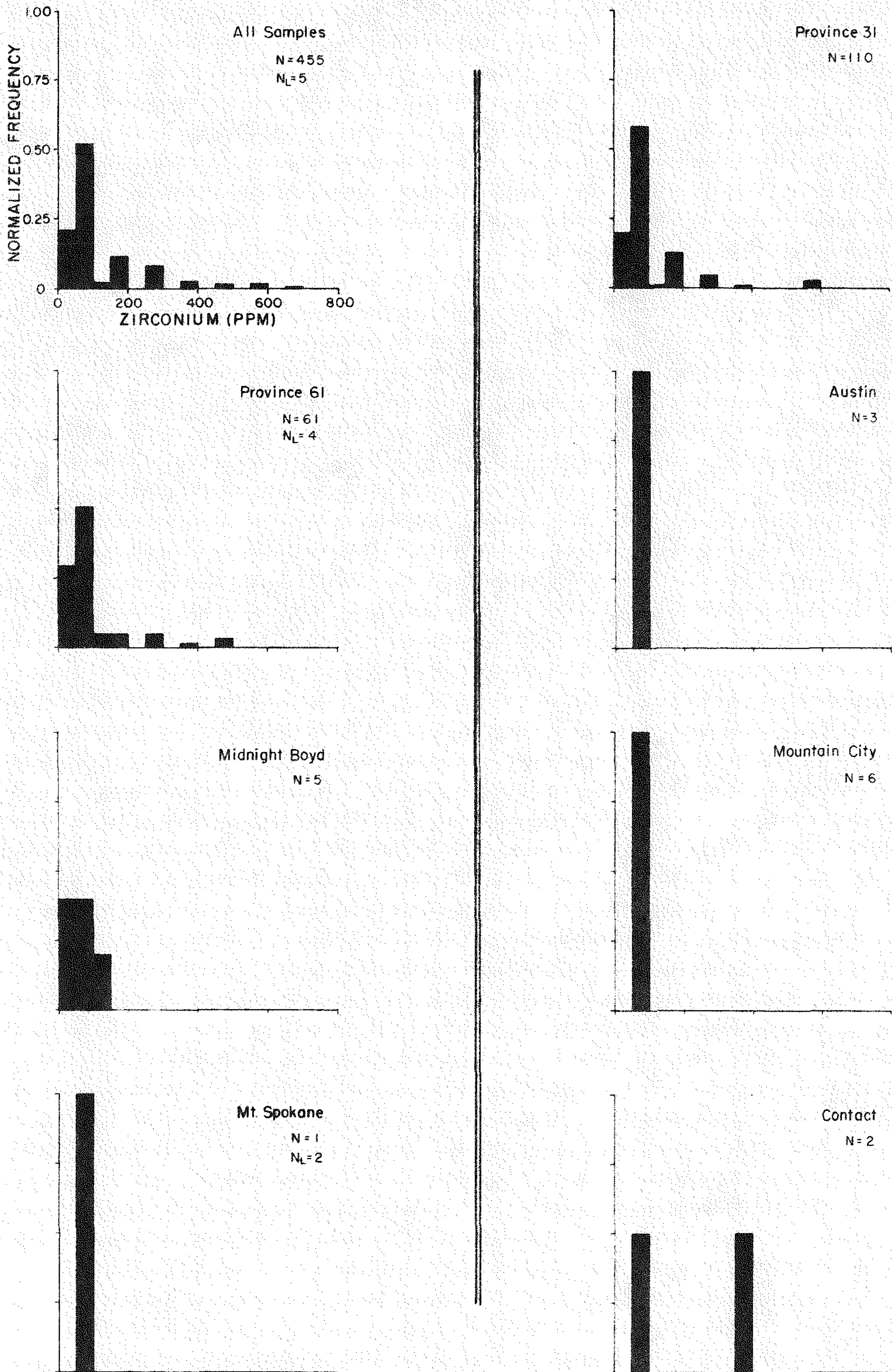


Figure 61. Frequency distribution of zirconium for all samples. Quantitative analyses. N = number of samples; N_L = number of samples below detection limit (not considered in histogram or N).

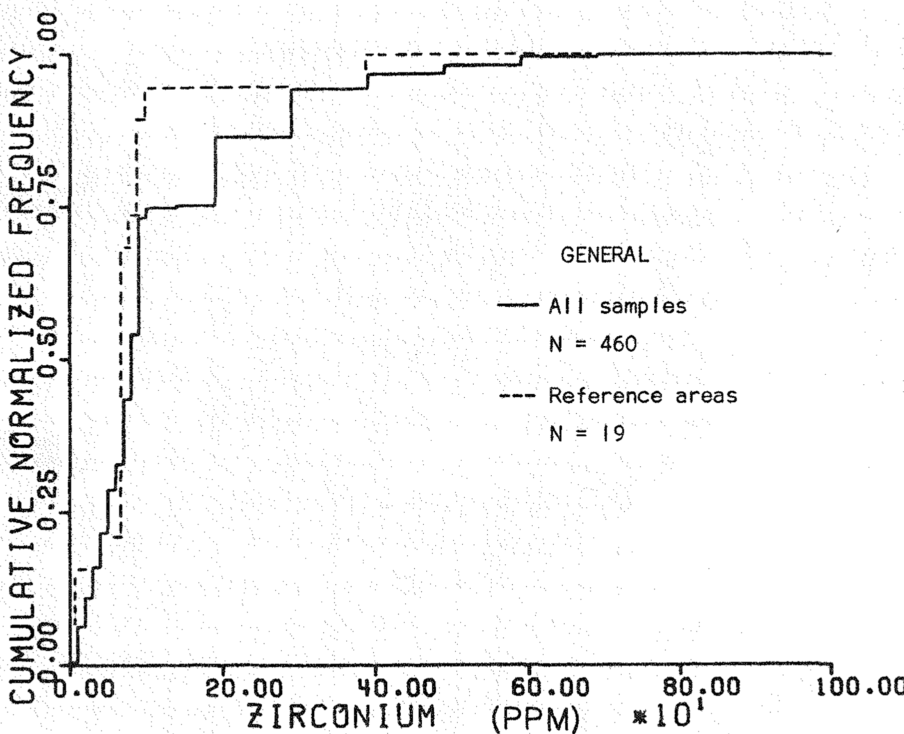


Figure 62. Cumulative frequency distribution of zirconium for all samples. Quantitative analyses.

Thorium

A comparison of quantitative data for thorium in the Reference Group and in all samples (Figures 63 and 64) leads to the conclusion that the former may be characterized by higher than average thorium concentrations. Individually, however, when compared with the data for the resident geologic province, thorium concentrations in the reference areas range from the very lowest (ie., Mount Spokane) to greater than most samples in the province (ie., Midnight Boyd and Contact). In contrast with uranium, to be discussed later, the range of thorium concentration within the subgroup of samples from each reference area is relatively small.

The correlation between thorium and the differentiation index in the Pilot Group (Figure 65) is poor. There is a fair correlation between thorium and potassium in the total group of samples (Figure 66), especially for the Mesozoic samples.

The thorium-zirconium correlation may be significant in at least the Cenozoic samples (Figure 67). The relatively high analytical error for the zirconium analyses may be a factor in minimizing the correlation, however.

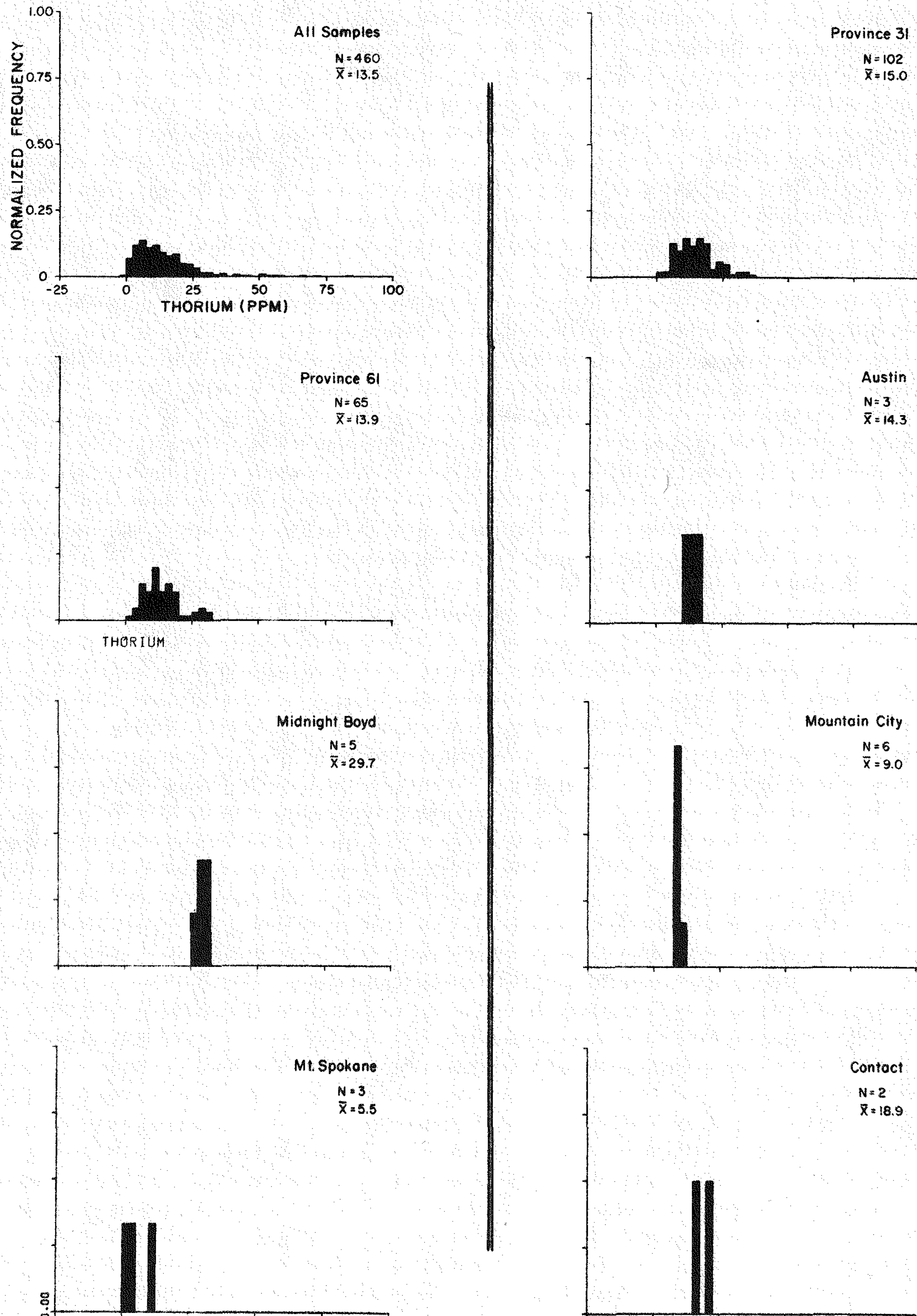


Figure 63. Frequency distribution of thorium for all samples. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.

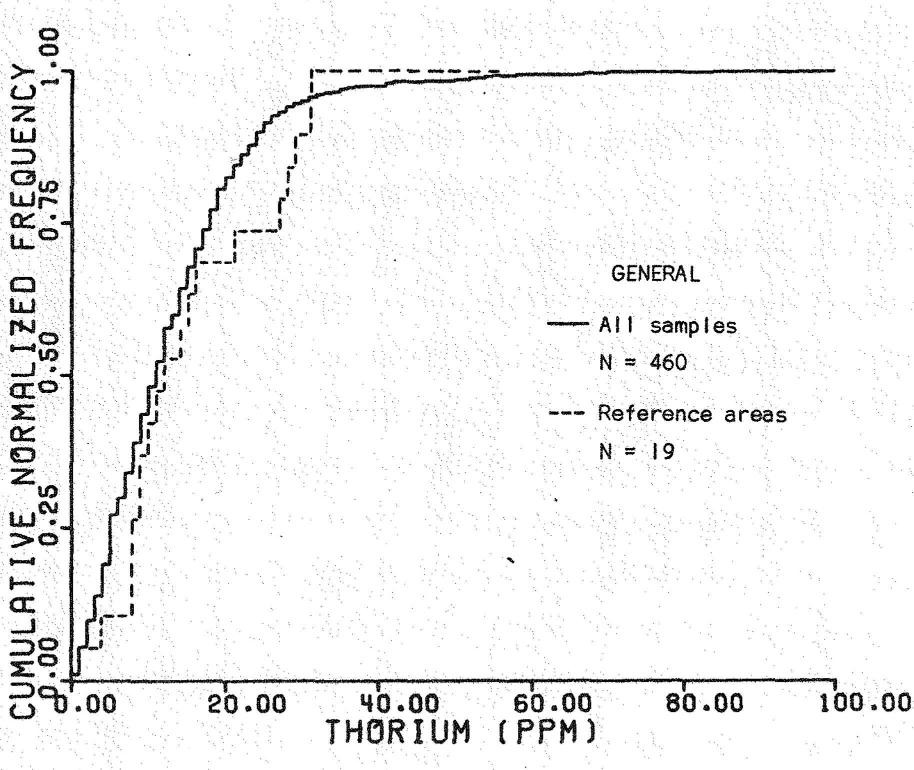


Figure 64. Cumulative frequency distribution of thorium for all samples. Quantitative analyses.

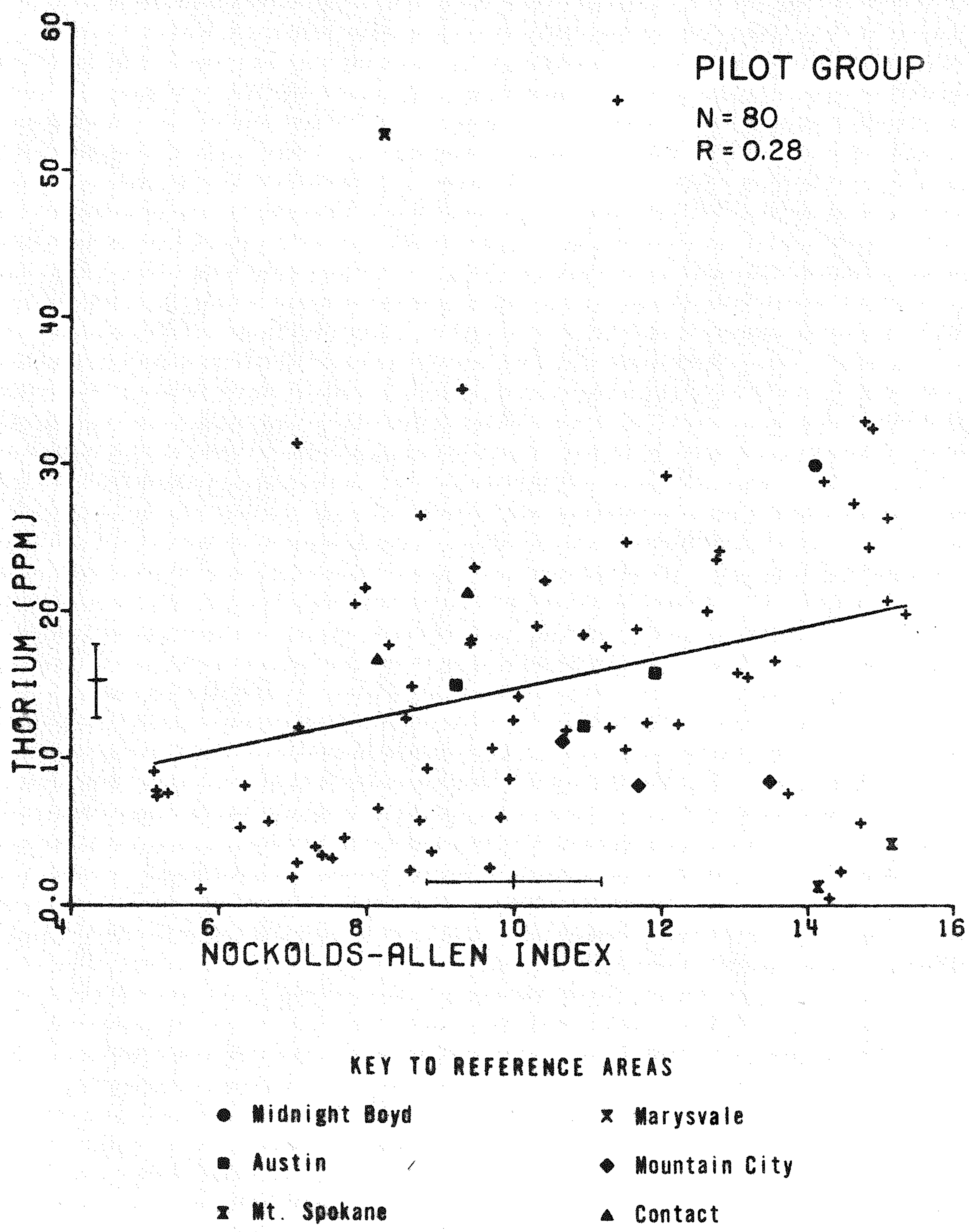
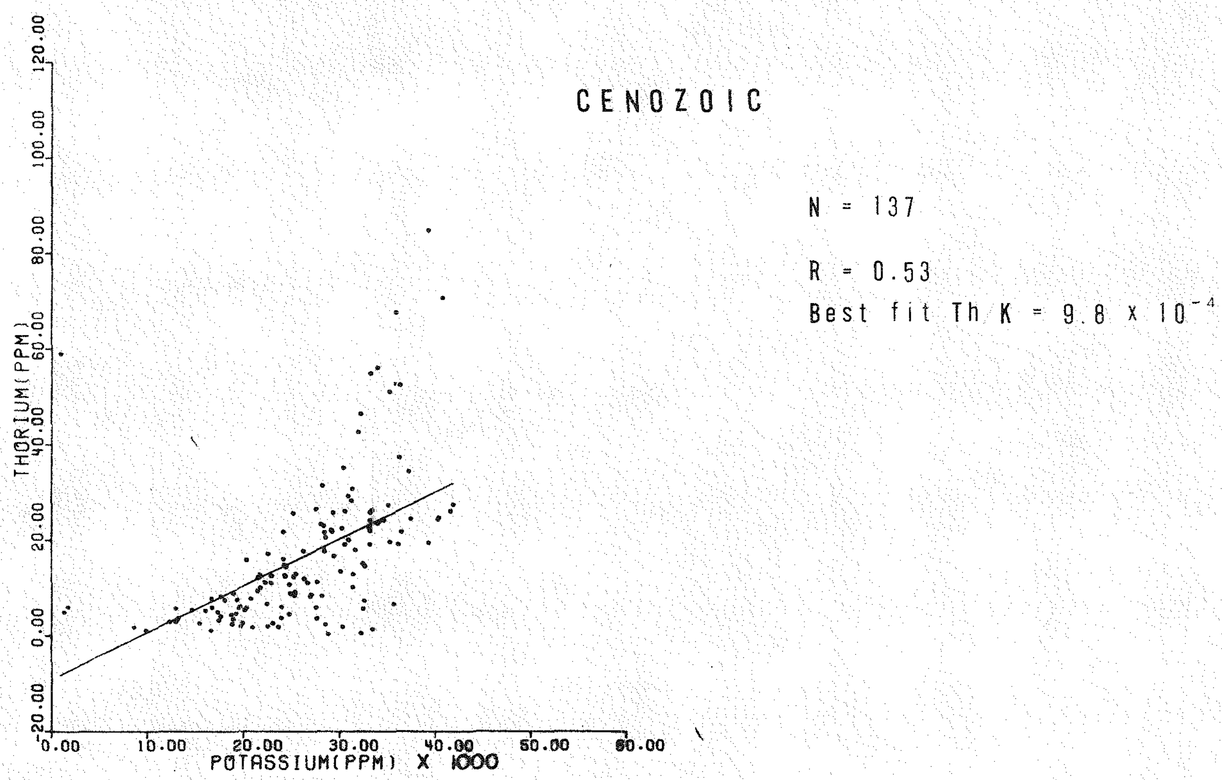


Figure 65. Plot of thorium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for thorium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



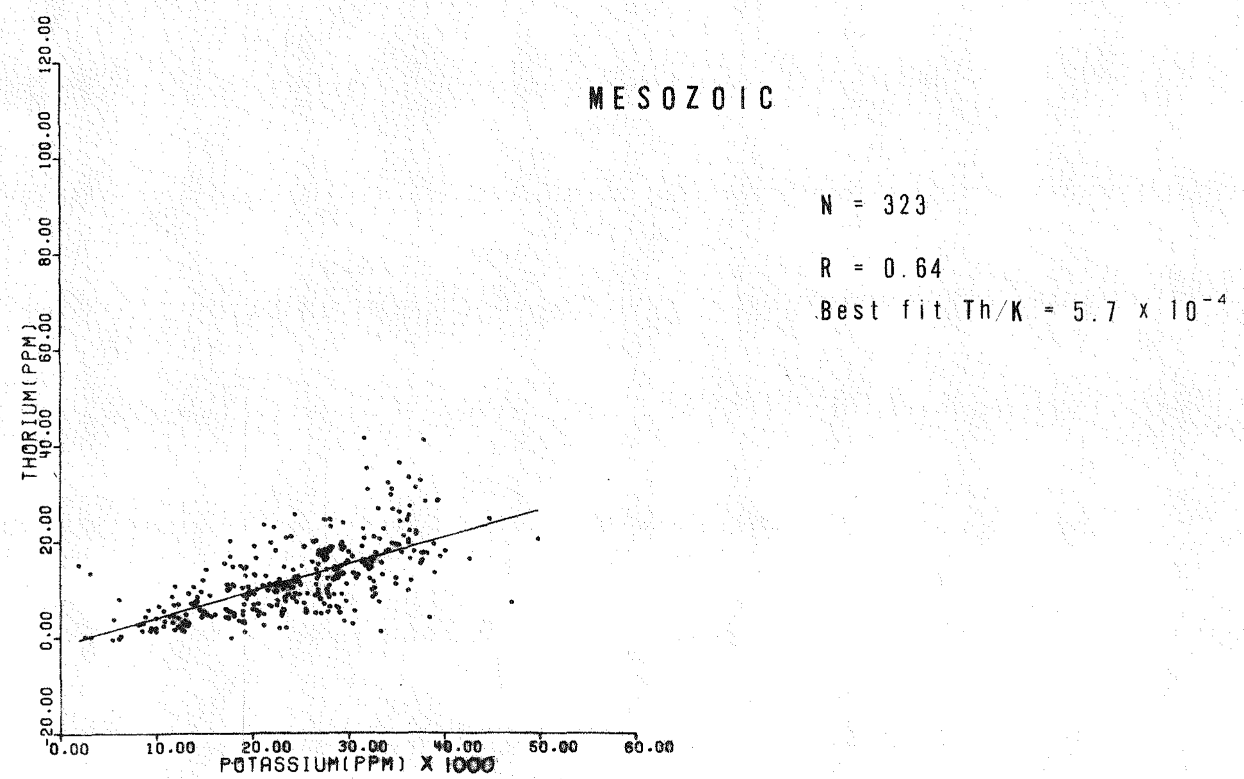
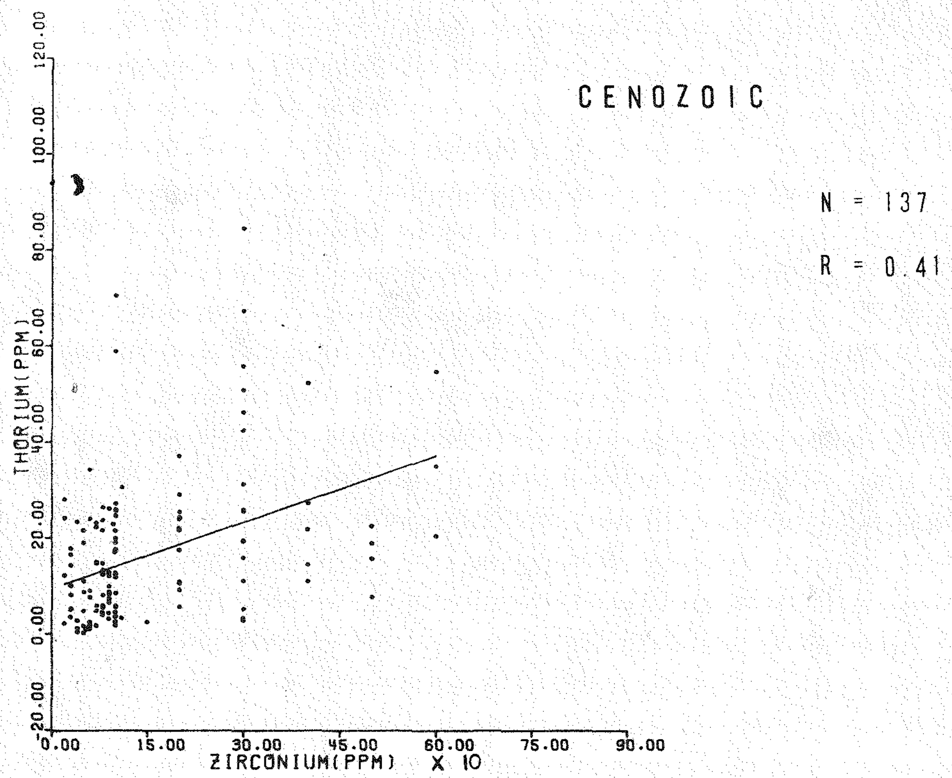


Figure 66. Plot of thorium versus potassium for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.



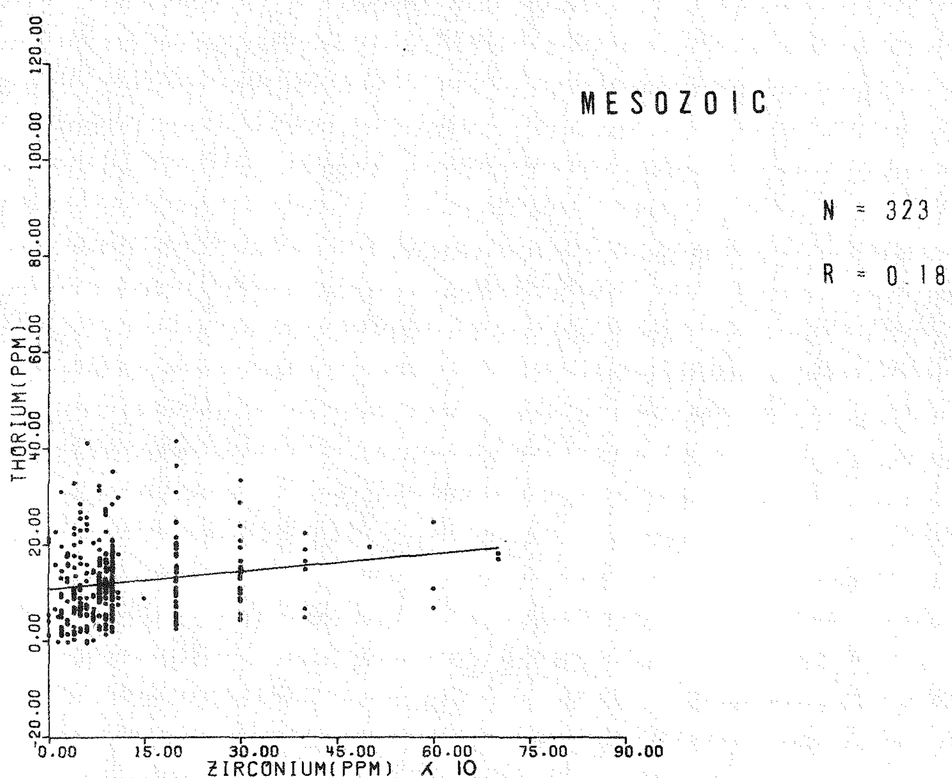


Figure 67. Plot of thorium versus zirconium for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.

