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CALGRAD: An Interactive Program in BASIC for the Calibration of Gamma-Ray Spectrometers

By F. B. Zelt[1]

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This program was written on a VAX-11/750 in VAX-11 BASIC V1.4. Although program tests have been made, no guarantee (expressed or implied) is made by the author regarding program correctness, accuracy, or proper execution on all computer systems. Any use of trade names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey. This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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CALGRAD: AN INTERACTIVE PROGRAM IN BASIC FOR THE CALIBRATION OF GAMMA-RAY SPECTROMETERS

By F. B. Zelt

ABSTRACT

Field measurement of gamma-ray spectra is a technique that is used by workers in various disciplines to assess the potassium, uranium, radium, and thorium content of geologic deposits and other materials. Reliable calibration of raw spectrometer data is essential to successful interpretation of spectrometer data. CALGRAD provides a reliable method for calibrating gamma-ray spectrometers, and it can be used with most techniques of field measurement that are currently in use. CALGRAD can be used by scientists and engineers who have no prior knowledge of calibration procedures or computer programming. The program teaches users about calibration procedures, and it provides graphical illustrations of the uncertainties of calibration factors. Users are provided with opportunities to fine-tune the calibration factors.

Factors calculated with CALGRAD were used to calibrate raw spectrometer data that were collected from outcrops of marine shale and chalk. The resulting estimates of potassium, uranium, and thorium contents were reasonably close to laboratory analyses of the rocks studied. Therefore, gamma-ray spectrometry and CALGRAD can be used to make reasonably accurate estimates of the potassium, uranium, and thorium content of outcrops of marine shale and chalk.

INTRODUCTION

Gamma-ray spectrometry is a versatile technique that is used to help assess uranium, oil, and gas resources, and uranium mill tailings. Gamma-ray spectra provide estimates of potassium, uranium, radium, and thorium content. Reliable measurements can be made in boreholes and on outcrops that contain as little as 1 percent potassium, 5 ppm uranium, and 10 ppm thorium (Fertl, 1979; Zelt, 1984). Fertl (1979) summarized several of the applications of gamma-ray spectrometry, which include recognizing paleoenvironments of deposition, lithologic facies, mineralogy, and abundance of organic matter in sedimentary rocks. Ratios of the elements are used in many of these applications. For example, Th/U is an indicator of the depositional environment of sedimentary rocks (Adams and Weaver, 1958). Reliable calibration of gamma-ray spectrometer readings is essential, particularly when ratios are used to study deposits that are relatively low in K, U, and Th.

Many methods are used to measure the gamma-ray spectra of rock and soil, including measurement in boreholes, on outcrops, in the laboratory, airborne measurements, measurements made with lead shielding, without lead shielding, and with and without lead shielding. Also, as gamma-ray spectrometry is applied to a wider range of geologic problems, geologists who are not familiar with calibration procedures will face the question of how to transform raw data, which is in counts per second, into concentrations of K, U, and Th. CALGRAD is designed to handle most methods of measuring gamma-ray spectra that are currently in use. As an interactive program, CALGRAD teaches the user about spectrometer calibration. The program provides a flexible calibration method that can be used by field geologists, geochemists, and geophysicists.

The program was written on a VAX-11/750 in VAX-11 BASIC V1.4. CALGRAD requires 42k bytes of disk for storage.

Two main types of detectors are presently used in gamma-ray spectrometry: detectors with sodium iodide crystals and detectors with germanium crystals. Sodium iodide detectors are used far more commonly than germanium detectors, largely because germanium detectors must be supercooled during operation. Sodium iodide detectors are also less expensive to purchase and operate than germanium detectors. The major oil and gas service companies use sodium iodide detectors in their borehole gamma-ray spectrometry (e.g., Fertl, 1979).

Calibration is an important part of spectrometer surveys in which sodium iodide crystals are used. The gamma-ray spectrum as observed with a sodium iodide detector consists of a series of broad peaks. Each of these peaks represents radiation emitted by the decay of one or more radionuclides, radiation that was emitted by the decay of other radionuclides but that has lost energy due to Compton scattering, and coincident gamma rays of lower energy that create the signals of higher-energy radiation in the detector (Marutzky and others, 1984; Ward, 1982). The effects of scattered and coincident radiation must be allayed through calibration. For example, a peak at 1.46 MeV is largely made up of gamma radiation from the decay of potassium-40. However, there is also down-scattered and coincident radiation from other radionuclides that must be subtracted from the 1.46 MeV peak. The amount of extraneous radiation is estimated and subtracted from the peak through calibration.

Germanium detectors have excellent resolution of gamma-ray peaks (Tanner and others, 1977). Therefore, the effects of scattered and coincident radiation are relatively small, and rigorous calibration methods may not be necessary.

ACKNOWLEDGMENTS

CALGRAD was written as part of an effort to develop outcrop measurement of gamma-ray spectra as a tool for petroleum exploration in sequences of marine shale. The field work and lab analyses were supported in part by the Department of Energy Western Gas Sands Program. The D.O.E. Grand Junction area office provided the spectrometer as an interagency loan to the U.S. Geological Survey Branch of Oil and Gas Resources. The work benefited greatly from the advice and published work of personnel of the Department of Energy and Bendix Field Engineering Corp. in Grand Junction, including D. Ward, B. N. Key, R. Malan, C. Monte, and R. Burger.

I am grateful to D. Gautier for his help and many useful comments, and to K. Krystinik for help with the statistics. J. Schmoker, K. Takahashi, and D. Mruk also made helpful suggestions. Jessie Donahue introduced me to gamma-ray spectrometry. Special thanks go to D. Zelt who helped in the field.

ANALYTICAL METHODS FOR CALIBRATION

The matrix method of calibration described by Stromswold and Kosanke (1978) is used in CALGRAD. In this method, it is assumed that potassium, uranium, thorium, and their daughter products account for all of the unscattered, scattered, and coincident radiation measured by the spectrometer. That is, the potassium-40 peak is assumed to be made up of radiation from the decay of potassium-40, scattered radiation from uranium, thorium, and their daughter products, and coincident rays from scattered radiation from potassium, uranium, thorium, and their daughter products.

If one assumes that the amounts and proportions of the daughter products of uranium and thorium are in constant proportion to the amounts of uranium and thorium, then the amount of non-scattered, scattered, and coincident radiation in the potassium-40 peak is proportional to the amounts of potassium, uranium, and thorium. Equation (1), from Stromswold and Kosanke (1978), illustrates this.

$$R_K = B_{11}C_K + B_{12}C_U + B_{13}C_{Th} \qquad (1)$$

where

R_K = total radiation in the 1.46 MeV potassium-40 peak, in counts per second,

B_{11}, B_{12}, B_{13} = constants,

C_K = concentration of potassium,

C_U = concentration of uranium, and

C_{Th} = concentration of thorium.

Because their peaks are not easily resolved, the direct decays of uranium-238 and thorium-232 are not measured by gamma-ray spectrometers with sodium iodide detectors. Instead, the 1.76 MeV peak of bismuth-214, a daughter product in the uranium-238 decay series, is used to estimate the abundance of uranium. The 2.62 MeV peak of thallium-208, a daughter product in the thorium-232 series, is used to estimate the abundance of thorium. These peaks are easily resolved with sodium iodide detectors (Ward, 1982). However, radon loss or disequilibrium in the uranium-238 or thorium-232 series could make estimation of the amounts of uranium-238 and thorium-232 with a sodium iodide detector difficult. Schwarcz and others (1982) and Tanner and others (1977) provide good reviews of disequilibrium in the uranium-238 series.

If we apply the assumptions implicit in equation (1) to the bismuth-214 peak (hereafter referred to as the uranium peak) and the thallium-208 peak (hereafter called the thorium peak), equations (2) and (3) result.

$$R_U = B_{21}C_K + B_{22}C_U + B_{23}C_{Th} \qquad (2)$$

$$R_{Th} = B_{31}C_K + B_{32}C_U + B_{33}C_{Th} \qquad (3)$$

If equations (1), (2), and (3) are combined, the matrices of equation (4) result.

$$\begin{bmatrix} R_K \\ R_U \\ R_{Th} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \times \begin{bmatrix} C_K \\ C_U \\ C_{Th} \end{bmatrix} \qquad (4)$$

or, in matrix notation (Stromswold and Kosanke, 1978):

$$\mathbf{R} = \mathbf{BC}. \qquad (5)$$

The nine constants in **B** can be found by solving nine equations. This is done for one peak at a time, as in equation (6).

$$\begin{bmatrix} R_{K_1} \\ R_{K_2} \\ R_{K_3} \end{bmatrix} = \begin{bmatrix} C_{K_1} & C_{U_1} & C_{Th_1} \\ C_{K_2} & C_{U_2} & C_{Th_2} \\ C_{K_3} & C_{U_3} & C_{Th_3} \end{bmatrix} \times \begin{bmatrix} B_{11} \\ B_{12} \\ B_{13} \end{bmatrix} \qquad (6)$$

where R_{K_1}, C_{K_1}, C_{U_1}, and C_{Th_1} are the known counting rate and concentrations at site 1; R_{K_2}, C_{K_2}, C_{U_2}, and C_{Th_2} are knowns from site 2, etc. Therefore, in order to solve for **B**, the counting rates and concentrations must be known from at least 3 sites. If data from N calibration sites are known, then N!/[3! x (N-3)!] combinations of 3 of the sites are possible, and each combination of 3 of the sites will yield a matrix **B**. Due to measurement uncertainties, each **B** will differ slightly. CALGRAD is designed to handle data from 3 to 19 calibration sites. Larger numbers of calibration sites provide more reliable results, and at least 5 calibration sites should be used. With 5 sites, 10 combinations are possible. With 19 sites, there are 969 possible combinations. A list of calibration sites in the U.S.A. is presented by George and Knight (1982). The concentrations of potassium, uranium, and thorium are known at these sites, and one has but to measure counting rates at the sites to calculate **B**.

Matrix **B** is not the final form of the calibration factors. In field applications, the goal of gamma-ray spectrometry is to estimate the concentrations of potassium, uranium, and thorium. Repeating equation (5), we have:

$$\mathbf{R} = \mathbf{BC} \qquad (5)$$

In the field, **R** is measured and **B** is known from calibration. The unknown **C** is to be solved for, so we have:

$$\mathbf{C} = \mathbf{B}^{-1}\mathbf{R}, \qquad (7)$$

where $\mathbf{B}^{-1}$ is the inverse of the 3X3 matrix **B**. If we let

$$\mathbf{A} = \mathbf{B}^{-1}, \qquad (8)$$

then we have

$$\mathbf{C} = \mathbf{AR}, \qquad (9)$$

where

$$\mathbf{A} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix}. \qquad (10)$$

A is referred to as the calibration matrix, and A_{11}, A_{12}, A_{13},...A_{33} are the calibration factors.

As mentioned previously, if data from 5 calibration sites are known, there will be 10 possible combinations of the 3 of the sites. CALGRAD computes a calibration matrix for each possible combination of 3 of the sites. The program also computes the medians and means and prints histograms of the calibration factors computed for all of the possible combinations.

For example, if data from 5 pads are put into CALGRAD, the program will compute 10 values for A_{11}, 10 values for A_{12}, etc. The program will print the median value for each calibration factor as a matrix of median calibration factors. If a histogram for A_{11} is requested, then CALGRAD will print a histogram of the values for A_{11}, the median, and the mean. The median is often a better measure of central tendency than the mean, due to occasional extreme variations in counting rate.

There is an important difference between the methods used in CALGRAD and those of Stromswold and Kosanke (1978). In equations (4) and (6), it is assumed that all of the radiation in the potassium, uranium, and thorium peaks comes from the deposit being studied. In field measurements, however, there are contributions from the atmosphere and from the terrain around the deposit being studied. This is called background radiation. In the method of Stromswold and Kosanke (1978), spectrometer measurements are taken at a calibration site that contains low concentrations of potassium (1.5%), uranium (2.2 ppm), and thorium (6.3 ppm). Stromswold and Kosanke (1978) consider the radiation measured by spectrometers at that calibration site to be "background." Using the potassium peak as an example, their equations can be expressed as:

$$\begin{bmatrix} R_{K_2} - R_{K_1} \\ R_{K_3} - R_{K_1} \\ R_{K_4} - R_{K_1} \end{bmatrix} = \begin{bmatrix} C_{K_2} - C_{K_1} & C_{U_2} - C_{U_1} & C_{Th_2} - C_{Th_1} \\ C_{K_3} - C_{K_1} & C_{U_3} - C_{U_1} & C_{Th_3} - C_{Th_1} \\ C_{K_4} - C_{K_1} & C_{U_4} - C_{U_1} & C_{Th_4} - C_{Th_1} \end{bmatrix} \begin{bmatrix} B_{11} \\ B_{12} \\ B_{13} \end{bmatrix}, \qquad (11)$$

where R_{K_1}, C_{K_1}, C_{U_1}, and C_{Th_1} are data from the "background" site and R_{K_2}, R_{K_3}, and R_{K_4} are from other calibration sites. The assumptions implicit to this approach are that: (1) the radiation measured at the "background" site primarily comes from the atmosphere and surrounding terrain rather than the deposit being measured, and (2) that the concentrations of potassium, uranium, and thorium at the "background" site are small relative to the other calibration sites. The first assumption may be good for unshielded detectors, but it is unwarrantable if lead shielding that blocks out radiation from the atmosphere and/or surrounding terrain is used. In Stromswold and Kosanke's example (the Department of Energy calibration sites at Walker Field Airport, Grand Junction, Colo.), the second assumption is also not warrantable. In addition, greater uncertainties are introduced with the subtractions in (11), because both the minuends and subtrahends are uncertain.

CALGRAD can be used to calibrate spectrometer measurements made with or without lead shielding, and with and without shielding. The approach used in CALGRAD for the potassium peak is:

$$\begin{bmatrix} R_{K_1} \\ R_{K_2} \\ R_{K_3} \end{bmatrix} = \begin{bmatrix} C_{K_1} & C_{U_1} & C_{Th_1} \\ C_{K_2} & C_{U_2} & C_{Th_2} \\ C_{K_3} & C_{U_3} & C_{Th_3} \end{bmatrix} \times \begin{bmatrix} B_{11} \\ B_{12} \\ B_{13} \end{bmatrix} + \begin{bmatrix} Z_K \\ Z_K \\ Z_K \end{bmatrix}, \qquad (12)$$

where Z_K (a counting rate) is the contribution of background radiation to the potassium peak in the area of the calibration sites. In this case, background radiation means radiation from the atmosphere and surrounding terrain. If one assumes that Z_K is small relative to the R_K's, or that Z_K at the calibration sites is close to Z_K in the field area, then the Z_K term can be disregarded. This assumption is good for measurements in which lead shielding is used to reduce background radiation. It is also good for unshielded measurements if background radiation in the field area is similar to background at the calibration sites.

If background radiation in the field differs from background at the calibration sites, then useful calibration factors can still be calculated using CALGRAD and the method of equation (12). One way to do this would be to measure Z_K, Z_U, and Z_{Th} at the calibration sites, using lead shielding to block radiation from the deposits used for calibration. An alternative method would be to run the data through CALGRAD, disregarding the Z terms for the moment. CALGRAD will yield plots similar to figure 1, which is a crossplot of the known concentrations of potassium at the Grand Junction calibration sites versus concentrations calculated using raw counting rate data collected with a Scintrex GAD-6 spectrometer with a GSP-3 detector and a calibration matrix generated by CALGRAD. If the calibration factors fit the data well, then the regression line (denoted by plusses) through the data points (shown by asterisks) will have a slope of approximately 1. The X-intercept in figure 1 represents background radiation in the potassium peak. (If the slope = 1, the X-intercept = the opposite of the Y-intercept). Using matrix B from (5), and the X-intercepts of the crossplots for potassium, uranium, and thorium, the Z factors can be estimated, as follows:

$$\begin{bmatrix} Z_K \\ Z_U \\ Z_{Th} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \times \begin{bmatrix} X_K \\ X_U \\ X_{Th} \end{bmatrix}, \qquad (13)$$

where X_K, X_U, and X_{Th} are the X-intercepts from the crossplots.

```
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                        *
      4.89  +                                      +
      4.65  +                                   +
      4.4   +                                +
      4.16  +                              *
KNOWN 3.91  +                           +
CONC. 3.66  +                        +
      3.42  +                      +
      3.17  +                   +
      2.93  +                +
      2.68  +              +
      2.43  +           +
      2.19  +        +
      1.94  +      **
      1.7   +   +
      1.45  + *
            +++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     3       3.7     4.5     5.2
                          CALC. CONC.
REGRESSION LINE:   Y = -.518837E-01  +  .992957 X
CORREL. COEFF. =  .999786     DETERMIN. COEFF. =  .999572
```

Figure 1.--Known potassium versus calculated potassium.

The matrix **B** is the inverse of the calibration matrix, and it can be calculated using a simple program such as Appendix A. Once the Z factors are known, then equation (12) is used to find new calibration factors. This can be done by subtracting Z_K from each R_K, Z_U from each R_U and Z_{Th} from each R_{Th}, and running the data through CALGRAD. The crossplots for known versus calculated concentrations of potassium, uranium, and thorium should now have X-intercepts that are close to zero. If the intercepts are not near zero, then the Z factors may have to be adjusted. To use the resulting calibration matrix, as in (9), background counts in the field area for the potassium, uranium, and thorium peaks must be known, and they must be subtracted from the raw data of matrix **R** prior to calculating concentrations.

USE OF SHIELDING

A complete discussion of field methods for the measurement of gamma-ray spectra is beyond the scope of this paper. Ward (1982) and Marutzky and others (1984) provide masterful reviews of the methodology of gamma-ray spectrometry. Their discussion of the statistical uncertainty of field measurements is particularly useful. Nevertheless, a brief discussion of the use of lead shielding in spectrometry will help to illustrate some of the features of CALGRAD.

Gamma-ray spectrometer measurements can be made with no shielding around the detector of the spectrometer. The radiation registered by the spectrometer would then include contributions from the atmosphere, surrounding terrain, and the deposit being studied. Unshielded measurements are greatly affected by the geometry of the surface of the deposit being studied. For example, measurements made at the base of a cliff will be significantly higher than measurements of the same deposit made at the top of a ridge. Shielding can be used to minimize the effects of changes in background radiation and surface geometry on spectrometer surveys. The use of shielding is also helpful if the deposits being studied have the low concentrations of potassium (<1%), uranium (<5 ppm), and thorium (<10 ppm) characteristic of average marine shales. This is because background radiation makes up a relatively large proportion of the total radiation measured by an unshielded detector on deposits such as average marine shales, and changes in background radiation could cause large errors.

Lead is the material commonly used to shield gamma-ray detectors. Lead shielding must be 4 to 5 cm thick to absorb 90 percent of the radiation in the 2.62 MeV thallium-208 peak (Marutzky and others, 1984).

There are several ways that shielding can be used to aid spectrometer surveys (Marutzky and others, 1984). Shielding can be wrapped around the detector, leaving an aperture through which radiation from the deposit being measured is permitted to strike the detector. Such a device is called a collimator, and it helps to eliminate the effects of background radiation. For simplicity, these measurements are referred to as unshielded in CALGRAD because there is no shielding between the detector and the deposit being measured.

Differential measurements (or delta measurements) are also made with shielding. In differential measurements, one set of readings is taken with shielding between the detector and the deposit. Another set of readings is taken (with the detector in precisely the same spot) without shielding between the detector and the deposit. The shielded measurements are subtracted from the unshielded readings to yield spectrometer readings that reflect the deposit being studied. The raw spectrometer data from differential measurements should be put into CALGRAD as shielded and unshielded data. The program executes the subtractions automatically. Differential measurements can be made with or without collimation of the detector. Figures 2 and 3 show one technique for making differential measurements without a collimator.

For reliable results, the measurement techniques used during calibration must be identical to those used in the field.

Spectrometer data should be recorded as number of counts per S seconds, where S is the counting time set on the spectrometer. Raw data should not be recorded as counts per second, because the statistical reliability of the data is a function of the total number of counts (Ward, 1982; Marutzky and others, 1984). Data can be entered into CALGRAD as counts per S seconds, where $S \geq 1$, but S must be entered near the beginning of the program and S must be constant for all calibration measurements. If the counting time was changed during calibration, then the data can be manipulated such that S is the greatest common factor of the counting times used during calibration. Up to 30 sets of readings from each calibration site can be put into CALGRAD.

THE PROGRAM

CALGRAD can be divided into four parts (Appendix B). Lines 10-2960 print a heading, dimension variables, and provide the user with a crash course on the calibration of gamma-ray spectrometers. There are three user comprehension tests, and at the end of this section of the program, the user is given an opportunity to review the examples.

The second part of the program is devoted to data input and calculation of calibration factors. On lines 2970-4180, the data are input and printed for checking. Incorrect entries can be corrected. Lines 4190-4770 are used to calculate the calibration factors that can be found with each combination of three of the calibration sites. A matrix of the median calibration factors is calculated, stored as matrix O, and printed.

Lines 4780-6750 and 12610-12620 comprise the third part of CALGRAD. In this segment of the program, the calibration factors are checked by calculating concentrations of potassium, uranium, and thorium at the calibration sites by multiplying the calibration factors by the raw spectrometer data. Crossplots are used to compare the calculated concentrations with the known concentrations of potassium, uranium, and thorium at the calibration sites. CALGRAD also recommends changes in the calibration factors. These recommended changes are based on the following procedure. Using potassium as an example, a series of three regressions are calculated by CALGRAD. In the first regression, the estimated concentration of potassium is subtracted from the known concentration of potassium at each calibration site. This "error" is then plotted against the concentration of potassium at each site. In the next regression, the estimated concentration of potassium and the slope of the first regression line multiplied by the concentration of potassium are both subtracted from the known concentration of potassium. These differences are then regressed against the known concentration of uranium at each site. In the third crossplot, the slope of the first crossplot is multiplied by the concentrations of potassium at each site.

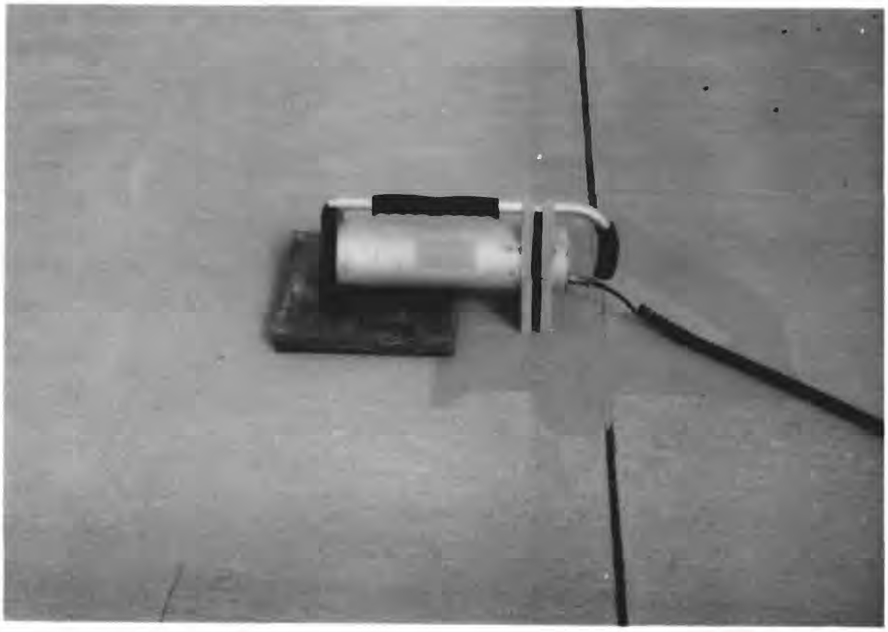

Figure 2.--Shielded measurement.

Figure 3.--Unshielded measurement.

The slope of the second crossplot is then multiplied by the concentrations of uranium at each site. Then, for each pad, these quantities and the estimated concentrations of potassium are subtracted from each known concentration of potassium. The resulting differences are then plotted against the concentration of thorium at each site. The process is then repeated with the slopes of the other two regressions being taken into account for each regression. After many repetitions, the resulting crossplots provide estimates of the amount of error in the calculated concentrations of potassium that can be attributed to the calibration factors A_{11}, A_{12}, and A_{13}. However, it must be noted that if the known concentration of potassium, uranium, and thorium in the pads are correlated, then this technique of attributing error to specific calibration factors may not be useful. Therefore, it is necessary to treat the recommended changes in the calibration factors with caution. If the recommended calibration factors are not close to the median or mean calibration factors, then perhaps the recommended changes should not be used.

The fourth segment of the program consists of a series of subroutines. This part of the program appears on lines 7000-12600 of Appendix B. Each subroutine is preceded by a REM statement that describes the subroutine's function. For example, the subroutine on lines 10080-10330 calculates the equation of the regression line and coefficients of correlation and determination for a series of data with two parameters. The subroutine on lines 10360-11450 prints a crossplot of data points with a regression line and correlation coefficients. The algorithm for the crossplots includes automatic scaling of the axes. Data points are printed as asterisks or numbers, and regression lines are plotted as plusses. In spaces that contain more than one data point, the numbers of data points in the space are printed.

TEST STUDY

Appendix C is an example run of CALGRAD. Data for this run were collected at the Department of Energy/Bendix Field Engineering calibration facility at Walker Field Airport, Grand Junction, Colo. (George and Knight, 1982). The data were collected with a Scintrex GAD-6 spectrometer and Scintrex GSP-3 detector obtained from the Department of Energy Grand Junction Area Office on an interagency loan to the U.S. Geological Survey, Branch of Oil and Gas Resources.

The measurements in the example were made with the differential technique of using lead shielding. At each calibration site, one set of measurements was made with lead plates under the detector (fig. 2). The lead plates total 12 inches (30.5 cm) long, 10.5 inches (26.7 cm) wide, 1.26 inches (3.2 cm) high, and 75 lbs (34 kg). The sodium iodide crystal in the GSP-3 detector is located near the front of the detector, and the crystal was centered over the lead plates. Markings on the top plate were used to center the detector consistently at each site. A second set of measurements was made without the lead shielding (fig. 3). Wooden holders were used to keep the detector in the same position with and without the lead, relative to the deposit being measured.

In the summer of 1983, a series of gamma-ray spectrometer measurements were made on outcrops of the Graneros Shale, Greenhorn Limestone, and Carlile Shale near Pueblo, Colo. The rocks measured include non-calcareous claystone, calcareous clayshale and claystone, and chalk exposed in the Rock

Canyon Anticline. The measurements were made with the spectrometer and lead shielding described above. In the less well-indurated rocks, measurements were made in holes dug approximately one cubit (54 cm, 21 inches) wide, one cubit plus two hands long (71 cm, 28 inches), and as much as one cubit deep (fig. 4). It was not always possible to dig such holes in the chalky part of the section, and in places the measurements were made with the detector vertical (figs. 5 and 6). The data were collected at intervals of 300 seconds, with the spectrometer on the differential setting (Scintrex, 1977). At least eight 300-second measurements were made at each site: four with and four without the lead shielding. In the less radioactive, chalky Bridge Creek Member of the Greenhorn Formation, up to sixteen 300-second measurements were made at each site.

Each morning, a set of measurements was made at the same site. This was done primarily to make certain that the spectrometer was working properly, as recommended by Ward (1982).

Using the calibration factors calculated with CALGRAD, the concentrations of potassium, uranium, and thorium in the Rock Canyon Anticline outcrops were estimated. Outcrop samples were also collected and analyzed for uranium (delayed neutron activation analysis, detection limit .1 ppm), thorium (instrumental neutron activation analysis, detection limit .1 ppm), and potassium (x-ray fluorescence, detection limit .01 percent) by X-ray Assay Labs of Canada. Figures 7, 8, and 9 show the correlation between results obtained in the field with the spectrometer and the laboratory analyses. It should be remembered that the spectrometer measured a sample mass that is 10^5 times larger than that measured in the laboratory analyses. Also, the calibration site and outcrop measurements of gamma-ray spectra have not been corrected for moisture content. To correct outcrop measurements for moisture content, the moisture content of the rocks must be measured (Marutzky and others, 1984).