Regression Analysis for Thorium

In view of the close association between thorium and uranium and the indications from this analysis that unusually high or low thorium concentrations may be indicative of favorability within a province, correlations between thorium and the following chemical parameters were investigated by means of a regression analysis program (WRAP):

Li, Na, Be, Mg, Ca, Sr, Ba, Ti, V, Mn, Fe, (Ca/Na + K), B and Zr

All analytical data for these elements are semiquantitative with the exception of zirconium and all project samples were used in the analysis. Other elements for which semiquantitative data are available were excluded from the analysis because the concentrations in an appreciable percentage of the samples were less than the detectable limit (the inclusion of this data, as zero values has the effect of increasing the probability of correlation).

The results obtained are summarized in Table 7. It is noted that the probability of correlation is greater than 95 percent for the following:

Be, Ca, Sr, Ba, Ca/Na + K, and Zr

The overall correlation coefficient, however, is relatively poor (0.50). The f-ratio is highest for zirconium (52), next highest for beryllium (35) and less than 10 for all others.

TABLE 7

RESULTS OF REGRESSION ANALYSIS ON THORIUM, URANIUM AND SELECTED ELEMENTS[1]

Parameter	Probability of Correlation[2]	
	Thorium[3]	Uranium[4]
Li	.44	.86
Na	.54	.79
Be	> .95	> .95
Mg	-.86	-.43
Ca	<-.95	<-.95
Sr	> .95	> .95
Ba	> .95	-.76
Ti	-.11	.28
V	.88	.82
Mn	.54	-.36
Fe	.89	.62
Ca/Na+K	<-.95	.52
B	-.08	-.28
Zr	> .95	> .90

[1] Using WRAP program; 496 samples; includes some samples later rejected on the basis of weathering.

[2] Negative sign indicates negative or inverse correlation.

[3] Overall correlation coefficient, 0.50.

[4] Overall correlation coefficient, 0.30.

Uranium

A comparison of quantitative data for uranium in the Reference Group and in the total group of samples (Figures 68 and 69) leads to the conclusion that the former is characterized by higher than average values. Approximately 16 percent of all samples are above 5 ppm whereas about 57 percent of the samples in the Reference Group are above this value. Three of the five reference areas (Midnight Boyd, Austin and Mountain City) meet the condition of high uranium content but the two others (Mount Spokane and Contact) do not (Figure 68).

The range of uranium concentration within the subgroup of samples from the reference areas (in particular the Midnight Boyd, Austin. and Mountain City areas) is anomalously high, even to the point (as in the case of Austin) of being comparable to the total range of all samples in the province (Figure 68). Again, this does not hold for the Mount Spokane and Contact areas.

Possible correlations of uranium with thorium, potassium, zirconium, and molybdenum - elements for which quantitative data are available for all the samples - were investigated (Figures 70, 71, 72, and 73). Of these, the correlation with thorium is the best, particularly in the Cenozoic samples which display a much broader range of thorium values than the Mesozoic (Figure 70). There is also a moderate correlation between uranium and potassium (Figure 71).

The correlation between uranium and zirconium (Figure 72), as in the thorium-zirconium correlation, may be affected by the high analytical error of the zirconium analyses.

The correlation between uranium and the differentiation index in the Pilot Group (Figure 74) is relatively poor.

The correlation between uranium and rubidium in the Pilot Group (Figure 75) is perhaps noteworthy. This was not anticipated from theoretical considerations.

Regression Analysis for Uranium

Possible correlations between uranium and other chemical parameters were investigated further by means of the regression analysis program (WRAP). The results (Table 7) indicate that the highest probability of correlation is with Be, Ca, Sr, and Zr. The overall correlation coefficient for the regression analysis is quite low, however, about 0.30.

3

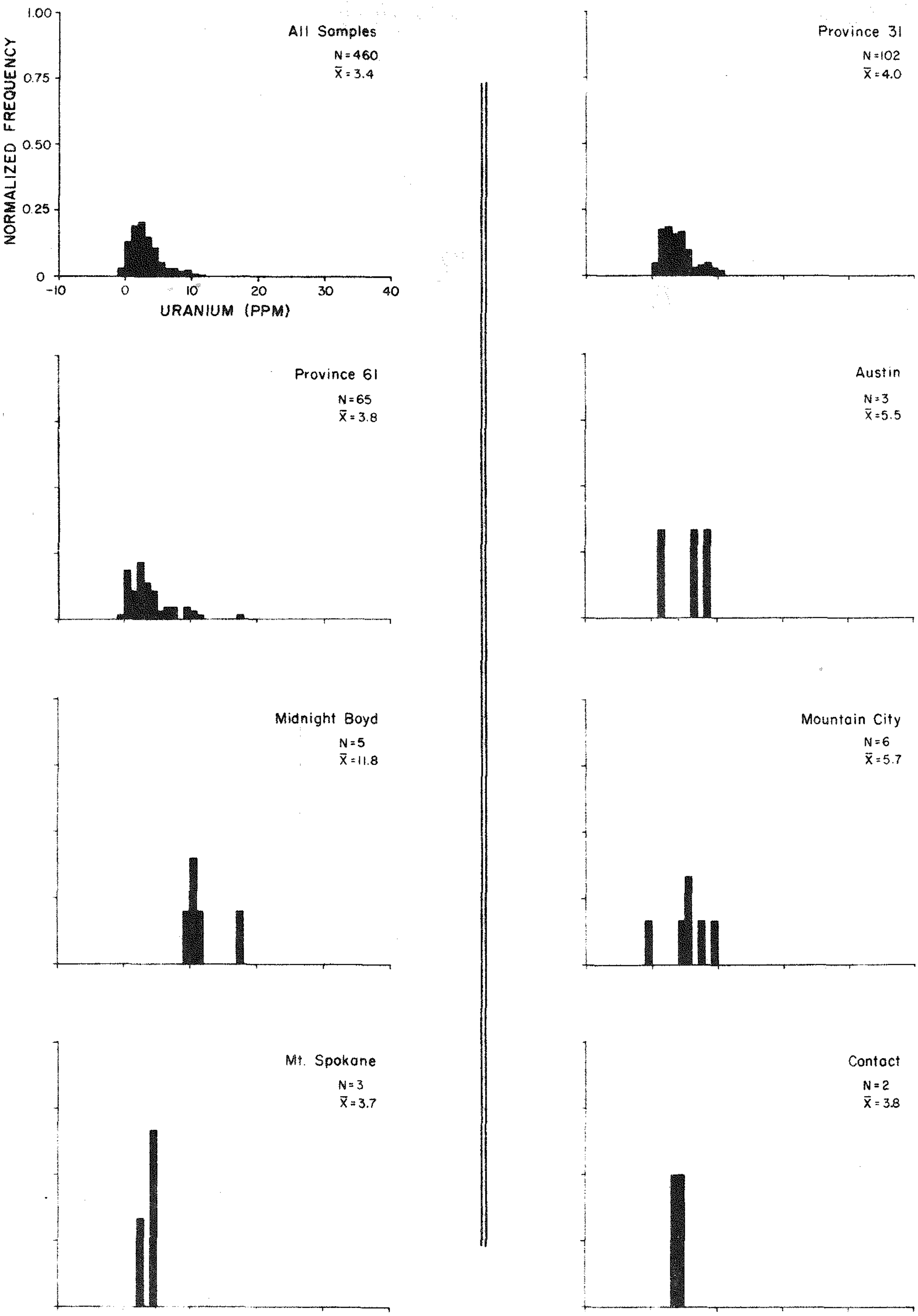


Figure 68. Frequency distribution of uranium for all samples. Quantitative analyses. N = number of samples; $\bar{x}$ = mean.

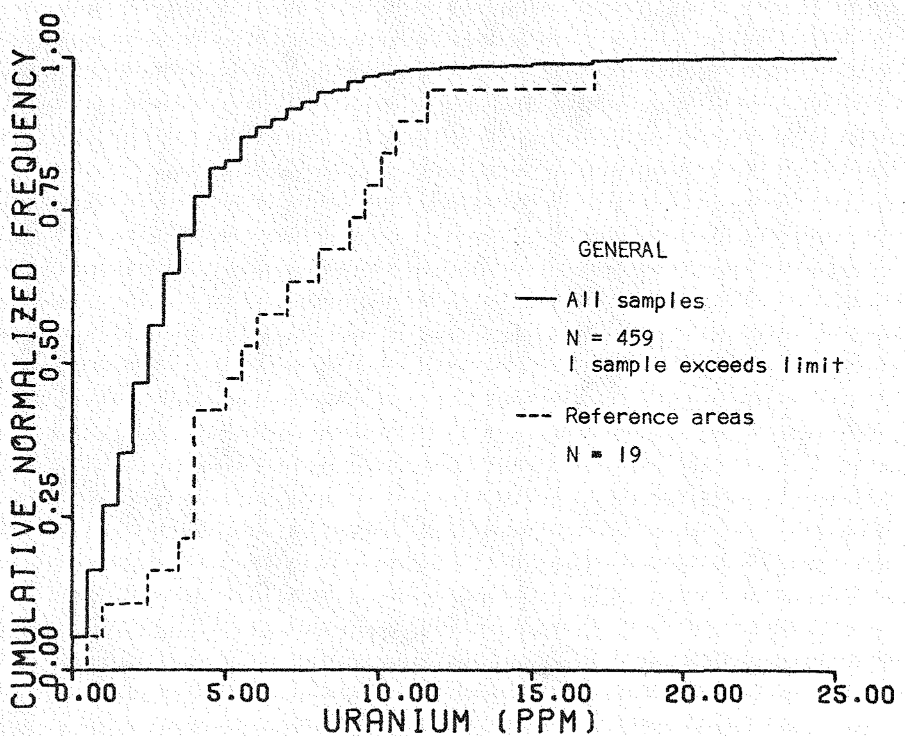


Figure 69. **Cumulative frequency distribution of uranium for all samples.** Quantitative analyses.

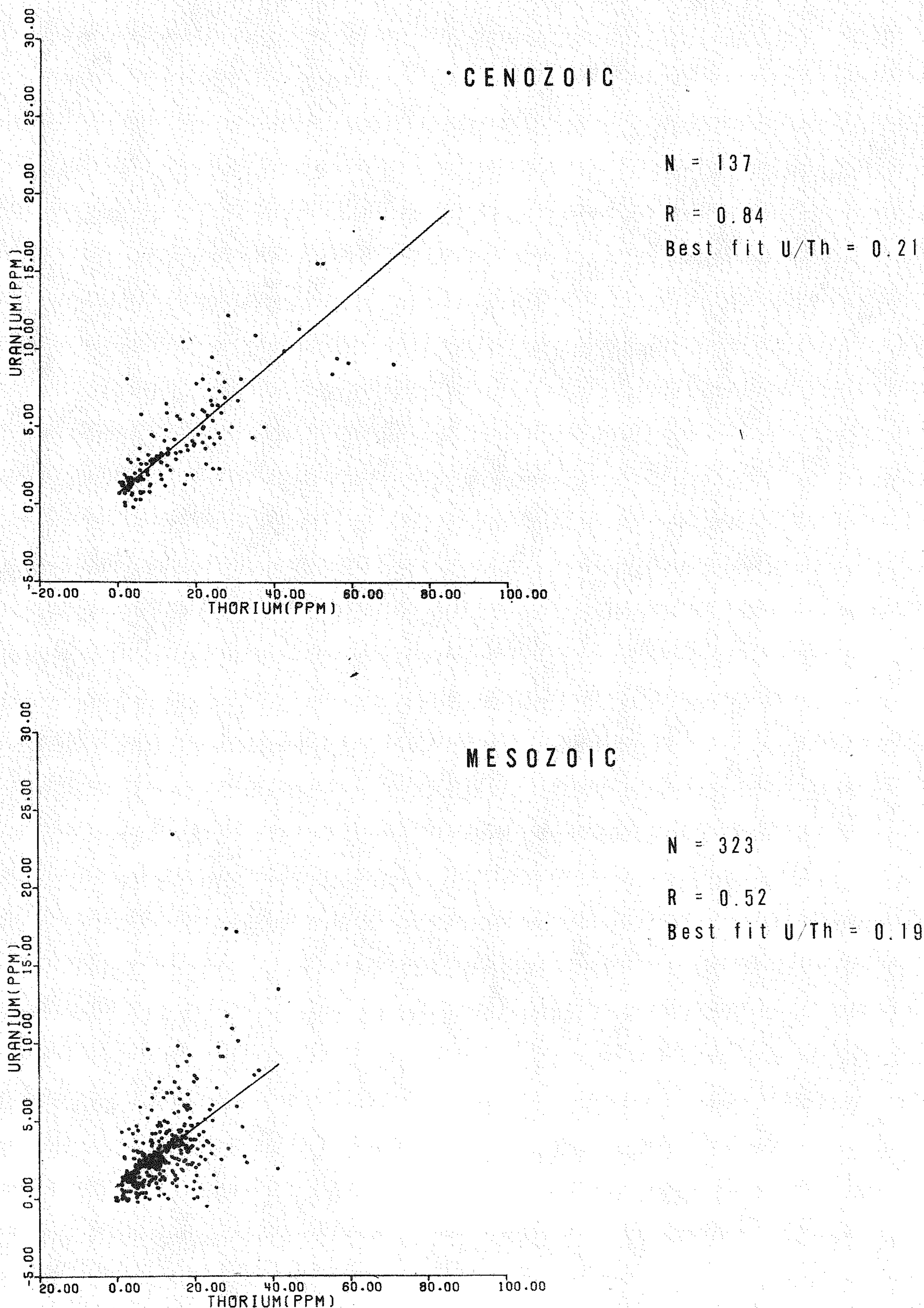
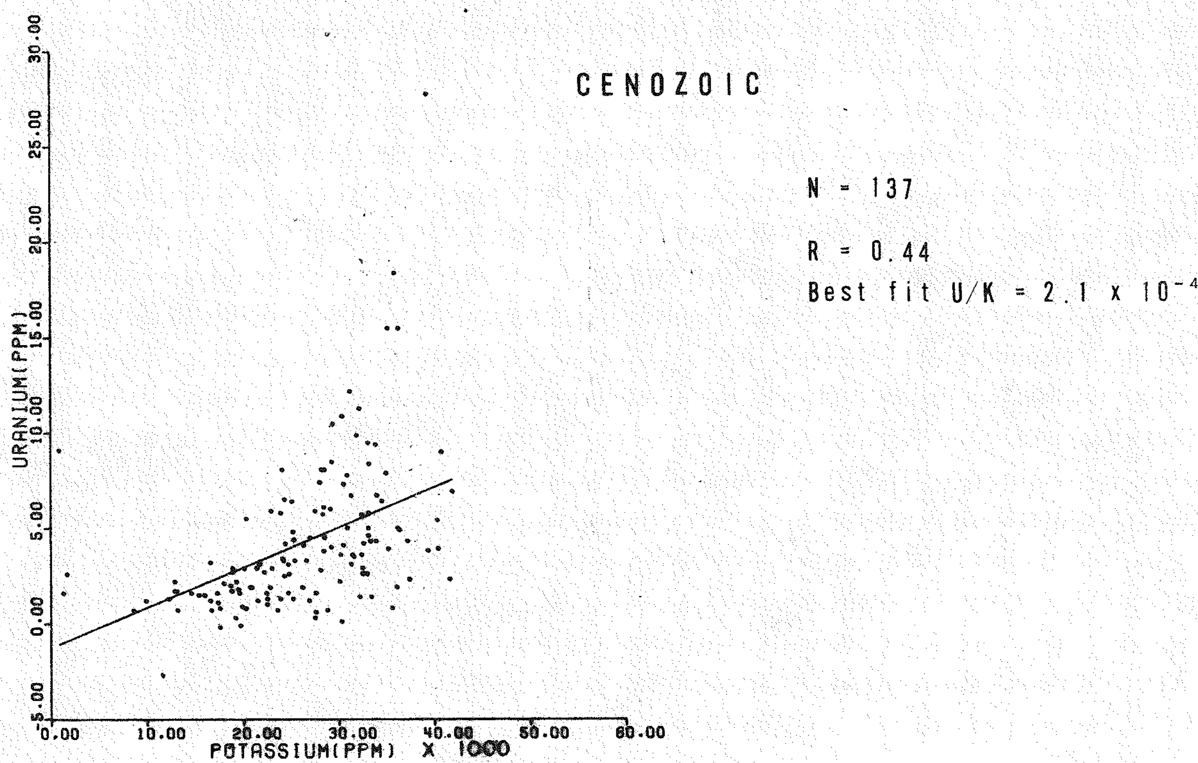


Figure 70. Plot of uranium versus thorium for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.



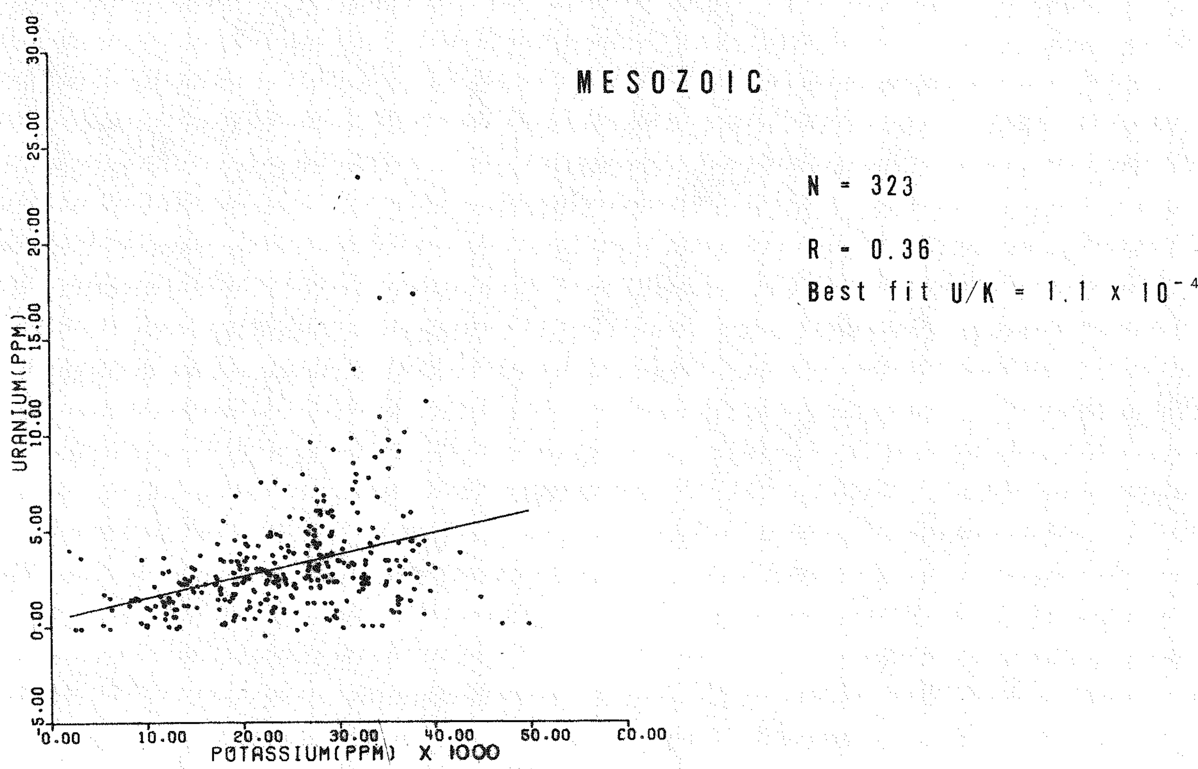
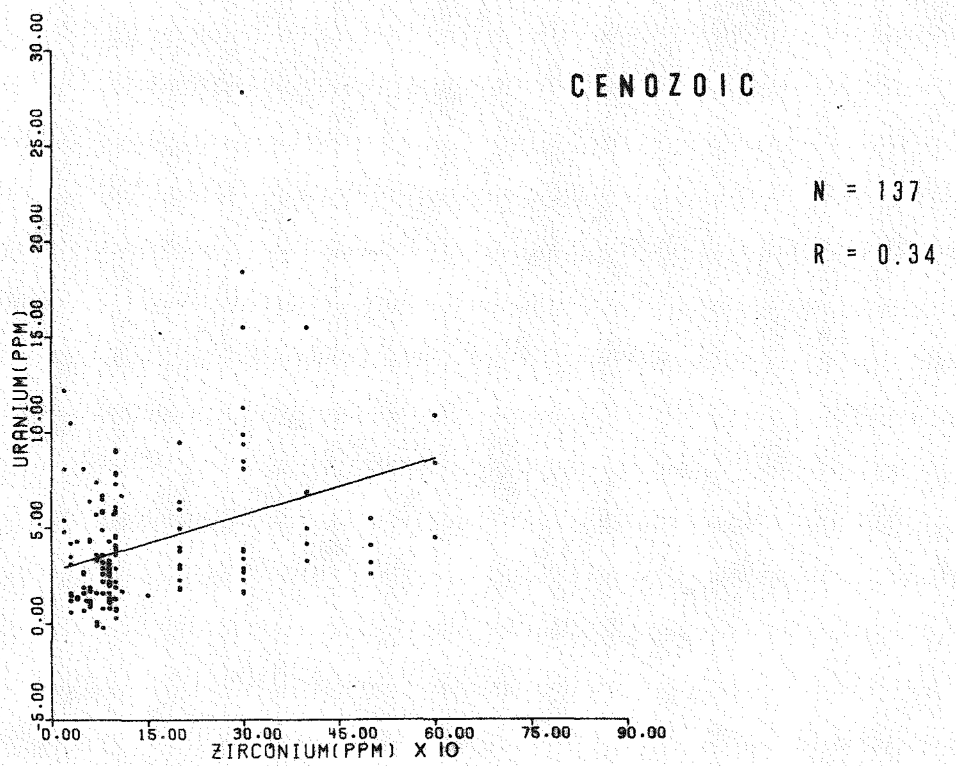


Figure 71. Plot of uranium versus potassium for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.



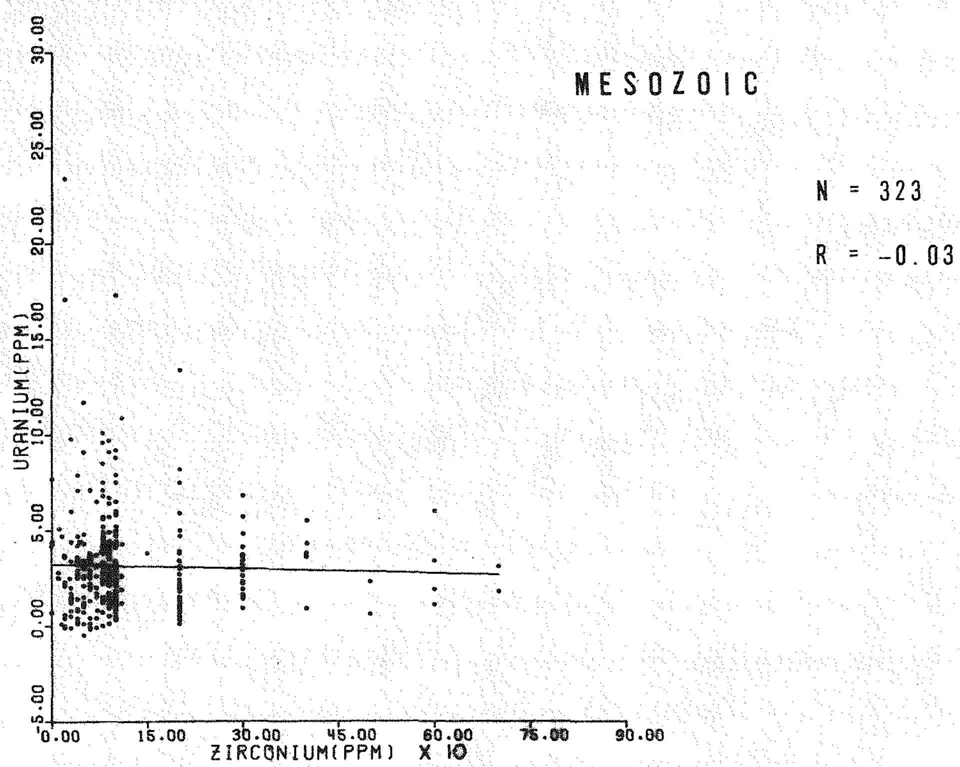
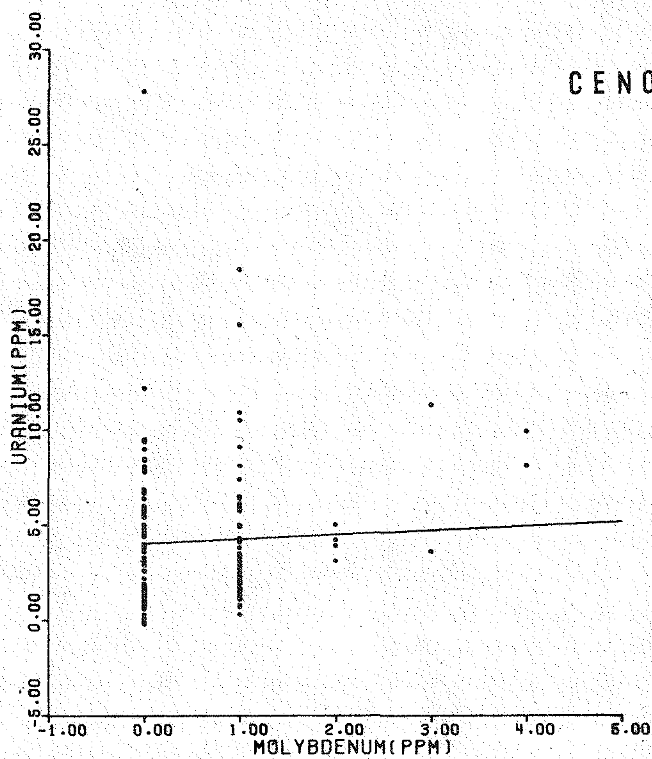


Figure 72. Plot of uranium versus zirconium for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.



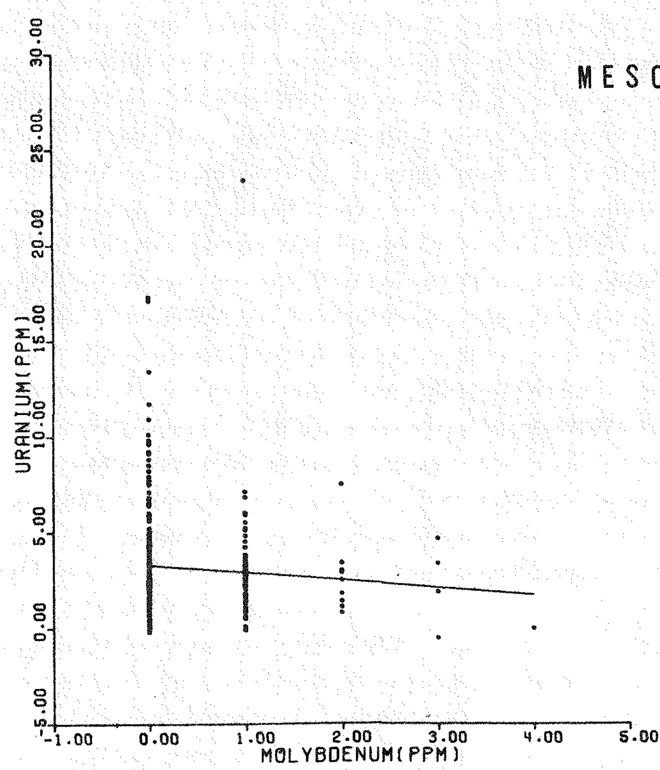


Figure 73. Plot of uranium versus molybdenum for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.

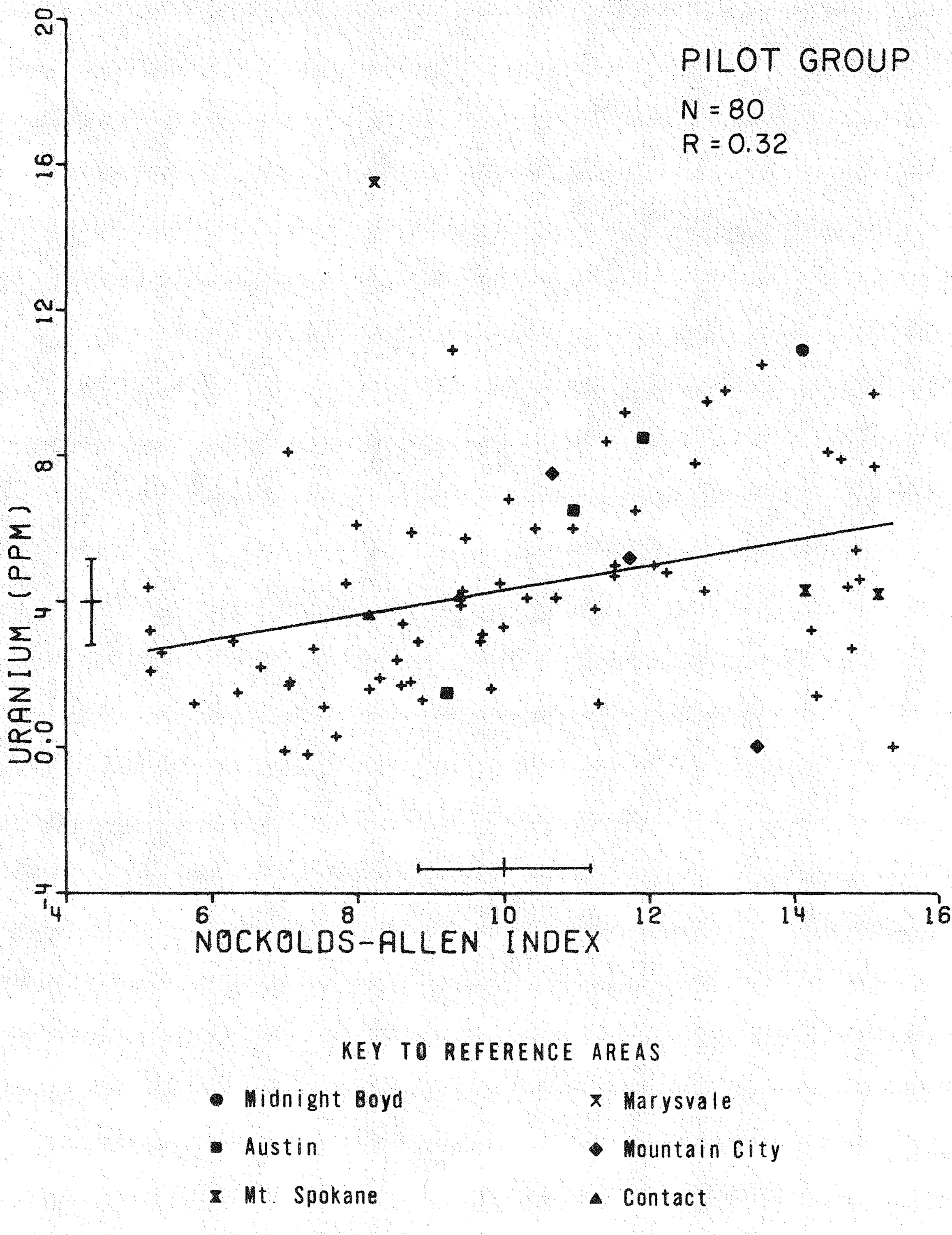
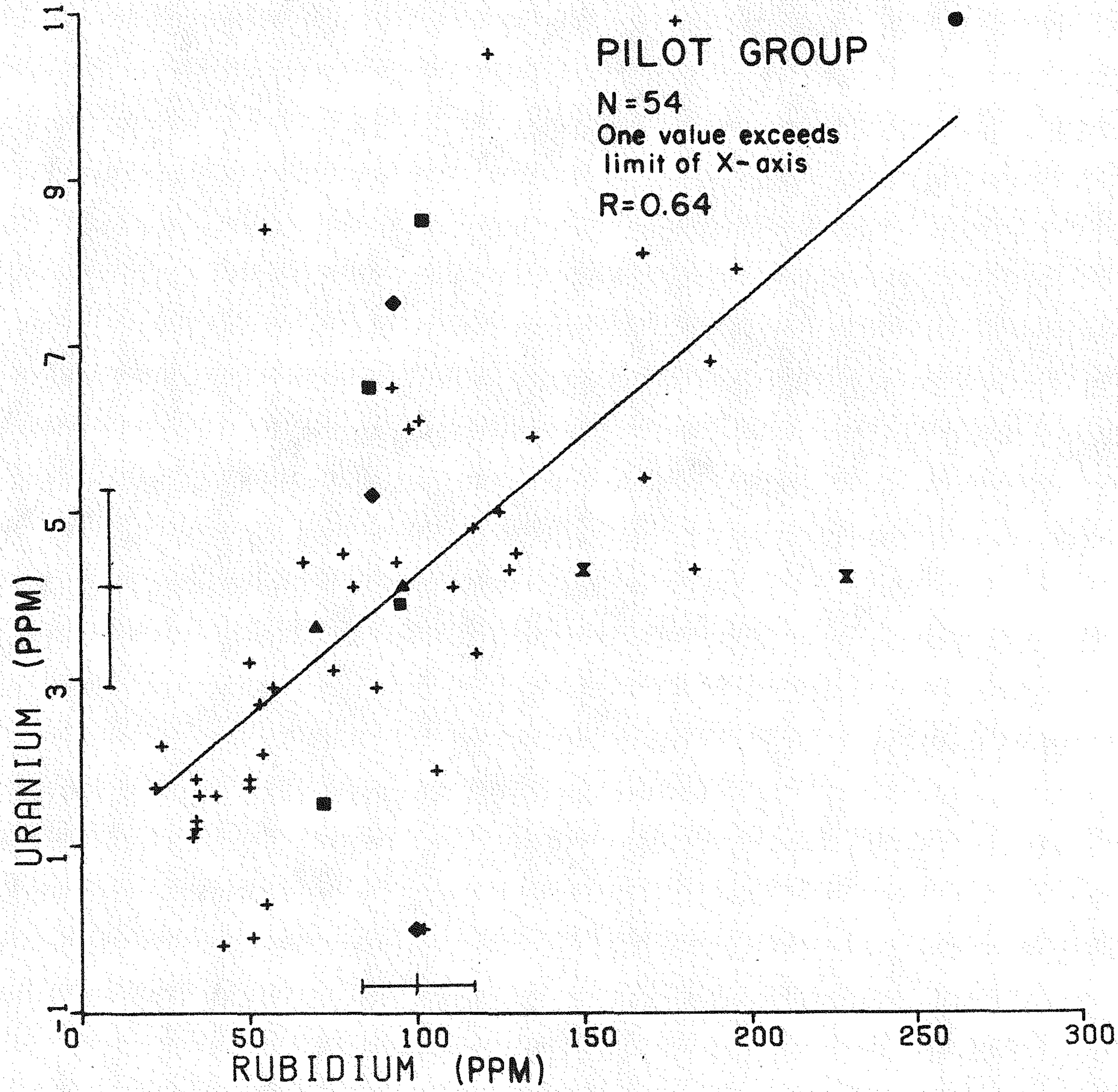


Figure 74. Plot of uranium versus Nockolds-Allen Index for the Pilot Group. Quantitative analyses for uranium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.



KEY TO REFERENCE AREAS

● Midnight Boyd
■ Austin
⧗ Mt. Spokane
x Marysvale
◆ Mountain City
▲ Contact

Figure 75. Plot of uranium versus rubidium for the Pilot Group. Quantitative analyses for rubidium and uranium. Showing best straight line fit; N = number of samples plotted, R = correlation coefficient. Error bar along axis indicates ±95 percent analytical confidence level.

Uranium-Thorium Ratio

The uranium-thorium ratio was investigated further because of (a) indications that concentrations of either element might be diagnostic of the reference areas, and hence candidates for favorability indicators and (b) the moderate degree of correlation between the two elements (Figure 70).

A comparison of quantitative data for the U/Th ratio in the Reference Group and in all samples (Figures76 and 77) leads to the conclusion that higher values are characteristic of the reference areas. This relationship is more the result of higher uranium concentration (Figure 69) than of lower thorium concentration (Figure 64). Initially it does not seem that the U/Th ratio would be more useful than uranium as an indicator of favorable areas.

With two exceptions (the Midnight Boyd and Contact areas) the variability of the U/Th ratio within the subgroups of samples from the reference areas is great, and in the case of Mt. Spokane, greatly exceeds the total range of values for the province (Figure 76).

The correlation between the U/Th ratio and potassium is insignificant (Figure 78).

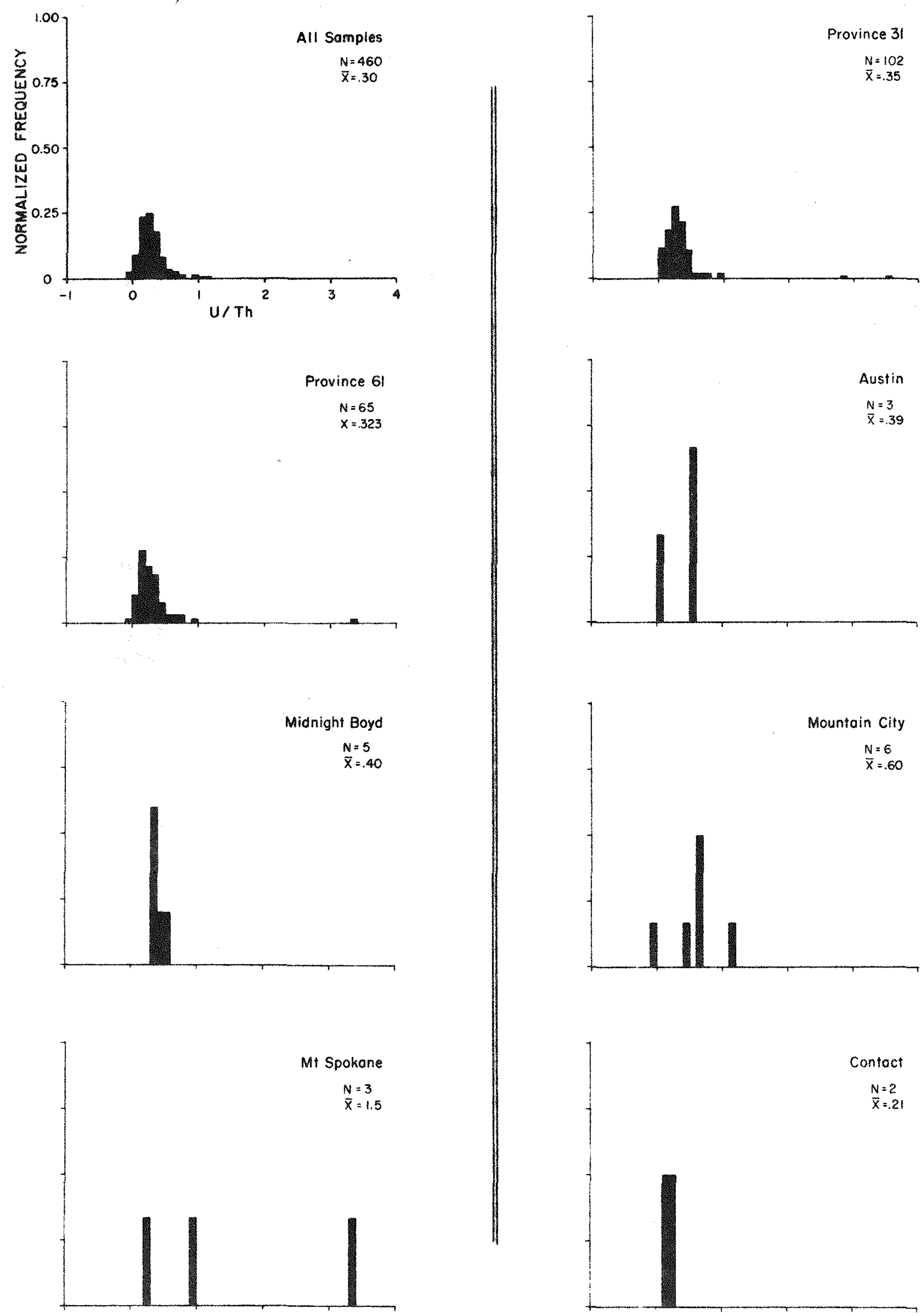


Figure 76. Frequency distribution of the ratio U/Th for all samples. Based on quantitative analyses of both elements. N = number of samples; $\bar{x}$ = mean.

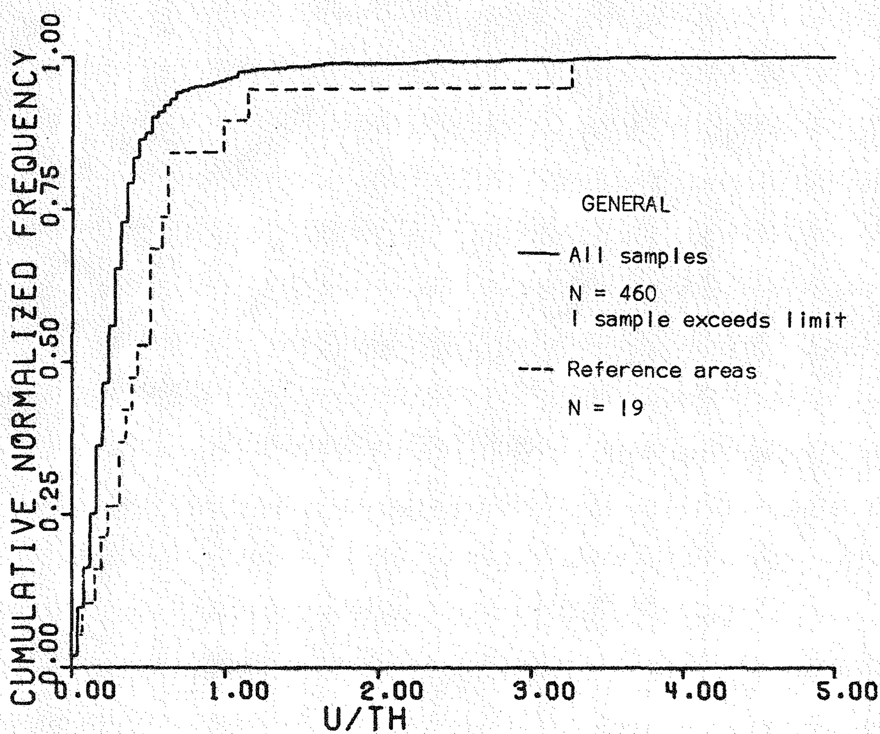
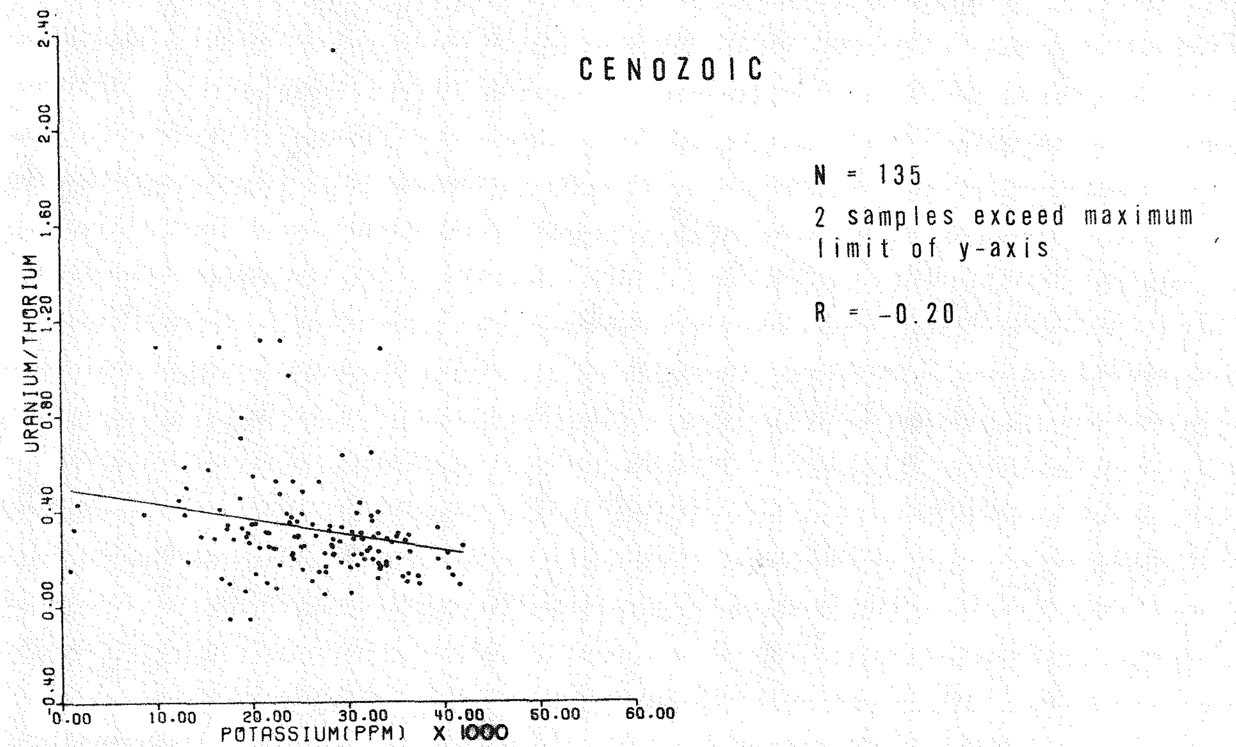


Figure 77. Cumulative frequency distribution of the ratio U/Th for all samples. Quantitative analyses.



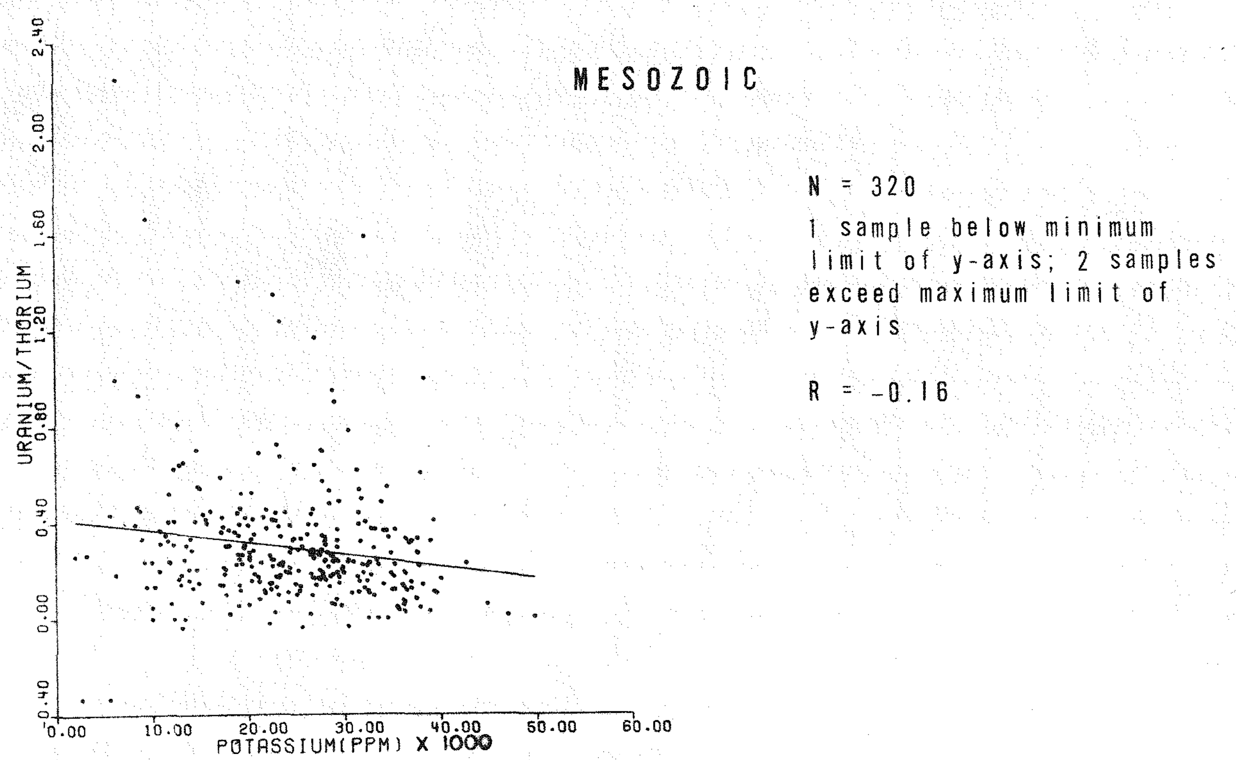


Figure 78. Plot of U/Th versus K for all samples. Showing best straight line fit. N = number of samples plotted; R = correlation coefficient.

Uranium-Potassium Ratio

The uranium-potassium ratio was also investigated further because of (a) indications that variability of uranium content may be used as an indicator, and (b) the substantial correlation between uranium and potassium (Figure 71).

A comparison of quantitative data for the U/K ratio in the Reference Group and in all samples (Figures 79 and 80) leads to the conclusion that higher values are characteristic of the Reference Group. The results follow very closely those for uranium with the exception that the relative degree of variability (or range of values) in the cases of Midnight Boyd, Austin, and Mountain City appears to be more diagnostic, and hence more useful as an indicator of favorability than uranium itself.

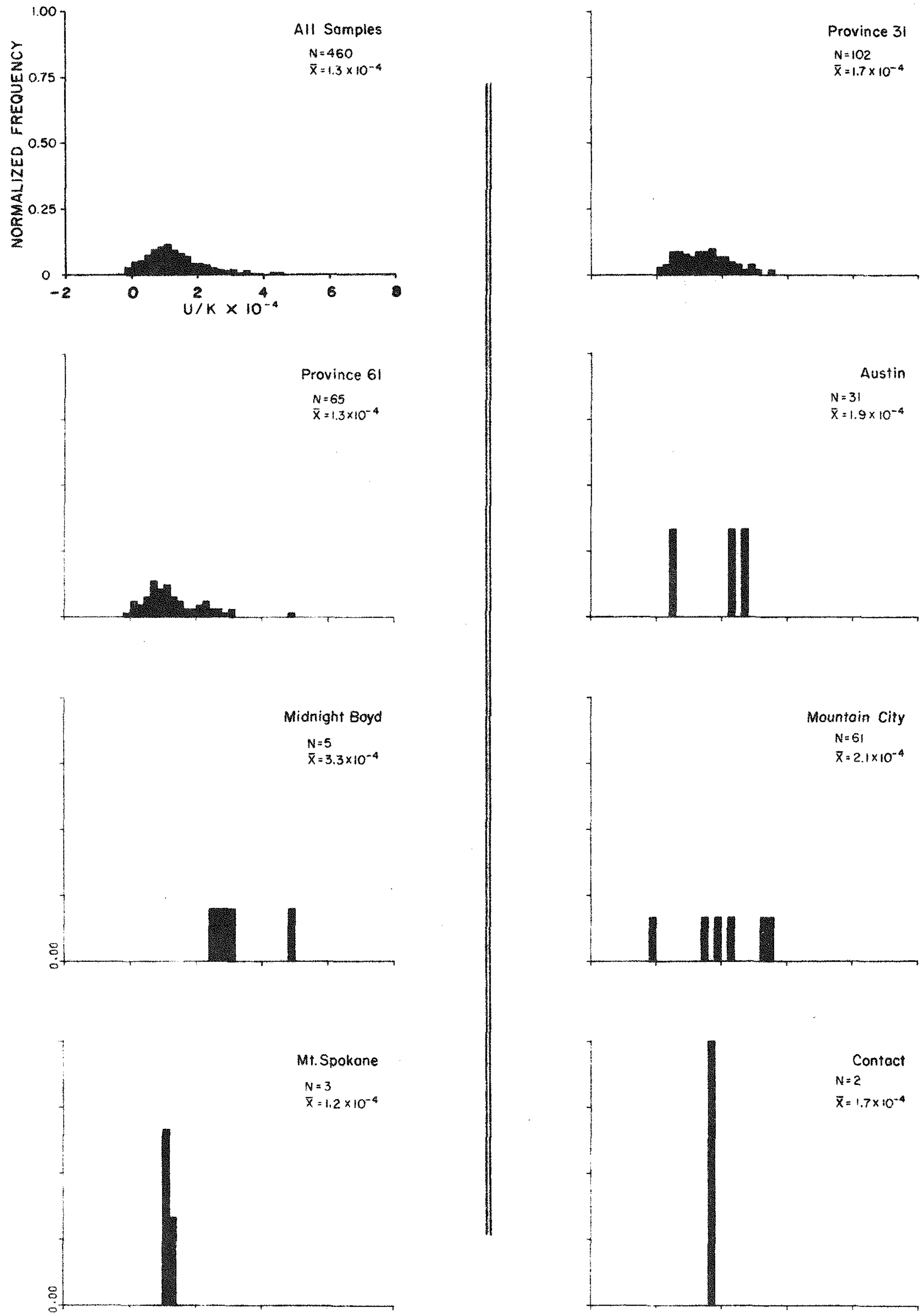


Figure 79. Frequency distribution of the ratio U/K for all samples. N = number of samples; $\bar{x}$ = mean.