Figures 7, 8, and 9 show that gamma-ray spectrometry of outcrops of marine shale and chalk can yield reasonably accurate estimates of potassium, uranium, and thorium content. Estimates of uranium and thorium content made with the spectrometer are close to estimates made by neutron activation. The daughter products of uranium and thorium in the rocks studied in outcrops along the Rock Canyon Anticline must be in secular equilibrium to about the same degree as the calibration pads at Walker Field Airport (including radon exhalation). According to Key (1984, personal comm.), uranium and thorium in the Walker Field Airport calibration pads are nearly in equilibrium with their daughter products. This is based on measurements of radionuclides made with gamma-ray spectrometers that have germanium crystals in their detectors. Potassium-40 is measured directly by gamma-ray spectrometers with sodium iodide crystals.

CONCLUSIONS

CALGRAD is a computer program in BASIC that provides field geologists, geochemists, and geophysicists with a means to calibrate gamma-ray spectrometer data. CALGRAD uses simultaneous equations to calculate a 3X3 matrix of calibration factors that can be used to convert raw spectrometer data into percent potassium, ppm uranium, and ppm thorium. CALGRAD is interactive.

Figure 4.--Field measurement in shale.

Figure 5.--Vertical shielded measurement.

Figure 6.--Vertical unshielded measurement.

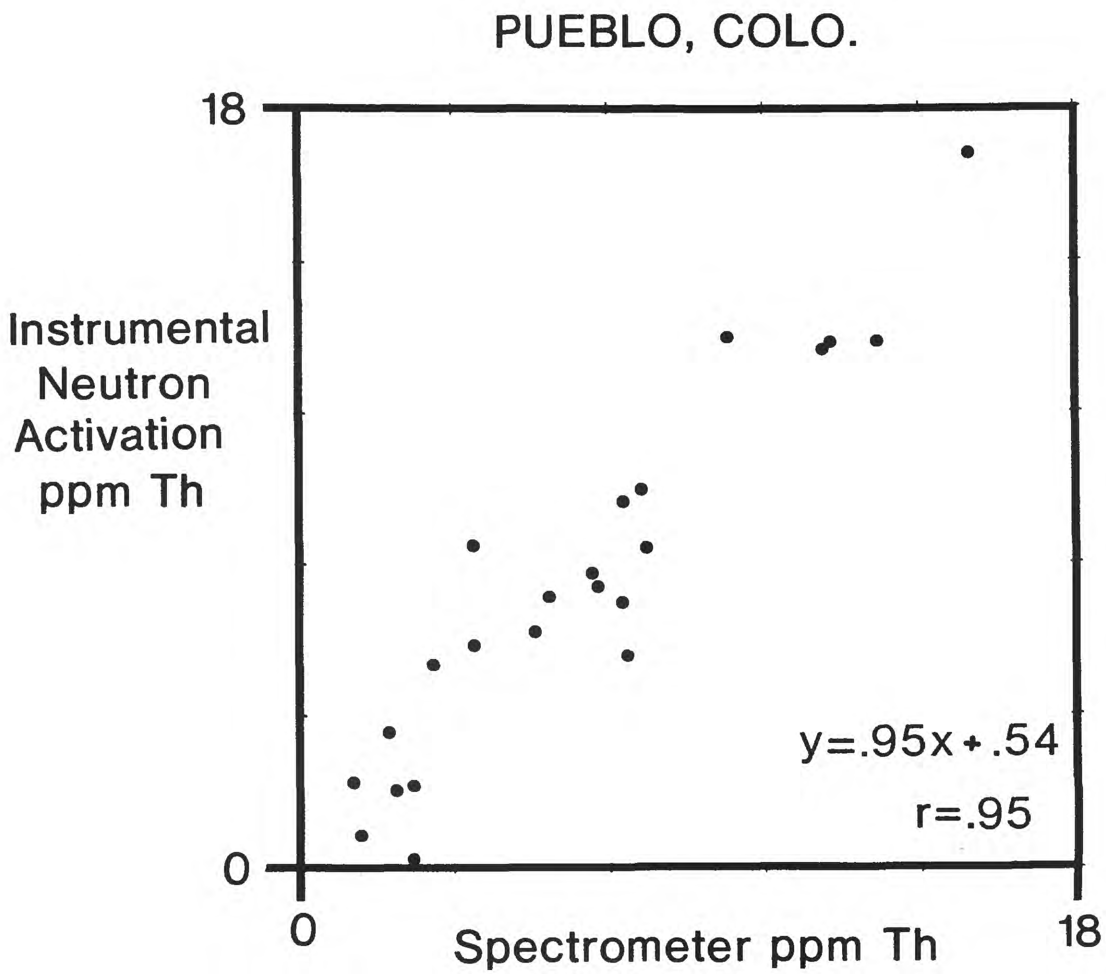

Figure 7.--Thorium lab analyses versus spectrometer measurements.

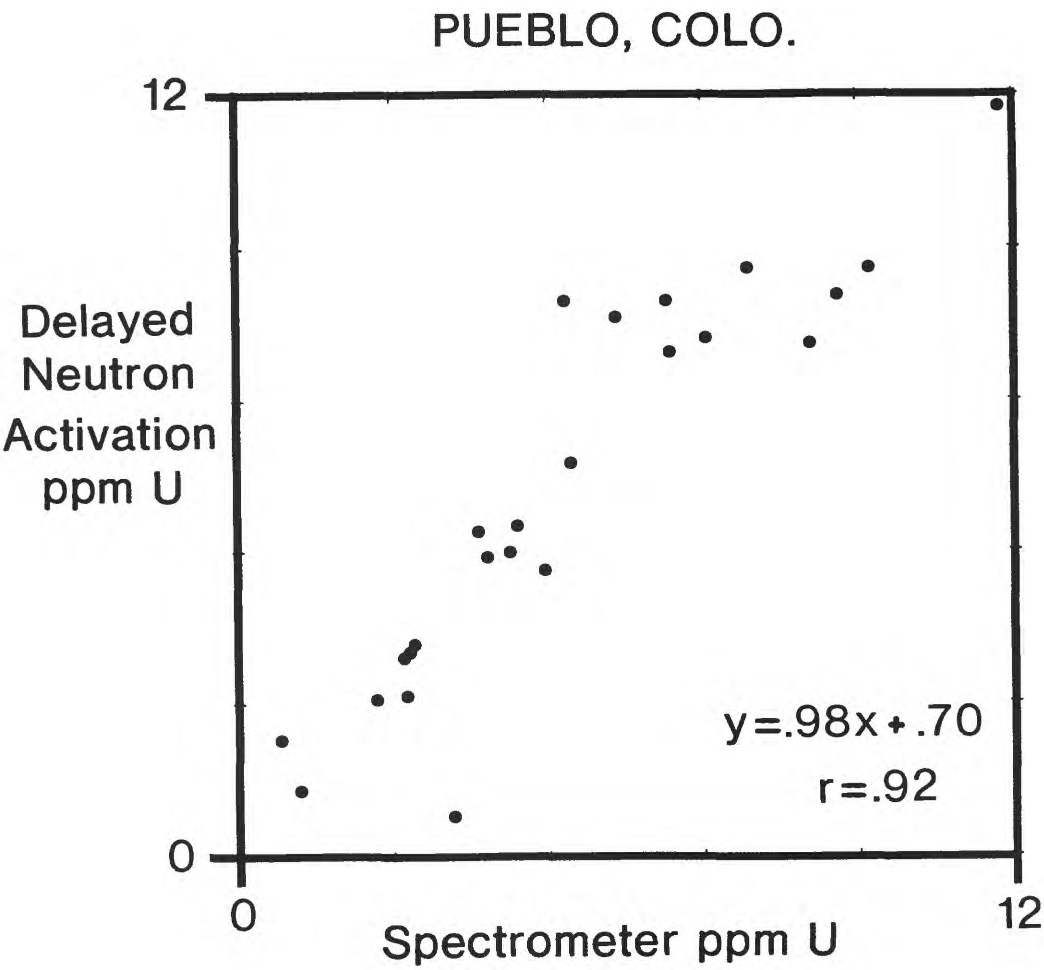

Figure 8.--Uranium lab analyses versus spectrometer measurements.

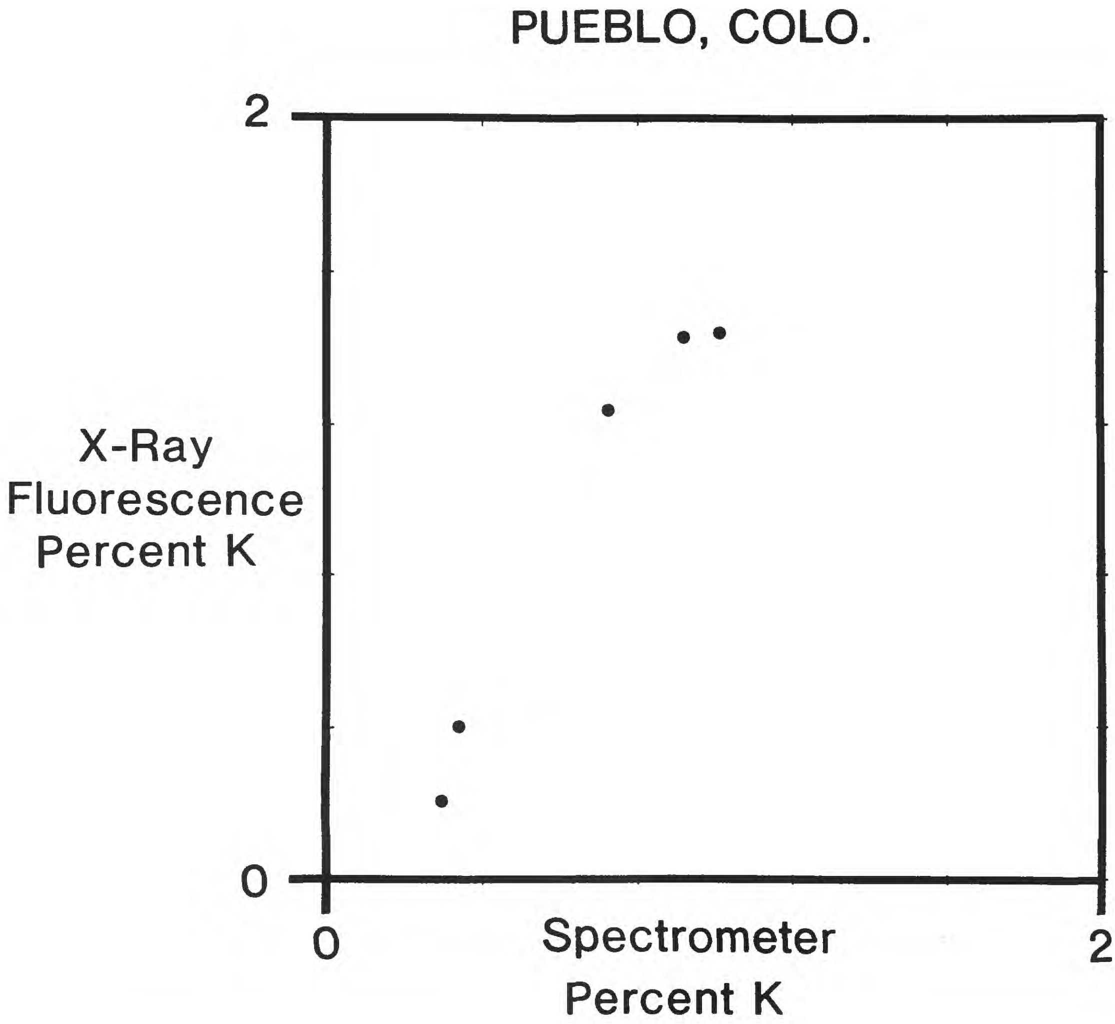

Figure 9.--Potassium lab analyses versus spectrometer measurements.

It teaches the user about calibration and field measurement of gamma-ray spectra. The program can be used for shielded, unshielded, and differential measurements made with instruments that have sodium iodide detectors. Users are also provided with crossplots of known versus calculated concentrations at the calibration sites. These crossplots can be used to fine-tune the calibration factors. Comparison of spectrometer measurements that were calibrated using CALGRAD with laboratory analyses shows that CALGRAD provides reasonably reliable calibration factors.

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APPENDIX A

A BASIC Program to Invert a 3X3 Matrix

```
10 DIM A(3,3),B(3,3)
20 PRINT "This program inverts a 3X3 matrix."
30 FOR X=1 TO 3
40  FOR Y=1 TO 3
50   PRINT "Please input the ";X;",";Y;" entry."
60   INPUT A(X,Y)
70  NEXT Y
80 NEXT X
90 MAT B=INV(A)
100 PRINT
110 PRINT "The input matrix is:"
120 MAT PRINT A;
130 PRINT
140 PRINT "The inverse matrix is:"
150 MAT PRINT B;
160 END
```

APPENDIX B

Listing of CALGRAD

```
10 PRINT
20 PRINT
30 PRINT "CCCCCCC       A      L        GGGGGGG  RRRRRRR      A      DDDDD"
40 PRINT "C            A A     L        G        R     R     A A     D    D"
50 PRINT "C           A   A    L        G  GGGG  RRRRRRR    A   A    D      D"
60 PRINT "C         AAAAAAA    L        G     G  R   R     AAAAAAA   D     D"
70 PRINT "CCCCCCC   A       A  LLLLLLL  GGGGGGG  R     R  A       A  DDDDD"
80 PRINT
90 PRINT
100 PRINT "                      by F.B. Zelt, 1984."
110 PRINT
120 PRINT
130 PRINT
135 DIM S(30),UN(30)
140 DIM Y1(20), N(20,2), X3(40), A(1500,3), X2(3000), O(3,3), O1(3,3), A1(3,3)
150 DIM C1(3,3), R(3,1), D(3,1), M(1500), X4(1500), W(20,3), W1(3,1), W3(100)
160 DIM W4(100), B(7000), B1(7000), B2(7000), X(7000), Y(7000), V(3,3)
170 DIM Z(7000), X1(100), J(100), I(100), B6(100,2), B4(100), Z9(100), G1(30)
180 DIM K(40,30), U(40,30), T(40,30), V1(1000), V2(1000), V3(1000)
190 PRINT "     This program is designed to calculate calibration factors for"
200 PRINT "the potassium (K), uranium (U) and thorium (Th) channels of gamma-"
210 PRINT "ray spectrometers.  To calibrate a spectrometer, readings must be"
220 PRINT "taken on sites at which the concentrations of K, U and Th are known,"
230 PRINT "such as the D.O.E./Bendix calibration pads in Grand Junction, Colo.."
240 PRINT "(A catalogue of calibration facilities has been published by George"
250 PRINT "and Knight (1982).)  The input to this program must consist of "
260 PRINT "spectrometer readings and known concentrations from at least 3"
270 PRINT "different sites (pads)."
280 PRINT
290 GOSUB 12280
300 PRINT
310 PRINT "     It very important to base the calibration factors"
320 PRINT "on reliable data.  Therefore, the data put into this program should"
330 PRINT "consist of spectrometer readings from calibration sites at which "
340 PRINT "the concentrations of K, U and Th are known to within standard"
350 PRINT "deviations of less than ten percent.  The concentrations also should "
360 PRINT "not vary greatly over the area measured by the spectrometer.  Ward"
370 PRINT "(1982) suggested that at least three spectrometer readings should"
380 PRINT "be taken from each calibration site (pad).  He further recommended"
390 PRINT "that if the readings at a site differ by more than twice the square"
400 PRINT "root of one reading, then more readings should be taken.  This "
410 PRINT "program is designed to handle up to 30 readings at each pad."
420 PRINT "Marutzky et al (1984) suggested that the minimum number"
430 PRINT "of counts in the window with the lowest number of counts (usually"
440 PRINT "Th) should be 1000 at each pad.  One thousand counts in the lowest"
450 PRINT "window would also be a good minimum number for the difference "
460 PRINT "between shielded and unshielded counts in differential measurements."
470 PRINT
480 GOSUB 12280
490 PRINT
500 PRINT "     This program uses a matrix method to find the calibration "
510 PRINT "factors.  The method used is similar but not identical to the method"
520 PRINT "described by Stromswold and Kosanke (1978).  Calibration factors"
530 PRINT "calculated with the method of Stromswold and Kosanke (1978) are"
540 PRINT "useful for measurements made with no lead shielding around the"
550 PRINT "detector of the spectrometer.  However, CALGRAD can be used to "
560 PRINT "calibrate measurements made with or without lead shielding around"
570 PRINT "the detector.  This program can also be used to calibrate differ-"
580 PRINT "ential measurements.  The calibration factors generated by this "
590 PRINT "program can be used to calibrate gamma-ray spectrometer measurements"
```

```
600 PRINT "of highly radioactive deposits such as uranium mill tailings and"
610 PRINT "uranium-rich black shales as well as measurements of deposits that"
620 PRINT "are relatively low in K, U and Th, such as average shales."
630 PRINT
640 GOSUB 12280
650 PRINT
660 PRINT "     There are several ways that lead shielding can be used to aid"
670 PRINT "spectrometer surveys (Marutzky et al, 1984).  Lead"
680 PRINT "shielding is generally used to take measurements in deposits that"
690 PRINT "are low in K, U and Th (such as average shales) and to take more"
700 PRINT "accurate measurements in deposits that are highly radioactive."
710 PRINT "For example, lead shielding can be placed strategically around the"
720 PRINT "detector of the spectrometer to block out background radiation."
730 PRINT "Lead shielding is also used to make differential measurements.  In"
740 PRINT "differential measurements, one set of readings is taken with "
750 PRINT "shielding between the detector and the deposit being studied."
760 PRINT "These measurements are considered to represent background radiation."
770 PRINT "Another set of measurements is made made with no shielding between "
780 PRINT "the detector and the deposit.  The background measurements are then"
790 PRINT "subtracted from the unshielded measurements to yield spectrometer"
800 PRINT "readings that (ideally) reflect only the deposit being studied."
810 PRINT
820 GOSUB 12280
830 PRINT
840 PRINT "     For simplicity, all non-differential measurements will be "
850 PRINT "referred to as unshielded.  Differential (also called delta) "
860 PRINT "measurements will consist to a set of shielded measurements and a"
870 PRINT "set of unshielded readings."
880 PRINT
890 PRINT "     For more information about gamma-ray spectrometer surveys,"
900 PRINT "including discussions of the uses of lead shielding, refer to "
910 PRINT "Marutzky et al (1984) and Ward (1982)."
920 PRINT
930 GOSUB 12280
940 PRINT
950 GOSUB 7040
960 PRINT
970 PRINT "     If data from more than 3 calibration pads are input, the"
980 PRINT "program uses every possible combination of 3 of the pads to find a"
990 PRINT "series of calibration matrices.  For example, if data from 4 pads"
1000 PRINT "are input, then 4!/(3! x (4-3)!) or 4 combinations of 3 of the pads"
1010 PRINT "will be possible, and four calibration matrices will be calculated."
1020 PRINT "The program then selects a matrix of the median calibration factors,"
1030 PRINT "which will be presented to you.  You will then have an opportunity"
1040 PRINT "to view all of the possible calibration factors (from all of the "
1050 PRINT "possible calibration matrices) and test the usefulness of each"
1060 PRINT "median calibration factor.  If data from 10 pads are put into the"
1070 PRINT "program, then each median calibration factor will be based on "
1080 PRINT "10!/(3! x (10-3)!) or 120 calibration factors.  Larger numbers of"
1090 PRINT "pads lead to more precise calibration matrices.  This program is"
1100 PRINT "designed to handle from 3 to 19 calibration pads, and it can be "
1110 PRINT "altered to handle more pads by redimensioning some of the variables."
1120 PRINT
1130 GOSUB 12280
1140 PRINT
1150 PRINT "     The median calibration matrix and the raw spectrometer data"
1160 PRINT "will be used to calculate the concentrations of K, U and Th"
1170 PRINT "in the pads.  The calculated concentrations will be compared with"
1180 PRINT "the known concentrations of K, U and Th in the pads, which you"
1190 PRINT "must enter into the program.  If the calculated concentrations"
```

```
1200 PRINT "are very close to the known concentrations, then the calibration"
1210 PRINT "factors are good.  If the calculated concentrations differ from"
1220 PRINT "the known concentrations, then changing the calibration factors"
1230 PRINT "slightly may improve the results.  This program will help you to"
1240 PRINT "test the usefulness of the calibration factors it has generated"
1250 PRINT "from your data.  The program will also let you change individual"
1260 PRINT "calibration factors and show the effects of such changes on the"
1270 PRINT "concentrations of K, U and Th calculated with the new calibration"
1280 PRINT "factors.  However, in order to do this, you must be familiar with"
1290 PRINT "the calibration matrix and how it is used to find concentrations"
1300 PRINT "of K, U and Th."
1310 PRINT
1320 GOSUB 12280
1330 PRINT
1340 PRINT "     The program will store the matrix of median calibration"
1350 PRINT "factors, which will be printed at the end of the program."
1360 PRINT "However, please keep a record of any changes in the calibration"
1370 PRINT "factors you decide to test, because only the most recent value"
1380 PRINT "for each calibration factor is stored in the changeable calibration"
1390 PRINT "matrix."
1400 PRINT
1410 PRINT "     If changes in the calibration factors do not result in calcu-"
1420 PRINT "lated concentrations that are close to the known concentrations,"
1430 PRINT "then perhaps the errors are not due to the calibration factors."
1440 PRINT "IF THE RAW SPECTROMETER DATA OR THE KNOWN CONCENTRATIONS ARE NOT"
1450 PRINT "RELIABLE (eg.-HAVE LARGE UNCERTAINTIES), THEN RELIABLE CALIBRATION"
1460 PRINT "CALIBRATION FACTORS CANNOT BE OBTAINED.  The following portion of"
1470 PRINT "this program will give you an indication of the MINIMUM uncertainty"
1480 PRINT "involved in using your field techniques and calibration factors."
1490 PRINT
1500 GOSUB 12280
1510 PRINT
1520 PRINT "     Depending on the field conditions and techniques used, "
1530 PRINT "disequilibrium in the uranium series can cause large errors in"
1540 PRINT "estimates of uranium content.  Therefore, THE U.S. GEOLOGICAL"
1550 PRINT "SURVEY, PRINCETON UNIVERSITY AND F.B.ZELT ASSUME NO RESPONSIBILITY"
1560 PRINT "OR LIABILITY FOR CALCULATIONS THAT ARE BASED ON THE RESULTS OF"
1570 PRINT "THIS PROGRAM."
1580 PRINT
1590 GOSUB 12280
1600 PRINT
1610 PRINT "     Please recall the use of calibration factors in determining"
1620 PRINT "the concentrations of K, U and Th.  The calibration factors are"
1630 PRINT "multiplied by the raw data to produce estimates of percent K,"
1640 PRINT "ppm U and ppm Th."
1650 PRINT
1660 GOSUB 7140
1670 PRINT
1680 PRINT "     Suppose that for each calibration pad, the % K calculated"
1690 PRINT "from the calibration factors and raw data is larger than the"
1700 PRINT "known % K.  A slight adjustment of one or more calibration factors"
1710 PRINT "could reduce this error.  If the error is positive; that is, if"
1720 PRINT "             K % calculated  >  K % known,"
1730 PRINT "then would one want to reduce of increase the calibration factors"
1740 PRINT "(please type R or I)";
1750 INPUT Q3$
1760 IF Q3$="R" THEN 1800
1770 PRINT "No, please think the problem through again."
1780 PRINT
1790 GO TO 1610
```

```
1800 PRINT "Yes, that is correct.  Of course, one would not change the caliba-"
1810 PRINT "tion factors without being certain that the new calibration factor"
1820 PRINT "is reasonably close to the median or mean of the calibration "
1830 PRINT "factors calculated from tne data."
1840 PRINT
1850 PRINT "      Now suppose that there is a positive error in the calculated"
1860 PRINT "% K, and that the error increases with increasing Thcps.  Which"
1870 PRINT "calibration factor would you consider changing:"
1880 PRINT "Row number = ";
1890 INPUT L8
1900 PRINT "Column number = ";
1910 INPUT L9
1920 IF L8=1 AND L9=3 THEN 1960
1930 PRINT "No."
1940 GOSUB 7140
1950 GO TO 1850
1960 PRINT "Good.  Now, please regard the following plot.  The asterisks (*) "
1970 PRINT "and numbers indicate data points, and the plusses (+) show the "
1980 PRINT "regression line."
1990 PRINT
2000 GOSUB 12280
2010 PRINT
2020 I(1)=2
2030 I(2)=4
2040 I(3)=5
2050 I(4)=8
2060 I(5)=10
2070 J(1)=.18
2080 J(2)=.42
2090 J(3)=.49
2100 J(4)=.83
2110 J(5)=.97
2120 P=5
2130 N=P
2140 GOSUB 9850
2150 W$(1)="Error"
2160 W$(2)="in U "
2170 W$(3)="Calc."
2180 W$(4)="dueto"
2190 W$(5)="A2,2 "
2200 W$(6)="     "
2210 W$(7)="Known"
2220 W$(8)=" Ucps"
2230 W$(9)="  -  "
2240 GOSUB 10080
2250 GOSUB 10360
2260 PRINT
2270 PRINT "      The crossplot above showed that a decrease in A(2,2) would"
2280 PRINT "reduce the error in the calculated ppm uranium."
2290 PRINT
2300 GOSUB 12280
2310 PRINT
2320 PRINT "      Here is another crossplot:"
2330 I(1)=10
2340 I(2)=12
2350 I(3)=12
2360 I(4)=15
2370 I(5)=20
2380 J(1)=-.52
2390 J(2)=-.61
```

```
2400 J(3)=-.57
2410 J(4)=-.7
2420 J(5)=-1.03
2430 GOSUB 9850
2440 W$(2)="in Th"
2450 W$(5)="A3,1 "
2460 W$(8)=" Kcps"
2470 GOSUB 10080
2480 GOSUB 10360
2490 PRINT
2500 PRINT "     Would you increase or decrease A(3,1) to reduce the error"
2510 PRINT "(Please type I or D)";
2520 INPUT Q3$
2530 IF Q3$="I" THEN 2570
2540 PRINT "No, A(3,1) should be increased."
2550 PRINT "Pernaps you should review this section."
2560 GO TO 2580
2570 PRINT "That is correct."
2580 PRINT "     Would you like to review the section about correcting the"
2590 PRINT "calibration factors, Y or N";
2600 INPUT Q3$
2610 IF Q3$="Y" THEN 1610
2620 PRINT
2630 PRINT "     In the second half of the program, you will have opportunities"
2640 PRINT "to fine-tune the calibration factors this program generates from"
2650 PRINT "your data.  You may notice that the program suggests changes in"
2660 PRINT "the calibration factors.  The changes suggested for some of the"
2670 PRINT "calibration factors may not seem reasonable.  For example, a"
2680 PRINT "suggested change may not be close to the median or mean of the"
2690 PRINT "group of calioration factors that was calculated.  Use your judgement"
2700 PRINT "to decide whether of not to use the suggested calibration factor"
2710 PRINT "changes.  In any event, the suggested changes indicate whether the"
2720 PRINT "calibration factors should be increased of decreased."
2730 PRINT
2740 PRINT "     Data entered into this program must be separated by commas or"
2750 PRINT "by pressing the RETURN key.  Data cannot be separated by spaces."
2760 PRINT
2770 GOSUB 12280
2780 PRINT
2790 PRINT
2800 PRINT "                          REFERENCES"
2810 PRINT
2820 PRINT "George,D.C. and Knight, L., 1982, Field calibration facilities for"
2830 PRINT "     environmental measurement of Radium, Thorium and Potassium;"
2840 PRINT "     GJ/TMC-01(82) UC-70A, 53pp."
2850 PRINT "Marutzky, S.J., Steele, W.D., Key, B.N., and Kosanke, K., 1984,"
2860 PRINT "     Surface gamma-ray measurement protocol; GJ/TMC-06, 30pp."
2870 PRINT "Stromswold, D.C. and Kosanke, K.L., 1978, Calibration and error"
2880 PRINT "     analysis for spectral radiation detectors; IEEE Trans. on"
2890 PRINT "     Nuclear Science, Vol. NS-25, No. 1, 782-786."
2900 PRINT "Ward, D.L., 1982, Surface radiometric surveys for uranium using"
2910 PRINT "     gross and spectral gamma-ray measurements; GJBX-97(82), 36pp."
2920 PRINT
2930 PRINT
2940 GOSUB 12280
2950 PRINT
2960 PRINT
2970 PRINT "PLEASE INPUT THE NUMBER OF CALIBRATION PADS ( # CALIBRATION SITES) ";
2980 INPUT P
2990 IF P<20 THEN 3060
```

```
3000 PRINT "THIS PROGRAM IS DESIGNED TO HANDLE 3 TO 19 CALIBRATION SITES."
3010 PRINT " TO RUN THE PROGRAM WITH 20 OR MORE CALIBRATION SITES, THE DIM"
3020 PRINT " STATEMENTS MUST BE CHANGED.  VARIABLES THAT HAVE BEEN DIMENSIONED"
3030 PRINT " TO 1000 SHOULD BE RE-DIMENSIONED TO N!/3!*(N-3)! WHERE N=NUMBER"
3040 PRINT " OF CALIBRATION SITES.  VARIABLES NOW DIMENSIONED TO 3000 SHOULD"
3050 PRINT " BE RE-DIMENSIONED ACCORDINGLY."
3060 PRINT "PLEASE INPUT THE NUMBER OF SECONDS PER MEASUREMENT";
3070 INPUT S
3080 PRINT "ARE THE DATA DIFFERENTIAL (DELTA) MEASUREMENTS, Y OR N?"
3090 PRINT "(FOR A DEFINITION OF OIFFERENTIAL MEASUREMENT, ANSWER Q )"
3100 INPUT Q$
3110 IF Q$="N" THEN 3200
3120 IF Q$="Y" THEN 3200
3130 PRINT "  DIFFERENTIAL MEASUREMENTS, ALSO CALLED DELTA MEASUREMENTS, ARE"
3140 PRINT "MADE BY TAKING TWO TYPES OF READINGS AT EACH SITE.  FOR EXAMPLE,"
3150 PRINT "ONE READING WITH LEAD SHIELDING AND ONE READING WITHOUT SHIELDING."
3160 PRINT
3170 PRINT "*********** YOU MUST ANSWER Y, N OR Q *************"
3180 PRINT
3190 GO TO 3080
3200 FOR X1=1 TO P
3210  PRINT
3220  PRINT
3230  PRINT "********  DATA FOR PAD ";X1;" ********"
3240  PRINT
3250  IF Q$="N" THEN 3360
3260  Q1$="SHIELDED"
3270  Y1=Y1+1
3280  PRINT "NUMBER OF SHIELDED MEASUREMENTS";
3290  INPUT N(Y1,1)
3300 IF N(Y1,1)<20 THEN 3340
3310 PRINT "ARE THERE REALLY ";N(Y1,1);" MEASUREMENTS, Y OR N ";
3320 INPUT Q2$
3330 IF Q2$="N" THEN 3280
3340 PRINT
3350 GOSUB 7350
3360  Q1$="UNSHIELDED"
3370  Y1=Y1+1
3380  PRINT
3390  PRINT "NUMBER OF UNSHIELDED MEASUREMENTS";
3400  INPUT N(Y1,2)
3410 IF N(Y1,2)<20 THEN 3450
3420 PRINT "ARE THERE REALLY ";N(Y1,2);" MEASUREMENTS, Y OR N ";
3430 INPUT Q2$
3440 IF Q2$="N" THEN 3390
3450 PRINT
3460 GOSUB 7350
3470 NEXT X1
3480 PRINT
3490 REM ************* DATA CHECK ***************
3500 PRINT "PLEASE CHECK THE DATA"
3510 X3=0
3520 FOR X1=1 TO P
3530  PRINT "*********** PAD ";X1;" ***********"
3540  IF Q$="N" THEN 3610
3550  PRINT "     SHIELDED DATA"
3560  PRINT " K", " U", " T"
3570  X3=X3+1
3580  FOR X2=1 TO N(X3,1)
3590   PRINT K(X3,X2), U(X3,X2), T(X3,X2)
```

```
3600  NEXT X2
3610  PRINT "    UNSHIELDED DATA"
3620  PRINT " K", " U", " T"
3630  X3=X3+1
3640  FOR X2=1 TO N(X3,2)
3650   PRINT K(X3,X2), U(X3,X2), T(X3,X2)
3660  NEXT X2
3670 PRINT
3680 IF X1=P THEN 3700
3690 GOSUB 12280
3700 NEXT X1
3710 PRINT
3720 PRINT"ARE THE DATA CORRECT, Y OR N";
3730 INPUT Q3$
3740 IF Q3$="Y" THEN 3910
3750 PRINT "WHICH PAD HAS INCORRECT DATA";
3760 INPUT Q4
3770 IF Q$="N" THEN 3800
3780 PRINT "IS THE INCORRECT DATA SHIELDED OR UNSHIELDED";
3790 INPUT Q1$
3800 PRINT "WHICH ROW OF ";Q1$;" DATA FOR PAD ";Q4$;" IS INCORRECT, 1,2,3,4, ETC., (TOP ROW = 1)";
3810 Y1=0
3820 INPUT Q5
3830 IF Q$="N" THEN 3870
3840 Y1=(2*Q4)-1
3850 IF Q1$="UNSHIELDED" THEN Y1=Y1+1
3860 GO TO 3880
3870 Y1=Q4
3880 PRINT "PLEASE INPUT THE CORRECT ";Q1$;" K, U, TH DATA FOR PAD ";Q4
3890 INPUT K(Y1,Q5), U(Y1,Q5), T(Y1,Q5)
3900 GO TO 3490
3910 PRINT
3920 REM **** INPUT OF CONCENTRATIONS ****
3930 PRINT
3940 PRINT "PLEASE INPUT THE KNOWN CONCENTRATIONS OF K, U, AND TH FOR EACH PAD."
3950 FOR X1=1 TO P
3960  PRINT
3970  PRINT "******* PAD ";X1;" *******"
3980  PRINT "PLEASE INPUT THE CONCENTRATION OF K IN %"
3990  INPUT C(X1,1)
4000  PRINT "CONCENTRATION OF U IN ppm"
4010  INPUT C(X1,2)
4020  PRINT "CONCENTRATION OF TH IN ppm"
4030  INPUT C(X1,3)
4040 NEXT X1
4050 PRINT "PLEASE CHECK THE CONCENTRATIONS."
4060 PRINT "PAD #"," K"," U"," TH"
4070 FOR X1=1 TO P
4080  PRINT X1, C(X1,1), C(X1,2), C(X1,3)
4090 NEXT X1
4100 PRINT
4110 PRINT "ARE THE CONCENTRATIONS CORRECT, Y OR N";
4120 INPUT Q3$
4130 IF Q3$="Y" THEN 4190
4140 PRINT "WHICH PAD HAS INCORRECT DATA: 1,2,3,ETC.";
4150 INPUT Q4
4160 PRINT "WHAT ARE THE CORRECT K,U,TH VALUES FOR PAD ";Q4
4170 INPUT C(Q4,1),C(Q4,2),C(Q4,3)
4180 GO TO 4050
4190 REM ***** FINDING ALL POSSIBLE COMBINATIONS OF THE PADS *****
```

```
4200 GOSUB 7450
4210 REM ******* FINDING MEDIANS FOR RAW DATA *******
4220 FOR X1=1 TO P
4230  IF Q$="N" THEN GOSUB 8000
4240  IF Q$="Y" THEN GOSUB 8190
4250 NEXT X1
4260 REM ***** FIND ALL POSSIBLE CALIBRATION MATRICES, USING ALL POSSIBLE *****
4270 REM ***** PAD COMBINATIONS.  *****
4280 X2=0
4290 FOR X1=1 TO B3
4300  X=X(X1)
4310  Y=Y(X1)
4320  Z=Z(X1)
4330  FOR X3=1 TO 3
4340   C1(1,X3)=C(X,X3)
4350   C1(2,X3)=C(Y,X3)
4360   C1(3,X3)=C(Z,X3)
4370  NEXT X3
4380  MAT C1=INV(C1)
4390  Q(X)=K(X,0)
4400  Q(Y)=K(Y,0)
4410  Q(Z)=K(Z,0)
4420  GOSUB 8820
4430  Q(X)=U(X,0)
4440  Q(Y)=U(Y,0)
4450  Q(Z)=U(Z,0)
4460  GOSUB 8820
4470  Q(X)=T(X,0)
4480  Q(Y)=T(Y,0)
4490  Q(Z)=T(Z,0)
4500  GOSUB 8820
4510 NEXT X1
4520 REM *** THE MATRIX A NOW CONTAINS ALL OF THE POSSIBLE CALIBRATION ***
4530 REM *** MATRICES.  A IS A  3*B3 X 3  MATRIX, WHERE B3 = # OF ***
4540 REM *** POSSIBLE COMBINATIONS OF PADS.  EACH CALIBRATION MATRIX ***
4550 REM *** IS A(I,J) WHERE I = 1,2,3 OR 4,5,6 OR 7,8,9,...3*B3 AND ***
4560 REM *** J = 1,2,3.  ***
4570 REM ********** FIND MEDIAN CALIBRATION MATRIX ***********
4580 N3=B3
4590 FOR X1=1 TO 3
4600  FOR X3=1 TO 3
4610   X4=0
4620   FOR X2=X3 TO 3*B3 STEP 3
4630    X4=X4+1
4640    M(X4)=A(X2,X1)
4650   NEXT X2
4660   GOSUB 8620
4670   O(X3,X1)=M
4680  NEXT X3
4690 NEXT X1
4700 REM *** MATRIX O IS NOW THE MATRIX OF MEDIAN CALIBRATON FACTORS.  ***
4710 PRINT "THE MEDIAN CALIBRATION MATRIX IS:"
4720 PRINT
4730 MAT O1=O
4740 MAT PRINT O;
4750 PRINT
4760 GOSUB 12280
4770 PRINT
4780 IF P>4 THEN 4830
4790 PRINT "     THIS CAL. MATRIX IS BASED ON DATA FROM A MINIMAL NUMBER OF"
```

```
4800 PRINT "PADS.  THE UNCERTAINTIES OF THE CAL. FACTORS ARE THEREFORE RATHER"
4810 PRINT "LARGE.  PLEASE USE MORE CALIBRATION SITES NEXT TIME."
4820 IF P<4 THEN 12610
4830 PRINT
4840 PRINT
4850 PRINT
4860 PRINT "THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:"
4870 PRINT
4880 MAT PRINT O1,
4890 PRINT
4900 GOSUB 12280
4910 PRINT
4920 PRINT "HERE IS A CROSSPLOT OF KNOWN AND CALCULATED CONCENTRATIONS OF ";
4930 REM **       CALCULATING CONCENTRATIONS OF K,U AND TH IN THE PADS, USING **
4940 REM ** THE FINAL CONCENTRATION MATRIX O1 AND THE SPECTROMETER DATA.      **
4950 REM ** THESE CONCENTRATIONS WILL BE COMPARED WITH THE KNOWN CONCENTRA-  **
4960 REM ** TIONS OF K,U AND TH IN THE PADS.                                  **
4970 GOSUB 9730
4980 X2=1
4990 GOSUB 9020
5000 PRINT "K, U AND TH:"
5010 N1=0
5020 FOR X1=1 TO P
5030  FOR X2=1 TO 3
5040   N1=N1+1
5050   I(N1)=W(X1,X2)
5060  J(N1)=C(X1,X2)
5070  NEXT X2
5080 NEXT X1
5090 N=3*P
5100 GOSUB 9850
5110 GOSUB 10080
5120 GOSUB 10360
5130 PRINT
5140 PRINT "NOW LET US CONSIDER THE DATA FOR POTASSIUM."
5150 PRINT
5160 PRINT
5170 PRINT "THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:"
5180 MAT PRINT O1,
5190 PRINT
5200 GOSUB 12280
5210 GOSUB 9730
5220 X2=1
5230 S8=1
5240 GOSUB 9020
5250 PRINT W$(1);" ";W$(2);" POTASSIUM VERSUS ";W$(7);" ";W$(8);" POTASSIUM"
5260 GOSUB 10080
5270 GOSUB 10360
5280 PRINT
5290 X2=1
5300 GOSUB 12330
5310 GOSUB 9190
5320 W$(2)="in K "
5330 W$(5)="A1,1 "
5340 W$(6)="cps K"
5350 GOSUB 10080
5360 GOSUB 10360
5370 PRINT
5380 W$(6)="cps U"
5390 W$(5)="A1,2 "
```

```
5400 X2=2
5410 GOSUB 9240
5420 GOSUB 10080
5430 GOSUB 10360
5440 PRINT
5450 W$(6)="cpsTh"
5460 W$(5)="A1,3 "
5470 X2=3
5480 GOSUB 9290
5490 GOSUB 10080
5500 GOSUB 10360
5510 PRINT
5520 PRINT
5530 PRINT "WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N";
5540 INPUT Q2$
5550 IF Q2$="N" THEN 5580
5560 GOSUB 9440
5570 PRINT
5580 PRINT "WOULD YOU LIKE TO RÉVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N";
5590 INPUT Q2$
5600 IF Q2$="Y" THEN 5170
5610 PRINT
5620 PRINT "NOW FOR THE DATA FOR URANIUM....."
5630 PRINT
5640 PRINT
5650 PRINT "THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:"
5660 MAT PRINT O1,
5670 PRINT
5680 GOSUB 12280
5690 GOSUB 9730
5700 X2=2
5710 S8=2
5720 GOSUB 9020
5730 PRINT W$(1);" ";W$(2);" URANIUM VERSUS ";W$(7);" ";W$(8);" URANIUM"
5740 GOSUB 10080
5750 GOSUB 10360
5760 PRINT
5770 X2=1
5780 GOSUB 12330
5790 GOSUB 9190
5800 W$(2)="in U "
5810 W$(5)="A2,1 "
5820 W$(6)="cps K"
5830 GOSUB 10080
5840 GOSUB 10360
5850 PRINT
5860 W$(6)="cps U"
5870 W$(5)="A2,2 "
5880 X2=2
5890 GOSUB 9240
5900 GOSUB 10080
5910 GOSUB 10360
5920 PRINT
5930 W$(6)="cpsTh"
5940 W$(5)="A2,3 "
5950 X2=3
5960 GOSUB 9290
5970 GOSUB 10080
5980 GOSUB 10360
5990 PRINT
```

```
6000 PRINT
6010 PRINT "WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N";
6020 INPUT Q2$
6030 IF Q2$="N" THEN 6060
6040 GOSUB 9440
6050 PRINT
6060 PRINT "WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N";
6070 INPUT Q2$
6080 IF Q2$="Y" THEN 5650
6090 PRINT
6100 PRINT "HERE ARE THE PLOTS AND DATA FOR THORIUM:"
6110 PRINT
6120 PRINT
6130 PRINT "THE FOLLOWING CAL. MATRIX WILL BE USED FOR THE PLOTS:"
6140 MAT PRINT O1,
6150 PRINT
6160 GOSUB 12280
6170 GOSUB 9730
6180 X2=3
6190 S8=3
6200 GOSUB 9020
6210 PRINT W$(1);" ";W$(2);" THORIUM VERSUS ";W$(7);" ";W$(8);" THORIUM"
6220 GOSUB 10080
6230 GOSUB 10360
6240 PRINT
6250 X2=1
6260 GOSUB 12330
6270 GOSUB 9190
6280 W$(2)="in Th"
6290 W$(5)="A3,1 "
6300 W$(6)="cps K"
6310 GOSUB 10080
6320 GOSUB 10360
6330 PRINT
6340 W$(6)="cps U"
6350 W$(5)="A3,2 "
6360 X2=2
6370 GOSUB 9240
6380 GOSUB 10080
6390 GOSUB 10360
6400 PRINT
6410 W$(6)="cpsTh"
6420 W$(5)="A3,3 "
6430 X2=3
6440 GOSUB 9290
6450 GOSUB 10080
6460 GOSUB 10360
6470 PRINT
6480 PRINT
6490 PRINT "WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N";
6500 INPUT Q2$
6510 IF Q2$="N" THEN 6540
6520 GOSUB 9440
6530 PRINT
6540 PRINT "WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR THORIUM, Y OR N";
6550 INPUT Q2$
6560 IF Q2$="Y" THEN 6130
6570 PRINT
6580 PRINT
6590 PRINT "HERE IS THE MATRIX OF MEDIAN CALIBRATION FACTORS:"
```

```
6600 MAT PRINT O,
6610 PRINT
6620 GOSUB 12280
6630 PRINT
6640 PRINT "HERE IS THE MATRIX OF CAL. FACTORS THAT INCLUDES THE LAST CHANGES"
6650 PRINT "YOU MADE, IF ANY:"
6660 MAT PRINT O1,
6670 PRINT
6680 PRINT "DO YOU WISH TO REVIEW OR CHANGE ANY CAL. FACTORS OR REVIEW THE"
6690 PRINT "CROSSPLOTS OR HISTOGRAMS, Y OR N";
6700 INPUT Q3$
6710 IF Q3$="Y" THEN 4850
6720 PRINT
6730 PRINT
6740 PRINT "**** GOOD LUCK WITH YOUR CALIBRATION FACTORS. ****"
6750 GO TO 12610
7000 REM **********************************************
7010 REM ****           SUBROUTINES               ****
7020 REM **********************************************
7030 REM *** EXPLANATION OF CALIBRATION MATRICES ***
7040 PRINT
7050 PRINT "     Please note how the calibration factors are used to find"
7060 PRINT "concentrations of K, U and Th.  You will need to know this later"
7070 PRINT "in the program.  Each calibration factor is denoted by"
7080 PRINT "A(i,j) where i = row number from top to bottom and j = column"
7090 PRINT "number from left to right.  At each site, the following equations"
7100 PRINT "are used to find the concentrations of K, U and Th:"
7110 PRINT
7120 GOSUB 12280
7130 PRINT
7140 PRINT "K %   =  A(1,1) x Kcps   +   A(1,2) x Ucps   +   A(1,3) x Thcps"
7150 PRINT "U ppm =  A(2,1) x Kcps   +   A(2,2) x Ucps   +   A(2,3) x Thcps"
7160 PRINT "Thppm =  A(3,1) x Kcps   +   A(3,2) x Ucps   +   A(3,3) x Thcps"
7170 PRINT
7180 PRINT "Where:"
7190 PRINT
7200 PRINT "K %   = Concentration of potassium in percent"
7210 PRINT "U ppm = Concentration of uranium in parts per million"
7220 PRINT "Kcps  = Counts per second in the K channel of the spectrometer"
7230 PRINT "A(1,1)= A calibration factor"
7240 PRINT
7250 PRINT "In matrix notation:"
7260 PRINT "      C = A x R"
7270 PRINT
7280 PRINT "where    C is the 3 x 1 matrix of concentrations"
7290 PRINT "         A is the 3 x 3 calibration matrix"
7300 PRINT "         R is the 3 x 1 matrix of spectrometer counting rates."
7310 PRINT
7320 GOSUB 12280
7330 RETURN
7340 REM *** SUBROUTINE TO INPUT RAW MEASURED DATA ***
7350 G2=0
7360 IF Q1$="UNSHIELDED" THEN G3=2
7370 IF Q1$="SHIELDED" THEN G3=1
7380 PRINT "PLEASE INPUT ";Q1$;" DATA FOR PAD ";X1
7390 FOR G1=1 TO N(Y1,G3)
7400  PRINT "PLEASE INPUT K, U, TH COUNTS"
7410  INPUT K(Y1,G1), U(Y1,G1), T(Y1,G1)
7420 NEXT G1
7430 RETURN
```

```
7440 REM **** SUBROUTINE TO GENERATE ALL POSSIBLE COMBINATIONS OF PADS ****
7450 B=0
7460 FOR X=1 TO (P-2)
7470  FOR Y=2 TO (P-1)
7480   FOR Z=3 TO P
7490    B=B+1
7500    X(B)=X
7510    Y(B)=Y
7520    Z(B)=Z
7530   NEXT Z
7540  NEXT Y
7550 NEXT X
7560 FOR B1=1 TO 2
7570  FOR B2=1 TO B
7580   IF X(B2)<=Y(B2) THEN 7620
7590   E=Y(B2)
7600   Y(B2)=X(B2)
7610   X(B2)=E
7620   IF Y(B2)<=Z(B2) THEN 7660
7630   E=Z(B2)
7640   Z(B2)=Y(B2)
7650   Y(B2)=E
7660   IF X(B2)<=Z(B2) THEN 7700
7670   E=Z(B2)
7680   Z(B2)=X(B2)
7690   X(B2)=E
7700  NEXT B2
7710 NEXT B1
7720 FOR B1=1 TO (B-1)
7730  FOR B2=B1+1 TO B
7740   IF X(B1)=Y(B1) THEN 7800
7750   IF Y(B1)=Z(B1) THEN 7800
7760   IF X(B1)=Z(B1) THEN 7800
7770   IF X(B1)<>X(B2) THEN 7830
7780   IF Y(B1)<>Y(B2) THEN 7830
7790   IF Z(B1)<>Z(B2) THEN 7830
7800 X(B1)=0
7810 Y(B1)=0
7820 Z(B1)=0
7830  NEXT B2
7840 NEXT B1
7850 B2=0
7860 FOR B1=1 TO B
7870  IF X(B1)=0 THEN 7920
7880  B2=B2+1
7890  X(B2)=X(B1)
7900  Y(B2)=Y(B1)
7910  Z(B2)=Z(B1)
7920 NEXT B1
7930 B3=B2
7940 REM *********** B3 = NUMBER OF PAD COMBINATIONS **************
7950 REM ** USE X(A), Y(A), Z(A) WHERE A=1 TO B3 AS THE PAD COMBINATIONS.  **
7960 RETURN
7970 REM ***** SUBROUTINE TO FIND MEDIAN VALUES FOR RAW, MEASURED DATA *****
7980 REM ***** USING DELTA VALUES, IF NECESSARY.  *****
7990 REM ************ NON-DELTA MEASUREMENTS ***********
8000 N3=N(X1,2)
8010 FOR B1=1 TO N3
8020  M(B1)=K(X1,B1)
8030 NEXT B1
```

```
8040 GOSUB 8620
8050 K(X1,0)=M/S
8060 FOR B1=1 TO N3
8070  M(B1)=U(X1,B1)
8080 NEXT B1
8090 GOSUB 8620
8100 U(X1,0)=M/S
8110 FOR B1=1 TO N3
8120  M(B1)=T(X1,B1)
8130 NEXT B1
8140 GOSUB 8620
8150 T(X1,0)=M/S
8160 RETURN
8170 REM *********** DIFFERENTIAL MEASUREMENTS ************
8180 REM ** N1 IS SHIELDED, N2 IS UNSHIELDED DATA **
8190 N1=N((2*X1)-1,1)
8200 N2=N((2*X1),2)
8210 N3=N1*N2
8220 REM ** SHIELDED **
8230 FOR B1=1 TO N1
8240  S(B1)=K((2*X1)-1,B1)
8250 NEXT B1
8260 REM ** UNSHIELDED **
8270 FOR B1=1 TO N2
8280  UN(B1)=K((2*X1),B1)
8290 NEXT B1
8300 GOSUB 8530
8310 GOSUB 8620
8320 K(X1,0)=M/S
8330 FOR B1=1 TO N1
8340  S(B1)=U((2*X1)-1,B1)
8350 NEXT B1
8360 FOR B1=1 TO N2
8370  UN(B1)=U((2*X1),B1)
8380 NEXT B1
8390 GOSUB 8530
8400 GOSUB 8620
8410 U(X1,0)=M/S
8420 FOR B1=1 TO N1
8430  S(B1)=T((2*X1)-1,B1)
8440 NEXT B1
8450 FOR B1=1 TO N2
8460  UN(B1)=T((2*X1),B1)
8470 NEXT B1
8480 GOSUB 8530
8490 GOSUB 8620
8500 T(X1,0)=M/S
8510 RETURN
8520 REM ******** FINDING ALL POSSIBLE DELTA VALUES ********
8530 G1=0
8540 FOR B1=1 TO N1
8550  FOR B2=1 TO N2
8560   G1=G1+1
8570   M(G1)=UN(B2)-S(B1)
8580  NEXT B2
8590 NEXT B1
8600 RETURN
8610 REM ******** PUTTING M() IN ORDER, FINDING MEDIAN M *********
8620 FOR B1=1 TO N3
8630  FOR B2=1 TO N3-B1
```

```
8640   IF M(B2)<=M(B2+1) THEN 8680
8650   E=M(B2)
8660   M(B2)=M(B2+1)
8670   M(B2+1)=E
8680  NEXT B2
8690 NEXT B1
8700 B1=2*(INT(N3/2))
8710 IF B1=N3 THEN 8760
8720 REM ** ODD N3 **
8730 B2=(INT(N3/2)+1)
8740 M=M(B2)
8750 GO TO 8800
8760 REM ** EVEN N3 **
8770 B2=N3/2
8780 M=(M(B2)+M(B2+1))/2
8790 REM ***** MEDIAN = M *****
8800 RETURN
8810 REM ****** SUBROUTINE TO FIND CALIBRATION MATRICES ******
8820 R(1,1)=Q(X)
8830 R(2,1)=Q(Y)
8840 R(3,1)=Q(Z)
8850 MAT D=C1*R
8860 REM ** SETTING THE "A-MATRIX" **
8870 X2=X2+1
8880 X5=X5+1
8890 A1(X5,1)=D(1,1)
8900 A1(X5,2)=D(2,1)
8910 A1(X5,3)=D(3,1)
8920 IF X5<3 THEN 9000
8930 MAT A1=INV(A1)
8940 FOR X6=1 TO 3
8950  A((2*(X1-1))+X1,X6)=A1(1,X6)
8960  A((2*(X1-1))+X1+1,X6)=A1(2,X6)
8970  A((2*(X1-1))+X1+2,X6)=A1(3,X6)
8980 NEXT X6
8990 X5=0
9000 RETURN
9010 REM *** SUBROUTINE FOR KNOWN VS. CALC. CONCENTRATION CROSSPLOTS ***
9020 W$(1)="KNOWN"
9030 W$(9)="     "
9040 W$(2)="CONC."
9050 W$(3)="     "
9060 W$(4)="     "
9070 W$(5)="     "
9080 W$(7)="CALC."
9090 W$(8)="CONC."
9100 W$(6)="     "
9110 N=P
9120 FOR X1=1 TO P
9130  I(X1)=W(X1,X2)
9140  J(X1)=C(X1,X2)
9150 NEXT X1
9160 GOSUB 9850
9170 RETURN
9180 REM *** SUBROUTINE FOR ERROR VS. C.P.S. K, U, OR T CROSSPLOTS ***
9190 FOR X1=1 TO P
9200  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,2)*U(X1,0))+(V(S8,3)*T(X1,0))
9210  I(X1)=K(X1,0)
9220 NEXT X1
9230 GO TO 9330
```

```
9240 FOR X1=1 TO P
9250  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,1)*K(X1,0))+(V(S8,3)*T(X1,0))
9260  I(X1)=U(X1,0)
9270 NEXT X1
9280 GO TO 9330
9290 FOR X1=1 TO P
9300  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,1)*K(X1,0))+(V(S8,2)*U(X1,0))
9310  I(X1)=T(X1,0)
9320 NEXT X1
9330 N=P
9340 W$(1)="Error"
9350 W$(3)="Calc."
9360 W$(4)="dueto"
9370 W$(7)="KNOWN"
9380 W$(8)="      "
9390 W$(9)="      "
9400 GOSUB 9850
9410 RETURN
9420 REM *** SUBROUTINE FOR ACCESSING HISTOGRAM SUBROUTINE ***
9430 REM *** AND CHANGING THE CALIBRATION FACTORS.         ***
9440 PRINT "HERE IS THE LATEST CALIBRATION MATRIX:"
9450 MAT PRINT O1,
9460 PRINT
9470 PRINT "WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:"
9480 PRINT "  ROW NUMBER = "
9490 INPUT F7
9500 PRINT "  COLUMN NUMBER = "
9510 INPUT F8
9520 PRINT
9530 GOSUB 11480
9540 PRINT
9550 PRINT "WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ";
9560 INPUT Q2$
9570 IF Q2$="N" THEN 9650
9580 PRINT "WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:"
9590 PRINT "  ROW NUMBER = ";
9600 INPUT F7
9610 PRINT "  COLUMN NUMBER = ";
9620 INPUT F8
9630 PRINT "PLEASE INPUT THE NEW CAL. FACTOR A(";F7;",";F8;")"
9640 INPUT O1(F7,F8)
9650 PRINT "WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N";
9660 INPUT Q2$
9670 IF Q2$="Y" THEN 9440
9680 PRINT "WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N";
9690 INPUT Q2$
9700 IF Q2$="Y" THEN 9580
9710 RETURN
9720 REM *** SUBROUTINE TO RECALCULATE CONCENTRATIONS USING O1 ***
9730 FOR X1=1 TO P
9740  R(1,1)=K(X1,0)
9750  R(2,1)=U(X1,0)
9760  R(3,1)=T(X1,0)
9770  MAT W1=O1*R
9780  W(X1,1)=W1(1,1)
9790  W(X1,2)=W1(2,1)
9800  W(X1,3)=W1(3,1)
9810 NEXT X1
9820 RETURN
9830 REM **** PUTTING THE KNOWN & CALCULATED CONCENTRATIONS IN NUMERICAL ****
```

```
9840 REM **** ORDER, IN PREPARATION FOR PLOTTING.  ****
9850 N3=N
9860 FOR X1=1 TO N
9870  M(X1)=I(X1)
9880 NEXT X1
9890 GOSUB 8620
9900 FOR X1=1 TO N
9910  W3(X1)=M(X1)
9920  M(X1)=J(X1)
9930 NEXT X1
9940 GOSUB 8620
9950 FOR X1=1 TO N
9960  W4(X1)=M(X1)
9970 NEXT X1
9980 M1=W3(1)
9990 M2=W3(N)
10000 M3=W4(1)
10010 M4=W4(N)
10020 REM ***     THE VARIABLES W3 AND W4 CONTAIN, IN NUMERICAL ORDER, THE ***
10030 REM *** NUMBERS TO BE PLOTTED ON THE X AND Y AXES, RESPECTIVELY.  W3 ***
10040 REM *** AND W4 WILL BE USED TO SCALE THE CROSSPLOTS.                ***
10050 RETURN
10060 REM **** THIS SUBROUTINE FINDS THE REGRESSION LINE, COEFF. OF CORRELATION,
10070 REM **** AND COEFF. OF DETERMINATION FOR DATA I(A),J(A) WHERE A=1 TO N.
10080 I2=0
10090 J2=0
10100 I=0
10110 J=0
10120 V=0
10130 FOR X1=1 TO N
10140  I=I+I(X1)
10150  J=J+J(X1)
10160  I2=I2+(I(X1)*I(X1))
10170  J2=J2+(J(X1)*J(X1))
10180  V=V+I(X1)*J(X1)
10190 NEXT X1
10200 S3=V-((I*J)/N)
10210 S1=I2-((I*I)/N)
10220 S2=J2-((J*J)/N)
10230 REM **** REGRESSION LINE:  Y=N1+N2*X  ****
10240 N2=S3/S1
10250 N1=((J/N)-(N2*(I/N)))
10260 REM **** COEFF. OF CORREL. = H  ****
10270 H=S3/SQR(S1*S2)
10280 REM **** COEFF.OF DETERMINATION = H1  ****
10290 H1=H*H
10300 REM **** THE PRECEEDING EQUATIONS CAN BE FOUND IN:  MENDENHALL, W., 1975,
10310 REM ****   INTRODUCTION TO PROBABILITY AND STATISTICS, FOURTH EDITION,
10320 REM ****   DUXBURY RESS, NORTH SCITUATE, MASS., pp. 254-257, 271-274.
10330 RETURN
10340 REM **** THIS SUBROUTINE PRINTS A CROSSPLOT OF THE DATA ****
10350 REM **** AND THE REGRESSION LINE.                        ****
10360 B8=0
10370 FOR B1=1 TO 16
10380  REM ** PRINTING LEFT AXIS **
10390  FOR B2=1 TO 100
10400   B6(B2,1)=0
10410   B6(B2,2)=0
10420  NEXT B2
10430  IF B1=6 OR B1=7 OR B1=8 OR B1=9 OR B1=10 THEN 10460
```

```
10440  PRINT "      ";
10450  GO TO 10480
10460  B8=B8+1
10470  PRINT W$(B8);
10480  J=M3+(16-B1)*(M4-M3)/15
10490  REM ** J IS THE Y-AXIS EQUIVALENT FOR ROW B1.  **
10500  J1=INT(100*J+.5)/100
10510  PRINT J1;
10520  PRINT TAB(12);"+";
10530  REM ** PRINTING DATA **
10540  Z9=0
10550  FOR B2=1 TO N
10560   IF J(B2)<M3+(15-(B1+.5)+1)*(M4-M3)/15 THEN 10650
10570   IF J(B2)>=M3+(15-(B1-.5)+1)*(M4-M3)/15 THEN 10650
10580   Z9=Z9+1
10590   B6(Z9,1)=INT((I(B2)-M1)*40/(M2-M1)+.5)
10600   B6(Z9,2)=INT((((J-N1)/N2)-M1)*40/(M2-M1)+.5)
10610   IF I(B2)-M1<.5 THEN 10630
10620   GO TO 10700
10630   B6(Z9,1)=M3
10640   GO TO 10700
10650   IF Z9>0 THEN 10700
10660   IF B2<>P THEN 10700
10670   Z9=1
10680   B6(Z9,2)=INT((((J-N1)/N2)-M1)*40/(M2-M1)+.5)
10690   B6(Z9,1)=0
10700  NEXT B2
10710  FOR B2=1 TO Z9
10720   FOR B4=1 TO Z9-B2
10730    IF B6(B4,1)<B6(B4+1,1) THEN 10770
10740    E=B6(B4,1)
10750    B6(B4,1)=B6(B4+1,1)
10760    B6(B4+1,1)=E
10770   NEXT B4
10780  NEXT B2
10790  FOR B2=1 TO Z9
10800   IF B6(B2,1)<>0 THEN 10830
10810   GOSUB 11030
10820   GO TO 11170
10830   IF B6(B2,1)=B6(B2,2) THEN 10860
10840   IF B6(B2,1)<B6(B2,2) THEN 10880
10850   IF B6(B2,1)>B6(B2,2) THEN 10930
10860   GOSUB 10980
10870   GO TO 11170
10880   GOSUB 10980
10890   IF B6(B2+1,1)=0 THEN 10910
10900   IF B6(B2+1,1)<B6(B2,2) THEN 11170
10910   GOSUB 11030
10920   GO TO 11170
10930   IF B6(B2-1,2)>=B6(B2,2) THEN 10950
10940   GOSUB 11030
10950   GOSUB 10980
10960   GO TO 11170
10970   REM ** SUBROUTINE **
10980   IF B6(B2,1)=B6(B2+1,1) THEN 11070
10990   IF B6(B2,1)=B6(B2-1,1) THEN 11010
11000   PRINT TAB(B6(B2,1)+13);"*";
11010   RETURN
11020   REM ** SUBROUTINE **
11030   IF B6(B2,2)>40 THEN 11060
```

```
11040    IF B6(B2,2)<=0 THEN 11060
11050    PRINT TAB(B6(B2,2)+13);"+";
11060    RETURN
11070    B9=0
11080    IF B6(B2-1,1)=B6(B2,1) THEN 11010
11090    FOR B5=1 TO 8 STEP 1
11100     IF B6(B2+B5,1)=B6(B2,1) THEN 11120
11110     GO TO 11130
11120     B9=B5+1
11130    NEXT B5
11140    IF B9=0 THEN 11160
11150    PRINT TAB(B6(B2,1)+13);B9;
11160    RETURN
11170  NEXT B2
11180  PRINT
11190 NEXT B1
11200 PRINT "              ";
11210 FOR B1=1 TO 45
11220  PRINT "+";
11230 NEXT B1
11240 PRINT
11250 B2=10
11260 IF M2>9.5 THEN B2=1
11270 FOR B1=0 TO 5
11280  PRINT TAB(INT((B1*40/5)+12+.5));INT(B2*(M1+(B1*40/5)*(M2-M1)/40)+.5)/B2;
11290 NEXT B1
11300 PRINT
11310 PRINT "                          ";W$(6);" ";W$(7);" ";W$(8);" ";W$(9)
11320 PRINT "REGRESSION LINE:    Y = ";N1;" + ";N2;"X"
11330 PRINT "CORREL. COEFF. = ";H;"     DETERMIN. COEFF. = ";H1
11340 IF W$(3)="      " THEN 11430
11350 IF W$(9)="  -  " THEN 11430
11390 IF H1<.01 THEN 11420
11400 PRINT "*** IT MAY BE WORTHWHILE TO CHECK A(";S8;",";X2;").  ***"
11410 GO TO 11430
11420 PRINT "A(";S8;",";X2;") MAY BE O.K. "
11430 PRINT
11440 GOSUB 12280
11450 RETURN
11460 REM *** HISTOGRAM PLOTTING SUBROUTINE ***
11470 REM ** CAL. FACTOR TO BE PLOTTED IS A(B7,B8) **
11480 Y2=0
11490 FOR Y1=F7 TO 3*B3 STEP 3
11500  Y2=Y2+1
11510  M(Y2)=A(Y1,F8)
11520 NEXT Y1
11530 N3=B3
11540 M(B3+1)=0
11550 GOSUB 8620
11560 PRINT"* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *"
11570 PRINT"                    A(";F7;",";F8;")"
11580 N=0
11590 Y2=INT(M(1))
11600 IF M(1)>0 THEN 11620
11610 Y2=INT(M(1)-1)
11620 Y3=INT(M(B3)+1)
11630 Y4=INT((ABS(M(B3)-M(1))/(B3/2))*10+.5)/10
11640 REM ** Y4 = CLASS SIZE **
11650 IF Y4>0 THEN 11670
11660 LET Y4=.5
```

```
11670 FOR Y1=1 TO B3
11680  IF M(Y1)>=Y2+Y4 THEN 11780
11690  IF N>0 THEN 11710
11700  PRINT Y2;TAB(7);"-"
11710  N=N+1
11720  PRINT TAB(8+N);"X";
11730  IF M(Y1+1)<Y2+Y4 THEN 11810
11740  PRINT
11750  N=0
11760  Y2=Y2+Y4
11770  GO TO 11810
11780  PRINT Y2;TAB(7);"-"
11790  Y2=Y2+Y4
11800  GO TO 11680
11810 NEXT Y1
11820 PRINT
11830 IF Y2>-Y4 THEN 11860
11840 PRINT Y2;TAB(7);"-"
11850 GO TO 11870
11860 PRINT Y2+Y4;TAB(7);"-"
11870 PRINT TAB(8);
11880 FOR Y1=1 TO 10 STEP 3
11890  PRINT Y1;
11900 NEXT Y1
11910 PRINT
11920 PRINT TAB(9);"FREQUENCY"
11930 PRINT
11940 PRINT "RANGE OF VALUES:  ";M(1);" TO ";M(B3);"   NUMBER OF VALUES = ";B3
11950 N=0
11960 FOR Y1=1 TO B1
11970  N=N+M(Y1)
11980 NEXT Y1
11990 N=N/B3
12000 PRINT "MEDIAN = ";O(F7,F8),"MEAN = ";N
12010 PRINT "VALUE USED IN LAST CROSSPLOTS:  ";O1(F7,F8)
12020 GOSUB 12280
12030 S8=F7
12040 X2=F8
12050 B=V(F7,F8)*ABS(O1(F7,F8))
12060 REM *** B = SUGGESTED CHANGE IN O1(F7,F8) ***
12070 IF B=0 THEN 12180
12080 IF O1(F7,F8)-B<M(1) OR O1(F7,F8)-B>M(B3) THEN 12150
12090 PRINT "      Various calculations suggest that ";O1(F7,F8)-B;" may be a"
12100 PRINT "better value for A(";F7;",";F8;").  If this seems reasonable in"
12110 PRINT "light of the histogram and other values for A(";F7;",";F8;"),"
12120 PRINT "then you may want to try ";O1(F7,F8)-B;" by substituting it for"
12130 PRINT O1(F7,F8);" and going through the plots for ";W$(2);" again."
12140 GO TO 12180
12150 IF B<0 THEN Q4$="increase"
12160 IF B>0 THEN Q4$="decrease"
12170 PRINT "You may want to ";Q4$;" A(";F7;",";F8;") slightly."
12180 PRINT "WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A(";F7;",";F8;"), Y OR N"
12190 INPUT Q3$
12200 IF Q3$="N" THEN 12260
12210 FOR Y1=1 TO B3
12220  PRINT M(Y1),
12230 NEXT Y1
12240 PRINT
12250 GOSUB 12280
12260 RETURN
```

```
12270 REM *** SUBROUTINE TO STOP OUTPUT ***
12280 PRINT"PLEASE PRESS RETURN TO CONTINUE.";
12290 WAIT 1800%
12300 INPUT Q4$
12310 RETURN
12320 REM *** SUBROUTINE TO FIND SUGGESTED CAL. FACTORS ***
12330 V6=0
12340 V6=V6+1
12350 FOR X1=1 TO P
12360  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,2)*U(X1,0))+(V(S8,3)*T(X1,0))
12370  I(X1)=K(X1,0)
12380 NEXT X1
12390 GOSUB 10080
12400 V(S8,1)=N2
12410 V1(V6)=N2
12420 FOR X1=1 TO P
12430  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,1)*K(X1,0))+(V(S8,3)*T(X1,0))
12440  I(X1)=U(X1,0)
12450 NEXT X1
12460 GOSUB 10080
12470 V(S8,2)=N2
12480 V2(V6)=N2
12490 FOR X1=1 TO P
12500  J(X1)=W(X1,S8)-C(X1,S8)+(V(S8,1)*K(X1,0))+(V(S8,2)*U(X1,0))
12510  I(X1)=T(X1,0)
12520 NEXT X1
12530 GOSUB 10080
12540 V(S8,3)=N2
12550 V3(V6)=N2
12560 IF V6>=1000 THEN 12600
12570 IF INT(V1(V6)*100000000+.5)<>INT(V1(V6-1)*100000000+.5) THEN 12340
12580 IF INT(V2(V6)*100000000+.5)<>INT(V2(V6-1)*100000000+.5) THEN 12340
12590 IF INT(V3(V6)*100000000+.5)<>INT(V3(V6-1)*100000000+.5) THEN 12340
12600 RETURN
12610 PRINT"############  END  OF  PROGRAM  ##############"
12620 END
```