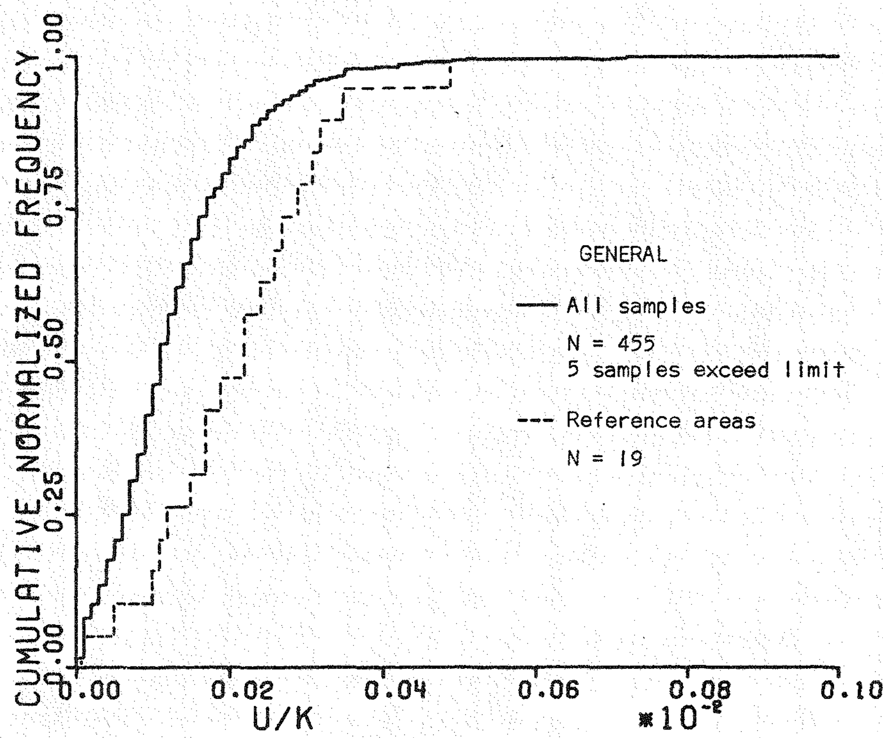


Figure 80. Cumulative frequency distribution of the ratio U/K for all samples. Quantitative analyses.

Summary

Reference Group Characteristics and Possible Favorability Indicators

The characteristics of the reference areas (as a group), as determined in the preceeding analysis, are summarized in Tables 8 and 9. The indicated limiting values or ranges cannot be taken at face value because of the undetermined affect of population size (ie., frequency distributions for the relatively few samples in the Reference Group were compared with those for the larger Pilot Group and for all samples). A qualitative rating of each of the elements as a possible indicator (last column, Tables 8 and 9) was made on the basis of (a) relative sizes of populations used in the analysis, (b) precision of the analytical data, and (c) relative difference between the frequency (or cumulative frequency) distributions in question.

A quantitative evaluation of each of the elements as an indicator and the determination of possible limiting values or ranges would require a statistical analysis of the data. This would be necessary to derive quantitative factors which could be used in exploration.

Although the complete evaluation of the results of this study will require further statistical and perhaps additional field and laboratory work, the results indicate that the Mesozoic and Cenozoic plutonic bodies associated with known vein-type uranium deposits are characterized by unique geochemical characteristics. Qualitatively, these characteristics are as follows:

1. very high Si
2. high Nockolds-Allen Index, Al, K, and Rb
3. average Fe^{+++}/Fe but limited range
4. low Na, Ca, Ti, Mn, and P
5. very low Fe, V
6. higher Th, U, and U/Th on the average
7. high range of U, U/Th on the average
8. high U/K and high range of U/K values

Distinctive Characteristics of the Reference Areas and Possible Additional Indicators

The distinctive or anomalous characteristics of the individual reference areas, as determined in the analysis in the preceeding section of the report, are summarized in Table 10. Further studies are necessary to determine if these characteristics may be useful as indicators on a local or regional scale. A study of the differences between the five separate areas of uranium deposits and their geologic environments may help to explain these distinctive chemical features.

Table 8

SUMMARY OF CHARACTERISTICS OF THE REFERENCE AREAS - MAJOR ELEMENTS

Parameter	Characteristics	Rating as Possible Indicator
Nockolds-Allen Index	greater than 8.0	good
Na	2.3-3.2%; upper limit probably more significant; lower values characteristic of Austin and Midnight Boyd	fair
K	>2%	good
Mg	——	not useful
Ca	0.5-2.8%; upper limit probably more significant	poor
Fe	<2.7%	fair
$\frac{Fe_2O_3}{FeO+Fe_2O_3}$	0.35-0.55	good
Ti	<0.35%	poor
Mn	<600 ppm	poor
Al	>7.9%	fair
Si	>31%	good
P	<1100 ppm	poor

Table 9

SUMMARY OF CHARACTERISTICS OF THE REFERENCE AREAS - MINOR ELEMENTS

Parameter	Characteristics	Rating as Possible Indicator
Li	generally high (Austin, Mt. City) but not enough variation to be useful	poor
Rb	>60 ppm; generally higher following K	fair
Be	suggestion of higher values	?
Sr	generally lower, following Ca	?
Ba	----	poor
V	<100 ppm; generally lower following Fe	fair
Zr	tends to be lower	fair
Th	higher than average as a group; may be useful on regional level	fair
U	higher as a group; high range (>7ppm for Midnight Boyd, Austin, and Mtn. City)	good
U/Th	higher as group; high range in some areas	fair
U/K	high average in Midnight Boyd and Mt. City; high range (>$2x10^{-4}$) in Midnight Boyd, Austin, Mt. City	very good

TABLE 10

SUMMARY OF DISTINCTIVE CHARACTERISTICS
OF INDIVIDUAL REFERENCE AREAS

Parameter	Reference Area Characteristics[1]				
	Province 31			Province 61	
	Contact	Austin	Mountain City	Midnight Boyd	Mount Spokane
Na	--	L	L	VL	--
K	--	(L)	--	--	--
Mg	VH	H	--	--	--
Ca	--	--	--	--	--
Fe	L	--	H	--	--
$\frac{Fe_2O_3}{FeO+Fe_2O_3}$	--	L	H	VL	--
Ti	--	H	--	--	--
Mn	VL	L	(H)	H	(L) (H)
Al	H	H	H	--	--
Si	--	--	--	--	--
P	(L)	--	--	--	(H)
Li	--	H	H	--	--
Rb	--	--	(L)	VH	(VH)
Be	H	--	--	H	--
Sr	--	--	--	--	--
Ba	--	H	H	--	--
V	--	--	--	--	--
Zr	(H)	--	--	--	--

Table 10 (continued)

Parameter	Reference Area Characteristics[1]				
	Province 31			Province 61	
	Contact	Austin	Mountain City	Midnight Boyd	Mount Spokane
Th	H	--	L	H	L
U	--	H,HR	H,HR	H,HR	--
U/Th	--	HR	H,HR	--	H,HR
U/K	--	HR	H,HR	H,HR	--

[1]These distinctive characteristics were identified in the analysis for each element in the preceeding section of the report. In each case the characteristic is determined from a comparison between data for samples from the reference area and one of the following: (1) average value for all project samples, (2) average value for all samples in the geologic province in which the reference area is located, and (3) the best straight line fit, in cases where the correlation with the Nockolds-Allen Index is good. A distinctive characteristic is noted only when the values for the reference area samples differ from the average values (or best straight line, as applicable) by an amount greater than the possible analytical error (95 percent confidence level = CL). The amount of difference (and sign) is indicated as follows:

VH: more than 2 CL high

H: 1 to 2 CL high

L: 1 to 2 CL low

VL: more than 2 CL low

A high range of values is indicated by the letters, HR. Parantheses indicate that the mean value does not meet the 1 CL condition but that individual values do.

PRELIMINARY IDENTIFICATION OF FAVORABLE AREAS

Although further work is required, as noted above, to determine the validity of cut-off values and of limiting ranges for the possible geochemical indicators given in Tables 8, and 9, two preliminary determinations of favorable areas, using the best possible indicators, were made.

Based on Selected Major Elements

Favorable areas identified on the basis of four possible major-element indicators which were rated as "good" (Table 8) are listed in Table 11. The eight samples selected are from six separate intrusive centers. Five of the eight samples are from the batholiths of northeastern Washington and northwestern Idaho, indicating that this may be a favorable area or "belt" for vein-type uranium deposits.

A quick review of Walker's (1963) data on vein-type uranium deposits indicates that uranium production areas and/or prospects are found in four out of the six (67 percent) intrusive centers identified as favorable in Table 11. When compared with the overall percentage (an estimated 34 percent) of Walker's production areas or prospects which are associated with intrusive centers sampled in the project, this indicates a measure of success in this determination of favorable areas.

Based on Potassium and the Ratio U/K

Favorable areas identified on the basis of potassium content and the uranium-potassium ratio are listed in Table 12. Since the range of U/K values is one of the criteria, samples are considered on the intrusive center basis and intrusive centers with only one sample are not considered.

Fourteen favorable intrusive centers are identified (Table 12). Four of the centers (including one in Northern Idaho) are located in the batholiths of northeastern Washington and northern Idaho, indicating a favorable "belt". A second favorable belt in eastern Nevada includes the following three intrusive centers: 31-43, 31-61, and 31-74.

Using Walker's (1963) data again, production areas and/or prospects are found in 6 out of the 14 favorable intrusive centers (43 percent). When compared with the overall percentage (34 percent) of production areas or prospects in the intrusive centers sampled in the project, there is only a slight margin, raising the question of the validity of this determination of favorable areas.

Table 11

PRELIMINARY IDENTIFICATION OF FAVORABLE AREAS BASED ON THE CONCENTRATIONS OF MAJOR ELEMENTS[1]

Sample Number[2]	Geologic Province - Intrusive Center	Locality
272	31-5	Haystack Peak, Utah
362	90-9	Sangre de Cristo, Colo.
1148	61-12	Loon Lake batholith, Wash.
1160	61-3	Loon Lake batholith, Wash.
1165	61-3	Kaniksu batholith, Wash.
1170	61-3	Loon Lake batholith, Wash.
1177	61-9	Colville batholith, Wash.
1282	31-65	Wassuk Range, Nevada

[1]Conditions: Nockolds-Allen Index greater than 8.0; potassium greater than 2 percent; $Fe_2O_3/FeO+Fe_2O_3$ between 0.30 and 0.50; silicon greater than 31 percent.

[2]See Appendix A and Plate 1 for location.

Table 12

PRELIMINARY IDENTIFICATION OF FAVORABLE AREAS
BASED ON POTASSIUM CONTENT AND THE RATIO U/K[1]

Geologic Province-Intrusive Center[2]	U/K(x10^{-4}) Min.	Max.	Mean	Number of Samples	Sample Numbers	Locality
24-8	.64	3.42	2.03	2	1262, 1263	Sierra Nevada, Calif.
31-43	.19	2.87	1.52	8	1208-1214, 1279	Ruby Range, Nev.
31-54	.27	3.12	1.69	2	1268, 1269	Wassuk Range, Nev.
31-61	.43	2.84	1.24	3	273,1254,1280	Kern Mts., Nev.
31-74	.56	2.90	1.73	2	1255, 1281	Cherry Creek Mts., Nev.
34-10	.94	7.24	4.09	2	1311, 1312	Cochise and Dragoon Mts., Ariz.
34-18	1.41	3.51	2.67	3	1595-1597	Ortiz Mtn., New Mex.
61-3	.71	3.12	1.60	11	1160-1170	Loon Lake & Kaniksu bath's, Wash.
61-4	.15	2.34	1.58	3	925-927	Northern Idaho
62-7	1.09	4.55	2.16	10	771-779, 783	Idaho batholith
62-8	1.51	3.06	2.23	3	784-786	Idaho batholith
61-11	0	2.32	1.08	5	923, 1151, 1152, 1159, 1196	Loon Lake batholith, Wash.
61-12	1.15	4.96	2.61	10	1146-1150, 1191-1195	Loon Lake batholith, Wash.
90-22	1.65	7.07	3.42	4	1129-1132	Front Range, Colo.

[1]Conditions: potassium content greater than 2 percent in every sample and range of U/K ratio for all samples in intrusive center is greater than 2 x 10^{-4}.

[2]First number is code for geologic province (Figure 6); second number is code for intrusive center, included only for the purpose of identification when referring to this table.

The validity of this determination of favorable areas is questionable, however, because of the level of possible analytical errors in the U/K values. The computed precision (95 percent confidence level) of a single determination is $\pm 0.56 \times 10^{-4}$ at 2.01×10^{-4} (Table E3, Appendix E). The favorable intrusive centers in Table 12 were selected on the basis that the range of U/K values is greater than 2×10^{-4}. Taking into consideration the analytical precision, however, it is probable that a number of the centers do not actually meet this condition.

RECOMMENDED FURTHER WORK

Further work should include, as planned for the second phase of the project, detailed studies of plutons and region or belts identified as favorable for vein-type uranium deposits. Also, a much closer look should be taken at the results of the first phase. A statistical analysis of the data should be made to determine quantitatively (a) the relative validity of the various possible geochemical indicators and (b) the most probable limiting values or ranges for the key indicators. Where the indicators were identified on the basis of semiquantitative data or on the basis of a small group of samples, additional laboratory work is needed.

Field studies should be undertaken to determine (a) the detailed characteristics of each of the major known vein-type deposits and their differences, and (b) the relationship between the intrusive rocks and the mineralization in each case. More samples should be collected from the plutons associated with uranium deposits to provide a strong statistical base for analyses of the type conducted in the first phase and to allow the determination of variations within the plutons of interest.

Further work might include investigations of elements not considered in this report. Also, a closer look might be taken at possible geochemical indicators which could be used on a local or geologic province scale.

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APPENDIX A

APPENDIX A

LOCATION AND IDENTIFICATION DATA FOR ACCEPTED SAMPLES

SAMPLE	STATE	COUNTY	LOCALITY NAME	LONGITUDE			LATITUDE			COLLECTOR	DATE		
NUMBER				DEG	MIN	SEC	DEG	MIN	SEC		YR	MO	DA
1	NEVADA	CLARK	DEAD MTN	114	43	6	35	15	36	MALAN	71	4	13
3	CALIFORNIA	SAN BERNARDINO	NEW YORK MTNS	115	17	55	35	18	50	MALAN	71	4	13
4	CALIFORNIA	SAN BERNARDINO	NEW YORK MTNS	115	20	0	35	17	47	MALAN	71	4	13
8	CALIFORNIA	SAN BERNARDINO	SILURIAN HILLS	115	55	6	35	26	24	MALAN	71	4	14
9	CALIFORNIA	SAN BERNARDINO	SILURIAN HILLS	115	51	42	35	22	6	MALAN	71	4	14
10	CALIFORNIA	SAN BERNARDINO	SILURIAN HILLS	115	47	34	35	24	24	MALAN	71	4	14
11	CALIFORNIA	SAN BERNARDINO	SODA MTNS	116	7	55	35	11	35	MALAN	71	4	14
12	CALIFORNIA	SAN BERNARDINO	NR VICTORVILLE	117	17	4	34	32	43	MALAN	71	4	14
13	CALIFORNIA	SAN BERNARDINO	GRANITE MTN	117	7	30	34	28	18	MALAN	71	4	15
16	CALIFORNIA	SAN BERNARDINO	GRANITE MTN	117	4	10	34	27	16	MALAN	71	4	14
17	CALIFORNIA	SAN BERNARDINO	RATTLESNAKE MTN	117	2	55	34	23	31	MALAN	71	4	15
19	CALIFORNIA	SAN BERNARDINO	FRY MTN	116	45	49	34	25	13	MALAN	71	4	15
20	CALIFORNIA	SAN BERNARDINO	BIG HORN MTN	116	29	34	34	20	6	MALAN	71	4	15
21	CALIFORNIA	SAN BERNARDINO	SAN BERN MTN	116	25	0	34	8	51	MALAN	71	4	15
22	CALIFORNIA	SAN BERNARDINO	L SAN BERN MTN	116	18	19	34	6	49	MALAN	71	4	15
23	CALIFORNIA	SAN BERNARDINO	SAN BERNARD MTNS	116	10	0	34	5	27	MALAN	71	4	15
24	CALIFORNIA	SAN BERNARDINO	SAN BERNARD MTNS	115	52	54	34	4	12	MALAN	71	4	15
25	CALIFORNIA	SAN BERNARDINO	SODA MTN	116	10	25	35	11	35	MALAN	71	4	14
26	CALIFORNIA	SAN BERNARDINO	CAVE MTN	116	18	45	35	5	6	MALAN	71	4	14
27	CALIFORNIA	SAN BERNARDINO	PARADISE RGE	116	45	49	35	9	32	MALAN	71	4	14
28	CALIFORNIA	SAN BERNARDINO	GRANITE MTNS	116	34	10	35	24	32	MALAN	71	4	14
29	CALIFORNIA	SAN BERNARDINO	TIEFORT MT	116	33	30	35	20	36	MALAN	71	4	14
30	CALIFORNIA	SAN BERNARDINO	STODDARD MTN	117	12	48	34	42	36	MALAN	71	4	14
31	CALIFORNIA	SAN BERNARDINO	PINTO MTNS	115	38	19	34	5	13	MALAN	71	4	15
32	CALIFORNIA	SAN BERNARDINO	COXCOMB MTNS	115	24	34	34	5	34	MALAN	71	4	15
33	CALIFORNIA	RIVERSIDE	COXCOMB MTNS	115	18	45	33	54	32	MALAN	71	4	15
34	CALIFORNIA	RIVERSIDE	LITTLE SAN B MTS	115	58	45	33	40	54	MALAN	71	4	16
35	CALIFORNIA	RIVERSIDE	COTTONWOOD MTNS	115	48	19	33	42	16	MALAN	71	4	16
36	CALIFORNIA	RIVERSIDE	OROCOPIA MTNS	115	43	0	33	39	24	MALAN	71	4	16
37	CALIFORNIA	RIVERSIDE	EAGLE MTNS	115	40	0	33	41	48	MALAN	71	4	16
38	CALIFORNIA	RIVERSIDE	EAGLE MTNS	115	29	0	33	44	30	MALAN	71	4	16
39	CALIFORNIA	RIVERSIDE	CHUCKWALLA MTNS	115	24	24	33	42	30	MALAN	71	4	16
40	CALIFORNIA	RIVERSIDE	SANTA ROSA MTNS	116	18	19	33	42	36	MALAN	71	4	16
41	CALIFORNIA	RIVERSIDE	SAN JACINTO MTNS	116	24	34	33	36	49	MALAN	71	4	16
42	CALIFORNIA	RIVERSIDE	SAN JACINTO MTNS	116	30	0	33	34	5	MALAN	71	4	16
43	CALIFORNIA	RIVERSIDE	SAN JACINTO MTNS	116	42	55	33	41	55	MALAN	71	4	16
44	CALIFORNIA	RIVERSIDE	NR CAHUILLA	116	45	25	33	32	23	MALAN	71	4	16

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
45	CALIFORNIA	RIVERSIDE	NR AGUANGA	116	50	25	33	25	54	MALAN	71	4	16
46	CALIFORNIA	SAN DIEGO	NR SANTA YSABEL	116	42	30	33	12	24	MALAN	71	4	17
47	CALIFORNIA	SAN DIEGO	NR RAMONA	116	51	15	33	3	4	MALAN	71	4	17
48	CALIFORNIA	SAN DIEGO	VALLECITO MTNS	116	22	30	33	7	50	MALAN	71	4	17
49	CALIFORNIA	SAN DIEGO	GRANITE MTNS	116	30	0	33	5	6	MALAN	71	4	17
50	CALIFORNIA	SAN DIEGO	LAGUNA MTNS	116	31	13	32	57	57	MALAN	71	4	17
51	CALIFORNIA	SAN DIEGO	LAGUNA MTNS	116	25	32	32	52	9	MALAN	71	4	17
52	CALIFORNIA	SAN DIEGO	NR LIVE OAK SPR	116	21	29	32	41	55	MALAN	71	4	17
53	CALIFORNIA	SAN DIEGO	NR PINE VALLEY	116	31	37	32	49	25	MALAN	71	4	17
54	CALIFORNIA	SAN DIEGO	NR DESCANSO	116	36	29	32	50	6	MALAN	71	4	17
55	CALIFORNIA	SAN DIEGO	NR ALPINE	116	46	13	32	50	6	MALAN	71	4	17
56	CALIFORNIA	SAN DIEGO	NR LAKESIDE	116	55	57	32	53	10	MALAN	71	4	17
57	CALIFORNIA	SAN DIEGO	NR RAMONA	116	55	0	33	4	46	MALAN	71	4	17
58	CALIFORNIA	SAN DIEGO	NR ESCONDIDO	117	7	4	33	11	55	MALAN	71	4	18
59	CALIFORNIA	SAN DIEGO	NR ESCONDIDO	117	9	10	33	18	4	MALAN	71	4	18
60	CALIFORNIA	SAN DIEGO	RED MT	117	9	34	33	24	12	MALAN	71	4	18
61	CALIFORNIA	RIVERSIDE	NR WINCHESTER	117	5	25	33	41	15	MALAN	71	4	18
62	CALIFORNIA	RIVERSIDE	LAKEVIEW MTNS	117	6	15	33	45	40	MALAN	71	4	18
63	CALIFORNIA	RIVERSIDE	SANTA ROSA HILLS	116	56	40	33	42	16	MALAN	71	4	18
64	CALIFORNIA	RIVERSIDE	SAN JACINTO MTNS	116	52	30	33	48	24	MALAN	71	4	18
65	CALIFORNIA	RIVERSIDE	SAN JACINTO MTNS	116	45	49	33	53	51	MALAN	71	4	18
66	CALIFORNIA	RIVERSIDE	NR RIVERSIDE	117	19	10	33	54	12	MALAN	71	4	18
67	CALIFORNIA	RIVERSIDE	NR RIVERSIDE	117	15	49	33	50	6	MALAN	71	4	18
68	CALIFORNIA	SAN BERNARDINO	SAN BERNARD MTNS	117	14	24	34	13	48	MALAN	71	4	19
69	CALIFORNIA	LOS ANGELES	SAN GABRIEL MTNS	117	53	44	34	9	33	MALAN	71	4	19
70	CALIFORNIA	LOS ANGELES	SAN GABRIEL MTNS	118	10	49	34	17	0	MALAN	71	4	19
71	CALIFORNIA	LOS ANGELES	SAN GABRIEL MTNS	118	5	18	34	26	6	MALAN	71	4	19
72	CALIFORNIA	LOS ANGELES	SAN GABRIEL MTNS	117	51	15	34	27	36	MALAN	71	4	19
73	CALIFORNIA	LOS ANGELES	NR HI VISTA	117	49	10	34	41	35	MALAN	71	4	19
74	CALIFORNIA	KERN	TEHACHAPI MTNS	118	19	34	35	2	33	MALAN	71	4	19
75	CALIFORNIA	KERN	TEHACHAPI MTNS	118	31	15	35	11	55	MALAN	71	4	19
76	CALIFORNIA	KERN	IRON MT	118	50	0	35	42	36	MALAN	71	4	20
77	CALIFORNIA	TULARE	NR SPRINGVILLE	118	49	17	36	6	28	MALAN	71	4	20
78	CALIFORNIA	TULARE	BLUE RDG	118	52	17	36	13	38	MALAN	71	4	20
79	CALIFORNIA	TULARE	SIERRA NEVADA	118	59	8	36	23	31	MALAN	71	4	20
80	CALIFORNIA	FRESNO	SIERRA NEVADA	119	30	0	36	53	51	MALAN	71	4	20
81	CALIFORNIA	FRESNO	SIERRA NEVADA	119	20	30	36	43	12	MALAN	71	4	20

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
82	CALIFORNIA	KERN	SIERRA NEVADA	118	40	49	35	30	20	MALAN	71	4	21
83	CALIFORNIA	KERN	HOBO RDG	118	33	19	35	34	25	MALAN	71	4	21
84	CALIFORNIA	KERN	NR CROOK PK	118	25	49	35	39	12	MALAN	71	4	21
85	CALIFORNIA	KERN	KIAVAH MT	118	12	30	35	41	35	MALAN	71	4	21
86	CALIFORNIA	KERN	KIAVAH MT	118	3	32	35	41	35	MALAN	71	4	21
87	CALIFORNIA	SAN BERNARDINO	NR CHINA LAKE	117	34	6	35	38	24	MALAN	71	4	21
88	CALIFORNIA	INYO	SIERRA NEVADA	117	55	54	35	50	42	MALAN	71	4	21
89	CALIFORNIA	INYO	COSO RANGE	117	52	24	36	3	42	MALAN	71	4	21
90	CALIFORNIA	INYO	SIERRA NEVADA	118	3	25	36	13	17	MALAN	71	4	21
91	CALIFORNIA	INYO	COSO RANGE	117	52	48	36	9	24	MALAN	71	4	21
92	CALIFORNIA	INYO	SIERRA NEVADA	118	12	51	36	35	47	MALAN	71	4	22
93	CALIFORNIA	INYO	ALABAMA HILLS	118	5	34	36	35	27	MALAN	71	4	22
94	CALIFORNIA	INYO	COSO RANGE	117	41	6	36	19	18	MALAN	71	4	22
95	CALIFORNIA	INYO	PANAMINT RANGE	117	11	30	36	26	18	MALAN	71	4	22
98	COLORADO	SAN MIGUEL	NR OPHIR	107	52	42	37	51	39	MARJANIEMI	71	6	14
100	COLORADO	SAN JUAN	NR SILVERTON	107	40	36	37	48	0	MARJANIEMI	71	6	15
101	COLORADO	LA PLATA	NR LA PLATA	108	3	18	37	24	30	MARJANIEMI	71	6	15
102	COLORADO	LA PLATA	NR LA PLATA	108	2	36	37	25	14	MARJANIEMI	71	6	15
103	COLORADO	MONTEZUMA	UTE MTN	108	48	36	37	14	10	MARJANIEMI	71	6	16
105	COLORADO	MONTEZUMA	UTE MTN	108	48	24	37	15	6	MARJANIEMI	71	6	16
106	UTAH	SAN JUAN	ABAJO MTNS	109	27	57	37	48	36	MARJANIEMI	71	6	16
107	UTAH	SAN JUAN	ABAJO MTNS	109	27	6	37	48	5	MARJANIEMI	71	6	16
108	UTAH	GARFIELD	HENRY MTNS	110	47	39	38	3	45	MARJANIEMI	71	6	17
109	UTAH	GARFIELD	HENRY MTNS	110	47	39	38	3	45	MARJANIEMI	71	6	17
110	UTAH	GARFIELD	HENRY MTNS	110	44	33	38	6	51	MARJANIEMI	71	6	17
111	UTAH	GRAND	LA SAL MTNS	109	15	0	38	32	2	MARJANIEMI	71	6	18
114	UTAH	GRAND	LA SAL MTNS	109	17	12	38	34	25	MARJANIEMI	71	6	18
125	COLORADO	CHAFFEE	SAWATCH RANGE	106	20	24	38	42	24	MARJANIEMI	71	6	25
126	COLORADO	LAKE	SAWATCH RANGE	106	24	30	39	4	7	MARJANIEMI	71	6	25
266	UTAH	JUAB	DESERT MTN	112	35	44	39	47	23	BASLER	71	7	12
267	UTAH	JUAB	E TINTIC MT	112	6	12	39	54	36	BASLER	71	7	12
268	UTAH	BOX ELDER	GROUSE CR MTNS	113	41	36	41	31	36	BASLER	71	7	13
269	UTAH	BOX ELDER	PILOT RANGE	113	59	54	41	14	54	BASLER	71	7	13
270	UTAH	TOOELE	GOLD HILL	113	47	0	40	10	0	BASLER	71	7	14
271	UTAH	TOOELE	GOLD HILL	113	46	0	40	8	0	BASLER	71	7	14
272	UTAH	JUAB	HAYSTACK PK	113	49	6	39	50	27	BASLER	71	7	14
273	NEVADA	WHITE PINE	KERN MTNS	114	12	48	39	44	6	BASLER	71	7	14

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
274	NEVADA	WHITE PINE	WHEELER PK	114	14	18	38	55	30	BASLER	71	7	15
276	UTAH	BEAVER	MINERAL MTNS	112	49	42	38	18	12	BASLER	71	7	16
277	UTAH	BEAVER	MINERAL MTNS	112	46	46	38	30	0	BASLER	71	7	16
278	UTAH	PIUTE	NR MARYSVALE	112	12	36	38	29	30	BASLER	71	7	16
284	UTAH	IRON	IRON SPRINGS	113	15	0	37	43	38	BASLER	71	7	17
286	UTAH	IRON	STODDARD MTN	113	24	25	37	33	45	BASLER	71	7	17
287	UTAH	WASHINGTON	PINE VALLEY MTNS	113	27	18	37	22	18	BASLER	71	7	17
357	COLORADO	GUNNISON	WEST ELK MTNS.	107	29	18	38	43	30	BASLER	71	7	26
358	COLORADO	DELTA	WEST ELK MTNS.	107	31	24	38	45	24	BASLER	71	7	26
359	COLORADO	GUNNISON	SAWATCH RANGE	106	22	0	38	34	48	BASLER	71	7	27
360	COLORADO	CHAFFEE	SANGRE DE CRISTO	105	55	12	38	34	36	BASLER	71	7	27
361	COLORADO	FREMONT	SANGRE DE CRISTO	105	53	0	38	33	48	BASLER	71	7	27
362	COLORADO	CHAFFEE	SANGRE DE CRISTO	105	57	12	38	40	0	BASLER	71	7	27
363	COLORADO	CHAFFEE	SAWATCH RANGE	106	15	18	38	48	0	BASLER	71	7	28
364	COLORADO	CHAFFEE	SAWATCH RANGE	106	24	54	38	59	12	BASLER	71	7	28
365	COLORADO	LAKE	SAWATCH RANGE	106	26	0	39	4	24	BASLER	71	7	28
366	COLORADO	PITKIN	MONTEZUMA BASIN	106	50	18	39	0	30	BASLER	71	7	29
367	COLORADO	PITKIN	PINE CREEK	106	48	42	39	2	36	BASLER	71	7	29
369	COLORADO	GUNNISON	MT. AXTELL	107	3	36	38	50	12	BASLER	71	7	29
371	COLORADO	GRAND	NR MARBLE	107	12	24	39	4	12	BASLER	71	7	29
385	ARIZONA	APACHE	CARRIZO MTNS.	109	15	48	36	52	0	BASLER	71	8	11
386	ARIZONA	APACHE	CARRIZO MTNS.	109	15	36	36	51	54	BASLER	71	8	11
632	OREGON	BAKER	PEDO MTN INTRU	117	30	0	44	28	6	BASLER	71	8	26
634	OREGON	GRANT	BALD MTN BATH	118	16	48	44	56	13	BASLER	71	8	27
635	OREGON	GRANT	BALD MTN BATH	118	16	42	44	56	49	BASLER	71	8	27
636	OREGON	GRANT	BALD MTN BATH	118	15	0	44	57	22	BASLER	71	8	27
637	OREGON	BAKER	BALD MTN BATH	118	9	58	44	58	41	BASLER	71	8	27
638	OREGON	BAKER	BALD MTN BATH	118	6	43	44	58	53	BASLER	71	8	27
639	OREGON	WALLOWA	WALLOWA BATH	117	22	39	45	15	18	BASLER	71	8	28
640	WASHINGTON	PIERCE	TATOOSH PLUTON	121	46	0	46	47	0	BASLER	71	8	29
641	WASHINGTON	LEWIS	TATOOSH PLUTON	121	44	18	46	45	18	BASLER	71	8	29
642	WASHINGTON	LEWIS	TATOOSH PLUTON	121	41	18	46	46	24	BASLER	71	8	29
644	WASHINGTON	YAKIMA	BUMPING LAKE PLU	121	15	12	46	54	13	BASLER	71	8	30
646	WASHINGTON	YAKIMA	BUMPING LAKE PLU	121	18	0	46	48	42	BASLER	71	8	30
647	WASHINGTON	YAKIMA	BUMPING LAKE PLU	121	21	49	46	47	54	BASLER	71	8	30
649	WASHINGTON	YAKIMA	TATOOSH PLUTON	121	26	59	46	53	48	BASLER	71	8	30
650	WASHINGTON	PIERCE	TATOOSH PLUTON	121	36	54	46	53	33	BASLER	71	8	30

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	MIN	SEC	LATITUDE DEG	MIN	SEC	COLLECTOR	DATE YR	MO	DA
651	WASHINGTON	PIERCE	TATOOSH PLUTON	121	35	25	46	55	0	BASLER	71	8	30
653	WASHINGTON	PIERCE	CARBON RIV STOCK	121	50	37	46	59	20	BASLER	71	8	31
654	WASHINGTON	PIERCE	CARBON RIV STOCK	121	51	0	47	1	12	BASLER	71	8	31
655	WASHINGTON	KING	SNOQUALMIE BATH	121	32	48	47	32	26	BASLER	71	8	31
656	WASHINGTON	KING	SNOQUALMIE BATH	121	29	19	47	35	25	BASLER	71	8	31
657	WASHINGTON	KING	SNOQUALMIE BATH	121	29	34	47	23	58	BASLER	71	8	31
771	IDAHO	CAMAS	IDAHO BATHOLITH	114	49	30	43	34	0	MARJANIEMI	71	9	18
772	IDAHO	ELMORE	IDAHO BATHOLITH	115	12	0	43	36	30	MARJANIEMI	71	9	18
773	IDAHO	ELMORE	IDAHO BATHOLITH	115	26	30	43	34	57	MARJANIEMI	71	9	19
774	IDAHO	BOISE	IDAHO BATHOLITH	115	46	30	43	49	36	MARJANIEMI	71	9	20
775	IDAHO	BOISE	IDAHO BATHOLITH	115	37	12	43	48	36	MARJANIEMI	71	9	20
776	IDAHO	ELMORE	IDAHO BATHOLITH	115	29	24	43	46	48	MARJANIEMI	71	9	20
777	IDAHO	ELMORE	IDAHO BATHOLITH	115	26	0	43	42	0	MARJANIEMI	71	9	20
778	IDAHO	ELMORE	IDAHO BATHOLITH	115	22	54	43	41	24	MARJANIEMI	71	9	20
779	IDAHO	BOISE	IDAHO BATHOLITH	115	40	18	43	41	15	MARJANIEMI	71	9	21
783	IDAHO	BOISE	IDAHO BATHOLITH	116	6	6	44	5	6	MARJANIEMI	71	9	22
784	IDAHO	CUSTER	IDAHO BATHOLITH	115	14	18	44	21	36	MARJANIEMI	71	9	22
785	IDAHO	CUSTER	IDAHO BATHOLITH	114	50	0	44	15	48	MARJANIEMI	71	9	23
786	IDAHO	CUSTER	IDAHO BATHOLITH	114	46	12	44	15	54	MARJANIEMI	71	9	23
889	OREGON	BAKER	COYOTE PT INTRU	117	55	30	44	55	22	BASLER	71	8	27
890	OREGON	BAKER	BALD MTN BATH	118	12	30	44	57	37	BASLER	71	8	27
892	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	13	12	47	42	17	BASLER	71	9	1
893	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	11	55	47	50	11	BASLER	71	9	1
894	WASHINGTON	CHELAN	CHELAN BATHOLITH	119	58	19	47	51	14	BASLER	71	9	1
895	WASHINGTON	OKANOGAN	CHELAN BATHOLITH	120	21	1	48	16	17	BASLER	71	9	1
896	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	37	0	48	1	5	BASLER	71	9	2
897	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	30	24	47	55	36	BASLER	71	9	2
898	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	25	24	47	52	48	BASLER	71	9	2
899	WASHINGTON	CHELAN	CHELAN BATHOLITH	120	21	42	47	44	35	BASLER	71	9	2
900	WASHINGTON	CHELAN	MT STUART BATH	120	40	59	47	35	23	BASLER	71	9	2
901	WASHINGTON	CHELAN	CHIWAWA RIDGEPLU	120	56	13	47	58	0	BASLER	71	9	2
902	WASHINGTON	CHELAN	MT STUART BATH	121	1	18	47	46	58	BASLER	71	9	2
903	WASHINGTON	KING	MT STUART BATH	121	8	0	47	43	39	BASLER	71	9	2
904	WASHINGTON	SNOHOMISH	SNOQUALMIE BATH	121	31	27	47	48	20	BASLER	71	9	2
905	WASHINGTON	WHATCOM	CHILLIWACK BATH	121	35	20	48	54	39	BASLER	71	9	14
907	WASHINGTON	SKAGIT	CHILLIWACK BATH	121	19	48	48	37	18	BASLER	71	9	15
908	WASHINGTON	WHATCOM	GOLDEN HORN BATH	120	52	33	48	40	26	BASLER	71	9	15

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	MIN	SEC	LATITUDE DEG	MIN	SEC	COLLECTOR	DATE YR	MO	DA
909	WASHINGTON	CHELAN	GOLDEN HORN BATH	120	41	38	48	30	26	BASLER	71	9	15
910	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	41	57	48	21	9	BASLER	71	9	15
911	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	38	30	48	47	18	BASLER	71	9	16
912	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	46	5	48	51	36	BASLER	71	9	16
913	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	56	12	48	49	30	BASLER	71	9	16
914	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	58	3	48	39	40	BASLER	71	9	16
915	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	58	3	48	39	40	BASLER	71	9	16
916	WASHINGTON	OKANOGAN	SIMILKAMEEN BATH	119	52	57	48	3	48	BASLER	71	9	16
917	WASHINGTON	OKANOGAN	COLEVILLE BATH	119	17	21	48	22	3	BASLER	71	9	17
918	WASHINGTON	OKANOGAN	COLEVILLE BATH	119	10	27	48	30	30	BASLER	71	9	17
919	WASHINGTON	OKANOGAN	COLEVILLE BATH	118	59	42	48	43	55	BASLER	71	9	17
920	WASHINGTON	OKANOGAN	COLEVILLE BATH	119	0	54	48	31	12	BASLER	71	9	17
921	WASHINGTON	OKANOGAN	COLEVILLE BATH	119	8	21	48	16	44	BASLER	71	9	17
922	WASHINGTON	FERRY	COLEVILLE BATH	118	29	42	48	4	21	BASLER	71	9	17
923	WASHINGTON	STEVENS	LOON LAKE BATH	117	34	8	47	51	4	BASLER	71	9	18
925	IDAHO	KOOTENAI	NORTHERN IDAHO	116	50	40	47	39	8	BASLER	71	9	18
926	IDAHO	KOOTENAI	NORTHERN IDAHO	117	0	19	47	49	13	BASLER	71	9	18
927	IDAHO	BONNER	NORTHERN IDAHO	116	41	9	47	59	30	BASLER	71	9	19
928	IDAHO	BONNER	NORTHERN IDAHO	116	42	18	48	13	48	BASLER	71	9	19
929	IDAHO	BONNER	NORTHERN IDAHO	116	31	57	48	27	31	BASLER	71	9	19
930	IDAHO	BOUNDARY	NORTHERN IDAHO	116	22	36	48	42	5	BASLER	71	9	19
931	IDAHO	BOUNDARY	NORTHERN IDAHO	116	28	37	48	41	35	BASLER	71	9	19
932	IDAHO	BOUNDARY	NORTHERN IDAHO	116	33	47	48	49	2	BASLER	71	9	19
933	IDAHO	BOUNDARY	NORTHERN IDAHO	116	20	41	48	53	5	BASLER	71	9	19
957	NEVADA	EUREKA	CORTEZ RANGE	116	23	52	40	16	4	BASLER	71	10	13
958	NEVADA	CHURCHILL	STILLWATER RANGE	118	11	34	39	39	39	BASLER	71	10	14
959	NEVADA	PERSHING	TRINITY RANGE	118	26	13	40	22	47	BASLER	71	10	14
960	NEVADA	HUMBOLDT	DISASTER PEAK	118	10	44	41	49	44	BASLER	71	10	15
961	NEVADA	HUMBOLDT	DIASTER PEAK	118	12	32	41	52	40	BASLER	71	10	15
962	NEVADA	PERSHING	NIGHTINGALE MTNS	119	15	42	40	2	48	BASLER	71	10	17
963	NEVADA	PERSHING	NIGHTINGALE MTNS	119	16	6	40	10	54	BASLER	71	10	17
964	NEVADA	WASHOE	GRANITE RANGE	119	20	27	40	43	22	BASLER	71	10	17
965	NEVADA	WASHOE	GRANITE RANGE	119	27	42	40	47	12	BASLER	71	10	17
966	NEVADA	DOUGLAS	PINE NUT RANGE	119	26	54	39	3	6	BASLER	71	10	18
967	NEVADA	LYON	PINE GROVE HILLS	119	10	11	38	34	19	BASLER	71	10	18
968	NEVADA	MINERAL	EXCELSIOR MTNS	118	31	37	38	14	16	BASLER	71	10	19
969	NEVADA	MINERAL	EXCELSIOR MTNS	118	28	36	38	17	30	BASLER	71	10	19

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
970	CALIFORNIA	MONO	SACRAMENTO CAN	118	20	45	37	32	42		71	10	19
971	CALIFORNIA	INYO	INYO MTNS	118	1	4	37	17	2	HASLER	71	10	20
972	CALIFORNIA	MONO	WHITE MTNS	118	1	1	37	33	43	HASLER	71	10	20
973	CALIFORNIA	INYO	CUCOMUNGO CANYON	117	41	31	37	20	23	HASLER	71	10	20
974	CALIFORNIA	INYO	INYO MTNS	117	55	47	37	15	7	HASLER	71	10	20
975	CALIFORNIA	INYO	INYO MTNS	118	8	16	36	50	38	HASLER	71	10	20
976	CALIFORNIA	INYO	INYO MTNS	118	9	28	36	54	7	HASLER	71	10	20
977	CALIFORNIA	INYO	PANAMINT RANGE	117	32	45	36	31	30	HASLER	71	10	21
978	CALIFORNIA	INYO	PANAMINT RANGE	117	28	37	36	34	47	HASLER	71	10	21
979	CALIFORNIA	INYO	ARGUS RANGE	117	25	29	36	14	9	HASLER	71	10	21
980	CALIFORNIA	INYO	ARGUS RANGE	117	24	10	36	2	16	HASLER	71	10	21
981	CALIFORNIA	INYO	ARGUS RANGE	117	21	50	35	53	34	HASLER	71	10	21
982	CALIFORNIA	SAN BERNARDINO	ARGUS RANGE	117	24	10	35	44	24	HASLER	71	10	21
983	CALIFORNIA	SAN BERNARDINO	ARGUS RANGE	117	25	55	35	39	46	HASLER	71	10	21
984	CALIFORNIA	SAN BERNARDINO	SPANGLER HILLS	117	33	21	35	34	11	HASLER	71	10	21
985	CALIFORNIA	SAN BERNARDINO	LANE MTN	116	58	58	35	3	25	HASLER	71	10	22
986	CALIFORNIA	SAN BERNARDINO	LUCERNE VALLEY	116	46	40	34	30	43	HASLER	71	10	22
987	CALIFORNIA	SAN BERNARDINO	FRY MTNS	116	42	43	34	32	27	HASLER	71	10	22
988	CALIFORNIA	SAN BERNARDINO	UPPER JOHNSON VA	116	38	27	34	35	34	HASLER	71	10	22
989	CALIFORNIA	SAN BERNARDINO	RODMAN MTNS	116	31	51	34	39	57	HASLER	71	10	22
990	CALIFORNIA	SAN BERNARDINO	IRON RIDGE	116	33	50	34	36	28	HASLER	71	10	22
991	CALIFORNIA	SAN BERNARDINO	UP JOHNSON VAL	116	39	50	34	29	52	HASLER	71	10	22
992	CALIFORNIA	SAN BERNARDINO	BULLION MTNS	115	43	22	34	14	6	HASLER	71	10	23
993	CALIFORNIA	SAN BERNARDINO	BRISTOL MTNS	115	47	16	34	40	30	HASLER	71	10	23
994	CALIFORNIA	SAN BERNARDINO	GRANITE MTNS	115	40	1	34	44	34	HASLER	71	10	23
995	CALIFORNIA	SAN BERNARDINO	PROVIDENCE MTNS	115	31	51	34	50	6	HASLER	71	10	23
996	CALIFORNIA	SAN BERNARDINO	WEAVER WELL	115	9	57	34	37	47	HASLER	71	10	23
997	CALIFORNIA	SAN BERNARDINO	MID HILLS	115	24	10	35	6	0	HASLER	71	10	24
998	CALIFORNIA	SAN BERNARDINO	MID HILLS	115	24	7	35	9	18	HASLER	71	10	24
999	NEVADA	CLARK	OPAL MTNS	114	52	22	35	41	38	HASLER	71	10	24
1120	COLORADO	BOULDER	FR RNG-POR MT ST	105	23	48	40	7	12	MALAN	70	8	23
1121	COLORADO	BOULDER	FR RNG-NR JAMSTN	105	23	54	40	6	36	MALAN	70	8	23
1123	COLORADO	BOULDER	FR RNG-NR SUNSET	105	27	54	40	2	48	MALAN	70	8	23
1128	COLORADO	BOULDER	FR RNG-NR CARIB	105	34	42	39	58	54	MALAN	70	8	23
1129	COLORADO	BOULDER	FR RNG-NR ELDORA	105	35	18	39	56	54	MALAN	70	8	23
1130	COLORADO	GILPIN	FR RNG-TOLLD STK	105	35	48	39	54	48	MALAN	70	8	23
1131	COLORADO	GILPIN	FR RNG-TOLLD STK	105	36	12	39	54	42	MALAN	70	8	23

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	MIN	SEC	LATITUDE DEG	MIN	SEC	COLLECTOR	DATE YR	MO	DA
1132	COLORADO	GILPIN	FR RNG-TOLLD STK	105	35	48	39	54	42	MALAN	70	8	23
1133	COLORADO	CLEAR CREEK	FR RNG-NR ID SPG	105	35	18	39	48	54	MALAN	70	8	23
1134	COLORADO	CLEAR CREEK	FR RNG-NR EMPIRE	105	43	12	39	45	48	MALAN	70	8	23
1135	COLORADO	CLEAR CREEK	FR RNG-NR EMPIRE	105	43	6	39	45	48	MALAN	70	8	23
1136	COLORADO	SUMMIT	FR RNG-MONTEZ ST	105	55	18	39	36	30	MALAN	70	8	23
1137	COLORADO	SUMMIT	FR RNG-MONTEZ ST	105	52	54	39	35	54	MALAN	70	8	23
1139	COLORADO	CHAFFEE	SAWATCH RNG	106	12	48	38	43	0	MALAN	70	8	23
1146	WASHINGTON	STEVENS	LN L BTH-IN TR P	118	19	30	47	58	24	MALAN	70	9	22
1147	WASHINGTON	STEVENS	LN L BTH-IN TR P	118	19	36	47	58	36	MALAN	70	9	22
1148	WASHINGTON	STEVENS	LN L BATH-PTRS L	117	56	12	47	51	6	MALAN	70	9	22
1149	WASHINGTON	STEVENS	LN LK BTH-PTRS L	118	5	48	47	52	54	MALAN	70	9	22
1150	WASHINGTON	STEVENS	LN L BTH-NR WPNT	118	0	12	47	54	42	MALAN	70	9	22
1151	WASHINGTON	STEVENS	LN L BTH-NR FORD	117	48	30	47	53	0	MALAN	70	9	22
1152	WASHINGTON	SPOKANE	LN L BTH-MT SPOK	117	24	0	47	46	48	MALAN	70	9	22
1153	WASHINGTON	SPOKANE	LN L BTH-MT SPOK	117	12	24	47	49	24	MALAN	70	9	22
1154	WASHINGTON	SPOKANE	LN L BTH-MT SPOK	117	9	36	47	51	6	MALAN	70	9	22
1155	WASHINGTON	SPOKANE	LN L BTH-DBRK MN	117	12	36	47	56	12	MALAN	70	9	22
1156	WASHINGTON	PEND OREILLE	LN L BTH-NR NWPT	117	19	18	48	5	54	MALAN	70	9	22
1158	WASHINGTON	PEND OREILLE	LN L BTH-NR CUSK	117	16	24	48	13	0	MALAN	70	9	22
1159	WASHINGTON	STEVENS	LN L BTH-NR LN L	117	35	42	48	2	30	MALAN	70	9	22
1160	WASHINGTON	STEVENS	LN L BTH-NR ARDN	117	51	24	48	26	42	MALAN	70	9	22
1161	WASHINGTON	STEVENS	LN L BTH-NR CLVL	117	42	24	48	30	24	MALAN	70	9	22
1162	WASHINGTON	STEVENS	LN L BTH-NR TIGR	117	33	6	48	34	42	MALAN	70	9	22
1163	WASHINGTON	PEND OREILLE	LN L BTH-NR TIGR	117	29	18	48	39	48	MALAN	70	9	22
1164	WASHINGTON	PEND OREILLE	KANK BTH-NR TIGR	117	20	0	48	41	30	MALAN	70	9	22
1165	WASHINGTON	PEND OREILLE	KANK BTH-NR TIGR	117	19	54	48	43	12	MALAN	70	9	22
1166	WASHINGTON	PEND OREILLE	LN L BTH-NR IONE	117	29	6	48	44	6	MALAN	70	9	22
1167	WASHINGTON	PEND OREILLE	LN L BTH-NR IONE	117	32	54	48	46	42	MALAN	70	9	22
1168	WASHINGTON	STEVENS	LN L BTH-SPIR PL	117	35	42	48	49	42	MALAN	70	9	22
1169	WASHINGTON	STEVENS	LN L BTH-SPIR PL	117	48	12	48	49	24	MALAN	70	9	22
1170	WASHINGTON	STEVENS	LN L BTH-SPIR PL	117	49	24	48	45	12	MALAN	70	9	22
1171	WASHINGTON	FERRY	COLV BTH-NR KT F	118	11	0	48	42	12	MALAN	70	9	22
1172	WASHINGTON	FERRY	COLV BTH-NR KT F	118	17	18	48	39	48	MALAN	70	9	22
1173	WASHINGTON	FERRY	LN L BTH-NR RPLC	118	30	36	48	35	24	MALAN	70	9	22
1174	WASHINGTON	FERRY	COLV BTH-NR KT F	118	21	24	48	38	30	MALAN	70	9	22
1175	WASHINGTON	FERRY	COLV BTH-NR ORNT	118	15	18	48	55	18	MALAN	70	9	22
1176	WASHINGTON	FERRY	COLV BTH-NR ORNT	118	15	0	48	47	36	MALAN	70	9	22