APPENDIX C

Example Run of CALGRAD

```
CCCCCCC      A      L       GGGGGGG  RRRRRRR      A      DDDDD
C           A A     L       G        R     R     A A     D    D
C          A   A    L       G  GGGG  RRRRRRR    A   A    D     D
C         AAAAAAA   L       G     G  R   R     AAAAAAA   D    D
CCCCCCC  A       A  LLLLLLL GGGGGGG  R     R  A       A  DDDDD
```

by F.B. Zelt, 1984.

This program is designed to calculate calibration factors for the potassium (K), uranium (U) and thorium (Th) channels of gamma-ray spectrometers. To calibrate a spectrometer, readings must be taken on sites at which the concentrations of K, U and Th are known, such as the D.O.E./Bendix calibration pads in Grand Junction, Colo.. (A catalogue of calibration facilities has been published by George and Knight (1982).) The input to this program must consist of spectrometer readings and known concentrations from at least 3 different sites (pads).

PLEASE PRESS RETURN TO CONTINUE.?

It very important to base the calibration factors on reliable data. Therefore, the data put into this program should consist of spectrometer readings from calibration sites at which the concentrations of K, U and Th are known to within standard deviations of less than ten percent. The concentrations also should not vary greatly over the area measured by the spectrometer. Ward (1982) suggested that at least three spectrometer readings should be taken from each calibration site (pad). He further recommended that if the readings at a site differ by more than twice the square root of one reading, then more readings should be taken. This program is designed to handle up to 30 readings at each pad. Marutzky et al (1984) suggested that the minimum number" of counts in the window with the lowest number of counts (usually Th) should be 1000 at each pad. One thousand counts in the lowest window would also be a good minimum number for the difference between shielded and unshielded counts in differential measurements.

PLEASE PRESS RETURN TO CONTINUE.?

This program uses a matrix method to find the calibration factors. The method used is similar but not identical to the method described by Stromswold and Kosanke (1978). Calibration factors calculated with the method of Stromswold and Kosanke (1978) are useful for measurements made with no lead shielding around the detector of the spectrometer. However, CALGRAD can be used to calibrate measurements made with or without lead shielding around the detector. This program can also be used to calibrate differential measurements. The calibration factors generated by this program can be used to calibrate gamma-ray spectrometer measurements of highly radioactive deposits such as uranium mill tailings and uranium-rich black shales as well as measurements of deposits that are relatively low in K, U and Th, such as average shales.

PLEASE PRESS RETURN TO CONTINUE.?

There are several ways that lead shielding can be used to aid spectrometer surveys (Marutzky et al, 1984). Lead shielding is generally used to take measurements in deposits that are low in K, U and Th (such as average shales) and to take more accurate measurements in deposits that are highly radioactive. For example, lead shielding can be placed strategically around the detector of the spectrometer to block out background radiation. Lead shielding is also used to make differential measurements. In differential measurements, one set of readings is taken with shielding between the detector and the deposit being studied. These measurements are considered to represent background radiation. Another set of measurements is made made with no shielding between the detector and the deposit. The background measurements are then subtracted from the unshielded measurements to yield spectrometer readings that (ideally) reflect only the deposit being studied.

PLEASE PRESS RETURN TO CONTINUE.?

For simplicity, all non-differential measurements will be referred to as unshielded. Differential (also called delta) measurements will consist to a set of shielded measurements and a set of unshielded readings.

For more information about gamma-ray spectrometer surveys, including discussions of the uses of lead shielding, refer to Marutzky et al (1984) and Ward (1982).

PLEASE PRESS RETURN TO CONTINUE.?

Please note how the calibration factors are used to find concentrations of K, U and Th. You will need to know this later in the program. Each calibration factor is denoted by A(i,j) where i = row number from top to bottom and j = column number from left to right. At each site, the following equations are used to find the concentrations of K, U and Th:

PLEASE PRESS RETURN TO CONTINUE.?

```
K %   =  A(1,1) x Kcps   +   A(1,2) x Ucps   +   A(1,3) x Thcps
U ppm =  A(2,1) x Kcps   +   A(2,2) x Ucps   +   A(2,3) x Thcps
Thppm =  A(3,1) x Kcps   +   A(3,2) x Ucps   +   A(3,3) x Thcps
```

Where:

```
K %    = Concentration of potassium in percent
U ppm  = Concentration of uranium in parts per million
Kcps   = Counts per second in the K channel of the spectrometer
A(1,1) = A calibration factor
```

In matrix notation:

C = A x R

where C is the 3 x 1 matrix of concentrations
A is the 3 x 3 calibration matrix
R is the 3 x 1 matrix of spectrometer counting rates.

PLEASE PRESS RETURN TO CONTINUE.?

If data from more than 3 calibration pads are input, the program uses every possible combination of 3 of the pads to find a series of calibration matrices. For example, if data from 4 pads are input, then 4!/(3! x (4-3)!) or 4 combinations of 3 of the pads will be possible, and four calibration matrices will be calculated. The program then selects a matrix of the median calibration factors, which will be presented to you. You will then have an opportunity to view all of the possible calibration factors (from all of the possible calibration matrices) and test the usefulness of each median calibration factor. If data from 10 pads are put into the program, then each median calibration factor will be based on 10!/(3! x (10-3)!) or 120 calibration factors. Larger numbers of pads lead to more precise calibration matrices. This program is designed to handle from 3 to 19 calibration pads, and it can be altered to handle more pads by redimensioning some of the variables.

PLEASE PRESS RETURN TO CONTINUE.?

The median calibration matrix and the raw spectrometer data will be used to calculate the concentrations of K, U and Th in the pads. The calculated concentrations will be compared with the known concentrations of K, U and Th in the pads, which you must enter into the program. If the calculated concentrations are very close to the known concentrations, then the calibration factors are good. If the calculated concentrations differ from the known concentrations, then changing the calibration factors slightly may improve the results. This program will help you to test the usefulness of the calibration factors it has generated from your data. The program will also let you change individual calibration factors and show the effects of such changes on the concentrations of K, U and Th calculated with the new calibration factors. However, in order to do this, you must be familiar with the calibration matrix and how it is used to find concentrations of K, U and Th.

PLEASE PRESS RETURN TO CONTINUE.?

The program will store the matrix of median calibration factors, which will be printed at the end of the program. However, please keep a record of any changes in the calibration factors you decide to test, because only the most recent value for each calibration factor is stored in the changeable calibration matrix.

If changes in the calibration factors do not result in calculated concentrations that are close to the known concentrations, then perhaps the errors are not due to the calibration factors. IF THE RAW SPECTROMETER DATA OR THE KNOWN CONCENTRATIONS ARE NOT RELIABLE (eg.-HAVE LARGE UNCERTAINTIES), THEN RELIABLE CALIBRATION CALIBRATION FACTORS CANNOT BE OBTAINED. The following portion of this program will give you an indication of the MINIMUM uncertainty involved in using your field techniques and calibration factors.

PLEASE PRESS RETURN TO CONTINUE.?

Depending on the field conditions and techniques used, disequilibrium in the uranium series can cause large errors in estimates of uranium content. Therefore, THE U.S. GEOLOGICAL SURVEY, PRINCETON UNIVERSITY AND F.B.ZELT ASSUME NO RESPONSIBILITY OR LIABILITY FOR CALCULATIONS THAT ARE BASED ON THE RESULTS OF THIS PROGRAM.

PLEASE PRESS RETURN TO CONTINUE.?

Please recall the use of calibration factors in determining the concentrations of K, U and Th. The calibration factors are multiplied by the raw data to produce estimates of percent K, ppm U and ppm Th.

```
K %    =  A(1,1) x Kcps   +   A(1,2) x Ucps   +   A(1,3) x Thcps
U ppm =  A(2,1) x Kcps   +   A(2,2) x Ucps   +   A(2,3) x Thcps
Thppm =  A(3,1) x Kcps   +   A(3,2) x Ucps   +   A(3,3) x Thcps
```

Where:

K %   = Concentration of potassium in percent
U ppm = Concentration of uranium in parts per million
Kcps = Counts per second in the K channel of the spectrometer
A(1,1)= A calibration factor

In matrix notation:
C = A x R

where C is the 3 x 1 matrix of concentrations
A is the 3 x 3 calibration matrix
R is the 3 x 1 matrix of spectrometer counting rates.

PLEASE PRESS RETURN TO CONTINUE.?

Suppose that for each calibration pad, the % K calculated from the calibration factors and raw data is larger than the known % K. A slight adjustment of one or more calibration factors could reduce this error. If the error is positive; that is, if
K % calculated > K % known,
then would one want to reduce of increase the calibration factors (please type R or I)? R

Yes, that is correct. Of course, one would not change the calibration factors without being certain that the new calibration factor is reasonably close to the median or mean of the calibration factors calculated from the data.

Now suppose that there is a positive error in the calculated % K, and that the error increases with increasing Thcps. Which calibration factor would you consider changing:
Row number = ? 1
Column number = ? 3
Good. Now, please regard the following plot. The asterisks (*) and numbers indicate data points, and the plusses (+) show the regression line.

PLEASE PRESS RETURN TO CONTINUE.?

```
      .97   +                                       +*
      .92   +                                     +
      .86   +                                  +
      .81   +                              *+
      .76   +                             +
Error .71   +                          +
in U  .65   +                        +
Calc. .6    +                     +
dueto .55   +                   +
A2,2  .5    +                *
      .44   +           * +
      .39   +           +
      .34   +        +
      .29   +     +
      .23   +   +
      .18   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
              2       4       5       7       8       10
                          Known  Ucps   -
REGRESSION LINE:   Y = -.294209E-03  +  .997059E-01 X
CORREL. COEFF. =  .996717     DETERMIN. COEFF. =  .993445
```

PLEASE PRESS RETURN TO CONTINUE.?

The crossplot above showed that a decrease in A(2,2) would reduce the error in the calculated ppm uranium.

PLEASE PRESS RETURN TO CONTINUE.?

```
     Here is another crossplot:
     -.52   +* +
     -.55   +     +  *
     -.59   +        +
     -.62   +        * +
     -.66   +             +
Error-.69   +                + * *
in Th-.72   +                  +
Calc.-.76   +                     +
dueto-.79   +                       +
A3,1 -.83   +                          +
     -.86   +                             +
     -.89   +                               +
     -.93   +                                  +
     -.96   +                                     +
     -1     +                                       +
     -1.03  +                                        *
            +++++++++++++++++++++++++++++++++++++++++++++
             10      12      14      16      18      20
                          Known  Kcps   -
REGRESSION LINE:   Y =  .235206E-01  + -.514145E-01 X
CORREL. COEFF. = -.985996     DETERMIN. COEFF. =  .972188

PLEASE PRESS RETURN TO CONTINUE.?
```

```
     Would you increase or decrease A(3,1) to reduce the error
(Please type I or D)? I
That is correct.
     Would you like to review the section about correcting the
calibration factors, Y or N? N

     In the second half of the program, you will have opportunities
to fine-tune the calibration factors this program generates from
your data.  You may notice that the program suggests changes in
the calibration factors.  The changes suggested for some of the
calibration factors may not seem reasonable.  For example, a
suggested change may not be close to the median or mean of the
group of calibration factors that was calculated.  Use your judgement
to decide whether of not to use the suggested calibration factor
changes.  In any event, the suggested changes indicate whether the
calibration factors should be increased of decreased.

     Data entered into this program must be separated by commas or
by pressing the RETURN key.  Data cannot be separated by spaces.

PLEASE PRESS RETURN TO CONTINUE.?
```

REFERENCES

George, D.C. and Knight, L., 1982, Field calibration facilities for environmental measurement of Radium, Thorium and Potassium; GJ/TMC-01(82) UC-70A, 53pp.

Marutzky, S.J., Steele, W.D., Key, B.N., and Kosanke, K., 1984, Surface gamma-ray measurement protocol; GJ/TMC-06, 30pp.

Stromswold, D.C. and Kosanke, K.L., 1978, Calibration and error analysis for spectral radiation detectors; IEEE Trans. on Nuclear Science, Vol. NS-25, No. 1, 782-786.