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
1177	WASHINGTON	FERRY	COLV BTH-NR ORNT	118	17	30	48	50	18	MALAN	70	9	22
1178	WASHINGTON	FERRY	COLV BTH-NR ORNT	118	24	0	48	52	0	MALAN	70	9	22
1179	WASHINGTON	FERRY	COLV BTH-NR CURL	118	27	0	48	52	42	MALAN	70	9	22
1180	WASHINGTON	FERRY	COLV BTH-NR CURL	118	29	42	48	53	36	MALAN	70	9	22
1181	WASHINGTON	FERRY	COLV BTH-NR RPBL	118	44	18	48	45	48	MALAN	70	9	22
1182	WASHINGTON	OKANOGAN	COLV BTH-NR RPBL	118	51	0	48	39	42	MALAN	70	9	22
1183	WASHINGTON	FERRY	COLV BTH-NR INCH	118	24	0	48	17	24	MALAN	70	9	22
1184	WASHINGTON	FERRY	COLV BTH-NR INCH	118	29	18	48	15	30	MALAN	70	9	22
1185	WASHINGTON	FERRY	COLV BTH-NR INCH	118	42	6	48	16	24	MALAN	70	9	22
1186	WASHINGTON	FERRY	COLV BTH-NR GC D	118	46	0	48	11	30	MALAN	70	9	22
1187	WASHINGTON	FERRY	COLV BTH-NR GC D	118	38	24	48	3	30	MALAN	70	9	22
1188	WASHINGTON	FERRY	COLV BTH-NR GC D	118	42	36	47	57	24	MALAN	70	9	22
1190	WASHINGTON	OKANOGAN	COLV BTH-NR GC D	118	56	30	48	0	54	MALAN	70	9	22
1191	WASHINGTON	STEVENS	COLV BTH-NR GC D	118	1	54	47	56	18	MALAN	70	9	22
1192	WASHINGTON	STEVENS	LN L BTH-NR MN M	118	4	30	47	55	36	MALAN	70	9	22
1193	WASHINGTON	STEVENS	LN L BTH-NR MN M	118	5	48	47	56	18	MALAN	70	9	22
1194	WASHINGTON	STEVENS	LN L BTH-NR MN M	118	7	30	47	55	30	MALAN	70	9	22
1195	WASHINGTON	STEVENS	LN L BTH-NR MN M	118	3	18	47	56	6	MALAN	70	9	22
1196	WASHINGTON	STEVENS	LN L BTH-NR MN M	117	49	42	47	53	54	MALAN	70	9	22
1197	UTAH	SALT LAKE	LITTLE CTNW STK	111	45	54	40	34	30	MALAN	70	10	30
1198	UTAH	SALT LAKE	LITTLE CTNW STK	111	42	30	40	34	18	MALAN	70	10	30
1199	NEVADA	ELKO	TOANO PASS STOCK	114	17	18	40	53	54	MALAN	70	10	30
1200	NEVADA	ELKO	GRANITE RNG	114	43	54	41	46	24	MALAN	70	10	30
1201	NEVADA	ELKO	GRANITE RNG	114	45	0	41	43	42	MALAN	70	10	30
1202	NEVADA	ELKO	NR MT CITY	116	2	30	41	53	24	MALAN	70	10	30
1203	NEVADA	ELKO	NR MT CITY	115	57	0	41	50	30	MALAN	70	10	30
1204	NEVADA	ELKO	NR MT CITY	115	53	30	41	52	18	MALAN	70	10	30
1205	NEVADA	ELKO	NR MT CITY	115	55	6	41	49	0	MALAN	70	10	30
1206	NEVADA	ELKO	NR MT CITY	115	50	0	41	50	6	MALAN	70	10	30
1207	NEVADA	ELKO	NR MT CITY	115	52	54	41	48	54	MALAN	70	10	30
1208	NEVADA	ELKO	RUBY RNG	115	30	6	40	20	12	MALAN	70	10	30
1209	NEVADA	ELKO	RUBY RNG	115	27	24	40	19	18	MALAN	70	10	30
1210	NEVADA	ELKO	RUBY RNG	115	28	24	40	20	6	MALAN	70	10	30
1211	NEVADA	ELKO	RUBY RNG	115	26	42	40	18	30	MALAN	70	10	30
1212	NEVADA	ELKO	RUBY RNG	115	25	18	40	25	12	MALAN	70	10	30
1213	NEVADA	ELKO	RUBY RNG	115	21	30	40	31	18	MALAN	70	10	30
1214	NEVADA	ELKO	RUBY RNG	115	14	48	40	42	0	MALAN	70	10	30

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
1215	NEVADA	HUMBOLDT	OSGOOD MT	117	15	54	41	11	0	MALAN	70	10	30
1216	NEVADA	HUMBOLDT	OSGOOD MTNS	117	16	0	41	8	30	MALAN	70	10	30
1218	NEVADA	HUMBOLDT	SANTA ROSA RNG	117	44	36	41	25	42	MALAN	70	10	30
1219	NEVADA	HUMBOLDT	JACKSON MTS	118	28	24	41	28	6	MALAN	70	10	30
1220	NEVADA	HUMBOLDT	PINE FOREST RNG	118	35	36	41	52	48	MALAN	70	10	30
1221	NEVADA	HUMBOLDT	PINE FOREST RNG	118	39	30	41	56	42	MALAN	70	10	30
1227	NEVADA	PERSHING	SELENITE RNG	119	17	0	40	39	6	MALAN	70	0	0
1228	NEVADA	PERSHING	SELENITE RNG	119	17	0	40	39	6	MALAN	70	0	0
1229	NEVADA	PERSHING	SELENITE RNG	119	17	30	40	19	30	MALAN	70	0	0
1230	NEVADA	PERSHING	SELENITE RANGE	119	16	18	40	25	24	MALAN	70	10	30
1231	NEVADA	PERSHING	SELENITE RANGE	119	15	48	40	35	36	MALAN	70	10	30
1232	NEVADA	PERSHING	TRINITY RANGE	118	38	6	40	17	0	MALAN	70	10	30
1233	NEVADA	PERSHING	TRINITY RANGE	118	34	42	40	13	36	MALAN	70	10	30
1234	NEVADA	PERSHING	TRINITY RANGE	118	32	36	40	11	24	MALAN	70	10	30
1235	NEVADA	CHURCHILL	TRINITY RANGE	118	42	42	39	59	30	MALAN	70	10	30
1236	NEVADA	WASHOE	NE OF RENO	119	41	18	39	46	24	MALAN	70	10	30
1237	NEVADA	WASHOE	NE OF RENO	119	38	42	39	51	48	MALAN	70	10	30
1238	NEVADA	WASHOE	NW OF RENO	119	51	6	39	36	54	MALAN	70	10	30
1239	CALIFORNIA	LASSEN	DIAMOND MT	120	1	18	39	56	0	MALAN	70	10	30
1240	CALIFORNIA	LASSEN	DIAMOND MT	120	4	48	39	59	30	MALAN	70	10	30
1241	CALIFORNIA	LASSEN	NR BECKWOURTH	120	5	48	39	47	12	MALAN	70	10	30
1242	CALIFORNIA	PLUMAS	NR BECKWOURTH	120	26	54	39	49	12	MALAN	70	10	30
1243	NEVADA	WASHOE	CARSON RANGE	119	47	42	39	13	24	MALAN	70	10	30
1244	NEVADA	DOUGLAS	CARSON RANGE	119	53	18	39	5	30	MALAN	70	10	30
1245	NEVADA	DOUGLAS	CARSON RANGE	119	51	6	38	58	36	MALAN	70	0	0
1246	NEVADA	DOUGLAS	CARSON RANGE	119	25	48	38	45	36	MALAN	70	0	0
1247	NEVADA	LYON	SMITH VALLEY RGE	119	12	36	38	49	12	MALAN	70	0	0
1248	NEVADA	CHURCHILL	SAND SPRGS. RGE.	118	20	24	39	15	48	MALAN	70	10	30
1249	NEVADA	LANDER	TOIYABE RANGE	117	3	0	39	29	42	MALAN	70	10	30
1250	NEVADA	LANDER	TOIYABE RANGE	116	58	42	39	27	0	MALAN	70	10	30
1251	NEVADA	LANDER	TOIYABE RANGE	116	57	12	39	25	12	MALAN	70	10	30
1252	NEVADA	NYE	TOIYABE RANGE	117	9	54	39	7	12	MALAN	70	10	30
1253	NEVADA	NYE	TOQUIMA RANGE	117	3	48	38	39	0	MALAN	70	10	30
1254	NEVADA	WHITE PINE	KERN MOUNTAINS	114	14	36	39	43	6	ELLIS	70	10	20
1255	NEVADA	WHITE PINE	HERRY CREEK RNG	114	54	48	39	51	54	ELLIS	70	10	20
1256	NEVADA	ESMERALDA	GOLD POINT	117	23	12	37	19	48	ELLIS	70	10	22
1257	NEVADA	ESMERALDA	SYLVANIA MTNS.	117	44	48	37	28	6	ELLIS	70	10	22

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	MIN	SEC	LATITUDE DEG	MIN	SEC	COLLECTOR	DATE YR	MO	DA
1258	CALIFORNIA	INYO	WHITE MOUNTAINS	117	56	30	37	25	54	ELLIS	70	10	22
1259	CALIFORNIA	INYO	BIG PINE	118	19	42	37	7	30	ELLIS	70	10	22
1260	CALIFORNIA	MONO	BLIND SPRING HIL	118	27	25	37	46	1	ELLIS	70	10	22
1261	CALIFORNIA	MONO	COWTRACK MTN.	118	49	17	37	53	10	ELLIS	70	10	22
1262	CALIFORNIA	TUOLUMNE	FAIRVIEW DOME	119	20	34	37	52	30	ELLIS	70	10	23
1263	CALIFORNIA	MARIPOSA	SIERRA NEVADA MT	119	45	25	37	44	39	ELLIS	70	10	23
1264	CALIFORNIA	TUOLUMNE	SIERRA NEVADA MT	119	40	42	38	19	25	ELLIS	70	10	23
1265	CALIFORNIA	EL DORADO	SIERRA NEVADA MT	120	16	42	38	46	21	ELLIS	70	10	24
1266	CALIFORNIA	EL DORADO	SIERRA NEVADA MT	120	5	34	38	48	4	ELLIS	70	10	24
1267	NEVADA	MINERAL	WASSUK RANGE	118	45	24	38	46	54	ELLIS	70	10	24
1268	NEVADA	MINERAL	WASSUK RANGE	118	42	54	38	34	36	ELLIS	70	10	24
1269	NEVADA	MINERAL	WASSUK RANGE	118	35	6	38	21	48	ELLIS	70	10	24
1270	NEVADA	MINERAL	VALLEY RANGE	118	7	18	38	35	42	ELLIS	70	10	25
1271	NEVADA	NYE	PARADISE RGE	117	54	12	38	51	48	ELLIS	70	10	25
1272	NEVADA	ESMERALDA	SILVER PK. RANGE	117	39	24	37	45	0	ELLIS	70	10	25
1273	NEVADA	ESMERALDA	WEEPAH HILLS	117	34	18	37	56	12	ELLIS	70	10	25
1274	NEVADA	NYE	TOQUIMA RANGE	117	1	24	38	30	18	ELLIS	70	10	26
1275	NEVADA	NYE	TOQUIMA RANGE	116	51	42	38	35	18	ELLIS	70	10	26
1276	NEVADA	NYE	GRANT RANGE	115	35	6	38	20	48	ELLIS	70	10	26
1277	NEVADA	WHITE PINE	EGAN RANGE	114	54	24	39	15	48	ELLIS	70	10	27
1278	NEVADA	ELKO	GOSHUTE MTNS.	114	18	36	40	17	18	ELLIS	70	10	27
1279	NEVADA	ELKO	RUBY RANGE	115	29	48	40	18	24	ELLIS	70	10	27
1280	NEVADA	WHITE PINE	KERN MOUNTAINS	114	15	6	39	41	36	ELLIS	70	10	20
1281	NEVADA	WHITE PINE	CHERRY CREEK MTS	114	54	30	39	52	0	ELLIS	70	10	20
1282	NEVADA	MINERAL	WASSUK RANGE	118	45	54	38	45	42	ELLIS	70	10	23
1285	NEW MEXICO	TORRANCE	W OF DURAN	105	27	36	34	29	6	MALAN	71	1	28
1286	NEW MEXICO	TORRANCE	N OF DURAN	105	21	18	34	29	6	MALAN	71	1	28
1287	NEW MEXICO	LOS ALAMOS	SW OF CORONA	105	46	6	34	9	42	MALAN	71	1	28
1288	NEW MEXICO	LOS ALAMOS	VICARILLA MTNS.	105	45	54	33	43	30	MALAN	71	1	28
1290	NEW MEXICO	LOS ALAMOS	CAPITAN MTNS.	105	28	30	33	36	42	MALAN	71	1	28
1291	NEW MEXICO	LOS ALAMOS	CAPITAN MTNS.	105	19	54	33	34	24	MALAN	71	1	28
1292	NEW MEXICO	LOS ALAMOS	CAPITAN MTNS.	105	21	30	33	35	48	MALAN	71	1	28
1296	NEW MEXICO	OTERO	JARILLA MTNS.	106	8	42	32	23	42	MALAN	71	1	28
1298	NEW MEXICO	DONA ANA	ORGAN MTNS.	106	35	24	32	22	48	MALAN	71	1	28
1299	NEW MEXICO	DONA ANA	ORGAN MTNS.	106	33	18	32	25	42	MALAN	71	1	28
1300	NEW MEXICO	LUNA	TRES HERMANES MT	107	42	54	31	54	6	MALAN	71	1	28
1302	NEW MEXICO	GRANT	E OF SILVER CITY	108	9	42	32	47	0	MALAN	71	1	28

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	MIN	SEC	LATITUDE DEG	MIN	SEC	COLLECTOR	DATE YR	MO	DA
1308	ARIZONA	COCHISE	CHIRICAHUA MTNS	109	19	24	31	51	36	MALAN	71	1	28
1309	ARIZONA	COCHISE	CHIRICAHUA MTNS	109	25	0	31	52	6	MALAN	71	1	28
1310	ARIZONA	COCHISE	COCHISE MTNS	109	56	0	31	55	30	MALAN	71	1	28
1311	ARIZONA	COCHISE	COCHISE MTNS	109	50	12	31	43	54	MALAN	71	1	28
1312	ARIZONA	COCHISE	DRAGOON MTNS	109	53	36	31	44	24	MALAN	71	1	28
1314	ARIZONA	COCHISE	TOMBSTONE HILLS	110	4	54	31	42	30	MALAN	71	1	28
1315	ARIZONA	COCHISE	LITTLE DRAGOON	110	6	24	32	1	18	MALAN	71	1	28
1316	ARIZONA	COCHISE	LITT DRAGOON MTS	110	4	24	32	3	48	MALAN	71	1	28
1317	ARIZONA	PIMA	SAN CATALINA MTS	110	41	24	32	22	42	MALAN	71	1	28
1318	ARIZONA	PIMA	SAN CATALINA MTS	110	43	18	32	20	54	MALAN	71	1	28
1320	ARIZONA	SANTA CRUZ	SANTA RITA MTNS	110	52	30	31	42	36	MALAN	71	1	28
1321	ARIZONA	PIMA	QUINLIA MTNS	111	31	48	32	1	42	MALAN	71	1	28
1322	ARIZONA	PIMA	QUINLIN MTNS	111	39	36	31	59	18	MALAN	71	1	28
1323	ARIZONA	PIMA	QUIJTOA MTNS	112	7	54	32	10	12	MALAN	71	1	28
1325	ARIZONA	PIMA	AJO RANGE	112	39	12	32	9	0	MALAN	71	1	28
1326	ARIZONA	PIMA	LITTLE AJO MTNS	112	53	24	32	22	0	MALAN	71	1	28
1327	ARIZONA	YUMA	AZTEC HILLS	113	26	42	32	46	24	MALAN	71	1	28
1328	ARIZONA	YUMA	MOHAWK MTNS	113	44	24	32	43	48	MALAN	71	1	28
1329	ARIZONA	YUMA	GILA MTNS	114	23	48	32	43	12	MALAN	71	1	28
1330	ARIZONA	YUMA	HARGUAHALA MTNS	113	30	48	33	44	24	MALAN	71	1	28
1331	ARIZONA	YUMA	GRANITE WASH MTS	113	40	6	33	44	36	MALAN	71	1	28
1332	ARIZONA	YUMA	GRANITE WASH MTS	113	45	18	33	51	30	MALAN	71	1	28
1334	ARIZONA	YUMA	DOME ROCK MTNS	114	18	42	33	41	6	MALAN	71	1	28
1335	CALIFORNIA	RIVERSIDE	W RIVERSIDE MTNS	114	40	18	34	4	12	MALAN	71	1	28
1590	COLORADO	HUERFANO	LA VETA PEAK	105	9	54	37	34	30	BASLER	72	3	7
1592	NEW MEXICO	COLFAX	CIMARRON MTNS.	105	9	42	36	32	18	BASLER	72	3	8
1594	NEW MEXICO	TAOS	SANGRE DE CRISTO	105	30	12	36	41	36	BASLER	72	3	8
1595	NEW MEXICO	SANTA FE	ORTIZ MTN.	106	11	24	35	21	24	BASLER	72	3	8
1596	NEW MEXICO	SANTA FE	ORTIZ MTN.	106	10	12	35	21	54	BASLER	72	3	8
1597	NEW MEXICO	SANTA FE	ORTIZ MTN.	106	10	12	35	21	54	BASLER	72	3	8
1598	ARIZONA	GRAHAM	BLACK ROCK CAN.	110	11	42	32	56	0	BASLER	72	3	11
1599	ARIZONA	GRAHAM	BLACK ROCK CAN.	110	11	54	32	55	54	BASLER	72	3	11
1600	ARIZONA	GILA	BLOODY TANKS WAS	110	54	0	33	22	48	BASLER	72	3	11
1601	ARIZONA	GILA	PINTO CREEK	110	58	0	33	22	0	BASLER	72	3	11
1602	ARIZONA	MARICOPA	BUCKEYE HILLS	112	38	12	33	15	42	BASLER	72	3	11
1604	ARIZONA	PIMA	GRANITE MTNS.	113	15	18	32	19	6	BASLER	72	3	12
1605	ARIZONA	YUMA	COPPER MTNS.	113	57	30	32	31	36	BASLER	72	3	13

APPENDIX A (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	LONGITUDE DEG	LONGITUDE MIN	LONGITUDE SEC	LATITUDE DEG	LATITUDE MIN	LATITUDE SEC	COLLECTOR	DATE YR	DATE MO	DATE DA
1606	ARIZONA	YUMA	COPPER MTNS.	113	58	30	32	30	18	BASLER	72	3	13
1607	ARIZONA	YUMA	MOHAWK MTNS.	113	29	18	32	27	24	BASLER	72	3	13
1608	ARIZONA	YUMA	MOHAWK MTNS.	113	29	18	32	27	54	BASLER	72	3	13
1609	ARIZONA	YUMA	PT OF THE PINTAS	113	39	30	32	25	12	BASLER	72	3	13
1610	ARIZONA	PIMA	LITTLE AJO MTNS.	112	56	30	32	18	36	BASLER	72	3	14
1611	ARIZONA	PIMA	ALTAR VALLEY	111	32	36	31	29	12	BASLER	72	3	14
1612	ARIZONA	SANTA CRUZ	PATAGONIA MTNS.	110	43	0	31	23	30	BASLER	72	3	14
1613	ARIZONA	SANTA CRUZ	PATAGONIA MTNS.	110	44	12	31	23	24	BASLER	72	3	15
1616	ARIZONA	PIMA	SIERRITA MTNS.	111	10	48	31	53	36	BASLER	72	3	15
1617	ARIZONA	PIMA	SIERRITA MTNS.	111	8	30	31	53	54	BASLER	72	3	15
1618	CALIFORNIA	IMPERIAL	CARGO MUCHACHO	114	47	6	32	48	12	BASLER	72	3	16
1619	CALIFORNIA	IMPERIAL	CARGO MUCHACHO	114	46	24	32	48	54	BASLER	72	3	16
1620	CALIFORNIA	IMPERIAL	CHOCOLATE MTNS.	115	21	6	33	18	36	BASLER	72	3	16
1621	CALIFORNIA	IMPERIAL	CHOCOLATE MTNS.	115	20	0	33	20	6	BASLER	72	3	16
1622	CALIFORNIA	RIVERSIDE	CHUCKWALLA MTNS.	115	8	24	33	27	12	BASLER	72	3	16
1625	CALIFORNIA	RIVERSIDE	GRANITE MTNS.	115	13	0	34	2	18	BASLER	72	3	16

APPENDIX B

APPENDIX B

IDENTIFICATION OF SAMPLES REJECTED

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	REASON FOR REJECTION
2	NEVADA	CLARK	SEARCHLIGHT	HIGHLY WEATHERED
5	CALIFORNIA	SAN BERNARDINO	IVANPAH MTNS	HIGHLY WEATHERED
6	CALIFORNIA	SAN BERNARDINO	IVANPAH MTNS	DISTANT FLOAT
7	CALIFORNIA	SAN BERNARDINO	IVANPAH MTNS	DISTANT FLOAT
96	CALIFORNIA	INYO	GREENWATER RANGE	PROBABLY VOLCANIC
97	CALIFORNIA	INYO	GREENWATER RANGE	PROBABLY VOLCANIC
99	COLORADO	OURAY	DALLAS DIVIDE	MODERATELY WEATHERED
112	UTAH	GRAND	LA SAL MTNS	MODERATELY WEATHERED
113	UTAH	GRAND	LA SAL MTNS	MODERATELY WEATHERED
275	UTAH	BEAVER	SAN FRAN MT	MODERATELY WEATHERED
280	UTAH	SEVIER	NR MARYSVALE	MODERATELY WEATHERED
282	UTAH	PIUTE	NR MARYSVALE	MODERATELY WEATHERED
283	UTAH	PIUTE	NR MARYSVALE	HIGHLY WEATHERED
368	COLORADO	GUNNISON	COPPER CREEK	HIGHLY WEATHERED
370	COLORADO	GUNNISON	MARCELLINA MTN.	MODERATELY WEATHERED
633	OREGON	BAKER	SPARTA INTRUSIVE	MODERATELY WEATHERED
643	WASHINGTON	LEWIS	COWLITZ RIV PLU	HIGHLY WEATHERED
645	WASHINGTON	YAKIMA	BUMPING LAKE PLU	MODERATELY WEATHERED
648	WASHINGTON	YAKIMA	BUMPING LAKE PLU	HIGHLY WEATHERED
652	WASHINGTON	PIERCE	TATOOSH PLUTON	MODERATELY WEATHERED
891	WASHINGTON	LEWIS	COWLITZ RIV PLU	HIGHLY WEATHERED
906	WASHINGTON	SKAGIT	BEDALORTHOGNEISS	MODERATELY WEATHERED
924	WASHINGTON	STEVENS	LOON LAKE BATH	HIGHLY WEATHERED
1119	COLORADO	BOULDER	FR RNG-POR MT ST	VOLCANIC?, HIGHLY WEATH.
1122	COLORADO	BOULDER	FR RNG-NR WARD	MODERATELY WEATHERED
1124	COLORADO	BOULDER	FR RNG-NR SUNSET	MODERATELY WEATHERED
1125	COLORADO	BOULDER	FR RNG-NR SUNSET	VOLCANIC?, HIGHLY WEATH.
1126	COLORADO	BOULDER	FR RNG-NR COP RK	HIGHLY WEATHERED
1127	COLORADO	BOULDER	FR RNG-NR COP RK	HIGHLY WEATHERED
1138	COLORADO	SUMMIT	TENMILE RNG	HIGHLY WEATHERED
1157	WASHINGTON	PEND OREILLE	LN L BTH-NR NWPT	MODERATELY WEATHERED
1189	WASHINGTON	FERRY	COLV BTH-NR GC D	HIGHLY WEATHERED
1217	NEVADA	HUMBOLDT	SANTA ROSA RNG	HIGHLY WEATHERED
1222	OREGON	LAKE	NR LAKEVIEW	VOLCANIC?
1223	OREGON	LAKE	NR LAKEVIEW	VOLCANIC?
1224	OREGON	LAKE	NR LAKEVIEW	VOLCANIC?
1225	OREGON	LAKE	NR LAKEVIEW	VOLCANIC?

APPENDIX B (continued)

SAMPLE NUMBER	STATE	COUNTY	LOCALITY NAME	REASON FOR REJECTION
1226	OREGON	LAKE	NR LAKEVIEW	VOLCANIC ?
1283	NEW MEXICO	SANDOVAL	SANDIS RANGE	MODERATELY WEATHERED
1284	NEW MEXICO	SANTA FE	CERILOS HILLS	HIGHLY WEATHERED
1289	NEW MEXICO	LOS ALAMOS	VICARILLA MTNS.	MODERATELY WEATHERED
1293	NEW MEXICO	LOS ALAMOS	SIERRA BLANCA MT	MODERATELY WEATHERED
1294	NEW MEXICO	OTERO	SIERRA BLANCA MT	HIGHLY WEATHERED
1295	NEW MEXICO	OTERO	JARILLA MTNS.	HIGHLY WEATHERED
1297	NEW MEXICO	DONA ANA	ORGAN MTNS.	HIGHLY WEATHERED
1301	NEW MEXICO	LUNA	COOKS RANGE	HIGHLY WEATHERED
1303	NEW MEXICO	GRANT	E OF SILVER CITY	HIGHLY WEATHERED
1304	NEW MEXICO	GRANT	S EDGE SILV CITY	MODERATELY WEATHERED
1305	NEW MEXICO	GRANT	BURRO MTNS	SULFIDE MINERALIZATION
1306	NEW MEXICO	GRANT	TYRONE STOCK	HIGHLY WEATHERED
1307	NEW MEXICO	HIDALGO	S OF LORDSBURG	HIGHLY WEATHERED
1313	ARIZONA	COCHISE	TOMBSTONE HILLS	MODERATELY WEATHERED
1319	ARIZONA	PIMA	RINCON MTNS	HIGHLY WEATHERED
1324	ARIZONA	PIMA	QUIJOTOA MTNS	VOLCANIC BRECCIA
1333	ARIZONA	YUMA	DOME ROCK MTNS	MODERATELY WEATHERED
1336	ARIZONA	MOHAVE	BLACK MTNS	HIGHLY WEATHERED
1591	COLORADO	HUERFANO	SPANISH PEAKS	MODERATELY WEATHERED
1593	NEW MEXICO	COLFAX	CIMARRON MTNS.	MODERATELY WEATHERED
1614	ARIZONA	SANTA CRUZ	SANTA RITA MTNS.	MODERATELY WEATHERED
1615	ARIZONA	SANTA CRUZ	SANTA RITA MTNS.	HIGHLY WEATHERED

APPENDIX C

APPENDIX C

URANIUM, THORIUM, AND POTASSIUM CONTENTS OF ACCEPTED SAMPLES

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1	2.5	27.0	.09	3.31	.76	8.16
3	3.3	13.5	.24	3.05	1.08	4.43
4	1.4	12.0	.12	3.65	.38	3.29
8	0	13.2	0	3.35	0	3.94
9	.8	17.9	.04	3.55	.23	5.04
10	2.7	11.7	.23	3.26	.83	3.59
11	3.4	17.9	.19	3.00	1.13	5.97
12	3.4	12.5	.27	3.49	.97	3.58
13	.7	21.4	.03	3.57	.20	5.99
16	4.4	13.6	.32	3.90	1.13	3.49
17	1.2	9.0	.13	2.85	.42	3.16
19	1.2	15.0	.08	2.92	.41	5.14
20	1.1	19.9	.06	3.62	.30	5.50
21	2.9	10.1	.29	2.68	1.08	3.77
22	2.6	15.4	.17	2.68	.97	5.75
23	3.7	14.3	.26	2.88	1.28	4.97
24	3.8	19.9	.19	2.93	1.30	6.79
25	3.3	19.1	.17	3.14	1.05	6.08
26	2.7	9.1	.30	2.93	.92	3.11
27	.9	8.3	.11	2.42	.37	3.43
28	.1	5.2	.02	2.65	.04	1.96
29	.8	6.8	.12	2.17	.37	3.13
30	1.0	5.4	.19	2.07	.48	2.61
31	3.1	18.2	.17	2.69	1.15	6.77
32	2.0	5.1	.39	2.71	.74	1.88
33	.8	4.6	.17	2.30	.35	2.00
34	3.4	22.3	.15	3.70	.92	6.03
35	1.8	17.0	.11	3.96	.45	4.29
36	2.9	24.4	.12	3.53	.82	6.91
37	1.9	41.3	.05	3.79	.50	10.90
38	2.7	21.6	.13	3.70	.73	5.84
39	3.1	13.0	.24	2.89	1.07	4.50
40	4.8	20.9	.23	2.35	2.04	8.89
41	3.4	15.1	.23	1.88	1.81	8.03
42	3.0	5.7	.53	2.04	1.47	2.79
43	3.0	5.5	.55	1.50	2.00	3.67
44	2.6	4.7	.55	1.48	1.76	3.18
45	1.1	6.9	.16	1.39	.79	4.96
46	4.5	3.2	1.41	1.92	2.34	1.67
47	2.3	5.9	.39	2.00	1.15	2.95
48	2.5	9.1	.27	2.02	1.24	4.50
49	.9	.4	2.25	.64	1.41	.63
50	4.7	5.2	.90	2.91	1.62	1.79
51	2.9	7.1	.41	1.23	2.36	5.77
52	1.1	8.6	.13	1.43	.77	6.01
53	2.2	10.7	.21	1.39	1.58	7.70
54	1.8	2.6	.69	2.12	.85	1.23
55	3.6	6.9	.52	1.18	3.05	5.85