Ward, D.L., 1982, Surface radiometric surveys for uranium using gross and spectral gamma-ray measurements; GJBX-97(82), 36pp.

```
PLEASE PRESS RETURN TO CONTINUE.?


PLEASE INPUT THE NUMBER OF CALIBRATION PADS ( # CALIBRATION SITES) ? 5
PLEASE INPUT THE NUMBER OF SECONDS PER MEASUREMENT? 300
ARE THE DATA DIFFERENTIAL (DELTA) MEASUREMENTS, Y OR N?
(FOR A DEFINITION OF DIFFERENTIAL MEASUREMENT, ANSWER Q )
? Q
  DIFFERENTIAL MEASUREMENTS, ALSO CALLED DELTA MEASUREMENTS, ARE
MADE BY TAKING TWO TYPES OF READINGS AT EACH SITE.  FOR EXAMPLE,
ONE READING WITH LEAD SHIELDING AND ONE READING WITHOUT SHIELDING.

*********** YOU MUST ANSWER Y, N OR Q *************

ARE THE DATA DIFFERENTIAL (DELTA) MEASUREMENTS, Y OR N?
(FOR A DEFINITION OF DIFFERENTIAL MEASUREMENT, ANSWER Q )
? Y


********  DATA FOR PAD  1  ********

NUMBER OF SHIELDED MEASUREMENTS? 30
ARE THERE REALLY  30  MEASUREMENTS, Y OR N ? Y

PLEASE INPUT SHIELDED DATA FOR PAD  1
PLEASE INPUT K, U, TH COUNTS
? 962,253,153
PLEASE INPUT K, U, TH COUNTS
? 944,273,173
PLEASE INPUT K, U, TH COUNTS
? 954,260,163
PLEASE INPUT K, U, TH COUNTS
? 999,260,200
PLEASE INPUT K, U, TH COUNTS
? 972,247,174
PLEASE INPUT K, U, TH COUNTS
? 870,248,160
PLEASE INPUT K, U, TH COUNTS
? 965,261,195
```

```
PLEASE INPUT K, U, TH COUNTS
? 983,252,163
PLEASE INPUT K, U, TH COUNTS
? 979,259,194
PLEASE INPUT K, U, TH COUNTS
? 933,258,150
PLEASE INPUT K, U, TH COUNTS
? 916,248,154
PLEASE INPUT K, U, TH COUNTS
? 943,270,168
PLEASE INPUT K, U, TH COUNTS
? 967,259,163
PLEASE INPUT K, U, TH COUNTS
? 945,233,166
PLEASE INPUT K, U, TH COUNTS
? 908,267,175
PLEASE INPUT K, U, TH COUNTS
? 1005,254,169
PLEASE INPUT K, U, TH COUNTS
? 891,241,194
PLEASE INPUT K, U, TH COUNTS
? 901,242,167
PLEASE INPUT K, U, TH COUNTS
? 955,286,174
PLEASE INPUT K, U, TH COUNTS
? 933,241,163
PLEASE INPUT K, U, TH COUNTS
? 928,287,156
PLEASE INPUT K, U, TH COUNTS
? 929,273,170
PLEASE INPUT K, U, TH COUNTS
? 918,222,183
PLEASE INPUT K, U, TH COUNTS
? 957,234,151
PLEASE INPUT K, U, TH COUNTS
? 887,266,160
PLEASE INPUT K, U, TH COUNTS
? 988,259,162
PLEASE INPUT K, U, TH COUNTS
? 904,246,143
PLEASE INPUT K, U, TH COUNTS
? 940,272,169
PLEASE INPUT K, U, TH COUNTS
? 912,214,174
PLEASE INPUT K, U, TH COUNTS
? 985,243,168

NUMBER OF UNSHIELDED MEASUREMENTS? 30
ARE THERE REALLY  30  MEASUREMENTS, Y OR N ? Y

PLEASE INPUT UNSHIELDED DATA FOR PAD  1
PLEASE INPUT K, U, TH COUNTS
? 1958,481,329
PLEASE INPUT K, U, TH COUNTS
? 1998,424,310
PLEASE INPUT K, U, TH COUNTS
```

```
? 2029,441,287
PLEASE INPUT K, U, TH COUNTS
? 1999,441,300
PLEASE INPUT K, U, TH COUNTS
? 2102,390,304
PLEASE INPUT K, U, TH COUNTS
? 2001,453,328
PLEASE INPUT K, U, TH COUNTS
? 2010,476,302
PLEASE INPUT K, U, TH COUNTS
? 2044,438,325
PLEASE INPUT K, U, TH COUNTS
? 1990,486,316
PLEASE INPUT K, U, TH COUNTS
? 2047,436,318
PLEASE INPUT K, U, TH COUNTS
? 1978,471,302
PLEASE INPUT K, U, TH COUNTS
? 1955,436,304
PLEASE INPUT K, U, TH COUNTS
? 1941,433,285
PLEASE INPUT K, U, TH COUNTS
? 2022,452,278
PLEASE INPUT K, U, TH COUNTS
? 1962,438,285
PLEASE INPUT K, U, TH COUNTS
? 2042,448,276
PLEASE INPUT K, U, TH COUNTS
? 1941,437,330
PLEASE INPUT K, U, TH COUNTS
? 2023,436,293
PLEASE INPUT K, U, TH COUNTS
? 1982,435,312
PLEASE INPUT K, U, TH COUNTS
? 2021,433,317
PLEASE INPUT K, U, TH COUNTS
? 1907,492,346
PLEASE INPUT K, U, TH COUNTS
? 1998,448,296
PLEASE INPUT K, U, TH COUNTS
? 2031,459,332
PLEASE INPUT K, U, TH COUNTS
? 1937,466,297
PLEASE INPUT K, U, TH COUNTS
? 1986,423,278
PLEASE INPUT K, U, TH COUNTS
? 2035,418,347
PLEASE INPUT K, U, TH COUNTS
? 1972,470,296
PLEASE INPUT K, U, TH COUNTS
? 1998,444,301
PLEASE INPUT K, U, TH COUNTS
? 2082,488,310
PLEASE INPUT K, U, TH COUNTS
? 2102,432,324
```

```
********  DATA FOR PAD  2  ********

NUMBER OF SHIELDED MEASUREMENTS? 20
ARE THERE REALLY  20  MEASUREMENTS, Y OR N ? Y

PLEASE INPUT SHIELDED DATA FOR PAD  2
PLEASE INPUT K, U, TH COUNTS
? 2782,395,193
PLEASE INPUT K, U, TH COUNTS
? 2629,392,220
PLEASE INPUT K, U, TH COUNTS
? 2605,413,183
PLEASE INPUT K, U, TH COUNTS
? 2544,403,204
PLEASE INPUT K, U, TH COUNTS
? 2588,414,203
PLEASE INPUT K, U, TH COUNTS
? 2619,401,194
PLEASE INPUT K, U, TH COUNTS
? 2586,389,209
PLEASE INPUT K, U, TH COUNTS
? 2565,404,204
PLEASE INPUT K, U, TH COUNTS
? 2549,416,203
PLEASE INPUT K, U, TH COUNTS
? 2643,426,213
PLEASE INPUT K, U, TH COUNTS
? 2590,383,206
PLEASE INPUT K, U, TH COUNTS
? 2622,372,214
PLEASE INPUT K, U, TH COUNTS
? 2573,393,189
PLEASE INPUT K, U, TH COUNTS
? 2594,402,186
PLEASE INPUT K, U, TH COUNTS
? 2612,410,204
PLEASE INPUT K, U, TH COUNTS
? 2595,412,213
PLEASE INPUT K, U, TH COUNTS
? 2510,392,188
PLEASE INPUT K, U, TH COUNTS
? 2607,396,187
PLEASE INPUT K, U, TH COUNTS
? 2731,405,199
PLEASE INPUT K, U, TH COUNTS
? 2595,394,202

NUMBER OF UNSHIELDED MEASUREMENTS? 20
ARE THERE REALLY  20  MEASUREMENTS, Y OR N ? Y
```

```
PLEASE INPUT UNSHIELDED DATA FOR PAD  2
PLEASE INPUT K, U, TH COUNTS
? 5888,774,363
PLEASE INPUT K, U, TH COUNTS
? 6078,724,422
PLEASE INPUT K, U, TH COUNTS
? 6111,786,405
PLEASE INPUT K, U, TH COUNTS
? 5948,815,379
PLEASE INPUT K, U, TH COUNTS
? 5833,806,358
PLEASE INPUT K, U, TH COUNTS
? 5984,761,404
PLEASE INPUT K, U, TH COUNTS
? 6058,768,344
PLEASE INPUT K, U, TH COUNTS
? 5996,779,384
PLEASE INPUT K, U, TH COUNTS
? 5947,758,384
PLEASE INPUT K, U, TH COUNTS
? 6003,760,396
PLEASE INPUT K, U, TH COUNTS
? 5941,781,377
PLEASE INPUT K, U, TH COUNTS
? 5959,769,419
PLEASE INPUT K, U, TH COUNTS
? 5891,810,413
PLEASE INPUT K, U, TH COUNTS
? 6019,793,410
PLEASE INPUT K, U, TH COUNTS
? 5954,792,395
PLEASE INPUT K, U, TH COUNTS
? 5901,807,405
PLEASE INPUT K, U, TH COUNTS
? 6112,748,354
PLEASE INPUT K, U, TH COUNTS
? 6054,757,386
PLEASE INPUT K, U, TH COUNTS
? 6040,751,390
PLEASE INPUT K, U, TH COUNTS
? 6023,764,390


********  DATA FOR PAD  3  ********

NUMBER OF SHIELDED MEASUREMENTS? 6

PLEASE INPUT SHIELDED DATA FOR PAD  3
PLEASE INPUT K, U, TH COUNTS
? 1682,836,875
PLEASE INPUT K, U, TH COUNTS
? 1734,805,831
PLEASE INPUT K, U, TH COUNTS
? 1682,811,920
```

```
PLEASE INPUT K, U, TH COUNTS
? 1728,864,863
PLEASE INPUT K, U, TH COUNTS
? 1734,816,866
PLEASE INPUT K, U, TH COUNTS
? 1680,852,835

NUMBER OF UNSHIELDED MEASUREMENTS? 6

PLEASE INPUT UNSHIELDED DATA FOR PAD  3
PLEASE INPUT K, U, TH COUNTS
? 3709,1701,1863
PLEASE INPUT K, U, TH COUNTS
? 3779,1646,1796
PLEASE INPUT K, U, TH COUNTS
? 3799,1714,1785
PLEASE INPUT K, U, TH COUNTS
? 3674,1677,1879
PLEASE INPUT K, U, TH COUNTS
? 3839,1704,1824
PLEASE INPUT K, U, TH COUNTS
? 3738,1702,1955


********  DATA FOR PAD  4  ********

NUMBER OF SHIELDED MEASUREMENTS? 14

PLEASE INPUT SHIELDED DATA FOR PAD  4
PLEASE INPUT K, U, TH COUNTS
? 2348,1489,239
PLEASE INPUT K, U, TH COUNTS
? 2306,1560,234
PLEASE INPUT K, U, TH COUNTS
? 2104,15143,246
PLEASE INPUT K, U, TH COUNTS
? 2261,1516,289
PLEASE INPUT K, U, TH COUNTS
? 2350,1488,247
PLEASE INPUT K, U, TH COUNTS
? 2262,1483,275
PLEASE INPUT K, U, TH COUNTS
? 2318,1443,246
PLEASE INPUT K, U, TH COUNTS
? 2275,1535,235
PLEASE INPUT K, U, TH COUNTS
? 2318,1426,254
PLEASE INPUT K, U, TH COUNTS
? 2332,1489,260
PLEASE INPUT K, U, TH COUNTS
? 2311,1476,240
PLEASE INPUT K, U, TH COUNTS
? 2230,1448,262
PLEASE INPUT K, U, TH COUNTS
? 2250,1569,251
PLEASE INPUT K, U, TH COUNTS
? 2331,1414,273
```

```
NUMBER OF UNSHIELDED MEASUREMENTS? 14

PLEASE INPUT UNSHIELDED DATA FOR PAD  4
PLEASE INPUT K, U, TH COUNTS
? 5050,3167,498
PLEASE INPUT K, U, TH COUNTS
? 5034
? 3204
? 452
PLEASE INPUT K, U, TH COUNTS
? 5031,3080,565
PLEASE INPUT K, U, TH COUNTS
? 4950,3209,495
PLEASE INPUT K, U, TH COUNTS
? 5089,3194,487
PLEASE INPUT K, U, TH COUNTS
? 5055,3183,482
PLEASE INPUT K, U, TH COUNTS
? 5066,3210,494
PLEASE INPUT K, U, TH COUNTS
? 4910,3152,512
PLEASE INPUT K, U, TH COUNTS
? 5040,3226,483
PLEASE INPUT K, U, TH COUNTS
? 5027,3096,492
PLEASE INPUT K, U, TH COUNTS
? 5058,3083,495
PLEASE INPUT K, U, TH COUNTS
? 5087,3200,510
PLEASE INPUT K, U, TH COUNTS
? 4969,3201,465
PLEASE INPUT K, U, TH COUNTS
? 4893,31476,479


********  DATA FOR PAD  5  ********

NUMBER OF SHIELDED MEASUREMENTS? 10

PLEASE INPUT SHIELDED DATA FOR PAD  5
PLEASE INPUT K, U, TH COUNTS
? 2929,1139,355
PLEASE INPUT K, U, TH COUNTS
? 2839,1089,381
PLEASE INPUT K, U, TH COUNTS
? 2911,1194,369
PLEASE INPUT K, U, TH COUNTS
? 2979,1123,424
PLEASE INPUT K, U, TH COUNTS
? 2875,1171,404
PLEASE INPUT K, U, TH COUNTS
? 2892,1173,376
PLEASE INPUT K, U, TH COUNTS
```

? 2818,1155,411
PLEASE INPUT K, U, TH COUNTS
? 2886,1134,352
PLEASE INPUT K, U, TH COUNTS
? 2859,1171,400
PLEASE INPUT K, U, TH COUNTS
? 2878,1143,398

NUMBER OF UNSHIELDED MEASUREMENTS? 10

PLEASE INPUT UNSHIELDED DATA FOR PAD 5
PLEASE INPUT K, U, TH COUNTS
? 6582,2347,850
PLEASE INPUT K, U, TH COUNTS
? 6415,2436,770
PLEASE INPUT K, U, TH COUNTS
? 6564,2494,803
PLEASE INPUT K, U, TH COUNTS
? 6584,2466,835
PLEASE INPUT K, U, TH COUNTS
? 6647,2505,774
PLEASE INPUT K, U, TH COUNTS
? 6585,2515,752
PLEASE INPUT K, U, TH COUNTS
? 6657,2447,792
PLEASE INPUT K, U, TH COUNTS
? 6444,2522,793
PLEASE INPUT K, U, TH COUNTS
? 6631,2486,800
PLEASE INPUT K, U, TH COUNTS
? 6493,2531,780

PLEASE CHECK THE DATA
*********** PAD 1 ***********
SHIELDED DATA

K	U	T
962	253	153
944	273	173
954	260	163
999	260	200
972	247	174
870	248	160
965	261	195
983	252	163
979	259	194
933	258	150
916	248	154
943	270	168
967	259	163
945	233	166
908	267	175
1005	254	169
891	241	194
901	242	167
955	286	174

[illegible]	[illegible]	[illegible]
933	241	163
928	287	156
929	273	170
918	222	183
957	234	151
887	266	160
988	259	162
904	246	143
940	272	169
912	214	174
985	243	168

UNSHIELDED DATA

K	U	T
1958	481	329
1998	424	310
2029	441	287
1999	441	300
2102	390	304
2001	453	328
2010	476	302
2044	438	325
1990	486	316
2047	436	318
1978	471	302
1955	436	304
1941	433	285
2022	452	278
1962	438	285
2042	448	276
1941	437	330
2023	436	293
1982	435	312
2021	433	317
1907	492	346
1998	448	296
2031	459	332
1937	466	297
1986	423	278
2035	418	347
1972	470	296
1998	444	301
2082	488	310
2102	432	324

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 2 ***********

SHIELDED DATA

K	U	T
2782	395	193
2629	392	220
2605	413	183
2544	403	204
2588	414	203
2619	401	194

2586	389	209
2565	404	204
2549	416	203
2643	426	213
2590	383	206
2622	372	214
2573	393	189
2594	402	186
2612	410	204
2595	412	213
2510	392	188
2607	396	187
2731	405	199
2595	394	202

UNSHIELDED DATA

K	U	T
5888	774	363
6078	724	422
6111	786	405
5948	815	379
5833	806	358
5984	761	404
6058	768	344
5996	779	384
5947	758	384
6003	760	396
5941	781	377
5959	769	419
5891	810	413
6019	793	410
5954	792	395
5901	807	405
6112	748	354
6054	757	386
6040	751	390
6023	764	390

PLEASE PRESS RETURN TO CONTINUE.?
*********** PAD 3 ***********

SHIELDED DATA

K	U	T
1682	836	875
1734	805	831
1682	811	920
1728	864	863
1734	816	866
1680	852	835

UNSHIELDED DATA

K	U	T
3709	1701	1863
3779	1646	1796
3799	1714	1785
3674	1677	1879
3839	1704	1824
3738	1702	1955

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 4 ***********

SHIELDED DATA

K	U	T
2348	1489	239
2306	1560	234
2104	15143	246
2261	1516	289
2350	1488	247
2262	1483	275
2318	1443	246
2275	1535	235
2318	1426	254
2332	1489	260
2311	1476	240
2230	1448	262
2250	1569	251
2331	1414	273

UNSHIELDED DATA

K	U	T
5050	3167	498
5034	3204	452
5031	3080	565
4950	3209	495
5089	3194	487
5055	3183	482
5066	3210	494
4910	3152	512
5040	3226	483
5027	3096	492
5058	3083	495
5087	3200	510
4969	3201	465
4893	31476	479

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 5 ***********

SHIELDED DATA

K	U	T
2929	1139	355
2839	1089	381
2911	1194	369
2979	1123	424
2875	1171	404
2892	1173	376
2818	1155	411
2886	1134	352
2859	1171	400
2878	1143	398

UNSHIELDED DATA

K	U	T
6582	2347	850
6415	2436	770
6544	2494	803

6584	2466	835
6647	2505	774
6585	2515	752
6657	2447	792
6444	2522	793
6631	2486	800
6493	2531	780

ARE THE DATA CORRECT, Y OR N? N
WHICH PAD HAS INCORRECT DATA? 4
IS THE INCORRECT DATA SHIELDED OR UNSHIELDED? SHIELDED
WHICH ROW OF SHIELDED DATA FOR PAD IS INCORRECT, 1,2,3,4, ETC., (TOP ROW = 1)?
3
PLEASE INPUT THE CORRECT SHIELDED K, U, TH DATA FOR PAD 4
? 2104,1514,246
PLEASE CHECK THE DATA
*********** PAD 1 ***********

SHIELDED DATA

K	U	T
962	253	153
944	273	173
954	260	163
999	260	200
972	247	174
870	248	160
965	261	195
983	252	163
979	259	194
933	258	150
916	248	154
943	270	168
967	259	163
945	233	166
908	267	175
1005	254	169
891	241	194
901	242	167
955	286	174
933	241	163
928	287	156
929	273	170
918	222	183
957	234	151
887	266	160
988	259	162
904	246	143
940	272	169
912	214	174
985	243	168

UNSHIELDED DATA

K	U	T
1958	481	329
1998	424	310

2029	441	287
1999	441	300
2102	390	304
2001	453	328
2010	476	302
2044	438	325
1990	486	316
2047	436	318
1978	471	302
1955	436	304
1941	433	285
2022	452	278
1962	438	285
2042	448	276
1941	437	330
2023	436	293
1982	435	312
2021	433	317
1907	492	346
1998	448	296
2031	459	332
1937	466	297
1986	423	278
2035	418	347
1972	470	296
1998	444	301
2082	488	310
2102	432	324

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 2 ***********

SHIELDED DATA

K	U	T
2782	395	193
2629	392	220
2605	413	183
2544	403	204
2588	414	203
2619	401	194
2586	389	209
2565	404	204
2549	416	203
2643	426	213
2590	383	206
2622	372	214
2573	393	189
2594	402	186
2612	410	204
2595	412	213
2510	392	188
2607	396	187
2731	405	199
2595	394	202

UNSHIELDED DATA

K	U	T
5888	774	363
6078	724	422
6111	786	405
5948	815	379
5833	806	358
5984	761	404
6058	768	344
5996	779	384
5947	758	384
6003	760	396
5941	781	377
5959	769	419
5891	810	413
6019	793	410
5954	792	395
5901	807	405
6112	748	354
6054	757	386
6040	751	390
6023	764	390

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 3 ***********

SHIELDED DATA

K	U	T
1682	836	875
1734	805	831
1682	811	920
1728	864	863
1734	816	866
1680	852	835

UNSHIELDED DATA

K	U	T
3709	1701	1863
3779	1646	1796
3799	1714	1785
3674	1677	1879
3839	1704	1824
3738	1702	1955

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 4 ***********

SHIELDED DATA

K	U	T
2348	1489	239
2306	1560	234
2104	1514	246
2261	1516	289
2350	1488	247
2262	1483	275
2318	1443	246
2275	1535	235
2318	1426	254

2332	1489	260
2311	1476	240
2230	1448	262
2250	1569	251
2331	1414	273

UNSHIELDED DATA

K	U	T
5050	3167	498
5034	3204	452
5031	3080	565
4950	3209	495
5089	3194	487
5055	3183	482
5066	3210	494
4910	3152	512
5040	3226	483
5027	3096	492
5058	3083	495
5087	3200	510
4969	3201	465
4893	31476	479

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 5 ***********

SHIELDED DATA

K	U	T
2929	1139	355
2839	1089	381
2911	1194	369
2979	1123	424
2875	1171	404
2892	1173	376
2818	1155	411
2886	1134	352
2859	1171	400
2878	1143	398

UNSHIELDED DATA

K	U	T
6582	2347	850
6415	2436	770
6564	2494	803
6584	2466	835
6647	2505	774
6585	2515	752
6657	2447	792
6444	2522	793
6631	2486	800
6493	2531	780

ARE THE DATA CORRECT, Y OR N? N
WHICH PAD HAS INCORRECT DATA? 4
IS THE INCORRECT DATA SHIELDED OR UNSHIELDED? UNSHIELDED
WHICH ROW OF UNSHIELDED DATA FOR PAD IS INCORRECT, 1,2,3,4, ETC., (TOP ROW =
? 14

PLEASE INPUT THE CORRECT UNSHIELDED K, U, TH DATA FOR PAD 4
? 4893,3146,479
PLEASE CHECK THE DATA
*********** PAD 1 ***********

SHIELDED DATA

K	U	T
962	253	153
944	273	173
954	260	163
999	260	200
972	247	174
870	248	160
965	261	195
983	252	163
979	259	194
933	258	150
916	248	154
943	270	168
967	259	163
945	233	166
908	267	175
1005	254	169
891	241	194
901	242	167
955	286	174
933	241	163
928	287	156
929	273	170
918	222	183
957	234	151
887	266	160
988	259	162
904	246	143
940	272	169
912	214	174
985	243	168

UNSHIELDED DATA

K	U	T
1958	481	329
1978	424	310
2029	441	287
1999	441	300
2102	390	304
2001	453	328
2010	476	303
2044	438	325
1990	486	316
2047	436	[illegible]
1978	471	303
1955	433	[illegible]
1941	433	285
2022	452	278
[illegible]	436	285

2042	[illegible]	276
1941	437	[illegible]
[illegible]	436	[illegible]
1982	435	[illegible]
2021	433	[illegible]
1907	492	[illegible]
1996	448	[illegible]
2031	[illegible]	[illegible]
1937	[illegible]	[illegible]
1984	[illegible]	278
[illegible]	[illegible]	347
[illegible]	470	[illegible]
[illegible]	444	[illegible]
2032	[illegible]	[illegible]
2102	[illegible]	[illegible]

PLEASE [illegible] TO CONTINUE.?
********** [illegible] 2 **********

SHIELDED DATA

K	U	T
2781	[illegible]	193
[illegible]	[illegible]	220
[illegible]	[illegible]	183
2544	[illegible]	204
[illegible]	414	203
2619	[illegible]	194
2586	389	209
2565	404	204
2549	416	203
2643	426	213
2590	388	206
2622	372	214
2573	393	189
2594	402	186
2612	410	204
2595	412	213
2510	392	188
2607	396	187
2731	405	199
2595	394	202

UNSHIELDED DATA

K	U	T
5888	774	363
6078	724	422
6111	786	405
5948	815	379
5833	806	358
5984	761	404
6058	768	344
5996	779	384
5947	758	384
6003	760	396
5941	781	377
5959	769	419
5891	810	413

6019	793	410
5954	792	395
5901	807	405
6112	748	354
6054	757	386
6040	751	390
6023	764	390

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 3 ***********

SHIELDED DATA

K	U	T
1682	836	875
1734	805	831
1682	811	920
1728	864	863
1734	816	866
1680	852	835

UNSHIELDED DATA

K	U	T
3709	1701	1863
3779	1646	1796
3799	1714	1785
3674	1677	1879
3839	1704	1824
3738	1702	1955

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 4 ***********

SHIELDED DATA

K	U	T
2348	1489	239
2306	1560	234
2104	1514	246
2261	1516	289
2350	1488	247
2262	1483	275
2318	1443	246
2275	1535	235
2318	1426	254
2332	1489	260
2311	1476	240
2230	1448	262
2250	1569	251
2331	1414	273

UNSHIELDED DATA

K	U	T
5050	3167	498
5034	3204	452
5031	3080	565
4950	3209	495
5089	3194	487
5055	3183	482

5066	3210	494
4910	3152	512
5040	3226	483
5027	3096	492
5058	3083	495
5087	3200	510
4969	3201	465
4893	3146	479

PLEASE PRESS RETURN TO CONTINUE.?

*********** PAD 5 ***********

SHIELDED DATA

K	U	T
2929	1139	355
2839	1089	381
2911	1194	369
2979	1123	424
2875	1171	404
2892	1173	376
2818	1155	411
2886	1134	352
2859	1171	400
2878	1143	398

UNSHIELDED DATA

K	U	T
6582	2347	850
6415	2436	770
6564	2494	803
6584	2466	835
6647	2505	774
6585	2515	752
6657	2447	792
6444	2522	793
6631	2486	800
6493	2531	780

ARE THE DATA CORRECT, Y OR N? Y

PLEASE INPUT THE KNOWN CONCENTRATIONS OF K, U, AND TH FOR EACH PAD.

******* PAD 1 *******
PLEASE INPUT THE CONCENTRATION OF K IN %
? 1.45
CONCENTRATION OF U IN ppm
? 2.19
CONCENTRATION OF TH IN ppm
? 6.26

******* PAD 2 *******
PLEASE INPUT THE CONCENTRATION OF K IN %
? 5.14
CONCENTRATION OF U IN ppm
? 5.09
CONCENTRATION OF TH IN ppm
? 8.48

```
******* PAD  3  *******
PLEASE INPUT THE CONCENTRATION OF K IN %
? 2.01
CONCENTRATION OF U IN ppm
? 5.14
CONCENTRATION OF TH IN ppm
? 45.33

******* PAD  4  *******
PLEASE INPUT THE CONCENTRATION OF K IN %
? 2.03
CONCENTRATION OF U IN ppm
? 30.29
CONCENTRATION OF TH IN ppm
? 9.19

******* PAD  5  *******
PLEASE INPUT THE CONCENTRATION OF K IN %
? 4.11
CONCENTRATION OF U IN ppm
? 20.39
CONCENTRATION OF TH IN ppm
? 1752
PLEASE CHECK THE CONCENTRATIONS.
PAD #          K             U              TH
 1             1.45          2.19           6.26
 2             5.14          5.09           8.48
 3             2.01          5.14           45.33
 4             2.03          30.29          9.19
 5             4.11          20.39          1752

ARE THE CONCENTRATIONS CORRECT, Y OR N? N
WHICH PAD HAS INCORRECT DATA: 1,2,3,ETC.? 5
WHAT ARE THE CORRECT K,U,TH VALUES FOR PAD  5
? 4.11,20.39,17.52
PLEASE CHECK THE CONCENTRATIONS.
PAD #          K             U              TH
 1             1.45          2.19           6.26
 2             5.14          5.09           8.48
 3             2.01          5.14           45.33
 4             2.03          30.29          9.19
 5             4.11          20.39          17.52

ARE THE CONCENTRATIONS CORRECT, Y OR N? Y
THE MEDIAN CALIBRATION MATRIX IS:

 .512268 -.449866 -.444573E-01
 .115035E-01  5.89409 -3.42353
-.127641E-01 -.369305  14.2546

PLEASE PRESS RETURN TO CONTINUE.?
```

```
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:

 .512268        -.449866        -.444573E-01
 .115035E-01     5.89409        -3.42353
-.127641E-01    -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?

HERE IS A CROSSPLOT OF KNOWN AND CALCULATED CONCENTRATIONS OF K, U AND TH:
      45.33 +                                          +*
      42.4  +                                        +
      39.48 +                                      +
      36.55 +                                    +
      33.63 +                                  +
KNOWN 30.7  +                               +*+
CONC. 27.78 +                             +
      24.85 +                           +
      21.93 +                         +
      19    +                       +  *
      16.08 +                     +*
      13.15 +                   +
      10.23 +                +*+
      7.3   +    *+*
      4.38  +    3 *
      1.45  +  3 *
            ++++++++++++++++++++++++++++++++++++++++++++++
             1        10       19       28       36       45
                              CALC. CONC.
REGRESSION LINE:    Y = -.14826  +  .997468 X
CORREL. COEFF. =   .99953     DETERMIN. COEFF. =   .999061

PLEASE PRESS RETURN TO CONTINUE.?

NOW LET US CONSIDER THE DATA FOR POTASSIUM.


THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .512268        -.449866        -.444573E-01
 .115035E-01     5.89409        -3.42353
-.127641E-01    -.369305         14.2546
```

```
PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                        *
      4.89  +                                      +
      4.65  +                                   +
      4.4   +                                +
      4.16  +                              *
KNOWN 3.91  +                           +
CONC. 3.66  +                        +
      3.42  +                      +
      3.17  +                   +
      2.93  +                +
      2.68  +              +
      2.43  +           +
      2.19  +        +
      1.94  +      **
      1.7   +   +
      1.45  + *
            +++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     3       3.7     4.5     5.2
                          CALC. CONC.
REGRESSION LINE:    Y = -.518837E-01  +  .992957 X
CORREL. COEFF. =  .999786     DETERMIN. COEFF. =  .999572

PLEASE PRESS RETURN TO CONTINUE.?

      .23   +                                        *
      .22   +
      .21   +
      .2    +                         *
      .19   +
Error .18   +                                    +
in K  .17   +                                +
Calc. .15   +                            +
dueto .14   +                        +
A1,1  .13   +               *    +
      .12   +               +
      .11   +           +
      .1    +       +
      .09   +   +
      .08   +                                   *
      .07   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11       12
                    cps K KNOWN
REGRESSION LINE:    Y =  .038395  +  .120092E-01 X
CORREL. COEFF. =  .585242     DETERMIN. COEFF. =  .342508
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 1 ).  ***
```

```
PLEASE PRESS RETURN TO CONTINUE.?

      .29   +                               *
      .27   +
      .26   +
      .25   +
      .24   +                                       +
Error .22   +                                  +
in K  .21   +                             +
Calc. .2    +                        +
dueto .18   +     *             +                    *
A1,2  .17   +              +
      .16   +         +        *
      .15   +    +
      .13   +
      .12   +
      .11   +
      .09   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cPs U KNOWN
REGRESSION LINE:    Y =  .121095  +  .209489E-01 X
CORREL. COEFF. =  .629528     DETERMIN. COEFF. =  .396305
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      .37   +             *
      .36   +
      .34   +
      .32   +
      .3    +*
Error .28   +
in K  .27   +
Calc. .25   +                                       +
dueto .23   +
A1,3  .21   +*
      .19   +                                        *
      .18   +
      .16   +
      .14   +
      .12   +
      .11   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cPsTh KNOWN
REGRESSION LINE:    Y =  .232102  +  .50671E-02 X
CORREL. COEFF. =  .563204E-01     DETERMIN. COEFF. =  .317199E-02
A( 1 , 3 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?
```

```
WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .512268       -.449866       -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                    A( 1 , 1 )
 0      -
        XXX
 .5     -
        XXXXXXX
 1      -
        1  4  7  10
        FREQUENCY

RANGE OF VALUES:   .494281  TO  .547652    NUMBER OF VALUES =  10
MEDIAN =  .512268           MEAN =  .513524
VALUE USED IN LAST CROSSPLOTS:   .512268
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that  .506116  may be a
better value for A( 1 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 1 ),
then you may want to try  .506116  by substituting it for
 .512268  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 1 ), Y OR N? Y
 .494281       .494728       .497365       .508788       .510149       .514387
     .514926       .515071       .537893       .547652
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 1 )
? .51
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? Y
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .51           -.449866       -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01  -.369305        14.2546
```

```
PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                         *
      4.89  +                                       +
      4.65  +                                    +
      4.4   +                                 +
      4.16  +                              *
KNOWN 3.91  +                           +
CONC. 3.66  +                        +
      3.42  +                      +
      3.17  +                   +
      2.93  +                +
      2.68  +             +
      2.43  +          +
      2.19  +       +
      1.94  +    + 2
      1.7   +  +
      1.45  + *
            ++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     3        3.7     4.4     5.2
                              CALC. CONC.
REGRESSION LINE:   Y = -.453293E-01  +  .997236 X
CORREL. COEFF. =  .999821     DETERMIN. COEFF. =  .999643

PLEASE PRESS RETURN TO CONTINUE.?

      .18   +                                         *
      .17   +
      .16   +
      .16   +
      .15   +                          *
Error .14   +                                         +
in K  .13   +                                    +
Calc. .12   +                               +
dueto .11   +                          +
A1,1  .1    +                *    +
      .09   +                +
      .08   +           +
      .08   +       +
      .07   + +
      .06   +*
      .05   +                                    *
            ++++++++++++++++++++++++++++++++++++++++++++
             4       5       7        9        11      12
                          cps K KNOWN
REGRESSION LINE:   Y =  .353906E-01  +  .839176E-02 X
CORREL. COEFF. =  .504529     DETERMIN. COEFF. =  .25455
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 1 ).   ***
```

PLEASE PRESS RETURN TO CONTINUE.?

```
      .21   +                               *
      .2    +
      .2    +
      .19   +
      .18   +
Error .17   +                                    +
in K  .16   +                                +
Calc. .15   +                           +
dueto .14   +                      +                 *
A1,2  .13   +                  +
      .12   +     *       +
      .11   +        +         *
      .1    +    +
      .09   +
      .08   +
      .07   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:   Y =  .840981E-01  +  .161707E-01 X
CORREL. COEFF. =  .659712     DETERMIN. COEFF. =  .43522
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 2 ).  ***
```

PLEASE PRESS RETURN TO CONTINUE.?

```
      .28   +             *
      .27   +
      .25   +
      .24   +
      .23   +*
Error .21   +
in K  .2    +
Calc. .19   +
dueto .17   +             +
A1,3  .16   +
      .15   +                                        *
      .13   +*
      .12   +
      .11   +
      .09   +
      .08   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:   Y =  .16771  +  .471015E-02 X
CORREL. COEFF. =  .694213E-01     DETERMIN. COEFF. =  .481931E-02
A( 1 , 3 ) MAY BE O.K.
```

PLEASE PRESS RETURN TO CONTINUE.?

```
WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .51           -.449866       -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 1 , 2 )
-3       -
-2.9     -
-2.8     -
-2.7     -
-2.6     -
-2.5     -
-2.4     -
-2.3     -
-2.2     -
-2.1     -
-2       -
-1.9     -
-1.8     -
-1.7     -
-1.6     -
-1.5     -
-1.4     -
-1.3     -
-1.2     -
-1.1     -
         X
-1       -
-.900001 -
-.800001 -
-.700001 -
-.600001 -
-.500001 -
        -XXXXXXXXX

-.400001 -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:  -1.02513  TO -.430975    NUMBER OF VALUES =  10
MEDIAN = -.449866          MEAN = -.507757
VALUE USED IN LAST CROSSPLOTS:  -.449866
PLEASE PRESS RETURN TO CONTINUE.?
```

```
     Various calculations suggest that -.457141  may be a
better value for A( 1 , 2 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 2 ),
then you may want to try -.457141  by substituting it for
-.449866  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 2 ), Y OR N? Y
-1.02513      -.477132      -.464575      -.457244      -.450291      -.449442
    -.446881      -.439946      -.435953      -.430975
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 2 )
? -.45
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? Y
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .51          -.45          -.444573E-01
 .115035E-01   5.89409      -3.42353
-.127641E-01  -.369305       14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                      *
      4.89  +                                    +
      4.65  +                                 +
      4.4   +                              +
      4.16  +                            *
KNOWN 3.91  +                         +
CONC. 3.66  +                      +
      3.42  +                    +
      3.17  +                 +
      2.93  +              +
      2.68  +            +
      2.43  +         +
      2.19  +      +
      1.94  +   + 2
      1.7   +  +
      1.45  + *
            ++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     3       3.7     4.4     5.2
                              CALC. CONC.
REGRESSION LINE:   Y = -.449073E-01  +  .997227 X
CORREL. COEFF. =  .999823     DETERMIN. COEFF. =  .999646
```

```
PLEASE PRESS RETURN TO CONTINUE.?

      .18   +                                        *
      .17   +
      .16   +
      .15   +
      .15   +                         *
Error .14   +                                        +
in K  .13   +                                   +
Calc. .12   +                              +
dueto .11   +                         +
A1,1  .1    +               *    +
      .09   +               +
      .08   +          +
      .07   +      +
      .07   + +
      .06   +*
      .05   +                                   *
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:   Y =  .035067  +  .829266E-02 X
CORREL. COEFF. =  .504612     DETERMIN. COEFF. =  .254634
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      .21   +                               *
      .2    +
      .19   +
      .18   +
      .18   +
Error .17   +                                    +
in K  .16   +                                +
Calc. .15   +                           +
dueto .14   +                      +                 *
A1,2  .13   +                  +
      .12   +     *       +
      .11   +        +         *
      .1    +    +
      .09   +
      .08   +
      .07   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:   Y =  .833855E-01  +  .159483E-01 X
CORREL. COEFF. =  .656872     DETERMIN. COEFF. =  .431481
*** IT MAY BE WORTHWHILE TO CHECK A( 1 , 2 ).  ***
```

```
PLEASE PRESS RETURN TO CONTINUE.?

       .28    +              *
       .26    +
       .25    +
       .24    +
       .22    +*
Error  .21    +
in K   .2     +
Calc.  .19    +
dueto  .17    +               +
A1,3   .16    +
       .15    +                                          *
       .13    +*
       .12    +
       .11    +
       .09    +
       .08    +*
              +++++++++++++++++++++++++++++++++++++++++++++
               .5      1       1.6      2.1      2.7      3.3
                          cpsTh KNOWN
REGRESSION LINE:    Y =  .165923  +  .46162E-02 X
CORREL. COEFF. =  .688481E-01     DETERMIN. COEFF. =  .474006E-02
A( 1 , 3 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .51           -.45           -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01   -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 1 , 1 )
 0      -
          XXX
 .5     -
          XXXXXXX
 1      -
          1  4  7  10
          FREQUENCY

RANGE OF VALUES:   .494281  TO  .547652   NUMBER OF VALUES =  10
MEDIAN =  .512268          MEAN =  .513524
VALUE USED IN LAST CROSSPLOTS:   .51
PLEASE PRESS RETURN TO CONTINUE.?
```

```
     Various calculations suggest that  .505771  may be a
better value for A( 1 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 1 ),
then you may want to try  .505771  by substituting it for
 .51  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 1 )
? .507
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .507          -.45            -.444573E-01
 .115035E-01    5.89409        -3.42353
-.127641E-01   -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                  A( 1 , 2 )
-3       -
-2.9     -
-2.8     -
-2.7     -
-2.6     -
-2.5     -
-2.4     -
-2.3     -
-2.2     -
-2.1     -
-2       -
-1.9     -
-1.8     -
-1.7     -
-1.6     -
-1.5     -
-1.4     -
-1.3     -
-1.2     -
-1.1     -
         X
-1       -
-.900001 -
-.800001 -
-.700001 -
-.600001 -
-.500001 -
         XXXXXXXXX

-.400001 -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -1.02513  TO -.430975    NUMBER OF VALUES =  10
MEDIAN = -.449866           MEAN = -.507757
VALUE USED IN LAST CROSSPLOTS:  -.45
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.457177  may be a
better value for A( 1 , 2 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 2 ),
then you may want to try -.457177  by substituting it for
-.45  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 2 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 2 )
? -.46
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? Y
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .507         -.46           -.444573E-01
 .115035E-01   5.89409       -3.42353
-.127641E-01  -.369305        14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                        *
      4.89  +                                     +
      4.65  +                                   +
      4.4   +                                +
      4.16  +                             *
KNOWN 3.91  +                           +
CONC. 3.66  +                        +
      3.42  +                     +
      3.17  +                   +
      2.93  +                +
      2.68  +             +
      2.43  +           +
      2.19  +        +
      1.94  +     + 2
      1.7   +  +
      1.45  + *
            ++++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     2.9     3.7     4.4     5.1
                          CALC. CONC.
REGRESSION LINE:   Y = -.381136E-02  +  1.00206 X
CORREL. COEFF. =  .999881     DETERMIN. COEFF. =  .999762

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      .02   +*
      .01   +
      .01   +
      0     +
      0     +
Error-.01   +     +                                  *
in K -.02   +            +
Calc.-.02   +                   +
dueto-.03   +                          +
A1,1 -.03   +                                +  *
     -.04   +               *                       +
     -.05   +
     -.05   +
     -.06   +
     -.06   +
     -.07   +                         *
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
```

REGRESSION LINE: Y = .689067E-02 + -.391087E-02 X
CORREL. COEFF. = -.418933   DETERMIN. COEFF. = .175505
*** IT MAY BE WORTHWHILE TO CHECK A(1 , 1). ***

PLEASE PRESS RETURN TO CONTINUE.?

```
      .01   +*
      0     +
      0     +
     -.01   +
     -.01   +
Error-.02   +
in K -.02   +
Calc.-.03   +   +
dueto-.03   +         +                     *
A1,2 -.04   +               +
     -.04   +                     +
     -.05   +                  *        +
     -.05   +                                 +
     -.06   +                                       +
     -.06   +
     -.07   +     *                                  *
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
```

REGRESSION LINE: Y = -.188844E-01 + -.701724E-02 X
CORREL. COEFF. = -.462723   DETERMIN. COEFF. = .214112
*** IT MAY BE WORTHWHILE TO CHECK A(1 , 2). ***

PLEASE PRESS RETURN TO CONTINUE.?

```
        .01    +*
        0      +
      -.01     +
      -.02     +
      -.02     +
Error-.03      +
in K -.04      +
Calc.-.05      +
dueto-.05      +                                          *
A1,3 -.06      +             *              +
      -.07     +
      -.07     +*
      -.08     +
      -.09     +
      -.1      +
      -.1      +*
               ++++++++++++++++++++++++++++++++++++++++++++++
                .5      1       1.6     2.1     2.7     3.3
                            cpsTh KNOWN
REGRESSION LINE:    Y = -.529751E-01  + -.28879E-02 X
CORREL. COEFF. = -.817385E-01      DETERMIN. COEFF. =  .668118E-02
A( 1 , 3 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .507          -.46           -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01   -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 1 , 1 )
 0      -
          XXX
 .5     -
          XXXXXXX
 1      -
          1  4  7  10
          FREQUENCY

RANGE OF VALUES:   .494281  TO  .547652    NUMBER OF VALUES =  10
MEDIAN =  .512268           MEAN =  .513524
VALUE USED IN LAST CROSSPLOTS:   .507
PLEASE PRESS RETURN TO CONTINUE.?
```

```
     Various calculations suggest that  .508983  may be a
better value for A( 1 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 1 ),
then you may want to try  .508983  by substituting it for
 .507  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 1 )
? .508
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508           -.46            -.444573E-01
 .115035E-01    5.89409         -3.42353
-.127641E-01   -.369305          14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 1 , 2 )
-3       -
-2.9     -
-2.8     -
-2.7     -
-2.6     -
-2.5     -
-2.4     -
-2.3     -
-2.2     -
-2.1     -
-2       -
-1.9     -
-1.8     -
-1.7     -
-1.6     -
-1.5     -
-1.4     -
-1.3     -
-1.2     -
-1.1     -
          X
-1       -
-.900001 -
-.800001 -
-.700001 -
-.600001 -
-.500001 -
         XXXXXXXXX

-.400001 -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -1.02513  TO -.430975    NUMBER OF VALUES =  10
MEDIAN = -.449866           MEAN = -.507757
VALUE USED IN LAST CROSSPLOTS:  -.46
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.456772  may be a
better value for A( 1 , 2 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 2 ),
then you may want to try -.456772  by substituting it for
-.46  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 2 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 2 )
? -.457
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01   -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 1
  COLUMN NUMBER =
? 3

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                  A( 1 , 3 )
-2        -
-1.9      -
-1.8      -
-1.7      -
-1.6      -
-1.5      -
-1.4      -
-1.3      -
-1.2      -
-1.1      -
-1        -
-.9       -
-.8       -
-.7       -
-.6       -
-.5       -
-.4       -
            X
-.3       -
-.2       -
            XXX
-.999997E-01 -
            XXXXX
 .312924E-06 -
 .1       -
 .2       -
 .3       -
            X
 .4       -
            1  4  7  10
            FREQUENCY
```

```
RANGE OF VALUES:  -.328676  TO  .372347    NUMBER OF VALUES =  10
MEDIAN = -.444573E-01       MEAN = -.667957E-01
VALUE USED IN LAST CROSSPLOTS:  -.444573E-01
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.443289E-01  may be a
better value for A( 1 , 3 ).  If this seems reasonable in
light of the histogram and other values for A( 1 , 3 ),
then you may want to try -.443289E-01  by substituting it for
-.444573E-01  and going through the plots for in K  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 1 , 3 ), Y OR N? N
-.328676       -.177083       -.174649       -.160882       -.480963E-01  -.408183E
01  -.393709E-01  -.373565E-01  -.333715E-01   .372347
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 3 )
? -.0445
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? Y
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .508         -.457         -.0445
 .115035E-01   5.89409      -3.42353
-.127641E-01  -.369305       14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                        *
      4.89  +                                      +
      4.65  +                                   +
      4.4   +                                +
      4.16  +                             *
KNOWN 3.91  +                           +
CONC. 3.66  +                        +
      3.42  +                     +
      3.17  +                   +
      2.93  +                +
      2.68  +             +
      2.43  +           +
      2.19  +        +
      1.94  +     + 2
      1.7   +   +
      1.45  + *
            +++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     2.9     3.7     4.4     5.1
                          CALC. CONC.
REGRESSION LINE:   Y = -.165882E-01  +  1.00047 X
CORREL. COEFF. =  .999893     DETERMIN. COEFF. =  .999786

PLEASE PRESS RETURN TO CONTINUE.?
```

```
       .05    +                                               *
       .04    +
       .04    +
       .04    +
       .03    +
Error  .03    +*
in K   .03    +
Calc.  .02    +
dueto  .02    +
A1,1   .02    +
       .01    +
       .01    +
       0      +                  *
       0      +
       0      +                            *
      -.01    +                                      *
              ++++++++++++++++++++++++++++++++++++++++++++
               4       5       7       9       11      12
                          cps K KNOWN
REGRESSION LINE:    Y =  .153419E-01  + -.910737E-04 X
CORREL. COEFF. = -.138154E-01      DETERMIN. COEFF. =  .190866E-03
A( 1 , 1 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?

       .05    +                                      *
       .04    +
       .04    +
       .04    +
       .03    +
Error  .03    +*
in K   .02    +
Calc.  .02    +
dueto  .02    +
A1,2   .01    +
       .01    +
       .01    +
       0      +                     *
       0      +
       0      +                                               *
      -.01    +      *
              ++++++++++++++++++++++++++++++++++++++++++++
               .6      1.6     2.6     3.6     4.6     5.6
                          cps U KNOWN
REGRESSION LINE:    Y =  .133333E-01  +  .741918E-04 X
CORREL. COEFF. =  .667781E-02      DETERMIN. COEFF. =  .445932E-04
A( 1 , 2 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?
```

```
         .05    +              *
         .04    +
         .04    +
         .04    +
         .03    +
Error    .03    +*
in K     .03    +
Calc.    .02    +
dueto    .02    +
A1,3     .01    +              +
         .01    +
         .01    +                                          *
         0      +
         0      +
         0      +*
        -.01    +*
                ++++++++++++++++++++++++++++++++++++++++++++
                 .5      1       1.6     2.1     2.7     3.3
                        cpsTh KNOWN
```

REGRESSION LINE: Y =   .155037E-01 + -.666124E-03 X
CORREL. COEFF. = -.327048E-01   DETERMIN. COEFF. = .106961E-02
A(1 , 3) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? N

NOW FOR THE DATA FOR URANIUM.....

THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:

```
 .508            -.457            -.0445
 .115035E-01      5.89409         -3.42353
-.127641E-01     -.369305          14.2546
```