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
56	1.4	1.5	.93	.86	1.63	1.74
57	1.5	4.5	.33	.89	1.69	5.06
58	2.8	7.1	.39	1.91	1.47	3.72
59	1.4	3.0	.47	.84	1.67	3.57
60	1.4	4.6	.30	1.81	.77	2.54
61	2.2	4.9	.45	1.61	1.37	3.04
62	1.3	3.2	.41	1.17	1.11	2.74
63	2.2	7.2	.31	1.36	1.62	5.29
64	.9	4.9	.18	1.31	.69	3.74
65	2.2	8.3	.27	1.94	1.13	4.28
66	.5	2.5	.20	1.08	.46	2.31
67	1.1	4.6	.24	1.18	.93	3.90
68	3.7	10.9	.34	2.80	1.32	3.89
69	1.4	10.0	.14	1.74	.80	5.75
70	2.0	20.3	.10	1.77	1.13	11.47
71	.1	0	0	1.78	.06	0
72	2.2	15.6	.14	1.71	1.29	9.12
73	3.7	23.2	.16	2.81	1.32	8.26
74	2.4	9.8	.24	2.25	1.07	4.36
75	.5	3.5	.14	1.30	.38	2.69
76	1.1	2.8	.39	.82	1.34	3.41
77	2.5	7.5	.33	1.40	1.79	5.36
78	3.6	23.6	.15	2.12	1.70	11.13
79	3.2	10.8	.30	1.96	1.63	5.51
80	1.6	4.6	.35	1.14	1.40	4.04
81	1.4	5.9	.24	.92	1.52	6.41
82	.9	6.7	.13	1.03	.87	6.50
83	7.1	25.8	.28	2.44	2.91	10.57
84	5.2	18.9	.28	2.83	1.84	6.68
85	3.8	15.7	.24	3.34	1.14	4.70
86	2.2	7.7	.29	1.42	1.55	5.42
87	5.1	22.8	.22	3.36	1.52	6.79
88	1.9	10.2	.19	1.76	1.08	5.80
89	3.0	18.2	.16	4.01	.75	4.54
90	3.2	20.8	.15	3.16	1.01	6.58
91	2.5	17.7	.14	3.82	.65	4.63
92	3.8	20.3	.19	2.66	1.43	7.63
93	3.2	17.8	.18	3.28	.98	5.43
94	1.3	9.9	.13	3.62	.36	2.73
95	3.0	12.9	.23	2.14	1.40	6.03
98	2.1	7.4	.28	1.80	1.17	4.11
100	6.1	21.6	.28	2.84	2.15	7.61
101	1.6	6.6	.24	2.24	.71	2.95
102	4.4	9.1	.48	2.53	1.74	3.60
103	1.7	2.4	.71	1.88	.90	1.28
105	1.2	1.1	1.09	1.66	.72	.66
106	1.8	5.8	.31	1.95	.92	2.97
107	1.1	3.2	.34	1.74	.63	1.84

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
108	1.7	3.4	.50	1.31	1.30	2.60
109	1.7	2.9	.59	1.29	1.32	2.25
110	2.2	5.7	.39	1.29	1.71	4.42
111	8.4	54.8	.15	3.32	2.53	16.51
114	1.3	3.7	.35	2.39	.54	1.55
125	5.7	23.0	.25	2.83	2.02	8.13
126	1.6	6.0	.27	1.96	.82	3.06
266	4.3	23.5	.18	3.39	1.27	6.93
267	4.5	20.5	.22	2.85	1.58	7.19
268	10.5	16.6	.63	2.94	3.57	5.65
269	4.8	12.3	.39	2.52	1.90	4.88
270	8.1	31.4	.26	2.82	2.87	11.13
271	10.9	35.1	.31	3.04	3.59	11.55
272	5.0	29.2	.17	3.09	1.62	9.45
273	1.2	8.2	.15	2.69	.45	3.05
274	1.8	12.1	.15	1.49	1.21	8.12
276	7.9	27.3	.29	3.50	2.26	7.80
277	5.4	24.3	.22	4.03	1.34	6.03
278	15.5	52.4	.30	3.63	4.27	14.44
284	1.3	17.1	.08	2.25	.58	7.60
286	1.9	17.7	.11	2.62	.73	6.76
287	5.9	26.5	.22	2.75	2.15	9.64
357	.3	4.6	.07	1.92	.16	2.40
358	-0.2	4.0	-0.05	1.76	-0.11	2.27
359	4.1	19.0	.22	3.05	1.34	6.23
360	-0.1	1.9	-0.05	1.97	-0.05	.96
361	2.7	3.4	.79	1.89	1.43	1.80
362	2.9	2.6	1.12	2.30	1.26	1.13
363	6.0	22.1	.27	2.91	2.06	7.59
364	6.5	12.4	.52	2.43	2.67	5.10
365	4.1	11.9	.34	2.63	1.56	4.52
366	3.2	7.8	.41	1.66	1.93	4.70
367	2.9	5.3	.55	2.01	1.44	2.64
369	4.5	8.6	.52	2.70	1.67	3.19
371	3.1	10.7	.29	2.47	1.26	4.33
385	.9	2.6	.35	1.99	.45	1.31
386	.7	1.8	.39	2.36	.30	.76
632	3.5	2.1	1.67	.95	3.68	2.21
634	1.3	1.6	.81	1.27	1.02	1.26
635	.1	2.1	.05	1.00	.10	2.10
636	.5	3.0	.17	1.28	.39	2.34
637	.4	1.7	.24	1.19	.34	1.43
638	0	2.3	0	1.23	0	1.87
639	1.1	3.5	.31	1.09	1.01	3.21
640	.7	5.9	.12	1.67	.42	3.53
641	2.0	4.4	.45	1.87	1.07	2.35
642	3.3	12.9	.26	2.54	1.30	5.08
644	1.2	1.1	1.09	.99	1.21	1.11

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
646	2.5	12.6	.20	2.43	1.03	5.19
647	3.2	12.7	.25	2.17	1.47	5.85
649	4.2	14.4	.29	2.44	1.72	5.90
650	.7	3.7	.19	1.32	.53	2.80
651	2.9	8.8	.33	1.89	1.53	4.66
653	3.1	10.0	.31	2.17	1.43	4.61
654	2.7	11.1	.24	2.22	1.22	5.00
655	.7	1.8	.39	.86	.81	2.09
656	2.2	7.5	.29	1.93	1.14	3.89
657	1.6	5.4	.30	1.46	1.10	3.70
771	2.4	5.9	.41	1.45	1.66	4.07
772	3.0	9.8	.31	1.97	1.52	4.97
773	2.8	9.3	.30	2.57	1.09	3.62
774	2.1	4.8	.44	1.53	1.37	3.14
775	2.6	2.1	1.24	2.35	1.11	.89
776	2.7	2.0	1.35	2.28	1.18	.88
777	7.9	35.4	.22	3.19	2.48	11.10
778	13.4	41.7	.32	3.17	4.23	13.15
779	17.3	28.5	.61	3.80	4.55	7.50
783	3.7	8.9	.42	1.56	2.37	5.71
784	2.6	4.4	.59	1.72	1.51	2.56
785	5.5	14.9	.37	1.80	3.06	8.28
786	6.0	24.7	.24	2.81	2.14	8.79
889	1.7	7.8	.22	2.26	.75	3.45
890	0	3.1	0	1.34	0	2.31
892	0	1.4	0	1.00	0	1.40
893	-0.1	.3	-0.33	.26	-0.38	1.15
894	-0.1	.2	-0.50	.32	-0.31	.63
895	.9	1.4	.64	1.29	.70	1.09
896	.9	4.2	.21	1.75	.51	2.40
897	1.7	4.9	.35	1.90	.89	2.58
898	2.3	6.0	.38	2.32	.99	2.59
899	-0.1	2.7	-0.04	1.31	-0.08	2.06
900	1.7	2.6	.65	1.33	1.28	1.95
901	1.3	4.2	.31	1.23	1.06	3.41
902	1.8	4.5	.40	1.57	1.15	2.87
903	.2	1.5	.13	.94	.21	1.60
904	.8	5.8	.14	2.03	.39	2.86
905	1.5	5.2	.29	1.60	.94	3.25
907	1.3	2.9	.45	1.23	1.06	2.36
908	1.6	4.9	.33	1.73	.92	2.83
909	1.5	2.6	.58	1.54	.97	1.69
910	.1	7.4	.01	4.70	.02	1.57
911	1.5	2.4	.63	1.23	1.22	1.95
912	2.6	12.1	.21	2.84	.92	4.26
913	2.2	7.5	.29	2.45	.90	3.06
914	.1	-0.3	-0.33	.55	.18	-0.55
915	2.1	7.3	.29	2.53	.83	2.89

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
916	-0.1	-0.1	1.00	.62	-0.16	-0.16
917	1.0	4.2	.24	1.00	1.00	4.20
918	1.4	9.5	.15	2.25	.62	4.22
919	3.0	6.6	.45	2.19	1.37	3.01
920	.7	5.2	.13	2.55	.27	2.04
921	.5	3.6	.14	1.91	.26	1.88
922	2.1	6.5	.32	2.80	.75	2.32
923	0	19.8	0	3.45	0	5.74
925	.6	19.6	.03	3.89	.15	5.04
926	7.1	16.1	.44	3.15	2.25	5.11
927	6.5	9.3	.70	2.78	2.34	3.35
928	1.0	10.2	.10	2.32	.43	4.40
929	.7	10.8	.06	1.20	.58	9.00
930	3.4	11.2	.30	1.80	1.89	6.22
931	1.0	14.3	.07	1.52	.66	9.41
932	.3	12.2	.02	2.28	.13	5.35
933	4.7	17.4	.27	2.75	1.71	6.33
957	4.7	11.4	.41	2.26	2.08	5.04
958	5.9	12.5	.47	2.29	2.58	5.46
959	1.7	5.6	.30	1.77	.96	3.16
960	3.8	9.0	.42	1.97	1.93	4.57
961	3.1	4.4	.70	1.47	2.11	2.99
962	4.2	10.1	.42	2.05	2.05	4.93
963	2.1	5.7	.37	1.08	1.94	5.28
964	2.5	5.9	.42	1.73	1.45	3.41
965	3.7	5.1	.73	2.31	1.60	2.21
966	2.8	6.8	.41	2.25	1.24	3.02
967	7.9	20.1	.39	2.63	3.00	7.64
968	3.4	13.2	.26	2.02	1.68	6.53
969	3.9	11.7	.33	2.48	1.57	4.72
970	3.1	13.2	.23	3.10	1.00	4.26
971	4.9	13.2	.37	2.93	1.67	4.51
972	2.2	7.5	.29	3.31	.66	2.27
973	5.0	12.4	.40	3.22	1.55	3.85
974	7.5	15.0	.50	3.18	2.36	4.72
975	4.4	16.6	.27	2.74	1.61	6.06
976	6.0	17.4	.34	2.77	2.17	6.28
977	3.4	9.1	.37	3.28	1.04	2.77
978	4.4	16.0	.28	3.76	1.17	4.26
979	8.8	18.1	.49	3.39	2.60	5.34
980	4.2	12.8	.33	2.47	1.70	5.18
981	2.0	6.0	.33	2.55	.78	2.35
982	1.4	3.1	.45	.87	1.61	3.56
983	.4	6.5	.06	2.87	.14	2.26
984	1.2	12.4	.10	2.67	.45	4.64
985	2.4	10.9	.22	2.36	1.02	4.62
986	1.5	20.5	.07	3.62	.41	5.66
987	2.1	11.2	.19	3.49	.60	3.21

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
988	3.0	18.4	.16	2.75	1.09	6.69
989	2.4	17.3	.14	2.71	.89	6.38
990	3.2	18.6	.17	2.79	1.15	6.67
991	2.2	19.1	.12	2.54	.87	7.52
992	.3	5.7	.05	1.90	.16	3.00
993	1.5	24.9	.06	4.48	.33	5.56
994	2.3	13.4	.17	2.95	.78	4.54
995	-0.2	5.4	-0.04	2.56	-0.08	2.11
996	2.2	10.0	.22	3.24	.68	3.09
997	1.7	3.9	.44	.56	3.04	6.96
998	2.2	21.1	.10	3.26	.67	6.47
999	4.6	25.8	.18	3.31	1.39	7.79
1120	5.8	19.1	.30	3.31	1.75	5.77
1121	2.9	14.8	.20	3.25	.89	4.55
1123	6.7	30.7	.22	3.13	2.14	9.81
1128	.1	1.8	.06	3.03	.03	.59
1129	6.9	27.4	.25	4.19	1.65	6.54
1130	9.0	70.6	.13	4.08	2.21	17.30
1131	9.4	56.0	.17	3.39	2.77	16.52
1132	27.8	84.7	.33	3.93	7.07	21.55
1133	3.3	14.8	.22	2.42	1.36	6.12
1134	15.5	51.0	.30	3.52	4.40	14.49
1135	18.4	67.5	.27	3.59	5.13	18.80
1136	6.4	24.1	.27	3.45	1.86	6.99
1137	7.3	26.0	.28	3.05	2.39	8.52
1139	7.4	23.3	.32	2.80	2.64	8.32
1146	4.4	5.6	.79	3.06	1.44	1.83
1147	5.6	15.9	.35	2.62	2.14	6.07
1148	3.3	12.6	.26	2.87	1.15	4.39
1149	9.1	26.9	.34	3.46	2.63	7.77
1150	6.8	14.2	.48	2.85	2.39	4.98
1151	7.7	20.7	.37	3.32	2.32	6.23
1152	2.3	11.2	.21	2.98	.77	3.76
1153	2.7	11.0	.25	2.27	1.19	4.85
1154	4.3	1.3	3.31	3.33	1.29	.39
1155	4.2	4.2	1.00	3.84	1.09	1.09
1156	3.4	19.5	.17	3.52	.97	5.54
1158	2.4	12.5	.19	2.78	.86	4.50
1159	2.3	12.5	.18	2.89	.80	4.33
1160	9.8	15.8	.62	3.14	3.12	5.03
1161	3.8	19.0	.20	2.53	1.50	7.51
1162	6.4	16.3	.39	3.15	2.03	5.17
1163	2.5	22.8	.11	3.15	.79	7.24
1164	7.1	10.1	.70	2.77	2.56	3.65
1165	4.7	10.6	.44	2.39	1.97	4.44
1166	2.0	8.4	.24	2.80	.71	3.00
1167	2.5	11.8	.21	2.44	1.02	4.84
1168	2.5	16.0	.16	3.24	.77	4.94

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1169	2,7	14,2	,19	2,42	1,12	5,87
1170	6,0	18,4	,33	2,93	2,05	6,28
1171	1,2	7,1	,17	2,74	,44	2,59
1172	1,7	14,5	,12	1,92	,89	7,55
1173	1,9	7,7	,25	2,07	,92	3,72
1174	,9	5,7	,16	2,04	,44	2,79
1175	2,0	9,7	,21	1,47	1,36	6,60
1176	1,2	11,2	,11	2,18	,55	5,14
1177	3,2	28,8	,11	3,94	,81	7,31
1178	2,6	14,8	,18	2,86	,91	5,17
1179	2,3	19,5	,12	3,50	,66	5,57
1180	3,8	14,3	,27	2,66	1,43	5,38
1181	,2	10,9	,02	1,81	,11	6,02
1182	,4	7,6	,05	2,97	,13	2,56
1183	4,8	17,5	,27	2,68	1,79	6,53
1184	3,1	5,4	,57	2,78	1,12	1,94
1185	2,6	7,6	,34	2,34	1,11	3,25
1186	2,5	7,1	,35	2,06	1,21	3,45
1187	4,0	17,0	,24	3,04	1,32	5,59
1188	3,4	16,0	,21	2,99	1,14	5,35
1190	,7	5,4	,13	2,30	,30	2,35
1191	10,9	29,9	,36	3,44	3,17	8,69
1192	10,1	31,4	,32	3,70	2,73	8,49
1193	11,7	28,6	,41	3,93	2,98	7,28
1194	9,1	27,5	,33	3,64	2,50	7,55
1195	17,1	31,1	,55	3,45	4,96	9,01
1196	4,3	18,1	,24	2,80	1,54	6,46
1197	3,8	17,6	,22	2,84	1,34	6,20
1198	3,6	12,8	,28	3,14	1,15	4,08
1199	2,2	18,2	,12	2,24	,98	8,12
1200	4,1	21,2	,19	2,40	1,71	8,83
1201	3,6	16,6	,22	2,04	1,76	8,14
1202	5,2	8,1	,64	2,70	1,93	3,00
1203	5,7	9,1	,63	2,49	2,29	3,65
1204	7,5	11,1	,68	2,34	3,21	4,74
1205	9,6	8,2	1,17	2,71	3,54	3,03
1206	4,2	9,2	,46	2,68	1,57	3,43
1207	0	8,5	0	3,25	0	2,62
1208	6,7	23,8	,28	3,40	1,97	7,00
1209	9,5	24,1	,39	3,31	2,87	7,28
1210	4,0	21,7	,18	2,92	1,37	7,43
1211	5,7	15,1	,38	3,24	1,76	4,66
1212	3,1	16,5	,19	3,64	,85	4,53
1213	,7	25,6	,03	3,63	,19	7,05
1214	2,3	33,5	,07	3,63	,63	9,23
1215	5,8	6,0	,97	2,39	2,43	2,51
1216	3,6	5,6	,64	3,24	1,11	1,73
1218	2,9	9,3	,31	2,14	1,36	4,35

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1219	4.1	14.3	.29	2.77	1.48	5.16
1220	2.8	8.6	.33	1.17	2.39	7.35
1221	2.3	9.3	.25	1.34	1.72	6.94
1227	2.2	8.9	.25	1.91	1.15	4.66
1228	2.7	32.9	.08	3.75	.72	8.77
1229	3.5	17.0	.21	1.77	1.98	9.60
1230	3.3	14.8	.22	2.33	1.42	6.35
1231	4.7	19.1	.25	2.02	2.33	9.46
1232	5.8	18.9	.31	2.81	2.06	6.73
1233	2.9	16.6	.17	2.78	1.04	5.97
1234	2.4	10.4	.23	3.27	.73	3.18
1235	2.1	9.0	.23	2.37	.89	3.80
1236	1.5	3.4	.44	1.89	.79	1.80
1237	3.3	13.1	.25	2.69	1.23	4.87
1238	1.5	8.1	.19	.62	2.42	13.06
1239	4.9	11.2	.44	2.66	1.84	4.21
1240	4.9	11.1	.44	2.29	2.14	4.85
1241	4.7	11.5	.41	2.29	2.05	5.02
1242	4.2	9.9	.42	2.16	1.94	4.58
1243	4.3	13.0	.33	2.03	2.12	6.40
1244	2.9	11.0	.26	2.23	1.30	4.93
1245	4.3	11.2	.38	1.74	2.47	6.44
1246	9.7	26.3	.37	3.53	2.75	7.45
1247	6.7	18.3	.37	3.41	1.96	5.37
1248	2.2	6.1	.36	1.72	1.28	3.55
1249	8.5	15.8	.54	3.16	2.69	5.00
1250	6.5	12.2	.53	2.85	2.28	4.28
1251	1.5	15.0	.10	2.51	.60	5.98
1252	5.9	6.2	.95	2.89	2.04	2.15
1253	5.9	17.7	.33	3.76	1.57	4.71
1254	1.4	.5	2.80	3.22	.43	.16
1255	8.5	25.7	.33	2.93	2.90	8.77
1256	3.8	16.5	.23	4.27	.89	3.86
1257	1.3	15.5	.08	3.75	.35	4.13
1258	1.6	11.1	.14	2.50	.64	4.44
1259	4.3	16.2	.27	2.75	1.56	5.89
1260	1.9	10.9	.17	2.11	.90	5.17
1261	2.4	12.7	.19	2.44	.98	5.20
1262	7.5	19.9	.38	2.19	3.42	9.09
1263	1.5	8.4	.18	2.34	.64	3.59
1264	6.8	13.0	.52	1.93	3.52	6.74
1265	3.4	14.9	.23	1.94	1.75	7.68
1266	2.8	10.5	.27	1.90	1.47	5.53
1267	4.0	15.2	.26	.20	20.00	76.00
1268	.8	15.4	.05	2.97	.27	5.19
1269	9.2	18.8	.49	2.95	3.12	6.37
1270	1.3	12.4	.10	3.08	.42	4.03
1271	.7	10.5	.07	2.42	.29	4.34

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1272	,3	5,2	,06	2,90	,10	1,79
1273	4,6	32,4	,14	3,41	1,35	9,50
1274	1,8	14,3	,13	3,21	,56	4,45
1275	4,4	16,2	,27	3,77	1,17	4,30
1276	1,3	8,4	,15	2,52	,52	3,33
1277	3,9	17,8	,22	3,78	1,03	4,71
1278	4,7	19,3	,24	2,92	1,61	6,61
1279	7,8	20,0	,39	3,09	2,52	6,47
1280	8,1	2,3	3,52	2,85	2,84	,81
1281	1,2	12,1	,10	2,15	,56	5,63
1282	5,0	24,7	,20	2,75	1,82	8,98
1285	2,6	6,0	,43	,17	15,29	35,29
1286	1,6	4,9	,33	,13	12,31	37,69
1287	9,1	59,0	,15	,09	101,11	655,56
1288	3,8	19,4	,20	3,93	,97	4,94
1290	4,3	26,2	,16	3,33	1,29	7,87
1291	2,3	24,4	,09	3,74	,61	6,52
1292	2,3	26,0	,09	4,16	,55	6,25
1296	2,2	13,4	,16	3,01	,73	4,45
1298	3,9	24,7	,16	4,04	,97	6,11
1299	3,6	22,4	,16	3,02	1,19	7,42
1300	4,9	21,7	,23	3,64	1,35	5,96
1302	,8	8,2	,10	1,76	,45	4,66
1308	4,2	14,5	,29	3,26	1,29	4,45
1309	5,0	21,9	,23	3,31	1,51	6,62
1310	5,0	37,3	,13	3,62	1,38	10,30
1311	2,5	8,9	,28	2,65	,94	3,36
1312	23,4	14,7	1,59	3,23	7,24	4,55
1314	1,9	11,0	,17	2,28	,83	4,82
1315	1,4	1,3	1,08	3,34	,42	,39
1316	1,6	4,5	,36	2,47	,65	1,82
1317	,6	3,6	,17	2,76	,22	1,30
1318	,8	6,6	,12	3,56	,22	1,85
1320	5,5	15,8	,35	2,03	2,71	7,78
1321	3,1	10,1	,31	3,13	,99	3,23
1322	4,3	34,4	,13	3,72	1,16	9,25
1323	2,6	22,6	,12	3,30	,79	6,85
1325	2,6	8,8	,30	2,48	1,05	3,55
1326	3,6	13,5	,27	,32	11,25	42,19
1327	-0,5	23,1	-0,02	2,22	-0,23	10,41
1328	,1	20,7	,00	4,98	,02	4,16
1329	-0,1	2,9	-0,03	3,04	-0,03	,95
1330	3,4	24,7	,14	3,61	,94	6,84
1331	3,6	9,3	,39	2,44	1,48	3,81
1332	2,8	8,3	,34	2,81	1,00	2,95
1334	5,9	31,0	,19	3,20	1,84	9,69
1335	1,0	5,8	,17	2,33	,43	2,49
1590	,7	,3	2,33	2,88	,24	,10

APPENDIX C (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1592	1.9	1.7	1.12	2.09	.91	.81
1594	12.2	28.2	.43	3.12	3.91	9.04
1595	3.4	16.0	.21	2.41	1.41	6.64
1596	11.3	46.4	.24	3.22	3.51	14.41
1597	9.9	42.6	.23	3.19	3.10	13.35
1598	2.6	7.3	.36	3.25	.80	2.25
1599	1.6	11.2	.14	2.76	.58	4.06
1600	1.0	1.9	.53	2.25	.44	.84
1601	.3	5.9	.05	2.75	.11	2.15
1602	1.9	19.1	.10	3.61	.53	5.29
1604	.6	1.3	.46	1.92	.31	.68
1605	.1	5.2	.02	1.81	.06	2.87
1606	.4	6.9	.06	2.01	.20	3.43
1607	1.3	4.6	.28	2.06	.63	2.23
1608	1.3	3.6	.36	1.86	.70	1.94
1609	.4	4.9	.08	2.12	.19	2.31
1610	1.9	16.7	.11	3.25	.58	5.14
1611	3.5	17.9	.20	3.16	1.11	5.66
1612	8.1	21.7	.37	2.41	3.36	9.00
1613	6.4	25.6	.25	2.51	2.55	10.20
1616	3.9	19.6	.20	3.52	1.11	5.57
1617	3.3	11.1	.30	2.66	1.24	4.17
1618	8.2	36.6	.22	3.53	2.32	10.37
1619	5.7	24.0	.24	2.94	1.94	8.16
1620	4.3	22.4	.19	3.63	1.18	6.17
1621	5.7	18.1	.31	3.68	1.55	4.92
1622	1.4	9.6	.15	2.23	.63	4.30
1625	.5	3.4	.15	2.95	.17	1.15

APPENDIX D

APPENDIX D

URANIUM, THORIUM, AND POTASSIUM CONTENTS OF REJECTED SAMPLES

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
2	3.3	13.5	.24	3.05	1.08	4.43
5	0	13.2	0	3.35	0	3.94
6	0	13.2	0	3.35	0	3.94
7	0	13.2	0	3.35	0	3.94
96	2.1	7.4	.28	1.80	1.17	4.11
97	2.1	7.4	.28	1.80	1.17	4.11
99	.8	2.5	.32	1.95	.41	1.28
112	7.0	23.7	.30	3.60	1.94	6.58
113	1.2	1.2	1.00	1.95	.62	.62
275	5.1	19.4	.26	2.48	2.06	7.82
280	9.3	31.1	.30	3.14	2.96	9.90
282	21.2	94.0	.23	4.23	5.01	22.22
283	9.4	41.2	.23	4.22	2.23	9.76
368	4.4	12.0	.37	2.97	1.48	4.04
370	3.3	7.7	.43	2.25	1.47	3.42
633	.4	-0.1	-4.00	.90	.44	-0.11
643	1.3	.9	1.44	.68	1.91	1.32
645	1.0	-0.6	-1.67	.39	2.56	-1.54
648	3.3	11.0	.30	2.07	1.59	5.31
652	2.8	10.8	.26	2.18	1.28	4.95
891	1.3	4.1	.32	1.07	1.21	3.83
906	1.2	1.9	.63	.63	1.90	3.02
924	2.1	16.6	.13	3.16	.66	5.25
1119	102.1	23.1	4.42	4.90	20.84	4.71
1122	1.0	4.0	.25	1.86	.54	2.15
1124	4.9	33.3	.15	3.25	1.51	10.25
1125	9.4	31.6	.30	3.93	2.39	8.04
1126	6.9	19.3	.36	3.23	2.14	5.98
1127	9.0	28.6	.31	3.19	2.82	8.97
1138	3.7	25.2	.15	2.72	1.36	9.26
1157	1.4	9.2	.15	2.57	.54	3.58
1189	2.4	7.2	.33	2.17	1.11	3.32
1217	1.8	4.6	.39	2.53	.71	1.82
1222	5.3	9.6	.55	3.43	1.55	2.80
1223	3.8	10.9	.35	3.45	1.10	3.16
1224	5.8	10.2	.57	3.59	1.62	2.84
1225	8.1	17.3	.47	3.43	2.36	5.04
1226	5.3	9.2	.58	3.86	1.37	2.38
1283	4.4	16.4	.27	2.23	1.97	7.35
1284	6.6	13.1	.50	2.66	2.48	4.92
1289	3.9	11.6	.34	2.22	1.76	5.23
1293	5.5	18.3	.30	3.51	1.57	5.21
1294	4.2	16.7	.25	3.07	1.37	5.44
1295	2.5	12.0	.21	2.97	.84	4.04
1297	3.4	24.6	.14	4.00	.85	6.15
1301	1.1	8.9	.12	2.91	.38	3.06
1303	1.8	9.6	.19	3.55	.51	2.70
1304	0	3.9	0	2.09	0	1.87

APPENDIX D (continued)

SAMPLE NUMBER	U PPM	TH PPM	U/TH	K PERCENT	U/K X10000	TH/K X10000
1305	2.0	5.8	.34	3.89	.51	1.49
1306	-0.3	5.2	-0.06	2.45	-0.12	2.12
1307	9.0	25.5	.35	3.24	2.78	7.87
1313	3.1	10.3	.30	2.49	1.24	4.14
1319	2.1	6.5	.32	2.12	.99	3.07
1324	3.4	14.7	.23	1.06	3.21	13.87
1333	-1.0	16.5	-0.06	2.18	-0.46	7.57
1336	2.4	20.3	.12	3.47	.69	5.85
1591	6.7	19.7	.34	3.42	1.96	5.76
1593	2.1	6.9	.30	1.79	1.17	3.85
1614	5.3	21.6	.25	2.59	2.05	8.34
1615	5.4	19.0	.28	2.78	1.94	6.83

APPENDIX E

ANALYTICAL PRECISION AND ACCURACY

This is a summary of results of the various investigations of analytical precision and accuracy which were undertaken in support of the proejct. It should be noted that most of these results were obtained in the course of routine analytical work for the project and not from controlled experiments conducted solely for the purpose of determining analytical precision or accuracy.