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM

```
      30.29 +                                          *
      28.42 +                                        +
      26.54 +                                     +
      24.67 +                                   +
      22.8  +                                 +
KNOWN 20.92 +                              +*
CONC. 19.05 +                            +
      17.18 +                         +
      15.3  +                      +
      13.43 +                    +
      11.56 +                 +
      9.68  +              +
      7.81  +            +
      5.94  +     **+
      4.06  +    +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++
             2       8       14      19      25      30
                           CALC. CONC.
```

```
REGRESSION LINE:    Y = -.341954  +  .987951 X
CORREL. COEFF. =  .999038      DETERMIN. COEFF. =  .998077

PLEASE PRESS RETURN TO CONTINUE.?

      2.94  +                                        *
      2.77  +
      2.6   +               *
      2.42  +
      2.25  +                                        +
Error 2.07  +                                   +
in U  1.9   +                         *    +
Calc. 1.73  +                         +
dueto 1.55  +                   +
A2,1  1.38  +              +
      1.21  +         +
      1.03  +    +
      .86   +
      .68   +                                   *
      .51   +
      .34   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:    Y =  .3832  +  .150673 X
CORREL. COEFF. =  .472474      DETERMIN. COEFF. =  .223231
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).   ***

PLEASE PRESS RETURN TO CONTINUE.?

      3.62  +                               *
      3.43  +
      3.23  +
      3.04  +
      2.84  +                  *                   +
Error 2.65  +                                +
in U  2.45  +                           +
Calc. 2.26  +                     +
dueto 2.06  +     *         +
A2,2  1.87  +         +                              *
      1.67  +   +
      1.48  +
      1.29  +
      1.09  +
      .9    +
      .7    +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  1.41358  +  .26405 X
CORREL. COEFF. =  .505414      DETERMIN. COEFF. =  .255443
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).   ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      4.38  +              *
      4.14  +
      3.9   +
      3.65  +
      3.41  +
Error 3.17  +                                         +
in U  2.92  +*                             +
Calc. 2.68  +                   +
dueto 2.43  +      +                                   *
A2,3  2.19  +*
      1.95  +
      1.7   +
      1.46  +
      1.22  +
      .97   +
      .73   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:   Y =  2.182  +  .30666 X
CORREL. COEFF. =  .264603     DETERMIN. COEFF. =  .700147E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
 .115035E-01   5.89409        -3.42353
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                  A( 2 , 2 )
 5      -
          XXX
 5.7    -
          XXXXX
 6.4    -
 7.1    -
          X
 7.8    -
 8.5    -
          X
 9.2    -
          1  4  7  10
          FREQUENCY
```

```
RANGE OF VALUES:   5.33939  TO  8.74813    NUMBER OF VALUES =  10
MEDIAN =  5.89409            MEAN =  6.24469
VALUE USED IN LAST CROSSPLOTS:   5.89409
PLEASE PRESS RETURN TO CONTINUE.?
You may want to decrease A( 2 , 2 ) slightly.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 2 ), Y OR N? Y
 5.33939        5.39793        5.50928        5.84445        5.88296        5.90523
     6.04365        6.24959        7.52632        8.74813
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 2 )
? 5.89
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
 .115035E-01    5.89          -3.42353
-.127641E-01   -.369305        14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                        *
      28.42 +                                      +
      26.54 +                                   +
      24.67 +                                 +
      22.8  +                              +
KNOWN 20.92 +                           +*
CONC. 19.05 +                         +
      17.18 +                      +
      15.3  +                   +
      13.43 +                 +
      11.56 +              +
      9.68  +           +
      7.81  +         +
      5.94  +    **+
      4.06  +   +
      2.19  +  *
            +++++++++++++++++++++++++++++++++++++++++++++
             2       8       14      19      25      30
                          CALC. CONC.
REGRESSION LINE:   Y = -.338614  +  .98861 X
CORREL. COEFF. =  .999043     DETERMIN. COEFF. =  .998088

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      2.89  +                                        *
      2.72  +
      2.55  +               *
      2.38  +
      2.21  +
Error 2.04  +                                   +
in U  1.87  +                         *    +
Calc. 1.7   +                         +
dueto 1.52  +                   +
A2,1  1.35  +              +
      1.18  +         +
      1.01  +    +
      .84   +
      .67   +                                   *
      .5    +
      .33   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9      11      12
                    cps K KNOWN
REGRESSION LINE:    Y =  .373294  +  .147637 X
CORREL. COEFF. =  .471048     DETERMIN. COEFF. =  .221886
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      3.56  +                               *
      3.37  +
      3.18  +
      2.99  +
      2.8   +                  *                    +
Error 2.6   +                                 +
in U  2.41  +                           +
Calc. 2.22  +                     +
dueto 2.03  +     *         +
A2,2  1.84  +         +
      1.64  +   +                                    *
      1.45  +
      1.26  +
      1.07  +
      .88   +
      .69   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  1.39175  +  .257237 X
CORREL. COEFF. =  .498718     DETERMIN. COEFF. =  .24872
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      4.3   +             *
      4.06  +
      3.82  +
      3.58  +
      3.34  +
Error 3.1   +                                       +
in U  2.86  +*                            +
Calc. 2.62  +                  +
dueto 2.38  +      +                                 *
A2,3  2.15  +*
      1.91  +
      1.67  +
      1.43  +
      1.19  +
      .95   +
      .71   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:   Y =  2.12726  +  .303783 X
CORREL. COEFF. =  .267544     DETERMIN. COEFF. =  .07158
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457         -.0445
 .115035E-01    5.89         -3.42353
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 1 )
-6      -
-5.1    -
         X
-4.2    -
-3.3    -
-2.4    -
-1.5    -
-.6     -
         XXXXXXXXX
 .3     -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01        MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:   .115035E-01
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that  .980516E-02  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try  .980516E-02  by substituting it for
 .115035E-01  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? Y
-4.33217      -.220661      -.104197      -.111891E-01   .674592E-02   .162611E
01   .338433E-01   .468814E-01   .922499E-01   .118221
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 1
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 1 , 1 )
? .508
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? 0
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508           -.457          -.0445
 0              5.89           -3.42353
-.127641E-01   -.369305        14.2546
```

```
PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                         *
      28.42 +                                       +
      26.54 +                                    +
      24.67 +                                  +
      22.8  +                               +
KNOWN 20.92 +                            +*
CONC. 19.05 +                          +
      17.18 +                       +
      15.3  +                    +
      13.43 +                  +
      11.56 +               +
      9.68  +            +
      7.81  +         +
      5.94  +     **+
      4.06  +    +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      25      30
                          CALC. CONC.
REGRESSION LINE:   Y = -.262738  +   .990307 X
CORREL. COEFF. =  .999098     DETERMIN. COEFF. =  .998197
```

```
PLEASE PRESS RETURN TO CONTINUE.?

      2.64  +                                         *
      2.48  +
      2.32  +               *
      2.17  +
      2.01  +
Error 1.85  +                                      +
in U  1.69  +                                +
Calc. 1.53  +                          *
dueto 1.38  +                     +
A2,1  1.22  +               +
      1.06  +          +
      .9    +    +
      .75   +
      .59   +                                    *
      .43   +
      .27   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:    Y =  .358058  +  .129291 X
CORREL. COEFF. =  .434989     DETERMIN. COEFF. =  .189215
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      3.19  +                                *
      3.02  +
      2.84  +
      2.67  +
      2.5   +                  *                     +
Error 2.32  +                                  +
in U  2.15  +                            +
Calc. 1.97  +                      +
dueto 1.8   +                +
A2,2  1.63  +     *    +
      1.45  +    +                                *
      1.28  +
      1.1   +
      .93   +
      .75   +
      .58   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  1.20413  +  .233005 X
CORREL. COEFF. =  .485493     DETERMIN. COEFF. =  .235704
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
       3.82  +             *
       3.61  +
       3.39  +
       3.18  +
       2.96  +
Error  2.75  +                                        +
in U   2.53  +*                              +
Calc.  2.31  +                 +                        *
dueto  2.1   +       +
A2,3   1.88  +*
       1.67  +
       1.45  +
       1.24  +
       1.02  +
       .81   +
       .59   +*
             ++++++++++++++++++++++++++++++++++++++++++++
              .5      1       1.6     2.1     2.7     3.3
                     cpsTh KNOWN
REGRESSION LINE:    Y =  1.8007  +  .301973 X
CORREL. COEFF. =  .294414     DETERMIN. COEFF. =  .866798E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508           -.457          -.0445
 0               5.89          -3.42353
-.127641E-01   -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                  A( 2 , 2 )
 5      -
          XXX
 5.7    -
          XXXXX
 6.4    -
 7.1    -
          X
 7.8    -
 8.5    -
          X
 9.2    -
          1  4  7  10
          FREQUENCY
```

```
RANGE OF VALUES:   5.33939  TO  8.74813    NUMBER OF VALUES =  10
MEDIAN =  5.89409            MEAN =  6.24469
VALUE USED IN LAST CROSSPLOTS:   5.89
PLEASE PRESS RETURN TO CONTINUE.?
You may want to decrease A( 2 , 2 ) slightly.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 2 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 2 )
? 5.85
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
 0              5.85          -3.42353
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                        *
      28.42 +                                      +
      26.54 +                                   +
      24.67 +                                 +
      22.8  +                              +
KNOWN 20.92 +                           +*
CONC. 19.05 +                         +
      17.18 +                      +
      15.3  +                   +
      13.43 +                 +
      11.56 +              +
      9.68  +           +
      7.81  +        +
      5.94  +    **+
      4.06  +   +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      25      30
                         CALC. CONC.
REGRESSION LINE:   Y = -.229255  +  .996817 X
CORREL. COEFF. =  .99915     DETERMIN. COEFF. =  .998301

PLEASE PRESS RETURN TO CONTINUE.?
```

```
            2.13  +                                        *
            2     +
            1.87  +               *
            1.74  +
            1.61  +
      Error 1.48  +                                        +
      in U  1.35  +                                  +
      Calc. 1.22  +                            +
      dueto 1.09  +                      +
      A2,1   .97  +                +        *
             .84  +          +
             .71  +    +
             .58  +
             .45  +                                   *
             .32  +
             .19  +*
                  +++++++++++++++++++++++++++++++++++++++++++++
                   4       5       7       9       11      12
                          cps K KNOWN
REGRESSION LINE:    Y =  .261244  +  .996145E-01 X
CORREL. COEFF. =  .400822     DETERMIN. COEFF. =  .160659
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

            2.61  +                               *
            2.47  +
            2.32  +
            2.18  +                  *
            2.03  +
      Error 1.89  +                                      +
      in U  1.74  +                               +
      Calc. 1.6   +                        +
      dueto 1.45  +                 +
      A2,2  1.31  +     *    +
            1.16  +   +
            1.02  +
             .87  +                                        *
             .73  +
             .58  +
             .44  +*
                  +++++++++++++++++++++++++++++++++++++++++++++
                   .6      1.6     2.6     3.6     4.6     5.6
                          cps U KNOWN
REGRESSION LINE:    Y =  .990772  +  .166421 X
CORREL. COEFF. =  .395796     DETERMIN. COEFF. =  .156655
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
        2.98  +             *
        2.81  +
        2.64  +
        2.47  +
        2.3   +
Error   2.13  +                                          +
in U    1.96  +                                  +
Calc.   1.79  +                         +                   *
dueto   1.61  +*            +
A2,3    1.44  +   +
        1.27  +*
        1.1   +
        .93   +
        .76   +
        .59   +
        .42   +*
              +++++++++++++++++++++++++++++++++++++++++++++
               .5     1       1.6     2.1     2.7     3.3
                      cpsTh KNOWN
REGRESSION LINE:    Y =  1.26576  +  .273845 X
CORREL. COEFF. =  .339368     DETERMIN. COEFF. =  .11517
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).   ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508           -.457          -.0445
 0               5.85          -3.42353
-.127641E-01   -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                   A( 2 , 1 )
-6        -
-5.1      -
         X
-4.2      -
-3.3      -
-2.4      -
-1.5      -
-.6       -
         XXXXXXXXX
 .3       -
         1  4  7  10
         FREQUENCY
```

```
ANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
EDIAN =  .115035E-01        MEAN = -.435401
ALUE USED IN LAST CROSSPLOTS:   0
LEASE PRESS RETURN TO CONTINUE.?
OULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? Y
4.33217      -.220661      -.104197      -.111891E-01   .674592E-02   .162611E-
1   .338433E-01   .468814E-01   .922499E-01   .118221
LEASE PRESS RETURN TO CONTINUE.?

OULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
HICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
 ROW NUMBER = ? 2
 COLUMN NUMBER = ? 1
LEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
 -.01
OULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
ERE IS THE LATEST CALIBRATION MATRIX:
.508          -.457          -.0445
.01           5.85           -3.42353
.127641E-01  -.369305         14.2546

HICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
 ROW NUMBER =
 2
 COLUMN NUMBER =
 2

 * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 2 , 2 )
5      -
        XXX
5.7    -
        XXXXX
6.4    -
7.1    -
        X
7.8    -
8.5    -
        X
9.2    -
        1  4  7  10
        FREQUENCY

ANGE OF VALUES:   5.33939  TO  8.74813    NUMBER OF VALUES =  10
EDIAN =  5.89409           MEAN =  6.24469
ALUE USED IN LAST CROSSPLOTS:   5.85
LEASE PRESS RETURN TO CONTINUE.?
ou may want to decrease A( 2 , 2 ) slightly.
OULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 2 ), Y OR N? N
```

```
WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 2 )
? 5.83
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508           -.457           -.0445
-.01             5.83           -3.42353
-.127641E-01   -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 3

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
              A( 2 , 3 )
-7       -
         XXXXXXXXX
-.6      -
 5.8     -
 12.2    -
 18.6    -
 25      -
         X
 31.4    -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:  -5.90231  TO  25.8663    NUMBER OF VALUES =  10
MEDIAN = -3.42353            MEAN = -.855179
VALUE USED IN LAST CROSSPLOTS:  -3.42353
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -4.36104  may be a
better value for A( 2 , 3 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 3 ),
then you may want to try -4.36104  by substituting it for
-3.42353  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 3 ), Y OR N? Y
-5.90231      -4.85716      -3.68761      -3.65696      -3.48325      -3.36381
    -3.3364       -3.2957       -2.83485       25.8663
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 3 )
? -3.43
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N
```

```
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457         -.0445
-.01            5.83         -3.43
-.127641E-01  -.369305        14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                         *
      28.42 +                                       +
      26.54 +                                    +
      24.67 +                                  +
      22.8  +                               +
KNOWN 20.92 +                            *
CONC. 19.05 +                         +
      17.18 +                       +
      15.3  +                    +
      13.43 +                 +
      11.56 +               +
      9.68  +            +
      7.81  +         +
      5.94  +    **+
      4.06  +   +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      24      30
                          CALC. CONC.
REGRESSION LINE:    Y = -.135831  +  1.00152 X
CORREL. COEFF. =  .999229     DETERMIN. COEFF. =  .998459

PLEASE PRESS RETURN TO CONTINUE.?

      1.63  +                                         *
      1.53  +               *
      1.42  +
      1.32  +
      1.22  +
Error 1.12  +
in U  1.01  +                                        +
Calc. .91   +                                  +
dueto .81   +                           +
A2,1  .71   +                    +
      .61   +             +
      .5    +      +
      .4    +                          *
      .3    +
      .2    +                                    *
      .09   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:    Y =  .179167  +  .687219E-01 X
CORREL. COEFF. =  .321687     DETERMIN. COEFF. =  .103482
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      1.98  +                                *
      1.87  +
      1.75  +                  *
      1.64  +
      1.52  +
Error 1.41  +
in U  1.3   +                                      +
Calc. 1.18  +                             +
dueto 1.07  +                     +
A2,2  .95   +             +
      .84   +    +*
      .72   +
      .61   +
      .5    +
      .38   +                                        *
      .27   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:   Y =  .706732  +  .110714 X
CORREL. COEFF. =  .30355     DETERMIN. COEFF. =  .921428E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      2.14  +             *
      2.01  +
      1.88  +
      1.75  +
      1.63  +
Error 1.5   +                                      +
in U  1.37  +                                +
Calc. 1.24  +                         +                *
dueto 1.11  +                 +
A2,3  .99   +         +
      .86   +* +
      .73   +*
      .6    +
      .48   +
      .35   +
      .22   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:   Y =  .710024  +  .251327 X
CORREL. COEFF. =  .406145     DETERMIN. COEFF. =  .164954
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.01            5.83          -3.43
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 1 )
-6       -
-5.1     -
         X
-4.2     -
-3.3     -
-2.4     -
-1.5     -
-.6      -
         XXXXXXXXX
 .3      -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01        MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.01
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.106872E-01  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.106872E-01  by substituting it for
-.01  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.011
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.011           5.83          -3.43
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 3
```

```
* * * * *  HISTOGR
                 A
-7       -
           XXXXXXXXX
-.6      -
 5.8     -
 12.2    -
 18.6    -
 25      -
           X
 31.4    -
           1  4  7  1(
           FREQUENCY

RANGE OF VALUES:  -5
MEDIAN = -3.42353
VALUE USED IN LAST C
PLEASE PRESS RETURN
     Various calcula
better value for A(
light of the histogr
then you may want to
-3.43  and going thr
WOULD YOU LIKE TO VIE

WOULD YOU LIKE TO CHA
WHICH CAL. FACTOR WOU
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW
? -3.48
WOULD YOU LIKE TO SEE
WOULD YOU LIKE TO CHAN

WOULD YOU LIKE TO REVI
THE PLOTS WILL BE BASE
 .508           -.457
-.011            5.83
-.127641E-01   -.369305
```

```
PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                          *
      28.42 +                                        +
      26.54 +                                     +
      24.67 +                                   +
      22.8  +                                +
KNOWN 20.92 +                             *
CONC. 19.05 +                           +
      17.18 +                        +
      15.3  +                     +
      13.43 +                  +
      11.56 +                +
      9.68  +             +
      7.81  +          +
      5.94  +     **+
      4.06  +   +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      24      30
                              CALC. CONC.
REGRESSION LINE:    Y = -.562668E-01  +  1.00105 X
CORREL. COEFF. =  .999322     DETERMIN. COEFF. =  .998645

PLEASE PRESS RETURN TO CONTINUE.?

      1.42  +                                          *
      1.33  +
      1.24  +
      1.14  +               *
      1.05  +
Error .96   +
in U  .87   +
Calc. .77   +                                    +
dueto .68   +                             +
A2,1  .59   +                       +
      .5    +                 +
      .41   +          +
      .31   +    +
      .22   +                         *
      .13   +
      .04   +*                                   *
            ++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                         cps K KNOWN
REGRESSION LINE:    Y =  .200007E-01  +  .663053E-01 X
CORREL. COEFF. =  .358809     DETERMIN. COEFF. =  .128744
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      1.8   +                               *
      1.69  +
      1.59  +
      1.48  +
      1.38  +                  *
Error 1.27  +
in U  1.16  +
Calc. 1.06  +                                  +
dueto .95   +                         +
A2,2  .84   +                 +
      .74   +     *  +
      .63   +
      .53   +
      .42   +
      .31   +                                        *
      .21   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  .580242  +  .981779E-01 X
CORREL. COEFF. =  .302287     DETERMIN. COEFF. =  .913776E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      1.97  +             *
      1.85  +
      1.73  +
      1.61  +
      1.49  +
Error 1.37  +
in U  1.25  +                                     +
Calc. 1.13  +                             +
dueto 1.01  +                    +                   *
A2,3  .9    +           +
      .78   +   +
      .66   + 2
      .54   +
      .42   +
      .3    +
      .18   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5       1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y =  .64776  +  .198005 X
CORREL. COEFF. =  .341862     DETERMIN. COEFF. =  .116869
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.011           5.83          -3.48
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 2 , 1 )
-6       -
-5.1     -
           X
-4.2     -
-3.3     -
-2.4     -
-1.5     -
-.6      -
           XXXXXXXXX
 .3      -
           1  4  7  10
           FREQUENCY

RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01        MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.011
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.117294E-01  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.117294E-01  by substituting it for
-.011  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.013
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.013           5.83          -3.48
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 2
```

```
* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 2 )
 5      -
         XXX
 5.7    -
         XXXXX
 6.4    -
 7.1    -
         X
 7.8    -
 8.5    -
         X
 9.2    -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:   5.33939  TO  8.74813    NUMBER OF VALUES =  10
MEDIAN =  5.89409            MEAN =  6.24469
VALUE USED IN LAST CROSSPLOTS:   5.83
PLEASE PRESS RETURN TO CONTINUE.?
You may want to decrease A( 2 , 2 ) slightly.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 2 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 2 )
? 5.82
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.013           5.82          -3.48
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 3

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 3 )
-7      -
         XXXXXXXXX
-.6     -
 5.8    -
 12.2   -
 18.6   -
 25     -
         X
 31.4   -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -5.90231  TO  25.8663    NUMBER OF VALUES =  10
MEDIAN = -3.42353            MEAN = -.855179
VALUE USED IN LAST CROSSPLOTS:  -3.48
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -4.16906  may be a
better value for A( 2 , 3 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 3 ),
then you may want to try -4.16906  by substituting it for
-3.48  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 3 ), Y OR N? Y
-5.90231      -4.85716      -3.68761      -3.65696      -3.48325      -3.36381
    -3.3364      -3.2957      -2.83485      25.8663
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 3 )
? -3.51
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
-.013           5.82          -3.51
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                             *
      28.42 +                                           +
      26.54 +                                        +
      24.67 +                                      +
      22.8  +                                   +
KNOWN 20.92 +                                *
CONC. 19.05 +                             +
      17.18 +                           +
      15.3  +                        +
      13.43 +                     +
      11.56 +                   +
      9.68  +                +
      7.81  +             +
      5.94  +    **+
      4.06  +    +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13       19       24       30
                          CALC. CONC.
REGRESSION LINE:    Y =  .101395E-01  +  1.00261  X
CORREL. COEFF. =  .999381      DETERMIN. COEFF. =  .998762
```

```
PLEASE PRESS RETURN TO CONTINUE.?

       1.14  +                                         *
       1.06  +
       .98   +
       .9    +
       .82   +               *
Error  .74   +
in U   .66   +
Calc.  .59   +
dueto  .51   +                                  +
A2,1   .43   +                            +
       .35   +                     +
       .27   +               +
       .19   +        +
       .11   +  +
       .03   +
      -.05   +*                        *         *
             ++++++++++++++++++++++++++++++++++++++++++++
              4       5       7       9         11      12
                         cps K KNOWN
REGRESSION LINE:    Y = -.101561  +  .552036E-01 X
CORREL. COEFF. =  .346214     DETERMIN. COEFF. =  .119864
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

       1.5   +                                *
       1.41  +
       1.31  +
       1.22  +
       1.12  +
Error  1.03  +                  *
in U   .94   +
Calc.  .84   +
dueto  .75   +                                +
A2,2   .65   +                     +
       .56   +           +
       .47   +      *
       .37   +
       .28   +
       .18   +
       .09   +*                                        *
             ++++++++++++++++++++++++++++++++++++++++++++
              .6      1.6     2.6     3.6     4.6     5.6
                         cps U KNOWN
REGRESSION LINE:    Y =  .428175  +  .710609E-01 X
CORREL. COEFF. =  .246667     DETERMIN. COEFF. =  .608448E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***
```

```
PLEASE PRESS RETURN TO CONTINUE.?

      1.6   +               *
      1.5   +
      1.4   +
      1.3   +
      1.2   +
Error 1.1   +
in U  1     +
Calc. .9    +                                  +
dueto .8    +                         +
A2,3  .7    +                +                      *
      .6    +       +
      .5    +*
      .4    +*
      .3    +
      .2    +
      .09   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6      2.1      2.7     3.3
                        cpsTh KNOWN
REGRESSION LINE:    Y =  .436925  +  .158757 X
CORREL. COEFF. =  .314241      DETERMIN. COEFF. =  .987475E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457         -.0445
-.013           5.82         -3.51
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 1 )
-6      -
-5.1    -
         X
-4.2    -
-3.3    -
-2.4    -
-1.5    -
-.6     -
         XXXXXXXXX
 .3     -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01        MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.013
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.137176E-01  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.137176E-01  by substituting it for
-.013  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? Y
-4.33217      -.220661      -.104197      -.111891E-01   .674592E-02   .162611
01   .338433E-01   .468814E-01   .922499E-01   .118221
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.015
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.015           5.82          -3.51
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 3

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 3 )
-7      -
         XXXXXXXXX
-.6     -
 5.8    -
 12.2   -
 18.6   -
 25     -
         X
 31.4   -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:  -5.90231  TO  25.8663    NUMBER OF VALUES =  10
MEDIAN = -3.42353            MEAN = -.855179
VALUE USED IN LAST CROSSPLOTS:  -3.51
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -4.06724  may be a
better value for A( 2 , 3 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 3 ),
then you may want to try -4.06724  by substituting it for
-3.51  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 3 ), Y OR N? N
```

```
WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 3 )
? -3.55
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508         -.457         -.0445
-.015          5.82         -3.55
-.127641E-01  -.369305       14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                        *
      28.42 +                                      +
      26.54 +                                   +
      24.67 +                                 +
      22.8  +                              +
KNOWN 20.92 +                           *
CONC. 19.05 +                        +
      17.18 +                      +
      15.3  +                   +
      13.43 +                +
      11.56 +              +
      9.68  +           +
      7.81  +        +
      5.94  +     2 +
      4.06  +   +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      24      30
                          CALC. CONC.
REGRESSION LINE:    Y =  .826483E-01  +  1.00235 X
CORREL. COEFF. =  .999431     DETERMIN. COEFF. =  .998862

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      .95   +                                        *
      .87   +
      .8    +
      .72   +
      .65   +
Error .57   +
in U  .5    +               *
Calc. .43   +
dueto .35   +                                    +
A2,1  .28   +                             +
      .2    +                      +
      .13   +                +
      .05   +         +
     -.02   +  +
     -.1    +*
     -.17   +                         *         *
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
```

REGRESSION LINE: Y = -.230483 + .513565E-01 X

CORREL. COEFF. = .367706   DETERMIN. COEFF. = .135208

*** IT MAY BE WORTHWHILE TO CHECK A(2 , 1). ***

PLEASE PRESS RETURN TO CONTINUE.?

```
      1.32  +                               *
      1.23  +
      1.14  +
      1.05  +
      .96   +
Error .87   +
in U  .78   +
Calc. .69   +                  *
dueto .6    +                                   +
A2,2  .51   +                       +
      .42   +          +
      .33   +     *
      .24   +
      .15   +
      .06   +*
     -.03   +                                        *
            +++++++++++++++++++++++++++++++++++++++++++++
              .6     1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
```