Analytical Precision

Gamma Spectrometric Analyses

The precision levels of gamma spectrometric analyses for uranium, thorium, and potassium were determined from repeated analyses of 8 samples (Table E1). These samples contained a range in concentration of the three elements (Figures E1, E2, and E3).

The objective of the investigation was to monitor the precision level of the combined sample preparation-analytical circuit as well as of the analytical circuit alone. Consequently, both single and multiple preparation of samples were involved (Table E1). The results (Figures E1, E2 and E3) indicate little or no contribution to the total error from sample preparation.

Precision values adopted for use in this report are indicated in Figures E1, E2, and E3 and are summarized in Table E2.

Other analyses

The precision values for rapid rock analyses, quantitative trace element analyses, and semiquantitative emission spectrographic analyses were determined by repeated analyses of a sample (Table E2). For most of the analyses, more than one sample preparation was used. When only one preparation was used in the rapid rock analyses, however, there was no significant improvement in reproducibility.

Chemical Ratios and Indices

The precision values for various chemical ratios and indices used in the report were determined and are given in Table E3.

Table E1

SAMPLES USED IN DETERMINATION OF THE PRECISION OF GAMMA SPECTROMETRIC ANALYSES

Sample Number	Number of Runs	Period of Analyses	Type of Preparation
360	7	9/15/71-5/5/72	single preparation
57	7	9/9/71-5/5/72	single preparation
320	9	12/71-3/72	single preparation
125	6	9/71-5/72	separate preparations; prepared in same manner as run-of-the-mill sample
125S	13	3/28/72	separate preparations; prepared by splitting
1199	5	4/21/71	separate preparations
1207	5	4/27/71	separate preparations
1266	5	5/3/71	separate preparations

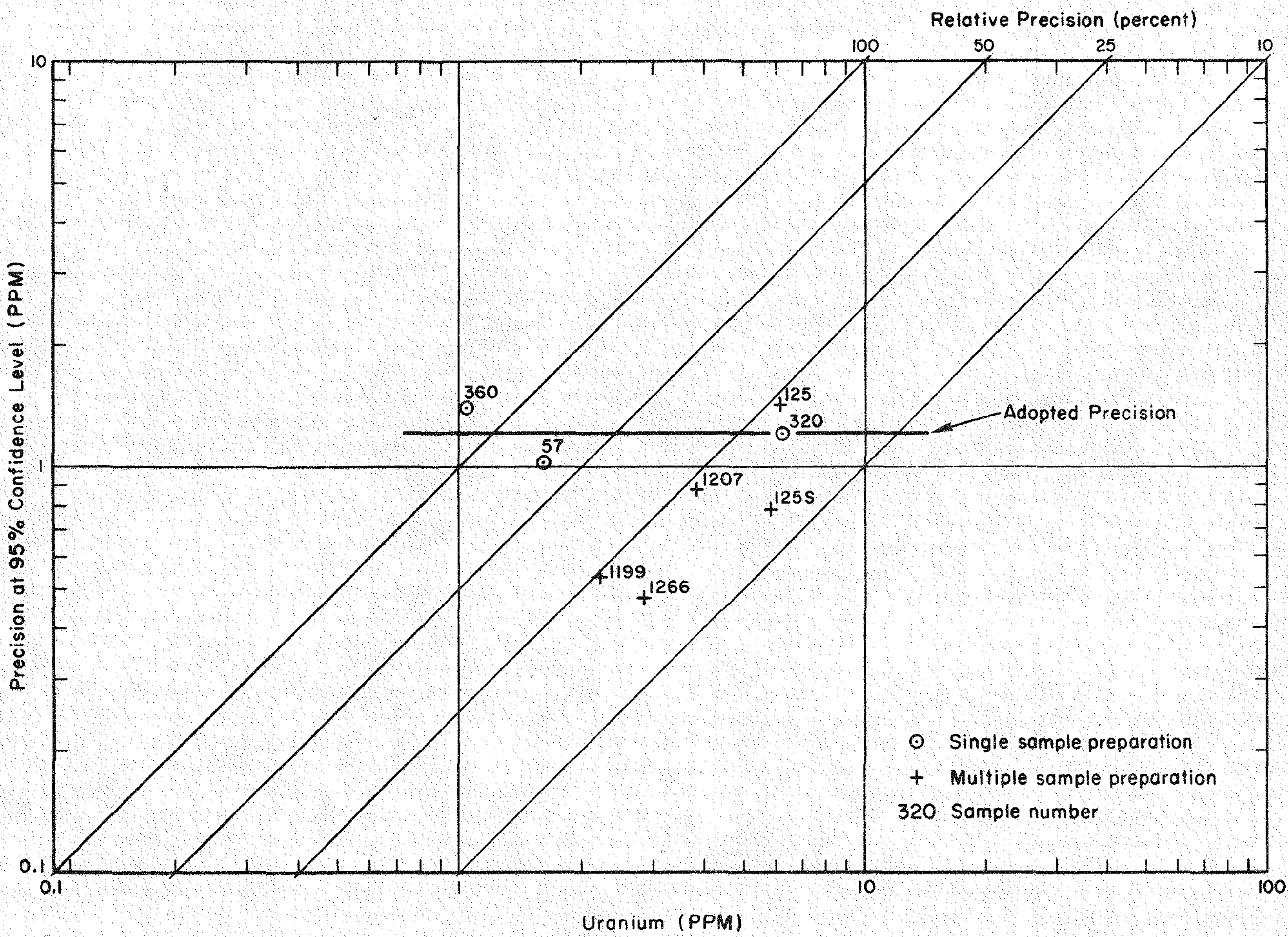

Figure E1. Precision of gamma spectrometric analyses for uranium as a function of uranium concentration

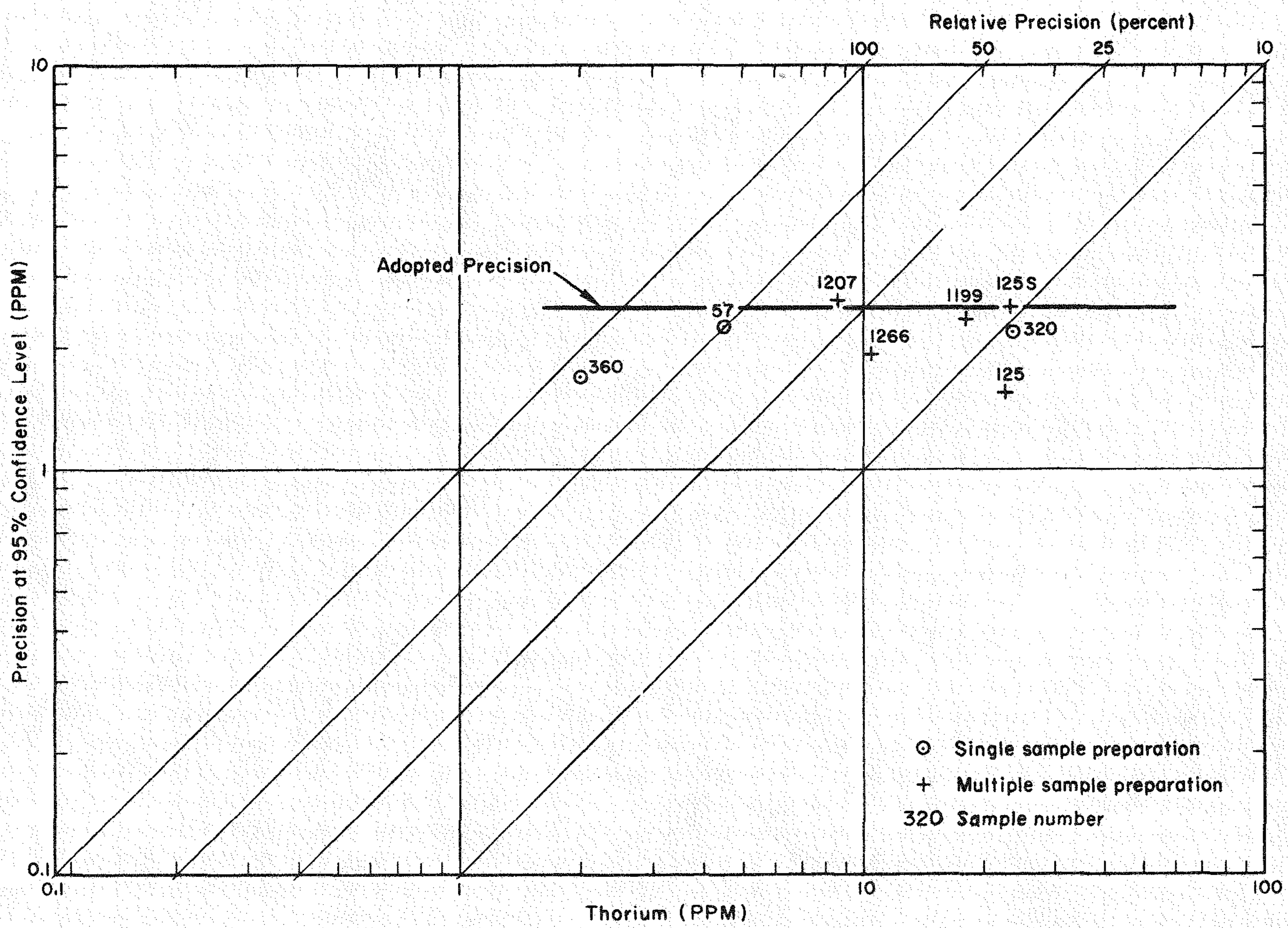

Figure E2. Precision of gamma spectrometric analyses for thorium as a function of thorium concentration

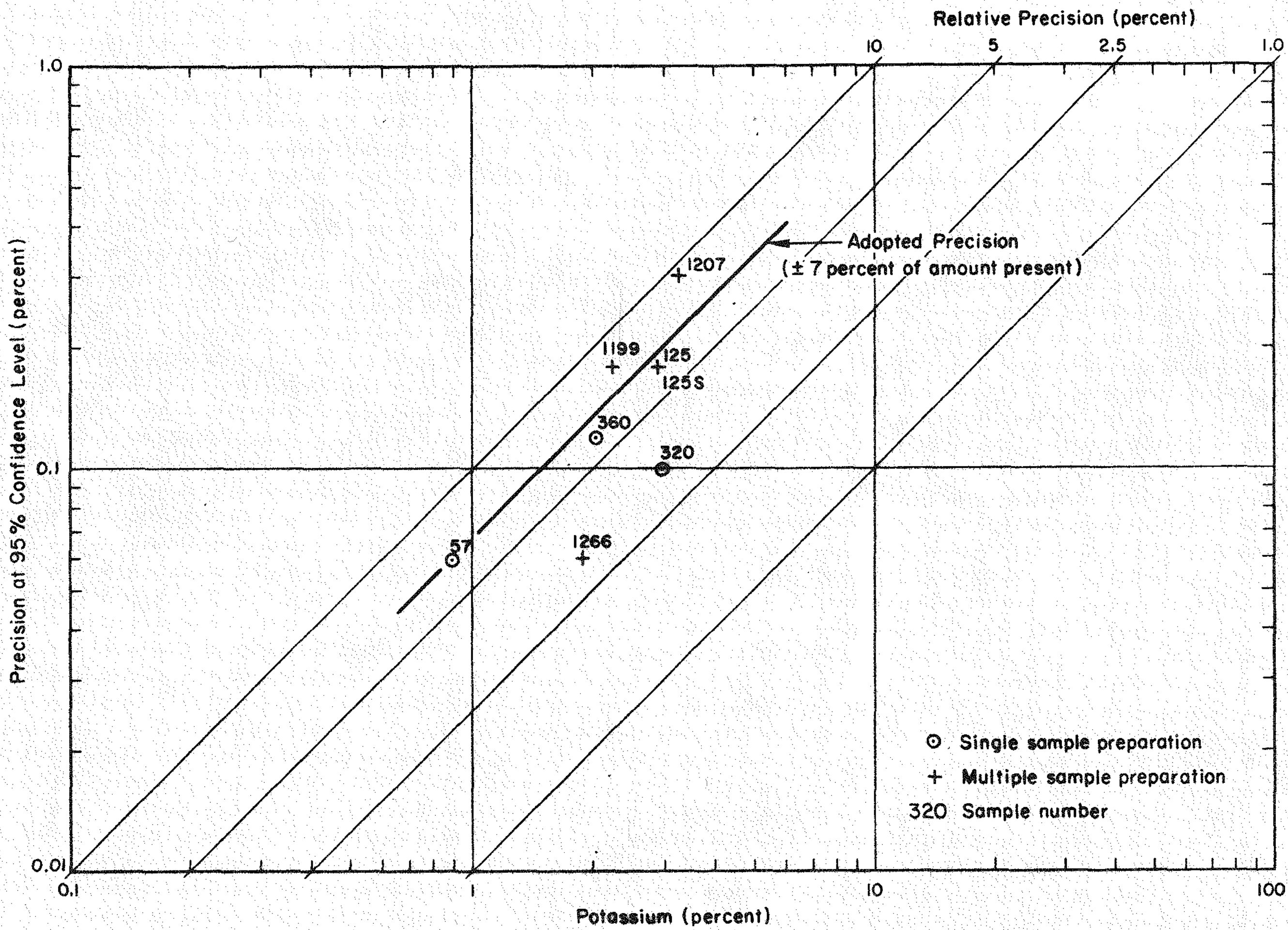

Figure E3. Precision of gamma spectrometric analyses for potassium as a function of potassium concentration

Table E2

PRECISION OF CHEMICAL ANALYSES

Analysis	Range or Level	Precision at 95% Confidence Level
I. Gamma spectrometric analyses[a]		
U	1-7ppm	±1.2
Th	2-25ppm	±2.5
K	0.8-5.0%	±7% of amt. present
II. Rapid rock analyses[b]		
Si	31.7%	±2.5
Ti	.36%	±0.06
Al	8.26%	±0.35
Fe^{+++}	1.53%	±0.10
Fe^{++}	1.48%	±0.12
total Fe	3.01%	±0.11
Mn	.053%	±0.005
Mg	.79%	±0.08
Ca	2.22%	±0.18
Na	2.58%	±0.20
K	3.11%	±0.25
P	.082%	±0.026

Table E2 (continued)

Analysis	Range or Level	Precision at 95% Confidence Level
III. Quantitative trace element analyses[c]		
Zr	90ppm	±31
Mo	0.5ppm	±1.1
Rb	106ppm	± 17
IV. Semiquantitative emission spectrographic analyses[c]		
Ti	0.40%	±0.25
Fe	3.1%	±0.4
Mn	0.11%	±0.06
Mg	1.0%	±0.5
Ca	4.3%	±3.4
Na	2.5%	±1.3
P	0.1%	± 0
B	10ppm	± 0
Ba	680ppm	±230
Be	2ppm	±1.5
Cu	18ppm	± 15
Ga	8ppm	± 13

Table E2 (continued)

Analysis	Range or Level	Precision at 95% Confidence Level
IV. Semiquantitative emission spectrographic analyses[c] (continued)		
Li	17ppm	± 20
Ni	10ppm	± 0
Pb	45ppm	±150
Sb	97ppm	± 16
Sn	2ppm	± 6
Sr	770ppm	±320
V	83ppm	± 27
Y	30ppm	± 30
Yb	2ppm	± 2
Zn	100ppm	± 0

NOTES:

[a]Results are based on repeated analyses of samples with different concentrations. See Table E1 and Figures E1, E2, and E3.

[b]Results are based on 8 separate analyses of the Metallogenic Standard Number 1. For Ca the precision is computed from that obtained for the $CaCO_3$ analysis.

[c]Results are based on 6 separate analyses of the Metallogenic Standard Number 1.

Table E3

PRECISION OF CHEMICAL RATIOS AND INDICES

Ratio or Index[a]	Number of Determinations	Level	Precision at 95% Confidence Level
U/Th	21	0.25	±0.08[b]
U/K x 10^4	21	2.01	±0.56[b]
Th/K x 10^4	21	8.13	±1.45[b]
Rb/K x 10^4	8	37.5	±8.6 [b]
$Fe_2O_3/(FeO+Fe_2O_3)$	8	0.54	±0.05[c]
Nockolds-Allen Index, 1/3Si + K - Ca - Mg	8	10.3%	±1.2[c]

[a]All analyses quantitative; potassium analysis by gamma-ray spectrometry.

[b]Computed from precision values for individual elements, as determined in this study (Table E2).

[c]Based on repeated determination of index for Metallogenic Standard Number 1.

Interlaboratory Comparison of Gamma Spectrometric Analyses

Splits of the Metallogenic Standard Number 1 (sample number 125, Appendix A) were submitted to two outside laboratories for comparative analysis (Table E4). The results for uranium and thorium are in good agreement. The potassium analysis in the LPI laboratory is about 10 percent below that in the Lawrence Berkeley Laboratory and almost 20 percent below the analysis in the USGS laboratory.

TABLE E4

RESULTS OF INTERLABORATORY COMPARISON,
METALLOGENIC STANDARD NUMBER 1

	Lucius Pitkin, Inc.[1]	U.S. Geological Survey, Denver[2]	Lawrence Berkely Laboratory[3]
Sample Number[4]	325	340	341
Counting Time(s)	2000 sec.	approx. 8 hrs.; 4 runs for U, Th;	405 min. 1542 min.
Th, ppm	22.7 ± 2.5	22.04 ± .42	21.3
U, ppm	5.5 ± 1.2	6.05 ± .08	5.97
K, percent	2.84 ± 0.20	3.33 ± .06	3.10

[1]Date of analysis, March 28, 1972. Precision, quoted at the 95 percent confidence level (approximately twice the standard deviation), is the reproducibility as determined from a large number of analyses using the same preparation and the same counting time.

[2]Carl Bunker, personal communication, October 10, 1972. Precision is at 95 percent confidence level.

[3]Harold Wollenberg, personal communication, May 10, 1972. Preliminary analysis. Precision values not available.

[4]All samples are splits of a single parent sample, crushed to less than 10 mesh before splitting.

APPENDIX F

SAMPLES FROM THE LAKEVIEW AREA, OREGON

Samples from the Lakeview area of Oregon (samples 1222-1226, Appendix B) were excluded from the study because of field and petrographic data indicating their subvolcanic or volcanic origin (see Figure 4 and accompanying discussion in the main body of the report). By comparison, all other samples considered in the study are clearly plutonic in nature. Routine chemical analyses were nevertheless performed on these samples (Appendix D and Table F1) and a brief analysis of the data is herein reported.

The analytical data on samples from the Lakeview area, are without significant exception, consistent with the conclusions drawn (in the main body of this report) with respect to the distinctive chemical characteristics of plutonic rocks associated with vein-type uranium deposits (cf., the Reference Group or "reference areas"). The results of a comparison of the data on the Lakeview area samples with the characteristics of the Reference Group are summarized in the following:

Major Elements

Nockolds-Allen Index	No data available
Sodium	Well within the range of values for the Reference Group (Figure 24B and Table F1)
Potassium	Relatively high; values for the Lakeview samples are close to the extreme upper limit of potassium values for the Reference Group (Figure 26 and Table F1)
Magnesium	Relatively low in the range of values for the Reference Group (Figure 29B and Table F1)
Calcium	Very near the lower limit of the range of values for the Reference Group (Figure 31B and Table F1)
Iron	Very near the lower limit of the range of values for the Reference Group (Figure 33B and Table F1)
Titanium	Near the lower limit of the range of values for the Reference Group (Figure 37B and Table F1)
Manganese	Within lower half of the range of values for the Reference Group (Figure 39B and Table F1)

Table F1

ANALYTICAL DATA FOR SAMPLES FROM LAKEVIEW AREA, OREGON[1]

(parts per million)

Element	Sample Number	1222	1223	1224	1225	1226
Na		25000	25000	30000	25000	20000
Mg		1000	1000	2000	1000	3000
Ca		8000	8000	10000	8000	10000
Fe		5000	8000	5000	8000	5000
Ti		300	500	500	500	600
Mn		500	600	600	800	300
Al		90000	80000	100000	100000	90000
P		--	--	--	--	--
Li		20	20	30	50	20
Be		3	3	3	5	3
Sr		--	--	--	--	50
Ba		--	--	--	--	--
V		--	--	--	10	10
Zr		60	50	50	80	80

[1] Semiquantitative emission spectrographic analysis; quantitative analysis for zirconium.

Blank means not detected.

Aluminum	No data available
Silicon	No data available
Phosphorus	Below detection limit but consistent with data for the Reference Group (Figure 45B and Table F1)

Minor Elements

Lithium	Relatively high; one of the 5 samples exceeds the upper limit for Reference Group (Figure 47 and Table F1)
Beryllium	Within lower part of range of values for the Reference Group (Figure 52 and Table F1)
Strontium	In the lower part of range for the Reference Group (Figure 53 and Table F1)
Barium	Not detected but consistent with data for Reference Group (Figure 56 and Table F1)
Vanadium	In the lower part of the range for Reference Group (Figure 58 and Table F1)
Zirconium	Low, consistent with indications of generally lower values in the Reference Group (Figure 62 and Table F1)
Thorium	Around mid-range for Reference Group and for all samples (Figure 64 and Appendix D)
Uranium	Significantly higher than the average for all samples (Figure 68 and Appendix D), consistent with the conclusion for the Reference Group (Figure 69). Also significantly variable (5ppm range), consistent with same conclusion drawn for certain reference areas.
U/Th	Significantly higher than the average for all samples (Figure 76 and Appendix D) and somewhat variable, consistent with findings for the Reference Group
U/K	Higher than the average for all samples (Figure 79 and Appendix D) and with an appreciable range of values, consistent with findings for Reference Group.


Generalized Map of Mesozic and Cenozoic Intrusive Rocks
Showing Sample Locations
EXPLANATION
Cenozoic Intrusive Rocks
Mesozoic Intrusive Rocks
961 Cenozoic Sample with Sample Number
1219 Mesozoic Sample with Sample Number
N.
50 0 50 100 150 200 250 MILES
SCALE
Geology from the Basement Rock Map of the United States, 1968, U.S. Geological Survey
BELLINGHAM
YAKIMA
SPOKANE
COEUR D ALENE
BOISE
POCATELLO
LAKEVIEW
ELKO
SALT LAKE CITY
RENO
DENVER
GRAND JUNCTION
FRESNO
ST GEORGE
LAS VEGAS
FLAGSTAFF
ALBUQUERQUE
NEEDLES
SAN BERNARDINO
PHOENIX
TUCSON
SAN DIEGO
EL PASO
120°
115°
110°
105°
45°
40°
35°

Plate 2

Map Showing Locations of Intrusive Centers and Average Uranium Content
EXPLANATION
4.50 Average Uranium
Intrusive Center Location (Less than 5ppm)
2 Number of Samples
Intrusive Center Location (5ppm or more)
Group of Anomalous Intrusive Centers
N.
50 0 50 100 150 200 250 MILES
SCALE
120°
115°
110°
105°
45°
40°
35°