REGRESSION LINE: Y = .307409 + .585042E-01 X

CORREL. COEFF. = .225048   DETERMIN. COEFF. = .506466E-01

*** IT MAY BE WORTHWHILE TO CHECK A(2 , 2). ***

```
PLEASE PRESS RETURN TO CONTINUE.?

      1.42  +             *
      1.33  +
      1.24  +
      1.15  +
      1.06  +
Error .96   +
in U  .87   +
Calc. .78   +
dueto .69   +                                  +
A2,3  .6    +                         +
      .51   +           +                                  *
      .41   +*+
      .32   +
      .23   +*
      .14   +
      .05   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .5       1       1.6      2.1      2.7      3.3
                         cpsTh KNOWN
REGRESSION LINE:   Y =  .353048  +  .115911 X
CORREL. COEFF. =  .245932     DETERMIN. COEFF. =  .604826E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457         -.0445
-.015           5.82         -3.55
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 2 , 1 )
-6      -
-5.1    -
         X
-4.2    -
-3.3    -
-2.4    -
-1.5    -
-.6     -
         XXXXXXXXX
 .3     -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01        MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.015
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.157703E-01  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.157703E-01  by substituting it for
-.015  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.02
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
-.02            5.82          -3.55
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                            *
      28.42 +                                          +
      26.54 +                                       +
      24.67 +                                     +
      22.8  +                                  +
KNOWN 20.92 +                               *
CONC. 19.05 +                            +
      17.18 +                          +
      15.3  +                       +
      13.43 +                    +
      11.56 +                  +
      9.68  +               +
      7.81  +            +
      5.94  +         2 +
      4.06  +    +
      2.19  +  *
            ++++++++++++++++++++++++++++++++++++++++++++++
             2       8       13       19       24       30
                              CALC. CONC.
REGRESSION LINE:   Y =  .116568  + 1.0031 X
CORREL. COEFF. =  .999447     DETERMIN. COEFF. =  .998895

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      .84   +                                         *
      .76   +
      .69   +
      .61   +
      .54   +
Error .47   +               *
in U  .39   +
Calc. .32   +
dueto .24   +                                  +
A2,1  .17   +                           +
      .1    +                   +
      .02   +           +
     -.05   +   +
     -.13   +*
     -.2    +                                   *
     -.28   +                         *
            ++++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:    Y = -.237106  +  .433824E-01 X
CORREL. COEFF. =  .319066     DETERMIN. COEFF. =  .101803
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      1.16  +                               *
      1.07  +
      .98   +
      .9    +
      .81   +
Error .72   +
in U  .63   +                  *
Calc. .55   +
dueto .46   +                                  +
A2,2  .37   +                    +
      .29   +     +
      .2    +     *
      .11   +
      .02   +*
     -.06   +
     -.15   +                                         *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  .225857  +  .479713E-01 X
CORREL. COEFF. =  .193259     DETERMIN. COEFF. =  .373489E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
       1.22  +             *
       1.13  +
       1.05  +
       .97   +
       .89   +
Error  .81   +
in U   .73   +
Calc.  .65   +
dueto  .56   +                                             +
A2,3   .48   +                                   +
       .4    +                         +
       .32   +       +                                        *
       .24   +*
       .16   +
       .08   +
       0     + 2
             ++++++++++++++++++++++++++++++++++++++++++++
              .5      1       1.6     2.1     2.7     3.3
                      cpsTh KNOWN
REGRESSION LINE:   Y =  .211108  +  .115124 X
CORREL. COEFF. =  .263264    DETERMIN. COEFF. =  .693082E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.02            5.82          -3.55
-.127641E-01  -.369305         14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 2 , 1 )
-6       -
-5.1     -
         X
-4.2     -
-3.3     -
-2.4     -
-1.5     -
-.6      -
         XXXXXXXXX
 .3      -
         1  4  7  10
         FREQUENCY
```

```
RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01       MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.02
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.208676E-01  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.208676E-01  by substituting it for
-.02  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? Y
-4.33217       -.220661       -.104197       -.111891E-01   .674592E-02   .162611E-
01   .338433E-01   .468814E-01   .922499E-01   .118221
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.03
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
-.03            5.82          -3.55
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                          *
      28.42 +                                        +
      26.54 +                                     +
      24.67 +                                  +
      22.8  +                                +
KNOWN 20.92 +                             *
CONC. 19.05 +                          +
      17.18 +                        +
      15.3  +                     +
      13.43 +                  +
      11.56 +                +
      9.68  +             +
      7.81  +          +
      5.94  +     2 +
      4.06  +    +
      2.19  +  *
            +++++++++++++++++++++++++++++++++++++++++++++
             2       7       13       19       24       30
                          CALC. CONC.
REGRESSION LINE:   Y =  .184673  +  1.00457 X
CORREL. COEFF. =  .999476     DETERMIN. COEFF. =  .998952
```

```
PLEASE PRESS RETURN TO CONTINUE.?

       .62   +                                        *
       .54   +
       .47   +
       .4    +
       .32   +                    *
Error  .25   +
in U   .18   +
Calc.  .1    +
dueto  .03   +                                 +
A2,1 -.04    +                      +
      -.12   +*      +
      -.19   +
      -.27   +
      -.34   +                                     *
      -.41   +
      -.49   +                             *
             ++++++++++++++++++++++++++++++++++++++++++++++
              4       5       7       9        11       12
                     cps K KNOWN
REGRESSION LINE:    Y = -.25035  +  .274347E-01 X
CORREL. COEFF. =  .21033     DETERMIN. COEFF. =  .442386E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

       .84   +                                  *
       .75   +
       .67   +
       .59   +
       .51   +
Error  .43   +                      *
in U   .35   +
Calc.  .27   +
dueto  .18   +                                  +
A2,2   .1    +        +
       .02   +
      -.06   +*     *
      -.14   +
      -.22   +
      -.31   +
      -.39   +                                           *
             ++++++++++++++++++++++++++++++++++++++++++++++
              .6      1.6     2.6     3.6     4.6     5.6
                     cps U KNOWN
REGRESSION LINE:    Y =  .627533E-01  +  .269069E-01 X
CORREL. COEFF. =  .117382     DETERMIN. COEFF. =  .137785E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      .8    +             *
      .73   +
      .65   +
      .58   +
      .5    +
Error .43   +
in U  .35   +
Calc. .28   +                                      +
dueto .2    +                             +
A2,3  .13   +                   +                    *
      .05   +          +
     -.03   +
     -.1    + 2
     -.18   +
     -.25   +
     -.33   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y = -.727637E-01  +  .11355 X
CORREL. COEFF. =  .297403     DETERMIN. COEFF. =  .884488E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457         -.0445
-.03            5.82         -3.55
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 2
  COLUMN NUMBER =
? 1

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                 A( 2 , 1 )
-6      -
-5.1    -
          X
-4.2    -
-3.3    -
-2.4    -
-1.5    -
-.6     -
          XXXXXXXXX
 .3     -
          1  4  7  10
          FREQUENCY
```

```
RANGE OF VALUES:  -4.33217  TO  .118221    NUMBER OF VALUES =  10
MEDIAN =  .115035E-01       MEAN = -.435401
VALUE USED IN LAST CROSSPLOTS:  -.03
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.030823  may be a
better value for A( 2 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 2 , 1 ),
then you may want to try -.030823  by substituting it for
-.03  and going through the plots for in U  again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 2 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 2
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 2 , 1 )
? -.015
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? Y
THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                          *
      28.42 +                                        +
      26.54 +                                     +
      24.67 +                                   +
      22.8  +                                +
KNOWN 20.92 +                             *
CONC. 19.05 +                          +
      17.18 +                        +
      15.3  +                     +
      13.43 +                  +
      11.56 +                +
      9.68  +             +
      7.81  +          +
      5.94  +      2 +
      4.06  +    +
      2.19  +  *
            +++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      24      30
                            CALC. CONC.
REGRESSION LINE:   Y =  .826483E-01  +  1.00235 X
CORREL. COEFF. =  .999431     DETERMIN. COEFF. =  .998862

PLEASE PRESS RETURN TO CONTINUE.?
```

```
        .95   +                                          *
        .87   +
        .8    +
        .72   +
        .65   +
Error   .57   +
in U    .5    +                *
Calc.   .43   +
dueto   .35   +                                     +
A2,1    .28   +                              +
        .2    +                       +
        .13   +                 +
        .05   +          +
       -.02   +  +
       -.1    +*
       -.17   +                          *         *
              ++++++++++++++++++++++++++++++++++++++++++++++
               4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:   Y = -.230483  +  .513564E-01 X
CORREL. COEFF. =  .367706     DETERMIN. COEFF. =  .135208
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

        1.32  +                                *
        1.23  +
        1.14  +
        1.05  +
        .96   +
Error   .87   +
in U    .78   +
Calc.   .69   +                   *
dueto   .6    +                                    +
A2,2    .51   +                        +
        .42   +          +
        .33   +     *
        .24   +
        .15   +
        .06   +*
       -.03   +                                         *
              ++++++++++++++++++++++++++++++++++++++++++++++
               .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:   Y =  .30741  +  .585042E-01 X
CORREL. COEFF. =  .225048     DETERMIN. COEFF. =  .506465E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      1.42  +             *
      1.33  +
      1.24  +
      1.15  +
      1.06  +
Error .96   +
in U  .87   +
Calc. .78   +
dueto .69   +                                    +
A2,3  .6    +                        +
      .51   +            +                            *
      .41   +*+
      .32   +
      .23   +*
      .14   +
      .05   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y =  .353048  +  .115911 X
CORREL. COEFF. =  .245932     DETERMIN. COEFF. =  .604827E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? N

HERE ARE THE PLOTS AND DATA FOR THORIUM:


THE FOLLOWING CAL. MATRIX WILL BE USED FOR THE PLOTS:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.127641E-01  -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. THORIUM VERSUS CALC. CONC. THORIUM
      45.33 +                                         *
      42.73 +                                      +
      40.12 +                                    +
      37.52 +                                 +
      34.91 +                              +
KNOWN 32.31 +                            +
CONC. 29.7  +                        +
      27.1  +                     +
      24.49 +                   +
      21.89 +                +
      19.28 +             +
      16.68 +           *
      14.07 +        +
      11.47 +     +
      8.86  +  *+*
      6.26  +      *
            ++++++++++++++++++++++++++++++++++++++++++++++
             6        14      22      30      37      45
                          CALC. CONC.
REGRESSION LINE:    Y =  .378609E-02  +  1.00231 X
CORREL. COEFF. =  .999993     DETERMIN. COEFF. =  .999987
```

```
PLEASE PRESS RETURN TO CONTINUE.?

     -.02   +*
     -.04   +
     -.06   +                                   *
     -.09   +
     -.11   +  +
Error-.13   +     +
in Th-.15   +              +
Calc.-.17   +                   +
dueto-.19   +                         +
A3,1 -.21   +                         *   +
     -.24   +                                  +
     -.26   +                                        +
     -.28   +
     -.3    +               *
     -.32   +
     -.34   +                                        *
            ++++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:    Y = -.032881  + -.183199E-01 X
CORREL. COEFF. = -.461056     DETERMIN. COEFF. =  .212573
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

     -.07   +*
     -.09   +
     -.11   +
     -.14   +
     -.16   +
Error-.19   +  +
in Th-.21   +        +                               *
Calc.-.23   +     *        +
dueto-.26   +                    +
A3,2 -.28   +                          +
     -.31   +                                +
     -.33   +                  *                   +
     -.35   +
     -.38   +
     -.4    +
     -.43   +                               *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y = -.159101  + -.319467E-01 X
CORREL. COEFF. = -.488346     DETERMIN. COEFF. =  .238482
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 2 ).  ***
```

```
PLEASE PRESS RETURN TO CONTINUE.?

     -.07   +*
     -.1    +
     -.13   +
     -.16   +
     -.19   +
Error-.22   +
in Th-.25   +*
Calc.-.28   +     +
ducto-.31   +               +                        *
A3,3 -.34   +*                         +
     -.37   +                                     +
     -.4    +
     -.42   +
     -.45   +
     -.48   +
     -.51   +             *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y = -.243904  + -.402446E-01 X
CORREL. COEFF. = -.28536     DETERMIN. COEFF. =  .814304E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?


WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457         -.0445
-.015           5.82         -3.55
-.127641E-01  -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 3
  COLUMN NUMBER =
? 1
```

```
* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
               A( 3 , 1 )
-2        -
-1.9      -
-1.8      -
-1.7      -
-1.6      -
-1.5      -
-1.4      -
-1.3      -
-1.2      -
-1.1      -
-1        -
-.9       -
-.8       -
-.7       -
-.6       -
-.5       -
-.4       -
-.3       -
-.2       -
-.999997E-01 -
        XXXXXXX
 .312924E-06 -
        XX
 .1       -
 .2       -
 .3       -
 .4       -
 .5       -
 .6       -
        X
 .7       -
        1  4  7  10
        FREQUENCY

RANGE OF VALUES:  -.320662E-01  TO  .635392    NUMBER OF VALUES =  10
MEDIAN = -.127641E-01        MEAN =  .534929E-01
VALUE USED IN LAST CROSSPLOTS:  -.127641E-01
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.125303E-01  may be a
be:Wvalue for A( 3 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 3 , 1 ),
then you may want to try -.125303E-01  by substituting it for
-.127641E-01  and going through the plots for in Th again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 3 , 1 ), Y OR N? Y
-.320662E-01  -.273429E-01  -.252218E-01  -.167655E-01  -.133687E-01  -.121596E-
01  -.807166E-02   .151378E-01   .019396        .635392
PLEASE PRESS RETURN TO CONTINUE.?
```

```
WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
   ROW NUMBER = ? 3
   COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 3 , 1 )
? -.0125
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.0125         -.369305        14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
   ROW NUMBER =
? 3
   COLUMN NUMBER =
? 2

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 3 , 2 )
-2       -
-1.9     -
-1.8     -
-1.7     -
-1.6     -
-1.5     -
-1.4     -
-1.3     -
-1.2     -
-1.1     -
-1       -
-.9      -
           X
-.8      -
           X
-.7      -
-.6      -
-.5      -
           X
-.4      -
           XXXXX
-.3      -
           XX

-.2      -
           1  4  7  10
           FREQUENCY
```

```
RANGE OF VALUES:  -.851351  TO -.278453    NUMBER OF VALUES =  10
MEDIAN = -.369305            MEAN = -.44382
VALUE USED IN LAST CROSSPLOTS:  -.369305
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.357507  may be a
better value for A( 3 , 2 ).  If this seems reasonable in
light of the histogram and other values for A( 3 , 2 ),
then you may want to try -.357507  by substituting it for
-.369305  and going through the plots for in Th again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 3 , 2 ), Y OR N? Y
-.851351       -.792686       -.41576        -.389946       -.372593       -.366017
    -.354644       -.32296        -.293791       -.278453
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 3
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 3 , 2 )
? -.363
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N

WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR THORIUM, Y OR N? Y
THE FOLLOWING CAL. MATRIX WILL BE USED FOR THE PLOTS:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.0125         -.363           14.2546

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. THORIUM VERSUS CALC. CONC. THORIUM
      45.33 +                                        *
      42.73 +                                     +
      40.12 +                                   +
      37.52 +                                +
      34.91 +                             +
KNOWN 32.31 +                           +
CONC. 29.7  +                        +
      27.1  +                     +
      24.49 +                   +
      21.89 +                +
      19.28 +             +
      16.68 +           *
      14.07 +        +
      11.47 +     +
      8.86  +  *+*
      6.26  +      *
            ++++++++++++++++++++++++++++++++++++++++++++++
             6       14       22      30      37      45
                          CALC. CONC.
REGRESSION LINE:   Y = -.155449E-01  +  1.00221 X
CORREL. COEFF. =  .999995     DETERMIN. COEFF. =  .999989

PLEASE PRESS RETURN TO CONTINUE.?
```

```
      -.01   +*
      -.02   +
      -.04   +                                         *
      -.06   +
      -.07   +    +
Error-.09    +        +
in Th-.11    +             +       *
Calc.-.12    +                  +
dueto-.14    +                      +
A3,1 -.16    +                           +
      -.17   +                                +
      -.19   +
      -.21   +
      -.22   +
      -.24   +             *
      -.26   +                                    *
             +++++++++++++++++++++++++++++++++++++++++++++
              4       5       7       9       11      12
                        cps K KNOWN
REGRESSION LINE:    Y = -.172722E-01  + -.132207E-01 X
CORREL. COEFF. = -.416856     DETERMIN. COEFF. =  .173769
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 1 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      -.04   +*
      -.06   +
      -.08   +
      -.1    +
      -.12   +                                    *
Error-.14    + +
in Th-.16    +        +
Calc.-.17    +    *       +
dueto-.19    +                  +
A3,2 -.21    +                        +
      -.23   +                              +
      -.25   +
      -.27   +               *
      -.29   +
      -.31   +
      -.33   +                         *
             +++++++++++++++++++++++++++++++++++++++++++++
              .6      1.6     2.6     3.6     4.6     5.6
                        cps U KNOWN
REGRESSION LINE:    Y = -.121162  + -.208947E-01 X
CORREL. COEFF. = -.379288     DETERMIN. COFFF. =  .143859
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
     -.04   +*
     -.06   +
     -.08   +
     -.1    +
     -.13   +
Error-.15   +
in Th-.17   +*+
Calc.-.19   +*
dueto-.22   +
A3,3 -.24   +
     -.26   +
     -.28   +
     -.3    +
     -.33   +
     -.35   +
     -.37   +
            ++++++++++
             .5      1
                      CPS
REGRESSION LINE:    Y =
CORREL. COEFF. = -.3440
*** IT MAY BE WORTHWHILE

PLEASE PRESS RETURN TO CO


WOULD YOU LIKE TO REVIEW O
HERE IS THE LATEST CALIBRA
 .508          -.457
-.015           5.82
-.0125         -.363

WHICH CAL. FACTOR WOULD YOU L
  ROW NUMBER =
? 3
  COLUMN NUMBER =
? 1
```

```
* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                A( 3 , 1 )
-2          -
-1.9        -
-1.8        -
-1.7        -
-1.6        -
-1.5        -
-1.4        -
-1.3        -
-1.2        -
-1.1        -
-1          -
-.9         -
-.8         -
-.7         -
-.6         -
-.5         -
-.4         -
-.3         -
-.2         -
-.999997E-01 -
             XXXXXXX
 .312924E-06 -
             XX
 .1         -
 .2         -
 .3         -
 .4         -
 .5         -
 .6         -
             X
 .7         -
             1  4  7  10
             FREQUENCY

RANGE OF VALUES:  -.320662E-01  TO  .635392    NUMBER OF VALUES =  10
MEDIAN = -.127641E-01        MEAN =  .534929E-01
VALUE USED IN LAST CROSSPLOTS:  -.0125
PLEASE PRESS RETURN TO CONTINUE.?
     Various calculations suggest that -.123347E-01  may be a
better value for A( 3 , 1 ).  If this seems reasonable in
light of the histogram and other values for A( 3 , 1 ),
then you may want to try -.123347E-01  by substituting it for
-.0125  and going through the plots for in Th again.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 3 , 1 ), Y OR N? N

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 3
  COLUMN NUMBER = ? 1
PLEASE INPUT THE NEW CAL. FACTOR A( 3 , 1 )
? -.012
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
```

```
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 3
  COLUMN NUMBER = ? 2
PLEASE INPUT THE NEW CAL. FACTOR A( 3 , 2 )
? -.36
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? Y
HERE IS THE LATEST CALIBRATION MATRIX:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.012          -.36            14.2546

WHICH CAL. FACTOR WOULD YOU LIKE TO CHECK OR CHANGE:
  ROW NUMBER =
? 3
  COLUMN NUMBER =
? 3

* * * * *  HISTOGRAM OF CAL. FACTORS  * * * * *
                  A( 3 , 3 )
 9      -
         X
 10     -
 11     -
 12     -
 13     -
 14     -
         XXXXXXXXX
 15     -
         1  4  7  10
         FREQUENCY

RANGE OF VALUES:   9.83448  TO  14.6383    NUMBER OF VALUES =  10
MEDIAN =  14.2546           MEAN =  13.865
VALUE USED IN LAST CROSSPLOTS:   14.2546
PLEASE PRESS RETURN TO CONTINUE.?
You may want to increase A( 3 , 3 ) slightly.
WOULD YOU LIKE TO VIEW ALL OF THE VALUES FOR A( 3 , 3 ), Y OR N? Y
 9.83448       14.1085       14.1772       14.2399       14.2471       14.2621
     14.2839       14.2929       14.5653       14.6383
PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO CHANGE ANY OF THE CAL. FACTORS, Y OR N ? Y
WHICH CAL. FACTOR WOULD YOU LIKE TO CHANGE:
  ROW NUMBER = ? 3
  COLUMN NUMBER = ? 3
PLEASE INPUT THE NEW CAL. FACTOR A( 3 , 3 )
? 14.26
WOULD YOU LIKE TO SEE ANOTHER HISTOGRAM, Y OR N? N
WOULD YOU LIKE TO CHANGE ANOTHER CAL. FACTOR NOW, Y OR N? N
```

```
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR THORIUM, Y OR N? Y
THE FOLLOWING CAL. MATRIX WILL BE USED FOR THE PLOTS:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.012          -.36            14.26

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. THORIUM VERSUS CALC. CONC. THORIUM
      45.33 +                                        *
      42.73 +                                     +
      40.12 +                                   +
      37.52 +                                +
      34.91 +                             +
KNOWN 32.31 +                           +
CONC. 29.7  +                        +
      27.1  +                     +
      24.49 +                   +
      21.89 +                +
      19.28 +             +
      16.68 +           *
      14.07 +        +
      11.47 +     +
      8.86  +  *+*
      6.26  +      *
            +++++++++++++++++++++++++++++++++++++++++++++
             6       14      22      30      37      45
                          CALC. CONC.
REGRESSION LINE:   Y = -.284996E-01  +  1.00179 X
CORREL. COEFF. =  .999995     DETERMIN. COEFF. =  .99999

PLEASE PRESS RETURN TO CONTINUE.?

      .01   +*
     -.01   +
     -.02   +                                   *
     -.03   +  +                      *
     -.05   +        +
Error-.06   +              +
in Th-.07   +                   +
Calc.-.08   +                         +
dueto-.1    +                               +
A3,1 -.11   +                                     +
     -.12   +
     -.14   +
     -.15   +
     -.16   +               *
     -.17   +
     -.19   +                                        *
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:   Y =  .771124E-02  + -.010109 X
CORREL. COEFF. = -.402823     DETERMIN. COEFF. =  .162266
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 1 ).  ***
```

```
PLEASE PRESS RETURN TO CONTINUE.?

     -.02   +*
     -.04   +
     -.05   +                                        *
     -.07   +
     -.08   +
Error-.1    +  +
in Th-.11   +     *     +
Calc.-.13   +                    +
dueto-.14   +                             +
A3,2 -.16   +                                      +
     -.17   +
     -.19   +                  *
     -.2    +
     -.22   +
     -.24   +
     -.25   +                               *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y = -.085098  + -.137208E-01 X
CORREL. COEFF. = -.299863     DETERMIN. COEFF. =  .899177E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

     -.02   +*
     -.03   +
     -.05   +
     -.07   +
     -.09   +
Error-.1    +*
in Th-.12   +*     +
Calc.-.14   +               +                        *
dueto-.15   +                        +
A3,3 -.17   +                                 +
     -.19   +
     -.21   +
     -.22   +
     -.24   +
     -.26   +
     -.27   +             *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y = -.941103E-01  + -.278351E-01 X
CORREL. COEFF. = -.341651     DETERMIN. COEFF. =  .116726
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
```

```
WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR THORIUM, Y OR N? N


HERE IS THE MATRIX OF MEDIAN CALIBRATION FACTORS:
 .512268       -.449866       -.444573E-01
 .115035E-01    5.89409       -3.42353
-.127641E-01   -.369305        14.2546

PLEASE PRESS RETURN TO CONTINUE.?

HERE IS THE MATRIX OF CAL. FACTORS THAT INCLUDES THE LAST CHANGES
YOU MADE, IF ANY:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.012          -.36            14.26

DO YOU WISH TO REVIEW OR CHANGE ANY CAL. FACTORS OR REVIEW THE
CROSSPLOTS OR HISTOGRAMS, Y OR N? Y

THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:

 .508          -.457          -.0445
-.015           5.82          -3.55
-.012          -.36            14.26

PLEASE PRESS RETURN TO CONTINUE.?

HERE IS A CROSSPLOT OF KNOWN AND CALCULATED CONCENTRATIONS OF K, U AND TH:
      45.33 +                                        +*
      42.4  +                                      +
      39.48 +                                    +
      36.55 +                                 +
      33.63 +                              +
KNOWN 30.7  +                           +*+
CONC. 27.78 +                        +
      24.85 +                     +
      21.93 +                   +
      19    +                + *
      16.08 +             + *
      13.15 +           +
      10.23 +        +*+
      7.3   +    *+*
      4.38  +  *+ 3
      1.45  + *
            ++++++++++++++++++++++++++++++++++++++++++++++
             1       10      19      28      37      45
                          CALC. CONC.
REGRESSION LINE:   Y =  .892544E-02  +  1.00221 X
CORREL. COEFF. =  .999833     DETERMIN. COEFF. =  .999667

PLEASE PRESS RETURN TO CONTINUE.?

NOW LET US CONSIDER THE DATA FOR POTASSIUM.
```

```
THE FOLLOWING CALIBRATION MATRIX WILL BE USED FOR THE PLOTS:
 .508          -.457          -.0445
-.015           5.82          -3.55
-.012          -.36            14.26

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. POTASSIUM VERSUS CALC. CONC. POTASSIUM
      5.14  +                                         *
      4.89  +                                       +
      4.65  +                                    +
      4.4   +                                 +
      4.16  +                              *
KNOWN 3.91  +                            +
CONC. 3.66  +                         +
      3.42  +                      +
      3.17  +                    +
      2.93  +                 +
      2.68  +              +
      2.43  +            +
      2.19  +         +
      1.94  +      + 2
      1.7   +    +
      1.45  + *
            ++++++++++++++++++++++++++++++++++++++++++++
             1.5     2.2     2.9     3.7     4.4     5.1
                             CALC. CONC.
REGRESSION LINE:    Y = -.165882E-01  +  1.00047 X
CORREL. COEFF. =  .999893     DETERMIN. COEFF. =  .999786

PLEASE PRESS RETURN TO CONTINUE.?

       .05  +                                         *
       .04  +
       .04  +
       .04  +
       .03  +
Error  .03  +*
in K   .03  +
Calc.  .02  +
dueto  .02  +
A1,1   .02  +
       .01  +
       .01  +
      0     +               *
      0     +
      0     +                         *
     -.01   +                                   *
            ++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                         cps K KNOWN
REGRESSION LINE:    Y =  .153419E-01  + -.910737E-04 X
CORREL. COEFF. = -.138154E-01     DETERMIN. COEFF. =  .190866E-03
A( 1 , 1 ) MAY BE O.K.
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```
PLEASE PRESS RETURN TO CONTINUE.?

      .05   +                               *
      .04   +
      .04   +
      .04   +
      .03   +
Error .03   +*
in K  .02   +
Calc. .02   +
dueto .02   +
A1,2  .01   +
      .01   +
      .01   +
      0     +                  *
      0     +
      0     +                                        *
     -.01   +     *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:   Y =  .133333E-01  +  .741918E-04 X
CORREL. COEFF. =  .667781E-02     DETERMIN. COEFF. =  .445932E-04
A( 1 , 2 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?

      .05   +             *
      .04   +
      .04   +
      .04   +
      .03   +
Error .03   +*
in K  .03   +
Calc. .02   +
dueto .02   +
A1,3  .01   +             +
      .01   +
      .01   +                                        *
      0     +
      0     +
      0     +*
     -.01   +*
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:   Y =  .155037E-01  + -.666124E-03 X
CORREL. COEFF. = -.327048E-01     DETERMIN. COEFF. =  .106961E-02
A( 1 , 3 ) MAY BE O.K.

PLEASE PRESS RETURN TO CONTINUE.?
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WOULD YOU LIKE TO REVIEW OF CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR POTASSIUM, Y OR N? N

NOW FOR THE DATA FOR URANIUM.....


THE PLOTS WILL BE BASED ON THIS CAL. MATRIX:
 .508           -.457          -.0445
-.015            5.82          -3.55
-.012           -.36            14.26

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. URANIUM VERSUS CALC. CONC. URANIUM
      30.29 +                                          *
      28.42 +                                        +
      26.54 +                                     +
      24.67 +                                   +
      22.8  +                                +
KNOWN 20.92 +                             *
CONC. 19.05 +                          +
      17.18 +                        +
      15.3  +                     +
      13.43 +                  +
      11.56 +                +
      9.68  +             +
      7.81  +          +
      5.94  +       2 +
      4.06  +   +
      2.19  +  *
            +++++++++++++++++++++++++++++++++++++++++++++
             2       8       13      19      24      30
                             CALC. CONC.
REGRESSION LINE:    Y =  .826483E-01  +  1.00235 X
CORREL. COEFF. =  .999431     DETERMIN. COEFF. =  .998862

PLEASE PRESS RETURN TO CONTINUE.?

      .95   +                                          *
      .87   +
      .8    +
      .72   +
      .65   +
Error .57   +
in U  .5    +              *
Calc. .43   +
dueto .35   +                                      +
A2,1  .28   +                               +
      .2    +                        +
      .13   +                  +
      .05   +          +
     -.02   +   +
     -.1    +*
     -.17   +                         *          *
            +++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                       cps K KNOWN
REGRESSION LINE:    Y = -.230483  +  .513565E-01 X
CORREL. COEFF. =  .367706     DETERMIN. COEFF. =  .135208
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 1 ).   ***
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```
PLEASE PRESS RETURN TO CONTINUE.?

      1.32  +                               *
      1.23  +
      1.14  +
      1.05  +
      .96   +
Error .87   +
in U  .78   +
Calc. .69   +                  *
dueto .6    +                                   +
A2,2  .51   +                       +
      .42   +          +
      .33   +     *
      .24   +
      .15   +
      .06   +*
     -.03   +                                        *
            +++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y =  .307409  +  .585042E-01 X
CORREL. COEFF. =  .225048     DETERMIN. COEFF. =  .506466E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

      1.42  +             *
      1.33  +
      1.24  +
      1.15  +
      1.06  +
Error .96   +
in U  .87   +
Calc. .78   +
dueto .69   +                                   +
A2,3  .6    +                        +
      .51   +            +                           *
      .41   +*+
      .32   +
      .23   +*
      .14   +
      .05   +*
            +++++++++++++++++++++++++++++++++++++++++++++
             .5      1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y =  .353048  +  .115911 X
CORREL. COEFF. =  .245932     DETERMIN. COEFF. =  .604826E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 2 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
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WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR URANIUM, Y OR N? N

HERE ARE THE PLOTS AND DATA FOR THORIUM:


THE FOLLOWING CAL. MATRIX WILL BE USED FOR THE PLOTS:
 .508           -.457          -.0445
-.015            5.82          -3.55
-.012           -.36            14.26

PLEASE PRESS RETURN TO CONTINUE.?
KNOWN CONC. THORIUM VERSUS CALC. CONC. THORIUM
      45.33 +                                         *
      42.73 +                                      +
      40.12 +                                    +
      37.52 +                                 +
      34.91 +                              +
KNOWN 32.31 +                            +
CONC. 29.7  +                         +
      27.1  +                      +
      24.49 +                    +
      21.89 +                 +
      19.28 +              +
      16.68 +            *
      14.07 +         +
      11.47 +      +
      8.86  +  *+*
      6.26  +       *
            ++++++++++++++++++++++++++++++++++++++++++++
             6       14      22      30      37      45
                          CALC. CONC.
REGRESSION LINE:   Y = -.284996E-01  +  1.00179 X
CORREL. COEFF. =  .999995     DETERMIN. COEFF. =  .99999

PLEASE PRESS RETURN TO CONTINUE.?

      .01   +*
     -.01   +
     -.02   +                                    *
     -.03   +  +                       *
     -.05   +        +
Error-.06   +              +
in Th-.07   +                   +
Calc.-.08   +                         +
dueto-.1    +                               +
A3,1 -.11   +                                     +
     -.12   +
     -.14   +
     -.15   +
     -.16   +               *
     -.17   +
     -.19   +                                          *
            ++++++++++++++++++++++++++++++++++++++++++++
             4       5       7       9       11      12
                    cps K KNOWN
REGRESSION LINE:   Y =  .771124E-02  + -.010109 X
CORREL. COEFF. = -.402823     DETERMIN. COEFF. =  .162266
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 1 ).   ***
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```
PLEASE PRESS RETURN TO CONTINUE.?

     -.02   +*
     -.04   +
     -.05   +                                        *
     -.07   +
     -.08   +
Error-.1    +  +
in Th-.11   +     *     +
Calc.-.13   +                    +
dueto-.14   +                             +
A3,2 -.16   +                                      +
     -.17   +
     -.19   +                  *
     -.2    +
     -.22   +
     -.24   +
     -.25   +                               *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .6      1.6     2.6     3.6     4.6     5.6
                    cps U KNOWN
REGRESSION LINE:    Y = -.085098  + -.137208E-01 X
CORREL. COEFF. = -.299863     DETERMIN. COEFF. =  .899177E-01
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 2 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?

     -.02   +*
     -.03   +
     -.05   +
     -.07   +
     -.09   +
Error-.1    +*
in Th-.12   +*     +
Calc.-.14   +               +                        *
dueto-.15   +                        +
A3,3 -.17   +                                 +
     -.19   +
     -.21   +
     -.22   +
     -.24   +
     -.26   +
     -.27   +             *
            ++++++++++++++++++++++++++++++++++++++++++++++
             .5       1       1.6     2.1     2.7     3.3
                    cpsTh KNOWN
REGRESSION LINE:    Y = -.941103E-01  + -.278351E-01 X
CORREL. COEFF. = -.341651     DETERMIN. COEFF. =  .116726
*** IT MAY BE WORTHWHILE TO CHECK A( 3 , 3 ).  ***

PLEASE PRESS RETURN TO CONTINUE.?
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WOULD YOU LIKE TO REVIEW OR CHANGE ANY OF THE CAL. FACTORS, Y OR N? N
WOULD YOU LIKE TO REVIEW ANY OF THE PLOTS FOR THORIUM, Y OR N? N


HERE IS THE MATRIX OF MEDIAN CALIBRATION FACTORS:
 .512268        -.449866        -.444573E-01
 .115035E-01    5.89409        -3.42353
-.127641E-01   -.369305         14.2546

PLEASE PRESS RETURN TO CONTINUE.?

HERE IS THE MATRIX OF CAL. FACTORS THAT INCLUDES THE LAST CHANGES
YOU MADE, IF ANY:
 .508          -.457           -.0445
-.015           5.82           -3.55
-.012          -.36             14.26

DO YOU WISH TO REVIEW OR CHANGE ANY CAL. FACTORS OR REVIEW THE
CROSSPLOTS OR HISTOGRAMS, Y OR N? N


**** GOOD LUCK WITH YOUR CALIBRATION FACTORS. ****
#############  END  OF  PROGRAM  ###############
Ready
```